PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON NEWVIEWS IN ENGINEERING AND TECHNOLOGY (ICNET) MAIDEN EDITION, FACULTY OF ENGINEERING, RIVERS STATE UNIVERSITY, PORT HARCOURT, NIGERIA.
27th October 2021
Available online at https://conference.rsujnet.org/

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PROGRAMME OF ACTIVITIES

Prof. Nlerum S. Okogbule - **Vice Chancellor and Chief Host**
Emeritus Prof. Steve Odi-Owei - **Conference Chairman**
Engr. Prof. Joseph A. Ajienka - **Special Guest of Honour**
Engr. Simbi K. Wabote - **Keynote Speaker 1**
Prof. Bariyima D. Kiabel - **Keynote Speaker 2**
Prof. Christopher O. Ahiakwo - **Host**
Mr. Cyprian Ojum - **Lead Paper Presenter**

S/N	Activity	Speaker	Time
1	Arrival of Dignitaries		9.00am – 10.00am
2	**Opening Ceremony**		**10.00am – 11.50am**
	1) Opening Prayer	Engr. Rev Nitoye Sampson	10.00am – 10.05am
	2) Welcome Address	Prof. C. O. Ahiakwo (Dean)	10.05am – 10.15am
	3) Chairman's Address	Emeritus Prof. S. Odi-Owei	10.15am – 10.30am
	4) Address by Chief Host	Prof. N. S. Okogbule	10.30am – 10.45am
	5) Speech by Special Guest of Honour	Engr. Prof. J. A. Ajienka	10.45am – 11.00am
	6) Keynote Address 1	Engr. S. K. Wabote	11.00am – 11.20am
	7) Keynote Address 2	Prof. B. D. Kiabel	11.20am – 11.40am
	8) Brief by Chairman, RD&P	Engr. Prof. F. T. Ademiluyi	11.40am – 11.45am
	9) Vote of Thanks/Conference Brief	Engr. Dr. S. Orike	11.45am – 11.50am
3	Tea Break		11.50am – 12.00noon
4	**Plenary Sessions**	**Session Chairs**	
	1) Agricultural, Environmental & Civil Engineering	Engr. Prof. M .J. Ayotamuno	12.00noon – 3.00pm
	2) Chem/Petrochemical & Petroleum Engineering	Engr. Prof. C. P. Ukpaka	12.00noon – 3.00pm
	3) Electrical & Computer Engineering	Engr. Prof. D. C. Idoniboyeobu	12.00noon – 3.00pm
	4) Marine & Mechanical Engineering	Engr. Prof. J. I. Sodiki	12.00noon – 3.00pm
5	Break		3.00pm – 3.10pm
6	**Rap-up Session**	Engr. Prof. C. O. Ahiakwo & Engr. Prof. F. T. Ademiluyi	3.10pm – 3.50pm
	Conference Rapporteurs: 1) Engr. Dr. R. N. Okparanma 2) Engr. Dr. E. O. Ekwulo 3) Engr. Prof. J. G. Akpa 4) Engr. Dr. A. S. Nwosi-Anele 5) Engr. Dr. H. N. Amadi 6) Engr. M. Franklin 7) Engr. K. Theophilus-Johnson 8) Engr. Dr. B. Nkoi		
7	Final Vote of Thanks	Engr. Dr. S. Orike	3.50pm – 3.55pm
8	Closing Prayer	Engr. Dr. E. A. Igwe	3.55pm – 4.00pm

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CONFERENCE THEME:

LEADING EDGE TECHNOLOGIES FOR ENTREPRENEURSHIP AND LOCAL CONTENT DEVELOPMENT IN THE 21ST CENTURY

WELCOME ADDRESS DELIVERED BY THE CONFERENCE HOST: PROF. CHRISTOPHER O. AHIAKWO (DEAN OF FACULTY OF ENGINEERING, RIVERS STATE UNIVERSITY, PORT HARCOURT)

1.0 INTRODUCTION

I am pleased to welcome you all to this Maiden Edition of International Conference on Newviews in Engineering and Technology. This Conference is planned by Faculty of Engineering, Rivers State University to be an annual event. The aim of which is to provide a forum annually for Engineers, Technologists, Technicians, Craftsmen, and stakeholders in the Engineering family to interact professionally and present solutions aimed at the development of the Engineering profession and the nation at large.

The theme of this year's conference is "Leading Edge Technologies for Entrepreneurship and Local Content Development in the 21st Century". Various sub-themes have been carefully selected to effectively address the theme. It is our conviction that a robust Engineering discussion will provide a very strong catalyst for sustainable local content entrepreneurship development of Nigeria. This, we believe, will also provide opportunities for an enhanced future of the economy of this Nation.

The essence of this year's conference is to explore the leading-edge technologies that will empower entrepreneurs with relevant information and skills necessary to make them succeed in their entrepreneurship goals and also enhance the development of local content inventions and creativities that would boast the nation's economy.

Leading Edge Technology is something that represents the most advanced or innovative aspect of a field, activity, profession, etc. It is also known as cutting edge technology or state-of-the-art technology. It refers to technological devices, techniques or achievements that employed the most current and high-level Information Technology (IT) developments. In other words, it is technology at the frontiers of knowledge

Entrepreneurship is often referred to as the concept of developing and managing a business venture for profit by taking several risks. Simply put, entrepreneurship is the willingness to start a new business and the ability to be creative / innovative in business so as to create wealth and improve one's standards of living.

Local Content Development is essentially, the securing, either directly or indirectly, the employment and procurement of local nationals and training them to acquire relevant skills. It is basically the use of locals to achieve technological transfer as well as the use of locally manufactured products in capital projects. In most cases, local content requires distinct policies by government for firms to use domestically-manufactured goods or domestically-supplied services in their operations so as to improve the local economy.

In all, Leading Edge Technology for Entrepreneurship and Local Content Development in the 21st Century simply means, to explore the most advanced or innovative aspect of developing and managing a business venture. This also includes the employment and procurement of local nationals to foster the development of local skills and promote effective technology transfer. The end result of which is the improvement of the local economy.

2.0 LEADING EDGE TECHNOLOGIES

Technology is playing important role in society today. It affects the way individuals communicate, learn and think. It helps and determines how people interact with each other on daily basis. People are using the advantages of technology to improve their environment and social live. Technology will continue to have stronger influence on mankind and will eventually become an inseparable part of the society. The world is advancing rapidly in technology, but Nigeria is not among the developing world. Hence the need for this Engineering conference.

As an institution, we believe that this conference will serve as a driving force or forum where professionals, experts and successful entrepreneurs will meet and share ideas on the emerging technologies in their research areas and also tell their success stories. As a faculty, we have in the "Drawing Board" a robust "**Centre for Renewable Energy Research"**. Our desire is to partner with the Industry, Government and Academia in developing the center. Inputs from this conference will be added advantage to the actualization of the center.

THANK YOU

KEYNOTE ADDRESS 1

BY ENGR. SIMBI KESIYE WABOTE FNSE, FIPS, THE EXECUTIVE SECRETARY, NIGERIAN CONTENT DEVELOPMENT AND MONITORING BOARD [NCDMB] AT THE MAIDEN EDITION OF THE INTERNATIONAL CONFERENCE ON NEW VIEWS IN ENGINEERING AND TECHNOLOGY ON THE 27TH OF OCTOBER, 2021

PROTOCOLS,

Let me begin by saying how elated I feel to be here at this Conference and to represent the Executive Secretary Nigerian Content Development and Monitoring Board, Engineer Simbi, Kesiye Wabote, who could not be here today due to other urgent national duties. Let me assert that the Executive Secretary holds this institution to a very high esteem, as his alma mater, and he remembers with a deep sense of nostalgia and gratitude, the hard work put in by the faculty and management in moulding him into a success story that he is today. On his behalf, let me say thank you and assure you that he will continue to be one of your great ambassadors.

The theme of this conference - **Leading Edge Technologies for Entrepreneurship and Local Content Development in the 21st Century**, could not have come at a better time considering the situation we find ourselves as a country and the numerous challenge that we face: hyperinflation, low level of the Naira, economic and social challenges and threats of divestment from major international investors in the oil and gas industry and the challenge of achieving high levels of local content in the major sectors of the Nigerian economy. I see three major and important components in the theme of the conference, which are important to the work that we do at the Nigerian Content Development and Monitoring Board. First is technology, which is the application of scientific knowledge for value creation and problem solving for the benefit of mankind. Technology, we often say is the big differentiator between the developed and underdeveloped nations, stable and chaotic democracies. Technology includes the systems, processes and procedures applied for the resolution of the problems of man. Nations that can produce technology, especially advanced technologies are considered powerful and dominate the economies of nations that cannot produce technology. One can safely argue that the current challenges faced by Nigeria as a nation, can be traced to the shortage of technologies.

The second is Entrepreneurship which is the '**desire to innovate, take risks, execute and to create value**'. Nations with large numbers of successful entrepreneurs grow at a faster pace than nations that do not have entrepreneurs. The entrepreneur is driven by the desire for value (profit, quality, lower cost,

efficiencies, and reputation). To sustain and grow entrepreneurship, the key requirements are the existence of entrepreneurial opportunities, capabilities, and capacity.

Entrepreneurship opportunities exist when there is effective and identifiable demand for the offerings of the entrepreneur. In the oil and gas industry for instance, the delivery of a field project demands materials, equipment, personnel, and finance. Entrepreneurs who can offer these services and materials are said to have entrepreneurial opportunity. Entrepreneurial capability refers to a distinct set of individual and organizational capabilities, competencies, and skills as well as experiences, actions, practices, and routines that are required to provide offerings efficiently and professionally to customers. They include the ability to aim to explore, integrate, and exploit untapped business opportunities within an instituted market context. Finally entrepreneurial capacity allows a firm to capitalize on a broad scope of fresh, alternative perspectives that may fundamentally challenge embedded assumptions and path-dependent cognitive schemas that a firm uses. Due to entrepreneurial capacity, a firm becomes exposed to many alternative viewpoints that represent heterogeneity of its external environment. Exposure to a broad array of alternative perspectives prompts a firm to reconsider the effectiveness of its internal operations. Firms that maintain strong entrepreneurial capacity are likely to succeed over time.

The delivery of local content revolves around the existence of the entrepreneur, who we also call the businessman. At the start of the Nigerian oil and Gas Industry Content Development Act, 2010, there were only a handful of Nigerian entrepreneurs delivering services in the oil and gas industry. Today, Nigeria can boast of a deluge of successful entrepreneurs, delivering value and making the difference in the entire value chain of the oil and gas industry, from exploration through development, production, transportation, and abandonment. The Nigerian Content Development and Monitoring Board has significantly grown opportunities for entrepreneurs through the numerous initiatives undertaken by the Board such as the Nigerian Content Equipment Category development, which seeks to ensure that Nigerian companies own a significant proportion of equipment, materials and resources used in the oil and Gas industry. Nigerian companies have also been supported through the Nigerian Content Development Fund (NCDF) to acquire equipment and technologies required to provide services to the Oil and Gas industry through our investment fund with the Bank of Industries. In so doing, the level of local content has grown from 5% in 2010 to about 35% in 2020 with the target of 70% in 2027, in mind.

One can say that the greatest opportunity for technology development lies in project delivery. For example, the delivery of a new field development project. From the well head to the crude oil tank, there are numerous opportunities for technology development and entrepreneurship. Some of the opportunities are entrepreneurially viable and available, while others are matured and constrained.

Local content development plays a major role when the question of the source of materials and equipment, the sources and ownership of capital, location of activities and finance and the number and competence of human capital are considered. From the discovery of crude oil in Nigeria in 1938 to the

eventual production and export from Oloibiri in 1958 up to 2010, the Nigerian oil and gas industry witnessed over three hundred billion US dollars capital flight, over two million job losses and achieved less than 5% in-country value addition.

The Nigerian Oil and Gas Industry Content Development Act 2010, was enacted to reverse the continued capital flight, catalyse industrialisation, promote the development and utilization of in-country capabilities for the industrialization of Nigeria through the effective implementation of the Nigerian Content Act." The key thrust of the NOGICD Act include,

1. integrating Nigerian entrepreneurs into the oil and gas value chain,
2. maximising the value delivered by Nigerian entities to the oil and gas industry,
3. maximising the use of Nigerian resources- materials, equipment, finance, services, and human capital,
4. supporting research and development to create new technologies required by the industry.
5. attracting investment to the oil and gas sector
6. linking the Nigeria oil and gas sector to the other sectors of the economy.

In my view, leading edge technologies will accelerate the pace of attainment of these objectives and open up opportunities for local entrepreneurs. Economies have witnessed the influx of leading-edge technologies and with it the balance of value has shifted in favour of developed nations, who have reliable and proven sources of technologies. By the same token, technologies used for oil and gas exploration have witnessed numerous changes and rightly, the planners of this conference have identified the more prominent changes such as the impact of digitalisation and artificial intelligence, internet of things, big data, augmented reality, virtual reality, renewable and green energies, just to mention a few.

These technologies are changing the processes for value realisation in the economy and nations that have them are prospering while dependent nations are still grappling with multitude of challenges. For us at the NCDMB, these technologies have once again led to capital flight, offshoring of opportunities and dependence on foreign human capital. If Nigeria fails to innovate at a faster pace and does not carry out advanced research and development, the much-touted Local Content will remain a mirage. To support the growth of local content, NCDMB has undertaken some deliberate interventions such as:

1. The Nigerian Content $50m R&D Fund to support research and development of cutting-edge technologies.

2. Nigerian Content Equipment Component Manufacturing Initiative (ECMI), which was conceived by the Board to address the gaps in Local manufacturing, assembly, fabrication, threading, coating, repair/maintenance, calibration and testing of equipment/equipment components etc. Local supply of equipment/equipment components in the Nigerian Oil and Gas Industry and

Ownership of equipment used for onshore and offshore services in the Nigerian Oil and Gas Industry.

3. The Nigerian Oil and Gas Parks which has been conceived to provide infrastructure for industrialisation. Six parks are being developed at Odukpani – Cross Rivers State, Emeyal-Bayelsa State, Onna- Akwa Ibom State, Ondo State, Delta State and Oguta-Imo State.

4. Marine Vessels Scheme (MVS), with the ultimate objective of increasing Marine Vessels ownership by indigenous companies operating in the Nigerian Oil and Gas Industry.

5. Nigerian Content Rig Ownership and Utilization Scheme – with the objective of driving the acquisition, ownership, and utilization of Rigs in the Nigerian Oil and Gas Industry

6. Nigerian Content Expatriate Quota Scheme – to regulate the influx of expats into the oil and gas industry

7. Investment in commercial ventures such as modular refining, oil and gas processing, and provision of infrastructure in the LPG value chain.

8. Nigerian Content $350m Intervention Fund with Bank of Industries

9. Institutional strengthening, upgrade of technical and Vocational schools, teachers training and support for Science, Technology, Engineering and Mathematic (STEM) development across the country.

As you deliberate today on the role leading edge technologies and entrepreneurship will play in local content development, let me assure you of the partnership and support of the NCDMB. It is our hope that your effort will lead to more technology development and patents in Nigeria and that our mantra that we produce what we use and use what we produce will not just remain a slogan but will be actualised in the not-too-distant future.

Conclusion

When faced with the enormity of our challenges and constraints in resources, it is not only advisedly that we are prudent and rational in focusing our efforts and in this regard, let me leave you with the following charge to ensure that your effort becomes successful, recognised, and celebrated.

1. Avoid ‘High tech for high-tech sake’. Let’s target our effort at commercially viable opportunities, one that will lead to the timely recouping of investments.
2. Let’s start with projects that are smart, industry relevant and have originality. It will be a waste of time to reinvent the wheel when there is so much to be done with the limited time and available resources to make our local content dream a reality.

3. Let's collaborate as much as possible with customers, league of innovators, venture capitalists, funding agencies, etc.
4. Let's focus on making impact on capacity and capabilities and support the industrialisation of the economy.
5. Let's leapfrog and support the development of technologies in the areas of energy transition, carbon capture, and digitalisation.
6. Let's stay committed and focused and with time, we shall persist and overcome.

Thank you for listening.

Dr. Ama Ikuru
General Manager, Capacity Building Division
Nigerian Content Development and Monitoring Board

KEYNOTE ADDRESS 2

ENTREPRENEURIAL MINDSET IMPERATIVES FOR THE 21ST CENTURY ENGINEER: GAINING FROM LEADING EDGE TECHNOLOGIES FOR LOCAL CONTENT DEVELOPMENT

Being a Keynote address by Prof. B. D. Kiabel, Director, Centre for Entrepreneurial Studies, Presented by Dr JMO Gabriel, Associate Professor, Department of Management, Faculty of Management Sciences, during the maiden International Conference on New-views in Engineering and Technology organized by the Faculty of Engineering, Rivers State University, Port Harcourt.

PREAMBLE

It is my pleasure to welcome every participant to this maiden edition of the international virtual conference on new views in engineering and technology hosted in the faculty of engineering of the Rivers State University, Port Harcourt, Nigeria. I count it a great pleasure to be selected as one of the key note speakers in this epoch-making event. I am not sure of how best I fit into this shoe; however, my strength is in the confidence you have bestowed on me as a matter of this choice.

Looking at the theme of this conference, "Leading edge technologies for entrepreneurship and local content development in the 21st Century, and its associated sub-themes which are also of state-of-the-art status, I cannot think of any other subject matter more suitable in this conglomeration of intellectuals and

practitioners of this caliber; and especially in the context of current global technological changes and radical pandemic disruptions. It therefore becomes irresistible for me to give great kudos to all those whose inputs brought about this event.

1.0 INTRODUCTION

The world has changed in ways that now requires everyone to think like an entrepreneur.

~ The Entrepreneurial Learning Initiative Inc.

Nigeria like other developing nations is indisputably struggling with several challenges, including lack of power supply, poor road networks, insufficient food supplies, security threats, agitation for self-governance and acute unemployment among others. These avalanches of problems have for sure brought the nation to its begging knees; made her to be looking from south to west, north to east in search of liberation and succor. In time such as this, the role of entrepreneurship can hardly be undermined in the quest for taking advantage of cutting-edge technological breakthrough for local content development. The role of entrepreneurship has been different across countries. Holcombe (1998:60) claims that, "the engine of economic growth is entrepreneurship." Entrepreneurship has also been assessed as a driving force of decentralization, economic restructuring and movement in the direction of market economy (Smallbone *et al*., 1996:16).

The cultivating ground for local content development is the Small and Medium Enterprises (SMEs) because they occupy a place of pride in virtually every country or state. Because of the significant roles played by SMEs in the development and growth of various economies, they (SMEs) have aptly been referred to as "the engine of growth" and "catalysts for socio-economic transformation of any country." SMEs represent a veritable vehicle for the achievement of national economic objectives of employment generation and poverty reduction at low investment cost as well as the development of entrepreneurial capabilities including indigenous technology (Ogbo & Agu, 2012).

Other intrinsic benefits of vibrant SMEs include access to the infrastructural facilities occasioned by the existence of such SMEs in their surroundings, the stimulation of economic activities such as suppliers of various items and distributive trades for items produced and or needed by the SMEs, stemming from rural urban migration, enhancement of standard of living of the employees of the SMEs and their dependents as well as those who are directly or indirectly associated with them. These forms of enterprises are the eventual service providers in the national local content program.

The Nigerian Oil and Gas Development Law of 2010 defines local content as "the quantum of composite value added or created in the Nigerian economy by a systematic development of capacity and capabilities through the deliberate utilization of Nigerian human, material, resources and services in the Nigerian Petroleum Industry resulting in the development of indigenous capabilities without compromising

quality, health, Safety and environmental standards.". by implication, the core elements of this local content programme according to Lunde (2013) are:

1. Local capacity availability
2. Local skills and capacity development
3. Strategic partnership with local firms
4. Development of local supply capacities
5. Procurement of local goods and services

The operational activities of the oil and gas industry require three kinds of services ranging from direct services, indirect services and specialized services for effective running of its business. Going by these services that may be required and the enabling conditions offered by the local content programme, it becomes indisputable that there is an urgent need for the development of entrepreneurial mindsets as veritable platform for taking advantage of the available human and material needs as made available through the local content development scheme. It was for this reason we aver that entrepreneurship has a pivotal role in our local content development agenda and overall economic stimulation as a country.

Going by this assertion, the fulcrum of this paper is therefore to stimulate the interest of every participant towards entrepreneurship to enable everyone join hands in taking advantage of leading-edge technologies in advancing the country's local content development and the entire economy at large. To achieve this, our discussion has been ordered as follows:

1. Understanding the concept of entrepreneurship and entrepreneurs
2. Qualities of successful entrepreneurs?
3. Entrepreneurial mindset and its imperatives
4. Myths about entrepreneurship
5. Engineers and entrepreneurship?
6. Challenges of engineer-entrepreneurs
7. Conclusion

2.0 UNDERSTANDING THE CONCEPT OF ENTREPRENEURSHIP

Entrepreneurship according Opigo (2018) can be conceptualized in multiple perspectives with a few as:

1. **Entrepreneurship as small business management**- in this approach, entrepreneurship is strictly linked with firms that qualify as small businesses and virtually includes all aspects of small or new business management.
2. **Entrepreneurship as imagination or creativity**- in this perspective, entrepreneurs are defined by personal and psychological perspectives such as imagination, and creativity. Entrepreneurship then is seen as a "specialize activity that some individuals are particularly well equipped to perform.
3. **Entrepreneurship as innovation**- this conception was championed by the great economist-Joseph Schumpeter who argued that entrepreneurs introduce 'new combination" of ideas and

resources and dynamically shakes up the economy out of its previous equilibrium state. A process he later described as "creative destruction".

4. **Entrepreneurship as alertness to opportunities**- this is credited to Israel Kirzner, an economist who described entrepreneurs as those who only need to be aware of profit opportunities and they are inn for it.
5. **Entrepreneurship as the ability to adjust**- this approach is proposed by the Nobel Prize-winning economist, Theodore Schultz. The approach assumes that innovation is occurring in the economy and measures entrepreneurship by how people adjust to large changes in the economy. Entrepreneurship is therefore perceived as "the ability to reallocate one's resources in response to changing circumstances".
6. **Entrepreneurship as charismatic leadership**- this view was largely pioneered by Max Weber. Entrepreneurship accordingly is the ability to articulate a plan, a set of rules, or a broader vision, and impose it on others".

Another useful definition has it that (Chandler 1990:8) entrepreneurship is dealing with uncertainty, making a distinction between risk, which can be calculated, and uncertainty, which cannot. Similarly, Schumpeter (1934:66) describes the entrepreneur as the bearer of the mechanism for change and economic development, and entrepreneurship as the undertaking of new ideas and new combinations, that is innovations. In essence, "Entrepreneurship does not necessarily mean a person venturing to set up his or her own company and selling a unique product or service to people who desire it. Entrepreneurship can also refer to those who handle daily responsibilities in an organization. This gives rise to the idea of intrapreneurship, which is a form of entrepreneurship in existing corporate settings.

2.1 Who are Entrepreneurs?

In answering this question, Drucker (1985:93) describes the entrepreneur as a person who is willing to risk his capital and other resources in new business venture, from which he expects substantial rewards if not immediately, then in the foreseeable future. Okpara (2000:3-4) sees the entrepreneur as an individual who has the zeal and ability to find and evaluate opportunities. He further observes that they are calculated risk-takers, who enjoy the excitement of challenges, not necessarily gamblers. In his assertion, Richard Cantilon (1755) described entrepreneurs as non-fixed income earners who pay known costs of production to earn uncertain incomes. Similarly, Jean-Baptiste Say -1800 described an entrepreneur as one who shifts economic resources out of an area of lower and into an area of higher productivity and greater yield.

Some entrepreneurs that have made great impact include-Oprah Winfrey, Walt Disney, J.K Rowling, Steve Jobs, Andrew Carnegie, Benjamin Franklin, Bill Gates, Jason Njoku, Anna Phosa, Aliko Dangote, Dr Aly El-Shafei-a trained academic and mechanical engineer who is now famed for his patented innovation-SEMAJIB-a versatile magnetic smart bearing which has interesting applications in electricity generation; among many others.

Going by these definitions, descriptions and examples of entrepreneurs, we can deduce that the entrepreneur are human beings who chose to make some differences in their lives and those of others in the world. They deliberately developed certain personality traits and behaviors that makes them stand

out to be described as entrepreneurs. implying that this individual can be anyone, be it male, female, educated, ill- educated, tall, short, black or white. And that individual must possess or develop those characteristics that can enable them prosper as entrepreneurs.

2.2 Entrepreneurial Mindset and its Imperatives

This is a set of skills that enables people to identify and make the most of opportunities, overcome and learn from setbacks, and succeed in a variety of settings. Every entrepreneur needs to imbibe this mindset to enable them go through the rigors of entrepreneurial journey.

1. Opportunity recognition
2. Creativity and Innovation
3. Future orientation
4. Comfort with risk
5. Communication and collaboration potentials
6. Flexibility and adaptability
7. Critical thinking abilities
8. Devotion to mission- love and passion for what they do
9. Determination-implement their intentions with doggedness
10. Curiosity
11. Resilient
12. Socially skilled

2.3 Myths on Entrepreneurship

Some myths about entrepreneurship as identified by Bhide (2000) are:

1. **The Risk-Taking Myth: "Most successful entrepreneurs take wild, uncalculated risks in starting their companies."**
2. **The High-Tech Invention Myth: "Most successful entrepreneurs start their companies with a break-through invention – usually technological in nature."**
3. **The Expert Myth: "Most successful entrepreneurs have strong track records and years of experience in their industries."-** Steve Wozniak, who helped found Apple Computers, was an "undistinguished" engineer at Hewlett-Packard when he built the first Apple computer. John Katzman was a part-time tutor at Hunter College in New York City when he founded the Princeton Review, a test-preparation and tutoring company.
4. **The Strategic Vision Myth: "Most successful entrepreneurs have a well-considered business plan and have researched and developed their ideas before taking action."-** While it might be easy to assume that most successful entrepreneurs start out with a well-considered plan of action, strategic planning and research are in fact hallmarks of the later stages of development, rather than a necessary initial ingredient. For many start-ups, extensive research and planning are often both unnecessary and financially impossible.
5. **The Venture Capital Myth: "Most successful entrepreneurs start their companies with millions in venture capital to develop their idea, buy supplies, and hire employees."**

2.4 Engineers and Entrepreneurship

Being an engineer does not in any way preclude anyone from practicing entrepreneurship. Afterall there are entrepreneurs described as engineering entrepreneurs. Engineering (or Technology) Entrepreneur are those who organizes, manages, and assumes the risk of an engineering (or technology) business or enterprise with the hope of making profit or losses. Typically, engineers (and engineering faculty members) have strong preferences for analytical, logical, quantitative thinking, often coupled with very structured, procedural thinking. For this reason, the Federal Government of Nigeria in 2006 directed Nigerian Higher Education Institutions (HEIs) to include Entrepreneurial Education (EED) as a compulsory course for all students with effect from the 2007/2008 academic session which resulted in the inclusion of EED in the curriculum of all Universities and other higher institutions of learning in Nigeria (Aliu, 2008).

To this end, engineers are expected play significant roles in the entrepreneurial agenda of our dear nation, Nigeria. Engineers can make great entrepreneurs by fulfilling expectations such as:

1. Being innovative- this is the specific instrument of entrepreneurship (Drucker, 1993). It is the act that endows resources with a new capacity to create wealth. There is no such thing as a resource until man finds a use for something in nature and thus endows it with economic value. Until then, every plant is a weed and every mineral just another rock.
2. Being able to develop new markets
3. Discover new sources of materials
4. Source and mobilize capital (Land, Machines, Materials, Money, Manpower)
5. Introduce new technologies, products and services

2.5 Challenges of Engineer-Entrepreneurs

The entrepreneurial engineer has several challenges to grapple with. Among such challenges are those of poor business skills, lack of basic infrastructural amenities and funding. The problem of funding however preoccupies the consciousness of most intending entrepreneurs. Most of who would say that they have ideas, and are disposed towards entrepreneurship, but no capital to proceed. It will tantamount to unhealthy pretense if anyone attempts to wish this fact away. However, while we would state that the most importance requirement for entrepreneurship is not capital but viable ideas, it is yet important to suggest some sources of funding for entrepreneurship in Nigeria. They are as follows:

1. Bootstrapping- this is a situation in which an entrepreneur starts a business with little or no capital. It entails financing a start-up by self -funding. It may also include raising seeds from friends, family members and personal finances (Kiabel, 2019).
2. Bank Loans
3. Trade Credits
4. Hire Purchase
5. Mortgages
6. Plough-back profits
7. Security exchanges (Buying/selling of shares and bonds)
8. Grants- these are funds that are disbursed to individuals or organisations for the purposes of business start-up or business expansion under a refundable or non-refundable conditions. Grants are also referred to as “Free money”.

Some examples of such grants in Nigeria currently include but not limited to-

1. Africa's Young Entrepreneur Empowerment Nigeria (AYEEN)- an initiative launched to help young aspiring entrepreneurs to achieve their business dreams. It provides funding for great business ideas.
2. Tony Elumelu Foundation Entrepreneurship Programme- Launched in 2015 and sponsored by the CEO of Heirs Holding (Tony Elumelu) to empower young African entrepreneurs. Over 7500 entrepreneurs have benefited from the grant since its launch.
3. Shell Live-Wire-Open to youths from Niger Delta region in Nigeria who are interested in starting a business.
4. GroFin Fund-an empowerment initiative that is committed to providing business support and grants for small and medium sized businesses in various key sectors of the economy.
5. Bank of Industry (BoI)- an initiative by FGN to financially support and help small and large business enterprises to grow.

3.0 CONCLUSION

In the present-day globalized society when technology is no longer a local product of its originating environment but can easily be transferred across the globe, it becomes more demanding for nations to brace up in taking advantage of leading-edge technology for the advancement of entrepreneurship and local content development. Considering the central role entrepreneur plays in the development of economies, it has become imperative for Nigerian engineers to wake up and think entrepreneurially using their specialized engineering knowledge with entrepreneurial mindset in enhancing creativity and innovativeness. This will not only bring about the growth and proliferation of engineering entrepreneurial ventures, but would also expand the country's capacity to taking advantage of the provisions of the local content laws. In so doing, more job would be created, and the country's economy would equally experience great prosperity and stability.

Engineers are no doubt very endowed with multiple skills and abilities to crack difficult problems, for these reasons, their interest and involvement in entrepreneurship would surely be accompanied with uncommon breakthroughs. Let us therefore stop thinking that entrepreneurship is an exclusive career for those who have attended business schools, not at all. Like our opening quotes rightly indicated, "the world has changed in ways that now requires everyone to think like an entrepreneur"-Let us therefore arise and join the game of entrepreneurship so that we can together make our country greater.

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UNIPORT

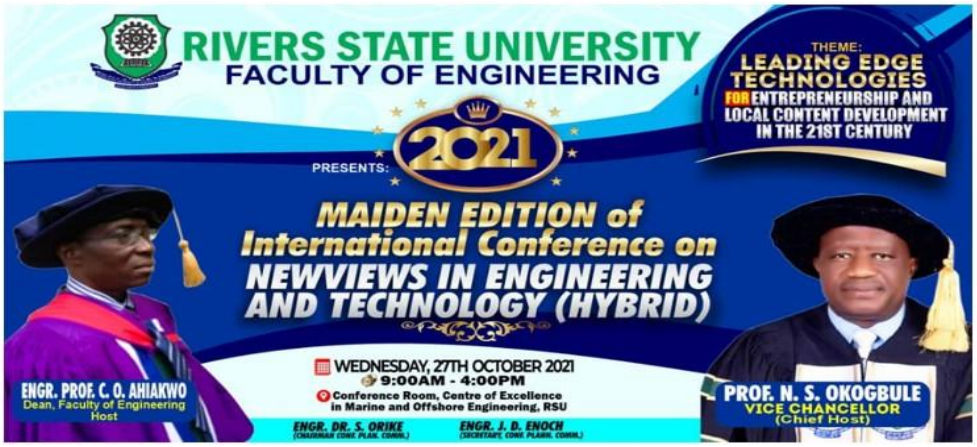
Re-Engineering Higher Education Institutions for Sustainable Development

Goodwill Message

INTERNATIONAL CONFERENCE ON NEWVIEWS IN ENGINEERING AND TECHNOLOGY, FACULTY OF ENGINEERING, RIVERS STATE UNIVERSITY, PORT HARCOURT, 27TH OCTOBER, 2021

Joseph A. Ajienka, ***FNSE, FAEng***
Emmanuel Egbogah Chair of Petroleum Engineering
University of Port Harcourt

Congratulations



Shanghai Rankings 2020 (Statistics by Country)

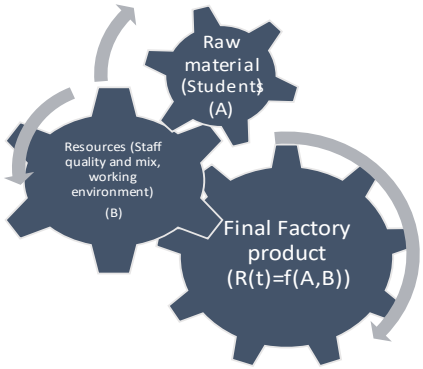
- **Shanghai Rankings of Global Universities (2020) and Status of Indian Universities**
- ***Hardev Singh Virk**** Professor of Eminence, SGGS World University, Fatehgarh Sahib (Punjab), India

- No Nigerian University ?????

Country	Top20	Top100	Top200	Top300	Top400	Top500	501-1000
United States	15	41	65	94	114	133	73
United Kingdom	3	8	20	28	34	36	29
France	1	5	8	12	16	17	13
Switzerland	1	5	7	7	7	8	1
Australia	—	7	8	15	22	23	11
China	—	6	24	38	57	81	87
China -Mainland	—	6	22	32	49	71	73
China -Hong Kong	—	—	2	4	5	5	2
China -Taiwan	—	—	—	2	3	5	10
China -Macau	—	—	—	—	—	—	2
Germany	—	4	10	19	24	30	19
Canada	—	4	9	12	18	19	9
Netherlands	—	4	9	10	10	12	1
Japan	—	3	7	8	10	14	26
Sweden	—	3	5	6	9	11	3
Belgium	—	2	4	5	7	7	1
Denmark	—	2	3	3	5	5	1
Singapore	—	2	2	2	2	2	2
Israel	—	1	4	4	4	6	1
Norway	—	1	2	2	3	3	2
Russia	—	1	1	1	2	3	8
Finland	—	1	1	1	2	3	5
Italy	—	—	3	7	10	17	29
Saudi Arabia	—	—	2	3	3	4	—
South Korea	—	—	1	6	9	11	21
Spain	—	—	1	5	9	13	27
Austria	—	—	1	3	5	7	7
Brazil	—	—	1	1	3	6	16
Portugal	—	—	1	1	2	3	3

OUTCOMES/PRODUCTS OF THE KNOWLEDGE FACTORY IN EDUCATION IDUSTRY

Mission	Outcomes/Products
Teaching & Learning	Quality Human Capital
Research & Development	New Discoveries, Patents,Innovation Products such new technologies, software, processes, policies, Programmes for Knowledge & Technology Transfer
Entrepreneurship	Licenses, Start-ups/Spin-offs, Products to market, Royalties; (Development of ICE Ecosystem); Secure the Future
IMPACT: Community Service/ Engagement	Job Creation Wealth Creation etc in short Sustainable Development !!!



Adapted from Redwood Sawyer

The Knowledge Society is Here

"The empires of the future are the empires of the mind"

Winston Churchill

INNOVATION IS KEY

Research is the transformation of Money into Knowledge

Innovation is the transformation of Knowledge into MONEY!

North Carolina State University IP Annual Report 2012

(After Essien, NUC Abuja, Retreat July, 2013)

No	Item	Quantity
1	Patent Issued	806
2	Patent Pending	248
3	IP Disclosure	3,450
4	ProductsTo Market	230
5	Startup Companies	100
6	Jobs Created	6,800
7	Jobs CreatedIn North CarolinaOnly	320
8	Royalty	$1.5 billion
Source	Office of Technology Licensing(OTL)	

CALTECH Innovation @ a Glance

Vice- President , Research Research Institutes, Centres and Labs: +47 OTTCP; Endowment:$ 2.199B (2015)	
Annual Data (FY 2016) **Innovations Reported** 229 Invention disclosures (Caltech campus only) 196 U.S. patents issued 1,922 U.S. patents active **Start-Ups** 9 Start-up companies formed **Commercialization & Partnerships** 67 Licenses (including options) 41 Companies sponsoring research 82 Companies giving gifts 225 Material Transfer Agreements $23M in corporate contracts & gifts	**Historical Data** **Innovations Reported** Nearly 3,200 invention disclosures (campus only) since 1985 Nearly 2,300 U.S. patents issued since 1985 **Start-Ups** Over 130 start-up companies formed since 1995 on average, 8 new companies started each year **Commercialization & Partnerships** over 700 new licenses and options granted since FY 1995 on average, 40–50 licenses executed per year

US University Score card for Patenting Licensing in 2008(after Essien, NUC Abuja, Retreat July, 2013)

No	Item	Quantity
1	New products	648
2	License agreement executed	5,039
3	Startup companies,72% based institutions	595
4	Startups operating from 1980	3,381
5	Royalty	$51.47billion
6	Invention disclosure	20,115
7	Patent application filed	18,949
8	Patent issued	3,280
9	Non us patent filed	848

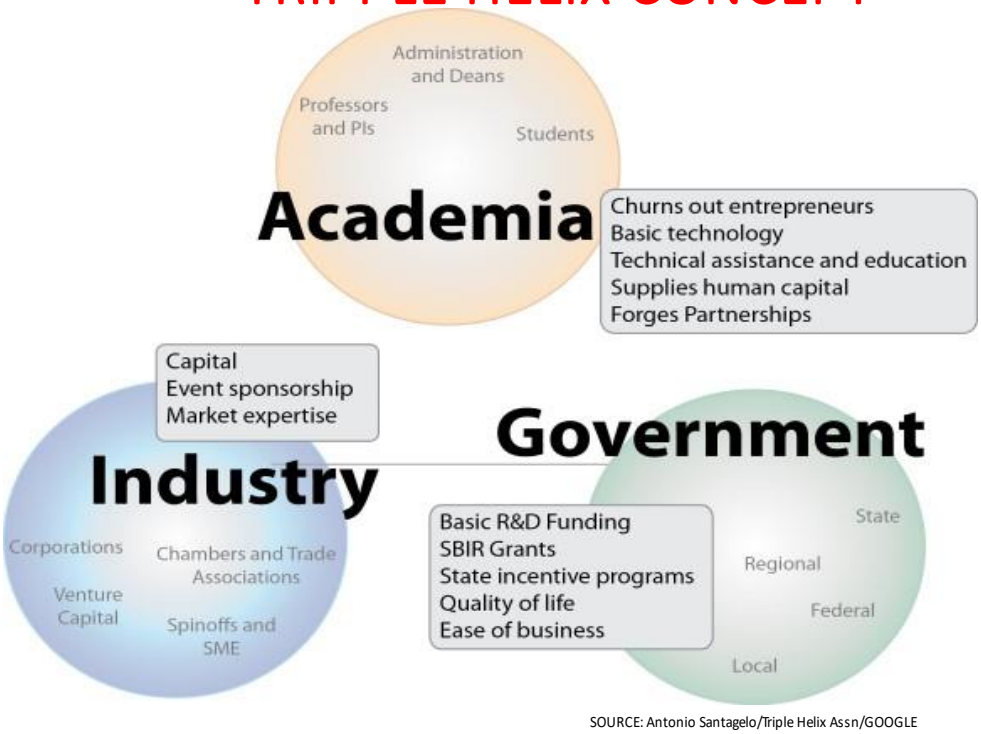
Some Cornell University Startups

The businesses listed below were founded on licensed Cornell technologies to help create jobs and economic vitality in New York State and beyond.

Developing Innovation, Commercialisation and Entrepreneurial Ecosystem !

Universities should be
Creative, Innovative, Productive to grow Knowledge Economy

TRIPPLE HELIX CONCEPT



SOURCE: Antonio Santagelo/Triple Helix Assn/GOOGLE

The World At Night

From the pictures, Africa is seen to be in almost total darkness.

Quality of Education and Engineering for Sustainable Development

We should not be left behind

The Best Entrepreneurial HEIs, Nobel Prize Winners and Billionaires are where the lights are.

So how do we light up Africa and contribute to sustainable Energy future and Infrastructure

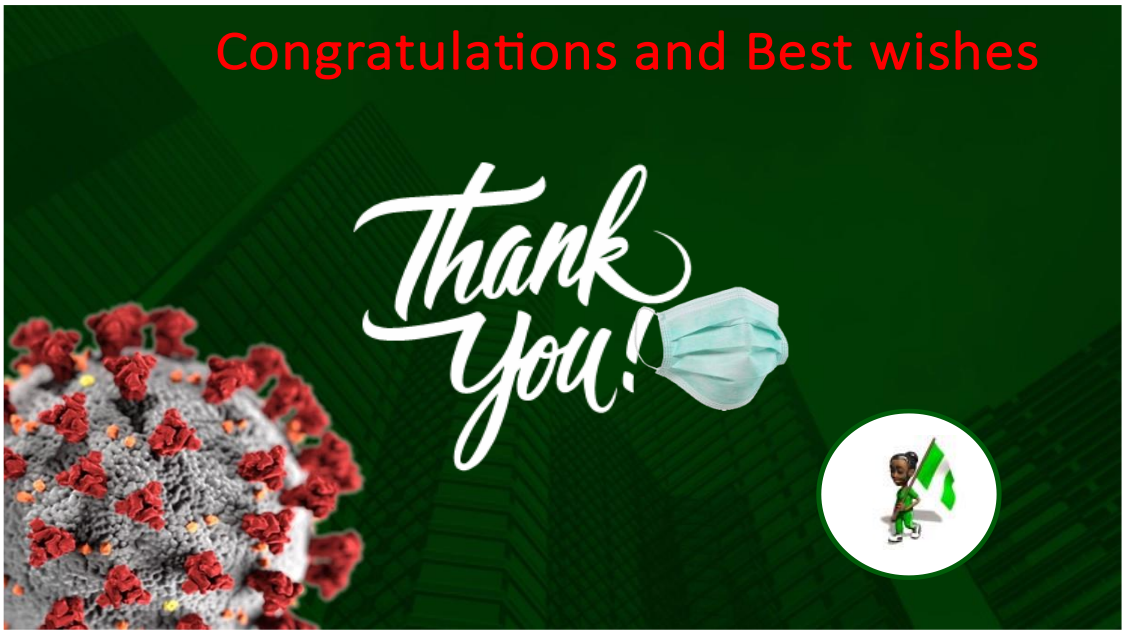
Conclusion

The transformation into Entrepreneurial University

DVC Research and Innovation global best practice

Establish Research Groups, Institutes, Centres and Labs to compete for research grants

Develop Innovation, Commercialisation and Entrepreneurial Ecosystem



PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON NEWVIEWS IN ENGINEERING AND TECHNOLOGY (ICNET) MAIDEN EDITION, FACULTY OF ENGINEERING, RIVERS STATE UNIVERSITY, PORT HARCOURT, NIGERIA.
27th October 2021
Available online at https://conference.rsujnet.org/

LEADING EDGE TECHNOLOGIES FOR ENTREPRENEURSHIP AND LOCAL CONTENT DEVELOPMENT IN THE 21ST CENTURY

LEAD PAPER PRESENTED BY MR. CYPRIAN OJUM AT THE MAIDEN EDITION OF THE INTERNATIONAL CONFERENCE ON NEW-VIEWS IN ENGINEERING AND TECHNOLOGY.

1.0 INTRODUCTION

In 2020, businesses and entrepreneurs were forced to respond to something that had never happened before, a global pandemic. One thing that kept them alive was how quick entrepreneurs were able to embrace technology as a tool to pivot their business, so it adapts to the demands of the time.
Technology helped Business owners work faster, improve efficiency, boost productivity, expand their reach globally and streamline their production process. Today, every facet of business has been touched by leading-edge technology. This touch has transformed the business world to a point that any company hoping to rise or stay at the very top must keep the same pace with technology.

2.0 DEFINITION OF KEY TERMS

2.1 Leading Edge Technology

Leading Edge Technologies refers to technology devices, techniques or achievements that employ the most current and high-level IT developments in other words, Technology at the frontiers of knowledge; the term can apply to technology of any type, including automotive, medical, engineering and countless other industries.

2.2 Local Content

The term “local content” has been defined by Ogbeifun as the engagement of Nigerians as employees, the participation of Nigerian investors in the industry and the use of Nigerian contractors in the execution of contracts. Obuaya provided his definition in line with the idea of value addition. He defines local content as a set of deliberate orientation and actions to build domestic capacity relevant for service and product delivery comparable within that industry and an opportunity to locally build a sustainable culture of service quality and capabilities exceeding customers' expectations and comparable to international standards through key local personnel and management. Though simple, Obuaya's definitions reflect on some important indices to examining the concept of local content such as 'deliberate orientation', 'capacity building', 'sustainable capability', 'product deliverability systems' and 'comparability.` Section 106 of the Nigerian Oil and Gas Industry Content Development Act 6 also defines the term 'Nigerian content' to mean “the quantum of composite value added or created in the Nigerian economy by a systematic development of capacity and capabilities through the deliberate utilization of Nigerian human and material resources and services in the Nigerian oil and gas industry. Local content is about securing direct and indirect opportunities for employment and procurement to home nationals, at the same time as fostering the development of local skills, technology transfer, and use of local manpower and local manufacturing in capital projects.

3.0 CONCEPTUAL ANALYSIS

Entrepreneurship emphasizes three principal concepts; the first is Innovation, the others are running a business and taking risks. The most critical concept or starting point of entrepreneurship is to decide on a new product or service that includes, applying a new technique or technology, opening a new market, or developing a new form of organization meant to produce or enhance a product.
Entrepreneurs have driven innovation and progress in various fields, which according to Professor Klaus Schwab, 2016; has given rise to the Fourth Industrial Revolution, with small businesses providing an unprecedented platform for the integration of technologies across digital, physical and biological spheres. Moreover, the speed at which this is happening is influencing work, services, educational needs and people's everyday activities. Examples of popular and successful entrepreneurs that have taken advantage of leading technologies include Bill Gates (Microsoft), Sam Walton (Wal-Mart), Steve Jobs (Apple Computer), Larry Page and Sergey Brin (Google). These individuals have all impacted on the way business is done today. Aside from contributing to their country's general economic well-being, founders of small businesses also contribute to the growth and vitality of specific areas of economic and socio-economic development, such as; creating jobs, sparking new innovations and providing opportunities for many people, including women and minorities, to achieve financial success and independence. In addition, they complement the economic activity of large organizations by providing them with components, services, and distribution of their products.

The field of Engineering has over the years, shaped and deepened the potential of creating entirely new ways of providing goods and services through technological innovations. In South Africa, entrepreneurs have created goods and services on various fronts through the innovations driven by engineering, science and technology. One example is Jobox, a platform that helps optimize the freelance economy and assists in getting people employed. Another is Strait Access Technologies, a start-up company that's driving breakthrough medical devices for heart valve replacement. In the United States, well known entrepreneurs have shown that to be successful, small business owners are required to be more innovative and competitive. One of such ways is the adoption of leading technologies or finding new ways of doing old things to help design products that capture the attention of local and global markets. This implies a deliberate and practical involvement of Engineering as a field of knowledge and practice. A well-known example occurred in 1994, a young computer science graduate working on Wall Street came up with the novel idea of selling books over the Internet. During the first year of operations, sales at Jeff Bezos' new company—Amazon.com—reached half a million dollars. In less than twenty years, annual sales had topped $107 billion. Not only did his innovative approach to online retailing make Bezos enormously rich, it also established a viable model for the e-commerce industry. This same model has been adopted in Nigeria; by enterprises like Jumia, Konga, 9jabet, Bolt etc. who are using current technologies like artificial intelligence, adaptive robotics, the Internet, big data, drones, 3D printing, 5G and cloud systems etc. to dominate the Nigerian e-market space.

What is evident is that the technology landscape is vastly complex because of the potential for integration, as well as the fact that technologies are constantly evolving. For entrepreneurs to develop relevant products, they need core competencies to tackle the new age technologies and reap the potential rewards. To accomplish this, entrepreneurs require a certain level of comprehension about what kinds of technologies are available, but also how they can enhance products and services with digital capabilities. Innovation and creativity remain fundamental skills, but additional competencies are also required. These

include the ability to cross-link business units through digital connectivity, rapid prototyping, and understanding how data-driven decisions can enable automated and personalized service offerings. What is sure is that entrepreneurs could create new ventures if they developed new competencies. However, these competencies call for the direct collaboration of practically every facet of engineering practice; be they mechanical, electrical, electronics, computer hardware and software engineers, robotic engineers, agric engineers and others.

4.0 RECOMMENDATIONS

1) The Nigerian Government needs to focus on enacting the right policies meant to actively encourage its citizenry to consider establishing small businesses willing to adopt leading technologies by making available new forms of business-friendly financing.
2) The Nigerian Government needs to enact policies that will directly encourage Engineering faculties of academic institutions and schools to embark on product development in collaboration with local entrepreneurs and to continually blend interdisciplinary skills towards competencies for graduates as well as those who engage in life-long learning. Most importantly, institutions must incorporate participation in some of the programmes that are already under way as well as forums where these skills can be applied.
3) With an intentional arrangement between Engineering practice and the business investment sector, Nigeria's entrepreneurial landscape can flourish. This won't only drive economic growth. It will also get young people economically active, and jobs will be created thereby chatting a better course for sustainable development and economic self-reliance in the country. This is in line with the laudable goals for Nigerian Content Development already gaining ground with the enactment of the Nigerian Oil and Gas Industry Content Development (NOGICD) Act and the establishment of the Nigerian Oil and Gas Industry Content Development Board (NCDMB) in April 2010. The huge successes made by the Board is already a testament as to the benefits of allowing engineering to support sustainable entrepreneurship through the deployment of relevant technology and innovations for capacity development, job creation and wealth/value domiciliation in our local economy.

5.0 CONCLUSION

This first edition of this seminar is a good place to begin. I thank the organizers for their thoughtfulness and their decision to bring professionalism to benefit the people in a practical way. I also wish to call on relevant Government agencies to support the University Authorities on this commendable initiative as it can constitute the springboard upon which Leading Edge Technologies can support Entrepreneurship and Local Content Development in the 21st Century Nigeria.

PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON NEWVIEWS IN ENGINEERING AND TECHNOLOGY (ICNET) MAIDEN EDITION, FACULTY OF ENGINEERING, RIVERS STATE UNIVERSITY, PORT HARCOURT, NIGERIA.
27th October 2021
Available online at https://conference.rsujnet.org/

Paper number: ICNET2021-001

A Comparative Study of Swarm Intelligence Techniques for Load Flow Optimization of the Nigerian 132kV Power Transmission Network

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ABSTRACT
This paper presents three swarm intelligence (SI) algorithms: Particle Swarm Optimization (PSO), Bee Colony Optimization (BCO) and Ant Colony Optimization (ACO) as Load Flow Optimizers (LFO) for the solution of a power systems network. Studies were performed considering the number of sample iterations while the settings of other SI systemic parameters are held constant. Experiments were conducted by applying the SI-LFO to a section of the Nigerian 132kV Power Transmission Network (Port-Harcourt region). Results show that the PSO gave the best fitness performance overall after three simulation runs and iteration values of 500, 600, 700 and 1000; with a power mismatch of $7.105*10^{-15}$, $7.354*10^{-6}$ and 0.078 respectively for PSO, BCO and ACO after 1000 iterations. This suggests that particle swarming approach of the PSO is a more reliable swarm-optimizer for load flow studies in this application.

Keywords: Load flow, Optimization, Power system, Swarm intelligence, Transmission network

Cite This Paper: Orike, S., & Oko, A. A. (2021). A Comparative Study of Swarm Intelligence Techniques for Load Flow Optimization of the Nigerian 132kV Power Transmission Network**.** *Proceedings of the International Conference on New-views in Engineering and Technology*, Faculty of Engineering, Rivers State University, Port Harcourt. Nigeria, 27th October, 2021, ICNET2021-001, 28 – 35.

1. INTRODUCTION

The power system network is a very important part of the modern society as it provides the basic infrastructure for heating, cooling and lighting among so many other essential functions to an ever-teeming populace. In order to meet the demands of consumers, proper planning of power system networks is essential. One essential tool or technique in this regard is the Load Flow Analysis (LFA) (Keyhani, 2016; Tostado *et al.*, 2019). Some of the immediate benefits of the LFA include the economic dispatch management and in transient stability studies.

Typically, the LFA requires the solution of a set of equality and inequality constraints needed to determine the power network system states and hence solve the power systems network (Tostado *et al.*, 2019). Traditional LFA tools such as the Newton-Raphson and Gauss-Seidel are very useful for some kinds of problems but when the power system network becomes more demanding, these techniques face high line R/X loading and convergence issues (Keyhani, 2016; Tostado *et al.*, 2019; Al-Anbarri & Naief, 2017).

In recent times, there has been a renewed interest in the use of meta-heuristics algorithms based on swarm intelligence for power flow problems (Ahiakwo et al., 2018; Acharjee & Goswami, 2009a; Acharjee & Goswami, 2009b; Acharjee & Goswami, 2009c; Gnanambal *et al.*, 2010; Gnanambal *et al.*, 2011; Jain *et al.*, 2016). Three popular techniques are the Particle Swarm Optimization (PSO), Bee Colony Optimization

(BCO) and Ant Colony Optimization (ACO). These algorithms have been successfully used in the solution of many other power system problems.

In this paper, we present a comparative analysis of the aforementioned swarm intelligence (SI) algorithms used as Load Flow Optimizers. These classes of algorithms (PSO, BCO and ACO) are compared on the basis of their fitness scores for a given number of parameter-specific iteration steps and for a given number of simulation trial runs. SI algorithms are applied to the solution of a section of the Nigerian 132-kV power network (Port-Harcourt region).

Particle Swarm Optimization (PSO), Bee Colony Optimization (BCO) and Ant Colony Optimization (ACO) are swarm meta-heuristics for constrained optimization of the Load Flow Optimization (LFO) in a power system network. PSO is a well-known social cognitive and meta-heuristic Artificial Intelligence (AI) approach that builds on the collective behavior of groups of particles which include flock of birds or fish schools (Kennedy & Eberhart, 1995). The key parameters of the PSO are its population size and the maximum number of iterations required to attain a solution objective. Some important parameters that have been added to PSO are the Constriction coefficient which controls the convergence rate of PSO and the Inertia damping weight ratio which is used to control the velocity of a swarming particle. In a PSO-LFO, particles (individuals) represent candidate load flow parameter solutions (Solaiman & Sheta, 2016). These solutions are bounded using an exploitative/explorative global best search procedure in which positions and hence speed of the particles is changed to obtain an optimal or best-fitting candidate.

BCO is an emerging swarm intelligence technique inspired by the beautiful organizational and foraging ability of honey bee swarms while combining the global optimum capabilities of evolutionary computers with a fitness-based model (Anireh & Osegi, 2019). It was developed by Karaboga (2005), and has been widely applied by power system researchers. In the BCO-LFO simulation, an evolutionary process comprising an exploitative and explorative procedure is used to evolve foods (candidate load flow power system parameter solutions) in order to determine the best possible solution candidate. This typically results in a set of sub-optimal solutions through simulation time. The exploitative functions are handled by two sub-routines referred to as the employed and onlooker bees while the explorative functions are performed by the scout-bees sub-routine (Bansal *et al*., 2013; Ekinci & Demirören, 2016). The key parameters of the BCO are its food number and the maximum number of iterations required to attain a solution objective. An important parameter also widely included is its limit trial which defines the number of food quality (solution) searches that will be performed by an employed bee; if the food presents no good solution after the specified number of searches it is discarded. Preliminary results of LFO for transient stability studies of Nigerian 132kV power transmission network using BCO are presented in Oko *et al.* (2019).

ACO is a popular metaheuristic approach that uses the intelligent foraging behaviour of ants to find good solutions to combinatorial problems. It was first introduced by Dorigo (1992). In an ACO-LFO, the ants always seek for the shortest path to food source(s) from their nest; these short paths represent the optimal or best fitting load flow parameters.

2. MATERIALS AND METHODS

Load Flow Optimization for Power System Network. In a load flow optimization (LFO), a power system network is solved in order to determine performance indicators such as the bus voltages and angles, real and reactive power flows

under certain system parameter configurations including the line admittances, bus and generator power requirements. In modelling an LFO, the active and reactive power mismatches are usually considered, represented as:

$$\Delta P_i = P^{inj} - \sum_{j=1}^{n} |V_i||V_j||Y_{ij}|\cos(\delta_i - \delta_j - \theta_{ij}) \quad (1)$$

$$\Delta Q_i = Q^{inj} - \sum_{j=1}^{n} |V_i||V_j||Y_{ij}|\sin(\delta_i - \delta_j - \theta_{ij}) \quad (2)$$

Where:

ΔP_i = active power mismatches at bus *i*

ΔQ_i = reactive power mismatches at bus *i*

P^{inj} = injected active power at bus *i*

Q^{inj} = injected reactive power at bus *i*

$|V_i|$ = absolute value of the voltage at bus *i*

$|V_j|$ = absolute value of the voltage at bus *j*

$|Y_{ij}|$ = absolute value of the admittance matrix of the ij^{th} *element*

θ_{ij} = admittance angle at bus *i, j*

δ_i = voltage angle of the bus *i*

δ_j = voltage angle of the bus *j*

The unknown vector of the LFO problem can also be further represented as a union set as in (3):

$$x_{LF} = \{\delta_{PV} \cup \delta_{PQ} \cup V_{PQ}\} \quad (3)$$

Where:

δ_{PV} = voltage angle vector of the PV buses

δ_{PQ} = voltage angle vector of the PQ buses

V_{PQ} = voltage magnitude vector of the PQ buses

The size of x_{LF} is computed using:

$$n_s = n_{PV} + 2n_{PQ} \quad (4)$$

Where:

n_{PV} = number of the PV buses

n_{PQ} = number of the PQ buses

Typically, a tolerance measure is used to stop the simulation run and reduce the computational expense. This is determined by the convergence rule in (5) and after repeating (1) to (4).

$$\max\{|\Delta P_i| \cup |\Delta Q_i|\} \leq \varepsilon \ \ \forall \ i \quad (5)$$

The generalized LFO procedure is as follows:

Step 1: Define Power Network Initial Parameter Conditions including the bus data and line data values; these values are needed later on for defining the LFO boundary constraints.

Step 2: Compute the Line Admittance of the power network buses and the corresponding angles.

Step 3: Define the LFO constraints (upper and lower bounds) basing on the power system optimization parameters: Bus Voltage, Bus Angle, Bus and Generator Real and Reactive Powers and Power Injections.

Step 4: Define the fitness (objective) function of the LFO; this function computes the load flow, power mismatches and the net power mismatches using the aforementioned constraints defined in the previous step (Step 3).

Step 5: Solve the power network by finding the best foods in accordance to the LFO algorithm routine and the fitness function defined in Step 4.

2.1 LFO using PSO

The solution operations detailing the PSO technique are presented as follows:

A population of individuals (particles) representing possible solutions are randomly created; these individual particles are bounded within a dimension; *j* and an explorative/exploitative search is performed by the PSO for a global best (*gb*) position.

Each particle in the population changes position within a search space until an optimal solution is attained; each particle is characterized by its

position, best position and velocity in the considered search space.

Each particle in the population exchange information within the neighborhood of other particles, memorize the best positions reached by a swarm of the population of particles while updating their positions for a given maximum number of iterations; the position update is modeled as:

$$v_{ij}^{new} = v_{ij}^{old} + c_1 \times r_{ij} \times \left(bp_{ij} - x_{ij}\right) + c_2 \times r_{2j} \times \left(gp_j - x_{ij}\right) \quad (6)$$

$$x_{ij}^{new} = x_{ij} + v_{ij}^{new} \quad (7)$$

Where:

v_{ij} = velocity of particle *i* in dimension *j*

x_{ij} = position of particle *i* in dimension *j*

c_1, c_2 = positive constants

r_{1j}, r_{2j} = random numbers

bp_{1j} = best position reached so far by the particle

gp_{1j} = global best position reached by the neighborhood.

2.2 LFO using BCO

In BCO, there are three classes of foraging bees (Bansal *et al*., 2013):

1) Employed bees
2) Onlooker bees
3) Scout bees

Employed bees (EBs) scout for food sources. Onlooker bees (OBs) minimize the objective by probabilistically selecting food sources with the best qualities. EBs set forth as Scout bees (SBs) once their food sources are completely exploited, which then forage for new sources of food. EBs and OBs perform exploitative duties while SBs perform explorative duties. The solution operations detailing the BCO technique are presented as follows:

A sequence of food sources (position or points of real values) is generated randomly according to the following formula:

$$x_{ij} = x_{\min j} + rand[0, 1]\left(x_{\max j} - x_{\min j}\right) \quad (8)$$

This is called the initialization phase.

An EB updates her position by replacing the fitness (nectar information) or simply the fitness value (FV) of an old solution with a new one if the new solution FV is better; the update equation for all EBs is defined as:

$$x_{ij}^{j} = x_{ij} + \phi_{ij}\left(x_{ij} - x_{kj}\right) \quad (9)$$

An OB analyzes all the solutions of FVs obtained from the EBs and selects a solution based on a fitness-related-probability as:

$$prob_i = \frac{fitness_i}{\sum_{i=1}^{SN} fitness_i} \quad (10)$$

An SB replaces an abandoned food source (i.e., a food source that is not updated) with a randomly chosen food source within the search space after a predetermined number of limit trials:

$$x_{ij} = x_{\min j} + rand[0, 1]\left(x_{\max j} - x_{\min j}\right), \quad for\ j \in \{1,2,\ldots,D\} \quad (11)$$

Where:

x_{ij} = position of food source *i* in direction *j*

$x_{\min j}$ = lower bound of x_i in direction *j*

$x_{\max j}$ = upper bound of x_i in direction *j*

SN = food source number

D = dimension of the problem

ϕ_{ij} = a random number between -1 and +1

$fitness_i$ = fitness value of solution *i*

2.3 LFO using ACO

ACO basically comprises of two key steps:

1) A solution construction or representation.
2) A pheromone update.

Step 1 is usually constructed from a finite set of solution values which is a subset of an empty partial solution (Socha & Dorigo, 2008).

Step 2 uses the idea of ant pheromone trails to update the good solutions by increasing its fitness values. For continuous domains, the following equations model the primary operations of the first step while a Monte Carlo operation takes care of important steps. Sampling a Gaussian function at construction step *i*, in accordance to the following probability:

$$p_i = \frac{\omega_l}{\sum_{r=1}^{k} \omega_r} \tag{12}$$

Where:

ω_l = a computed weight of a chosen solution

ω_r = a computed weight of other solutions

Computing a weighted standard deviation:

$$\sigma_l^i = \xi \sum_{e=1}^{k} \frac{\left| s_e^i - s_l^i \right|}{k-1} \tag{13}$$

Where:

k = size of solution archive

s_l = chosen solution

s_e = other solutions

ξ = a convergence intensification factor

Tables 1 to 3 give the key system parameters used to simulate the three LFOs in this work.

Table 1: PSO System Parameters

Parameters	Default Values
Maximum Iteration	1000
Population Size	50
Constriction coefficients	2.05
Inertia Damping Weight Ratio	1.00
No. of runs	10

Table 2: BCO System Parameters

Parameters	Default Values
Maximum Iteration	1000
Food Number	50
Limit trials	500
No. of runs	10

Table 3: ACO System Parameters

Parameters	Default Values
Maximum Iteration	1000
Population Size	50
Sample size	10.00
Intensification factor	0.40
Deviation distance ratio	1.00
No. of runs	10

Small signal voltage stability experiments in the context of load flow of a section of the Nigerian 132kV power transmission network (Port-Harcourt region) is conducted on an Intel i-core-2 PC using a 2.3GHz processor. The considered Nigerian sub-transmission network is a 1-machine, 14-bus system with most interconnecting lines of the double circuit type. All simulations are performed using MATLAB. Data for the NPHC-132 1-machine, 14-bus power system is obtained from the Transmission Company of Nigeria (TCN).

3. RESULTS AND DISCUSSION

The fitness plots of applying PSO, BCO AND ACO LFO approaches to the Nigerian 132-kV power transmission network (Port-Harcourt region), 1-machine 14-bus system are as shown in Figures 1 to 3.

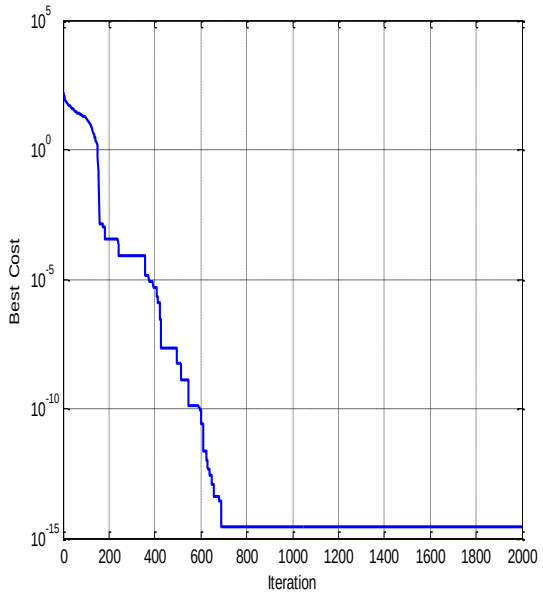

Figure 1 PSO-LFA Fitness Plot

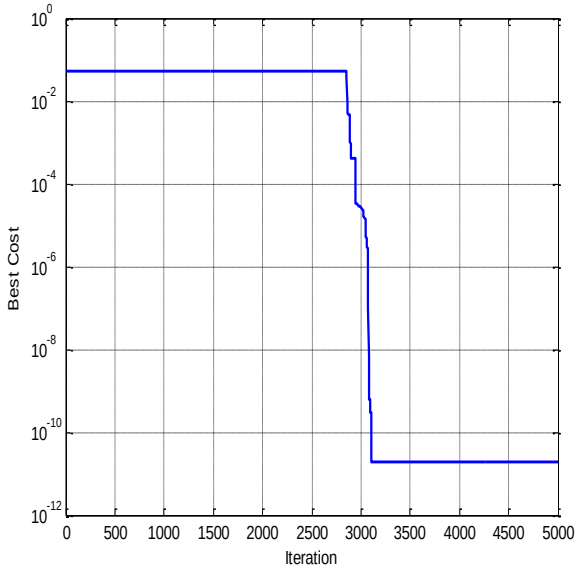

Figure 2 BCO-LFA Fitness Plot

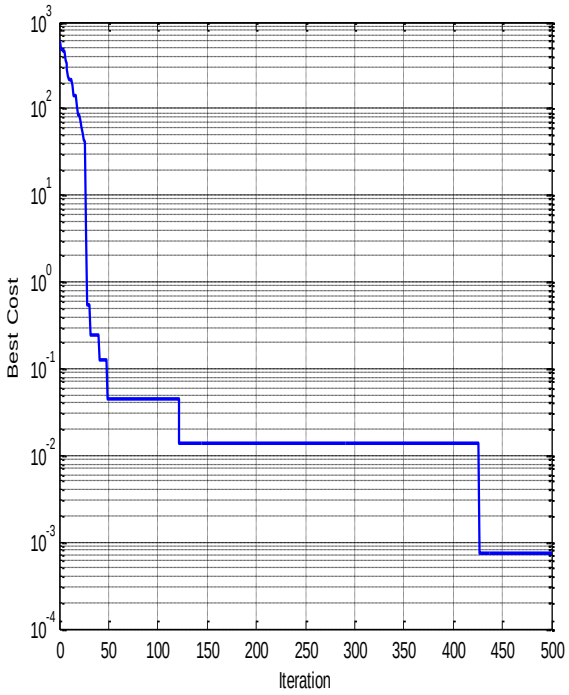

Figure 3 ACO-LFA Fitness Plot

The power mismatches (fitness scores) as computed by the three LFO algorithms are shown in Table 4, and the solved bus voltages (mean voltages) at maximum set iteration values. The results are obtained after three simulation runs and iteration values of 500, 600, 700 and 1000. For the power mismatch test, only the results of the best simulation run (from the three simulated cases) are considered.

Table 4: LFO Power Mismatch Performance

Iteration Values	**PSO-LFO Power Mismatch**	**BCO-LFO Power Mismatch**	**ACO-LFO Power Mismatch**
500	$3.197*10^{-14}$	61.655	0.583
600	0.000	30.496	0.171
700	0.000	8.520	0.655
1000	$7.105*10^{-15}$	$7.354*10^{-06}$	0.078

A performance optimization study of three swarm intelligence techniques, the PSO, BCO and ACO load flow optimization (LFO) was presented. The study investigated the influence of one of the LFO optimization parameters called the "iteration" or "maxcycle" parameter on the power mismatch value and voltage response during a load flow optimization. The study bus considered is the Nigerian 132kV sub-transmission Port-Harcourt region. The results indicate that higher value of the iteration parameter improves the power mismatch value and hence stabilizes the voltage response. The PSO and BCO showed close correlation and gave realistic load flow solutions, but however, PSO has comparatively lower values in terms of best fitness and power mismatch as shown in Figs. 1-3 and Table 4. This makes the PSO algorithm a better approach for solving the current problem.

4. CONCLUSION

This work investigated new ways of approaching the power system stability studies based on predictive optimization through the use of the following three swarm intelligence algorithms: the Bee Colony Optimization (BCO) which is based on the Artificial Bee Colony (ABC) algorithm, Ant Colony Optimization (ACO) and the Particle Swarm Optimization (PSO) algorithm for optimizing the load flow part of a power system network prior to stability studies.

Power mismatch results also show that stability is reasonably guaranteed at a certain iteration value (for instance an iteration of 1000 is just sufficient for the power network using the PSO-LFO and BCO-LFO. Also, the power mismatch reduces as the iteration value increases.

Future studies will explore the potential of the various swarm-based LFOs in power system load flow studies for various power system networks and in transient/steady state stability studies. These studies will be conducted in comparison with other alternative and promising swarm intelligence techniques including algorithmic variants of the considered techniques.

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PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON NEWVIEWS IN ENGINEERING AND TECHNOLOGY (ICNET) MAIDEN EDITION, FACULTY OF ENGINEERING, RIVERS STATE UNIVERSITY, PORT HARCOURT, NIGERIA.
27th October 2021
Available online at https://conference.rsujnet.org/

Paper number: ICNET2021-002

Leading-Edge Production Engineering Technologies

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ABSTRACT

Production engineering technologies are ever advancing to tackle problems encountered in manufacturing of products and rendering of services. This paper presents a number of challenges encountered by producers, and the industrial revolutions that these producers have kickstarted to handle these production challenges, while also identifying leading-edge production engineering technologies that have enabled these technological revolutions. The methodology employed was the systematic literature review of scholarly articles published between 2010 and 2021. The result of the research was the identification of some leading-edge production engineering technologies that are helping producers improve productivity such as robotics, smart factories and Internet of Things (IoT); Artificial Intelligence and predictive maintenance; 3D printing and additive manufacturing.

Keywords: Additive Manufacturing, Internet of Things, Production Engineering, Robotics, Smart Factories.

Cite This Paper: Wofuru-Nyenke, O. K. (2021). Leading-Edge Production Engineering Technologies. *Proceedings of the International Conference on New-views in Engineering and Technology Maiden Edition*, Faculty of Engineering, Rivers State University, Port Harcourt. Nigeria, 27th October, 2021, ICNET2021-002, 36 – 44.

1. INTRODUCTION

Production Engineering is a specialisation of Mechanical Engineering, that deals with the planning, designing, development, implementation, operation, maintenance, and management of all processes involved in the manufacturing of products or rendering of services. Traditional production activities are saddled with numerous challenges which affect productivity. Some challenges are manual handling and safety, maintaining the right inventory levels, lack of efficient and profitable production of customised and small-lot products through monitoring and controlling automated and complex manufacturing, stand-alone and segregated manufacturing and weak integration of production systems, product life cycle and intercompany value chain (Shi *et al.*, 2020). Other challenges identified by Khan and Turowski (2016) include poor data integration and management, poor process flexibility as demanded by customisation and security of people, products and production facilities environment. With the advent of leading-edge technologies in production and manufacturing, organisations are additionally faced with challenges such as how best to implement and keep up with these technologies in order to achieve operational goals such as reduced costs, improved efficiency, increased safety and product innovation while staying relevant and competitive.

Various industrial and technological revolutions have been provoked to combat the challenges of traditional production and manufacturing, from Industry 1.0 to Industry 5.0. The First Industrial Revolution also known as Industry 1.0 occurred around the 1780s and involved an evolution from traditional manufacturing processes to manufacturing processes which used water and steam. Moreover, the use of fuel sources such as steam and coal made machine use more feasible, and allowed for faster and easier production and

the possibility of all kinds of innovations and technologies. The Second Industrial Revolution, Industry 2.0, also known as the Technological Revolution occurred around the 1870s and saw the introduction of newer technological systems, especially superior electrical technology at the time, which enabled manufacturers to use more sophisticated machines and carry out mass-production using assembly lines, thereby improving productivity. The Third Industrial Revolution, occurred around the 1970s and began with the first computer era and involved the use of electronics and Information Technology to improve automated production with the aid of the Internet, connectivity and renewable energy. Even though the automated systems of Industry 3.0 were dependent on human input and intervention, the era saw the use of these systems within assembly lines to perform human tasks using Programmable Logic Controllers (PLC). Industry 3.5 which occurred around the 1980s saw the offshoring of production to low-cost economies in order to reduce the costs of production further. The Fourth Industrial Revolution, Industry 4.0, which is the industrial revolution of today, is the period of smart machines, storage systems, and manufacturing facilities that could automatically share information, initiate operations, and control one another without the need for human interaction, all made possible with the aid of the Internet of Things (IoT). Rossi (2018) explained that Industry 4.0 brings robots, interconnected devices and fast networks of data within a factory environment together, to improve the productivity of the factory and execution of routine tasks that are best conducted by robots and not humans. The Fifth Industrial Revolution, Industry 5.0, which is the industrial revolution of the future, will see the return of human hands into the industrial framework and the reconciliation of humans and machines in order to work together to improve productivity. While the current Industry 4.0 era is concerned with the conversion of traditional factories into IoT-enabled smart facilities that use cognitive computing and interconnect through cloud servers, the industry 5.0 era will have mass implementation of Cobotics where humans will be back in the industrial production process collaborating with the smart machines and systems. Therefore, workers will be upskilled to provide value-added tasks in production, leading to mass customisation and personalisation for customers (Rossi, 2018). This will create higher-value jobs and enable workers and humans to focus on the responsibility of product and service design, enabling the development of products and services that are considerably more bespoke and personal.

The main objective of this paper is to provide a description of the latest technologies that can help production companies improve productivity in the present day. The paper attempts to fill a research gap posed by the need for a study that aggregates the modern-day production engineering technologies.

2. MATERIALS AND METHODS

The methodology employed was the systematic literature review of scholarly articles published between 2010 and 2021, which were related to the topic of Leading-Edge Technologies in Production Engineering. The search engine utilised was Google Scholar and papers were sourced from various publishers. A five-phase process was followed in conducting the literature review. Phase 1 was a pilot search of articles in order to get an in-depth understanding of the literature, Phase 2 was the location of the studies by encompassing a large body of relevant articles, Phase 3 was the development and use of a selection and evaluation criteria or inclusion/exclusion criteria such as articles being published between 2010 to 2021 and being published in English, Phase 4 was the analysis and synthesis of the selected articles, Phase 5 was reporting of the results.

3. RESULTS AND DISCUSSION

The result of the literature review carried out was the identification of leading-edge production engineering technologies which provide advanced manufacturers with an advantage in manufacturing and production engineering. These technologies include robotics, smart factories and Internet of Things (IoT); Artificial Intelligence and predictive maintenance; 3D printing and additive manufacturing.

3.1 Robotics, Smart Factories and Internet of Things

Robotics refers to an interdisciplinary field that involves design, construction, operation and use of robots within production processes. In order to improve production rates, many organisations are implementing the use of advanced robots to improve production. Nowadays, robotics is also offered as a service to allow organisations which cannot normally afford the cost of acquiring and implementing advanced robotics within their production processes to rent robots and use them as part of their workforce.

A smart factory is a highly computerized production floor that continuously collects and shares data through connected machines, devices and production systems. The four intelligent features of smart factories as listed by Shi *et al.* (2020) include the ability to self-organize, learn, and maintain environmental as well as their own information for analysing their behaviours and abilities; interoperability and real-time control of the internet; high integration using robot vision systems and artificial intelligence technologies; and the use of virtual reality technology such as signal processing, animation technology, intelligent reasoning, prediction, simulation and multimedia technologies to virtualize manufacturing processes and products and facilitate the human-machine integration of smart factory. With the use of smart factories, companies will no longer need to set up unique production runs to fabricate identical products or parts, enabling customised production to be as affordable as mass production. These will aid the factories in becoming more efficient, with a decrease in raw material waste. Pech *et al.* (2021) enumerated some of the devices utilised in smart factories grouping them into motion, position, proximity and speed sensors which monitor the machine or product position on the production lines (Cottone *et al.*, 2013; Luo *et al.*, 2019; Shoaib *et al.*, 2014); vibration and torque sensors which utilise Fourier transform signal processing to detect failures in machine components (Kiangala & Wang, 2018; Kozlowski *et al.*, Uhlmann *et al.*, 2017); acoustical, sound and ultrasonic sensors which utilise microphone devices together with machine learning to estimate relevant information such as the character of an object and its location (Kaptan *et al.*, 2018; Ryu & Kim, 2020); pressure, force, touch and tension sensors which identify the pressure deviations in the object of interest or environment based on barometric, piezoelectric, capacitive, optical or resonant sensing principles (Musselman & Djurdjanovic, 2012); optical, light and machine vision sensors which capture visual data and conduct a digitisation process using machine learning algorithms (Mennel *et al.*, 2020; Sergiyenko *et al.*, 2018); temperature sensors which obtain temperature information directly using resistive temperature detectors, thermistors and thermocouples or indirectly using infrared sensors (Sadiki *et al.*, 2019; Salvatore, *et al.*, 2017; Villalobos *et al.*, 2020); liquid, flow, gas and chemical sensors which are useful for monitoring the current intensity in pipelines using magnetic, ultrasonic or thermal detectors (Chien & Chen, 2020; Farahani *et al.*, 2014); electronic current, energy and magnetic sensors which measure the current draw of machines (Alberto *et al.*, 2018; Jureschi, 2016; Zhang *et al.*, 2019); virtual sensors which are embedded in the software layer of machines to enhance the knowledge of the machines (Al-Jlibawi *et al.*, 2019; Indri *et al.*, 2019); and nuclear, chemical,

microparticles and nanoparticles sensors which enable monitoring directly within the monitored object (Jia *et al.*, 2021; Thakkar *et al.*, 2021; Singh *et al.*, 2021).

Gillis (2021) described the Internet of Things (IoT) as a network of integrated computing devices, mechanical and digital machinery, objects, animals, or people with distinct identifiers and possessing the ability to transfer data without the need for human-to-human or human-to-computer interaction. With the use of IoT's cheap, connected and increasingly abundant sensors, organisations can now monitor various aspects of manufacturing than ever before, including machinery, deliveries, and even employees.

Figure 1 shows the principal benefits of manufacturing operations automation.

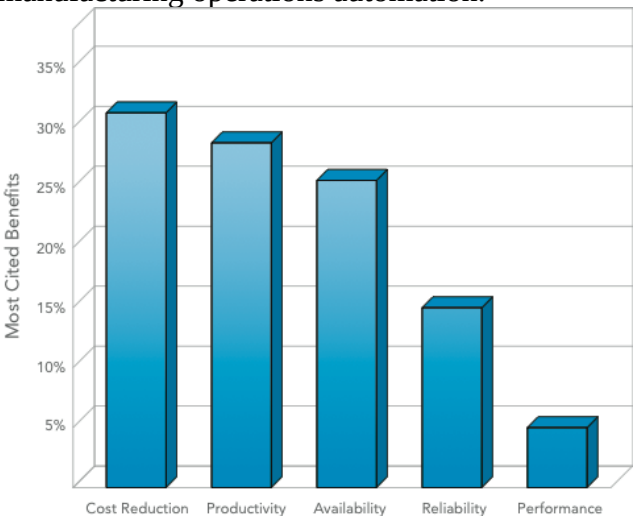

Figure 1: Benefits of Manufacturing Operations Automation (Christiansen, 2020).

From Figure 1, the benefits of manufacturing operations automation include cost reduction, increased productivity, availability, reliability and performance. With cost reduction being the highest benefit of automating manufacturing operations (Christiansen, 2020).

3.2 Artificial Intelligence and Predictive Maintenance

Product supply chains are complex, stochastic systems that present logistics analysts with issues such as increasingly diverse and difficult to predict variable customer demand (Kantasa-ard *et al.*, 2020). Machine learning, a subset of Artificial intelligence, enables these analysts to predict the number of products/services that will be purchased during a definite future period. This information is crucial for producers to optimize their inventory levels and conduct replenishment decisions. Truly, machine learning methods have been shown to provide significantly less biased and more accurate forecasts than well-established, statistical methods (Kantasa-ard *et al.*, 2020; Spiliotis & Makridakis, 2020).

Machine breakdowns in the middle of a production run can have a negative impact on the schedule, cause delivery delays, or force employees to work overtime to make up for lost time (Pech *et al.*, 2021). Predictive maintenance anticipates system breakdowns in order to save maintenance costs (Selcuk, 2016; Tortorella, 2018). Therefore, predictive maintenance provides a set of tools based on continuous monitoring of the machine or process, to determine when a particular maintenance operation is necessary (Bukhsh *et al.*, 2019; Carvalho *et al.*, 2019). Predictive maintenance is also related to production robotization and Internet of Things, as a result of the fact that it involves the use of intelligent sensors which aid in collecting large amounts of data, which are efficiently analysed to support intricate decision-making and management of complex systems (Pech *et al.*, 2021). This allows for early detection of faults through tools based on historical data such as machine learning, thereby minimising maintenance costs, enabling implementation of zero-waste production, and reduction of the number of major failures. However, a challenge of predictive maintenance is the potential risk of Distributed Denial-of-Service (DDoS) attacks, which is a malicious attempt to interrupt a targeted server, service, or network's routine traffic by

flooding the target or its surrounding infrastructure with internet traffic.

Figure 2 shows the most common applications and use cases of Artificial Intelligence in manufacturing.

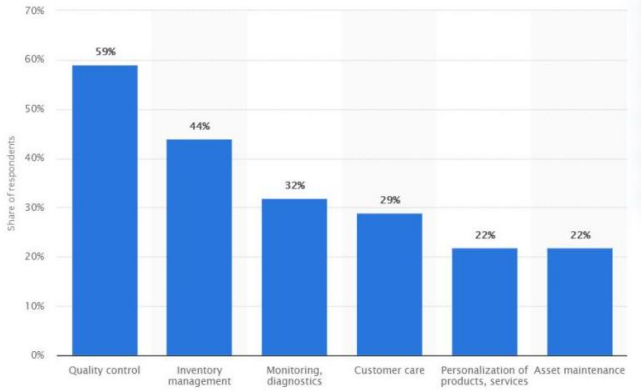

Figure 2: Applications of Artificial Intelligence in Manufacturing (Dilmegani, 2020).

From Figure 2, the common use cases of Artificial Intelligence in manufacturing include quality control, inventory management, monitoring diagnostics, customer care, personalization of products/services and asset maintenance. With quality control being the area of highest application of Artificial Intelligence in manufacturing, and personalization of products/services and asset maintenance being areas of lowest applications of Artificial Intelligence in manufacturing (Dilmegani, 2020).

3.3 3D Printing and Additive Manufacturing

One of the main enablers of customised manufacturing at scale is 3D printing and additive manufacturing. As its name implies additive manufacturing adds material to create an object and differs from traditional creation of objects by milling, machining, carving, shaping which involve material removal. According to Tumbleston *et al.* (2015), additive manufacturing processes such as 3D printing utilise time-consuming, stepwise layer-by-layer approaches for fabricating objects. In essence, 3D printing employs the use of computer-aided design (CAD) software or 3D object scanners which slice the object into ultra-thin layers and direct the path of a nozzle or print head for precisely depositing material in accurate geometric shapes, layer by layer, with each successive layer bonding to the preceding layer of melted or partially melted material to create the object. Therefore, 3D printers are used for giving physical form to digital designs ranging from personalised medical and dental products to adapted airplane and automobile parts.

A variety of different additive manufacturing processes exists such as powder bed fusion technology which melts or partially melts ultra-fine layers of material in a three-dimensional space using lasers, electron beams, or thermal print heads, blasting away superfluous powder from the item as the process completes; binder jetting where alternate layers of powdered material and a liquid binder are laid down by the print head; directed energy deposition where either a wire of filament feed stock or powder is melted by an electron beam gun or laser installed on a four-axis or five-axis arm; material extrusion where extruded polymers are drawn through a heated nozzle mounted on a movable arm, with the nozzle moving horizontally and the bed moving vertically, allowing the melted material to be built layer after layer with proper adhesion between layers achieved through temperature control or the use of chemical bonding agents; material jetting where a print head swings back and forth, similar to a 2D inkjet printer's head, but this time on the x, y, and z axes to build 3D objects, with layers hardening as they cool or curing with UV light; laminated object manufacturing and ultrasonic additive manufacturing which are two sheet lamination methods: laminated object manufacturing uses alternate layers of paper and glue, and ultrasonic additive manufacturing uses thin metal sheets connected by ultrasonic welding; and vat photopolymerization where in a vat of liquid resin photopolymer, an object is formed, with the

photopolymerization process curing each microfine resin layer using ultraviolet light carefully directed by mirrors.

Figure 3 shows the various ways 3D printing has been implemented.

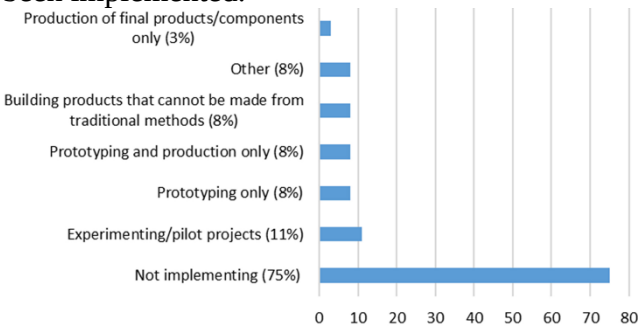

Figure 3: Implementations of 3D Printing (Olsson *et al.*, 2019).

From Figure 3, there is a low implementation of 3D printing, with the technology being implemented mostly in experimenting and development of pilot projects. Though 3D printing is predominantly used to generate prototypes and mock-ups as a result of the high cost of production, the impact of 3D printing is both disruptive and revolutionary (Garret, 2014). However, 3D printing in manufacturing is expected to mature in the coming years, changing from use in experimentations and prototype productions to production of low volume, bespoke and high-value products (Gebler *et al.*, 2014; Tumbleston *et al.*, 2015). The advantages of 3D printing for industry are ability to print many geometric structures, simplification of the product design process, relative environmental friendliness, increased flexibility, reduced warehousing costs and enabling adoption of mass customisation business strategy (Economist, 2011; Yin *et al.*, 2017). However, the disadvantages of 3D printing are that the 3D printing process takes time, 3D printed parts may not be as sturdy and might not meet tolerances (Yin *et al.*, 2017).

4. CONCLUSION

This research contributes to knowledge by providing a description of the latest technologies that are helping production companies improve productivity in the present day. The research has stated various challenges of traditional production systems and expounded on the various industrial revolutions and their technologies, concentrating on the technologies of the current Industry 4.0 and those of the future Industry 5.0 which together constitute the leading-edge technologies of production and manufacturing engineering. These leading-edge production engineering technologies are robotics, smart factories and Internet of Things (IoT); Artificial Intelligence and predictive maintenance; 3D printing and additive manufacturing. It is obvious that with the advent of these leading-edge technologies, organisations implementing them are experiencing increased productivity with a reduction in production times and cost of getting products to market. Therefore, by the use of robots and smart facilities which are more agile, versatile and clever, various production processes are getting faster, cheaper and more precise.

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PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON NEWVIEWS IN ENGINEERING AND TECHNOLOGY (ICNET) MAIDEN EDITION, FACULTY OF ENGINEERING, RIVERS STATE UNIVERSITY, PORT HARCOURT, NIGERIA.
27th October 2021
Available online at https://conference.rsujnet.org/

Paper number: ICNET2021-003

Impact of Black Soot in Niger Delta Region of Nigeria and a Modified Crude Oil Artisanal Refining Process

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ABSTRACT

This report presents a review of the implication of artisanal refining process in the Niger Delta region of Nigeria, Nigeria as a sub-Saharan country and the world at large. This study also presents a modified artisanal refining process as an immediate option to eliminate air pollution resulting from black soot generated from artisanal refining process, improve on product specification and maximize product yield in the absence of a political will and resources to introduce modular refining to replace the ongoing artisanal refining that produces soot with the attendant fatal consequences in the region. The modified process considering chemical engineering processes, principles will consist of an enclosed system with a fume cupboard - chimney for the furnace, four optimized heat exchangers, a Counter Current Flow Packed Tower (CCFPT), a force draft fan, a flue gas tank and a black soot slurry tank. In the modified process the vent gas is collected and used as a fuel for heating the crude oil while the waste water from the soot slurry is collected for further separation and treatment in a water treatment plant. To enable efficient process and equipment control strategy instrumentation of the process with the inclusion of Pressure and temperature gauges.

Keywords: Crude Oil, Nigeria, Kpo-fire, Black-Soot, Air pollution, Refining, Artisanal Refining.

Cite This Paper: Izionworu, V. O., Ayotamuno, I. & Godswill, N. (2021). Impact of Black Soot in Niger Delta Region of Nigeria and a Modified Crude Oil Artisanal Refining Process. *Proceedings of the International Conference on New-views in Engineering and Technology Maiden Edition*, Faculty of Engineering, Rivers State University, Port Harcourt. Nigeria, 27th October, 2021, ICNET2021-003, 45 – 55.

1. INTRODUCTION:

Air pollution as an age long environmental challenge occurs when harmful substances different from the natural composition of air are discharged into the environment at levels that is detrimental to – the health of humans and animals, plants and the atmosphere and natural environment (Natural Resources Defense Council, 2018). The air contaminants are classified either as natural contaminants – natural fog, volcanic eruption, particulates (aerosols) in the form of dust, smoke, fog, fumes, gases, heat, noise energy etc. (Whyte *et al*., 2020; Godish and Davis, 2015). Records of some past air pollution incidents show that in 1306 of our Common Era King Edward proclaimed a ban on burning sea-coal in London because of a major smoke and soot pollution, about 570 years after in 1873, air pollution caused by dense coal-smoke saturated fog caused the death of 268 person in London as. In 1909, 1000 persons died of smoke accumulation in Glasgow, Scotland and about 4000 persons were killed by a severe Sulphur-laden fog in 1952. The United States of America has also been impacted on by air pollution. Records reveal that in 1953 a smog incident resulted in more than 170 deaths in New York and in 1963 trapped air pollutants resulted in the death of 405 persons (Center for Chemical Process Safety, 2006). Since the reported incidents there has been many of such environmental pollutions occurring in different parts of the world. Regrettably, air pollution has increased in countries where mining and artisanal activities

that explore natural resources go on without regards to acceptable best practices (Efobi et al., 2019). While the challenge eventually ends up a global issue as currently conversed by the United Nations in the 2021 UN Assembly, the inhabitants of affected nations like Nigeria and its Niger Delta Region being one had hit by the environmental pollution are exposed to different health hazards and risks resulting from disproportionate and avoidable levels of air pollution.

In a recent bombshell United Nations report code named "Code Red for Humanity" (BBC Report, 2021) a catastrophe of some sort is portrayed for planet earth and humans. In that report it is said that human activities which included air pollution, is causing an unprecedented warming of the atmosphere, land and oceans resulting in a gradual but steady rise in sea level with a prediction of the possibility of sea level rising up to 2 meters by the end of this century. Global warming is already predicted to rise up to 1.5 degrees by 2040, ten years earlier than the predicted 2050 year. A number of countries have been affected significantly from climate change leading to hundreds of deaths. This include the blistering heat wave that affected west coast of United States of America and Canada, with a disturbing 300 or more deaths and about 13 million people that were affected by massive floods that engulfed China, while countries like Germany, Belgium, Luxembourg, Switzerland and the Netherlands suffered what has been described as the worst flooding experience in decade after a heavy rain fall that claimed over 180 lives (Matt, 2021; Sam, 2021).

Nigeria is battling with its sad share of climate change resulting partly from over 50 years of massive oil exploration and production activities and the rising population (Whyte *et al.*, 2020; Olowoporoku et al., 2012; Yakubu, 2018). Again, Nigeria suffers extensive environmental degradation occasioned by several factors including gas flaring (Brandt, 2020) and oil spills (UNEP, 2011a; Zabbey *et al.*, 2017). Although Nigeria is signatory to the fight against climate change, not much success has been recorded in the effort to reduce or eliminate environmental pollution largely because the country's economy is driven by the huge revenue from oil and gas activities. While the effort to reduce gas flaring is commendable there is yet need for more to be done (Brandt, 2020). The need to eliminate gas flaring established and adopted since 1984 has not been achieved and the implication is rising air pollution from greenhouse gas emissions caused by the continuous burning of fossil fuel and deforestation (Akinola, 2017).

The Niger Delta region of Nigeria (Plate 1), the seat of oil and gas production activities in Nigeria and home to a vast mangrove forest (Okonkwo *et al.*, 2015) is faced with an increasing air pollution challenge because of the identified reasons adduced by Anejionu (2015) and in recent years the risk has doubled with increase in artisanal refining of crude oil in the region (Okhumode, 2018; Whyte, 2020)). Artisanal refining referred to as "Kpo Fire" - a localized unregulated distillation of crude oil hydrocarbons to produce petrol, diesel and kerosene in the creeks of Bayelsa, Rivers and other Crude Oil rich States has been established as destroying the regions of the country and the globe. This activity discharges particulate matter– soot, seen in Plates 2, 3, 4 and 5, rated as $PM_{2.5}$, carbon dioxide, methane and other gases into the atmosphere (Whyte, 2020; UNEP, 2011b). Air pollution in Nigeria and Rivers State in particular is not without the dangerous effects and the increased risk of mortality among those exposed to it (Okhumode 2018).

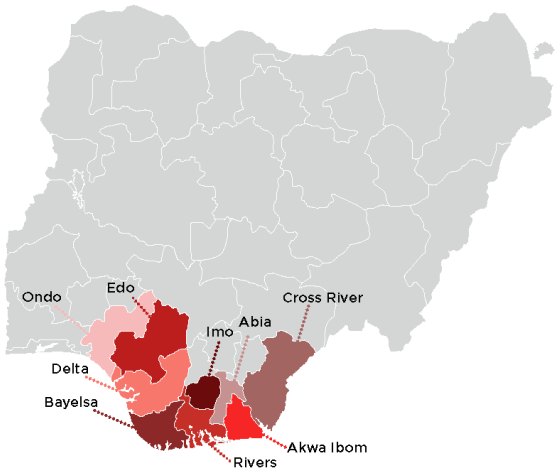

Plate 1: Niger Delta States of Nigeria (SDN, 2020)


Plate 2: Up in smoke: illegal refining in Bayelsa state (Reuters - Financial Times, 2015)

However, the search for air pollution solution should start with availability of data, sadly Africa is in want of data on the effect of air pollution on Africans and Nigerians. Coker and Kizito in research in 2018 identified a paucity of ambient air pollution epidemiologic data in sub-Saharan Africa as major challenge. Petkova, *et al* in a report published in 2013 had identified that there is lack of data on air pollution studies in Africa. Petkova *et al.*, (2013) reported that available evidence from short- and long-term air monitoring studies when collected and analyzed reveal a level of pollution that is higher than international guidelines while Amegah and Agyei-Mensah (2017) in an effort to bridge the gap created by lack of data reported on exposure of sub-Saharan Africa dwellers to ambient air pollution as a major treat that has led to the death of some 176,000 persons and another 626,000 suffering from Disability Adjusted Life Years (DALY's). This report is in agreement with the report of World Health Organization (WHO) that identified environmental pollution as having catastrophic effect on inhabitants of poor economies of the world like Nigeria. The estimate according to WHO is that Nigeria and other countries in this category has 91% of all 4.2 million recorded deaths linked to atmospheric pollution (Whyte, 2020). This sickening report is substantiated by a 2015 World Bank Environmental monitoring data (World Bank, 2015) showing Nigeria had 94% of its population exposed to air pollution beyond the WHO acceptable limits of air quality (Whyte *et al* 2020; WHO, 2016). This situation has not improved as seen in World Bank Group report (2016).

Rivers State the hub of oil and gas exploration in the Niger Delta region lacks empirical data which the government in power made effort to solve by setting up a team of expert to empirically generate base line data on air pollution for the state. (Whyte *et al, 2020).* This indigenous oil rich state *has* been faced with deadly air pollution challenges which include acid rain and soot pollution (Whyte *et al*, 2020). Soot particulate matter is classified as $PM_{2.5}$ and contains carbonaceous particles with attached polycyclic aromatic hydrocarbons (PAHs) (Boffetta, Jourenkova & Gustavsson, 1997). Research shows that a number of fatal diseases result from exposure to soot and its associated volatile organic compounds (VOC's) (Okhumode, 2018). Prominent among these diseases are respiratory problems such as Chronic Obstructive Pulmonary Disease (COPD) and asthma. Others are bronchiolitis, lung cancer and cardiovascular events. A dysfunction of the central nervous system when inhaled soot penetrates deep into bronchiolar tissue, and cutaneous diseases are all part of the challenge (Ioannis *et al*, 2020; Subramaniam, 2014). These have been previously classified as being either

cancer that are localized and systemic in nature, mild to possibly severe respiratory disorder and cardiovascular dysfunctions. Niranjan and Thakur (2017) who reported these also reported on the possibility of soot causing damage to deoxyribonucleic acid (DNA), a life squinter in human and that there are short-term effects which include irritation of the eyes, nose and throat, cough and chest tightness.

The events of the past two centuries continues to plague African, and Nigeria and the Niger Delta in particular in the past 5 decades since the commencement of crude oil exploration. Residents of Rivers and Bayelsa states in the Niger Delta have reported increased rates of difficulty in breathing, cough, frequent and deadly asthma attacks from its sufferers and skin maladies (Whyte *et al,* 2020). No doubt that Soot is a major hazard to the population in the two states put together.

To manage the rampaging effect of air pollution Nigerian government have set up different agencies driven by laws to mitigate or eliminate the sources of soot. These include environmental laws and regulations such as the Constitution of the Federal Republic of Nigeria, the National Oil Spill Detection and Response Agency (NOSDRA) Act (2006), Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN), National Environment Standards and Regulation Enforcement Agency (NESREA) Act of 2007 and very recently the 2021 Petroleum Industry Bill (PIB) that was newly signed into law as the Petroleum Industry Act (PIA). Whyte (2017) posits that despite the presence of these regulatory agencies not much has been achieved giving rise to recent heightened concerns over air pollution in Rivers State as soot continues to pollute the air in many areas of the state.

Incessant soot pollution indicates a lack of efficient monitoring and regulation of the oil industry and the will power to eliminate the threat (Sam et al., 2017). This implies a lack of empirical data on the extent of pollution in the region. To address this fundamental challenge the Rivers State government set up a team of experts to generate empirically preliminary air quality data. The expert report revealed artisanal refining, emissions from asphalt factories and improper burning of mixed waste as major causes of soot pollution in the State. Other possible causes identified include the burning of used and expired tires and emissions from vehicular (Rivers State Government, 2019).

It seems that the environmental hazard occasioned by soot seem difficult to control because of the economic advantage of the activities that produce it. As captured in the expert report one of the major activities that stands out in soot generation is artisanal refining of crude oil. It was reported that from 2009 to 2013 Nigeria lost 109 billion dollars to oil theft. In another report, the Nigerian Extractive Industry Transparency Initiative (NEITI) stated that Nigeria lost 105 billion dollars due to the activities of oil thieves in the downstream sector (Nigeria's Oil & Gas monthly, 2013).

These loses are closely related with the feelings of the indigenous people of the Niger Delta that their oil was taken away without much for them and so the youths of the region see artisanal crude oil refining as a way of recuperating lost wealth. Government agencies saddled with the responsibility to protect national resources have responded to prevent the continuous oil theft. The response of government agencies to deter and stop the artisanal activities is usually to burn storage tankers and illegal local refineries as seen in Plate 3, and these burning activities essentially increase air pollution and its associated health hazards in the region as seen in Plates 4 and 5.

Plate 3: Burning Artisanal Refinery (The Atlantic, 2013)

Plate 4: Soot in the environment in Port Harcourt Sky (Legit.ng, 2017)

More than ten years after artisanal refining of crude oil began in the region, records show that rather than being curtailed there has been increase in the number of artisanal refining. Camp profitability is said to have increased from 17% in 2012 to 60% and 62% in 2017 in Bayelsa and Rivers State respectively with increase in refining capacity from 45% to 88% within the period.

Plate 5: Soot on plant leave. (PM News Nigeria)

This translates to 61 camps in 2016 in Bayelsa that reduced to 48 due to security activities, but in Rivers State the number of camps increased from 535 to 1,275 camps indicating increase in capacity and increase in soot production. The total supply chain earnings increased twenty fourfold from an estimated 24 million pounds in 2012 to 578 million pounds five years after in 2017 in both states of Bayelsa and Rivers State. (SDN, 2018).

The expanding artisanal refinery in the face of security checks, land and water pollution as more 5.9 million liters of crude oil was spilled in 2019 (SDN, 2020) and life damaging hazards indicates the need for a lasting solution to stop the perceived but obvious economic rape of the nation's resources, the feeling of deprivation by the indigenous people of the Niger Delta region of Nigeria, lack of employment for the teaming youths and increasing environmental hazards caused by unregulated artisanal refining of crude oil calls for an urgent acceptance and gradual modification of the artisanal refineries.

1.1 Illegal Refining of Crude Oil Process Description

The illegal production of petroleum products majorly produces three components which are diesel, fuel and kerosene.

This process is unsafe and also produce components of petroleum products with impurities. The first step in the artisanal process is the loading of crude oil into a cylindrical reactor (pot) which will then be heated at the base of the cylindrical reactor. Crude oil from an open tank which serve as fuel to the system is channeled to the bottom for continuous burning and to increase the intensity of the heat on the reactor as desired. The artisanal distillation process after 2 to 3 hours of heating results in the evaporation of components that pass through a pipe at the top of the cylindrical reactor Plate 6. These components mostly kerosene and diesel will be received by an open tank. The flow diagram of this process is seen in Plate 7.

Plate 6: Artisanal Refining Process in Progress (Advocacy Centre, 2015)

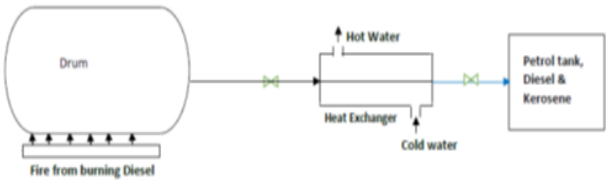

Plate 7: Current Artisanal Refining Process in Progress

The kerosene and diesel collected in different tanks will then be cooled by inserting a water hose inside the heat exchangers for kerosene, diesel and Petrol to condense. When these components have been cooled, then the water will be allowed to flow out through an opening at the bottom of the receiver (tank of kerosene, Petrol and diesel). After the heating is carried out on the cylindrical tank, there will be residue at the bottom of the tank which is discharged through an opening at the base of the tank into the surrounding.

Based on the difficulties associated with total eradication of artisanal crude oil refining, prevalent soot challenge leading to dangerous climate change with global impact, the associated health implications and the lack of political will and resources to invest in Modular refinery, a simple but efficient artisanal refining process is required to quickly transit from a production process that produces massive soot to one that drastically reduces the extent of soot discharged to the environment. To achieve this objective, this paper presents an alternative option – a modified process that ensures improved quality of product, service delivery (Izionworu & Ukaeme, 2014) and eliminates soot production using a chimney box during artisanal production of petrol, diesel and kerosene and a Counter Current Flow Packed Tower (CCFPT) a Water wash for collection of the soot generated in the furnace housed by the Chimney. It is a process that provides an immediate solution to eradicate soot production and an initial artisanal refining process that can be modified further with use.

2. MATERIALS AND METHODS:

2.1 Materials for the Modified Process of the Artisanal Production of Petroleum Products

To eliminate soot production and improve the method in the production of petroleum product during artisanal refining the following equipment modification is recommended:

2.1.1 Equipment Description

The equipment required for the crude system modification are:

i. Open squared drum: where the crude that serve as fuel is stored.
ii. Cylindrical drum (the distillation Colum): this is where the crude is loaded.
iii. Furnace: This is a system set up to generate heat to the process.
iv. Chimney: This is a housing set to accommodate the distillation Colum and also the furnace and contain the soot resulting from the burning process seen in Plate 8.
v. Counter Current Flow Packed Tower (CCFPT) (Water wash): Plate 8 shows the Counter Current Flow Packed Tower used to trap the soot while the gas will be allowed to flare.
vi. Heat exchanger: There is one heat exchanger in the Crude oil tank and a set

of three heat exchangers for condensation of products from the separation tank to the Receivers.

vii. Receivers (Kerosene, PMS and diesel Receivers): The Receivers shown in Plate 8 receives and temporarily stores the refined products before transfer to product storage tank.

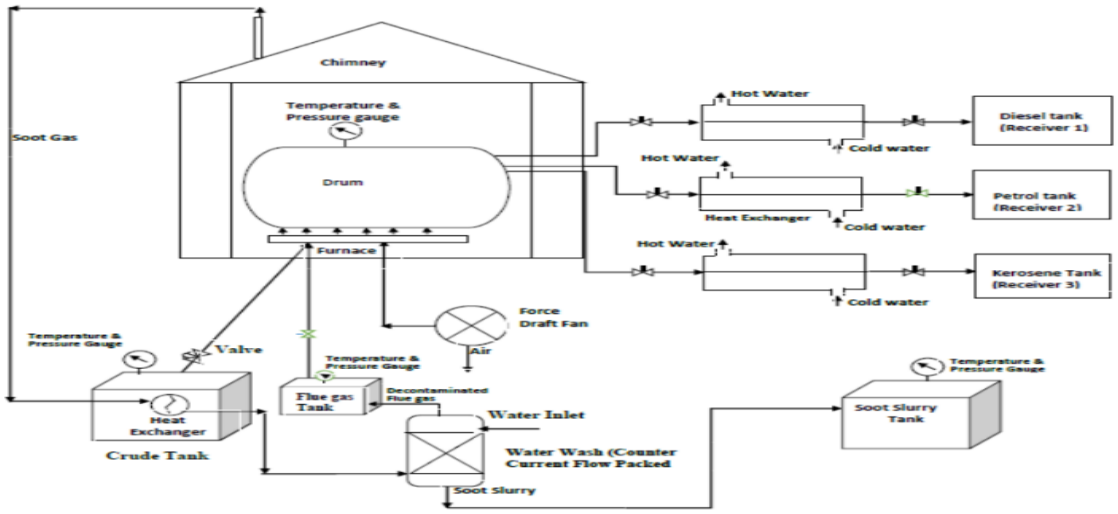

Plate 8: Modified Process of the Current Process for the Illegal Refining of Crude Oil

3. RESULTS AND DISCUSSION

3.1 Process Description

The crude oil is first loaded inside the distillation Colum (cylindrical tank) and the heat is generated from the furnace to raise the temperature at which the petroleum products will be heated to their separation temperature. A crude stored in a squared tank which flows through a pipe serves as fuel for this process.

When the crude has been heated to an elevated temperature, the lighter product evaporates and then is collected by the receiver. The other components are also collected through the same procedure at their distillation temperature.

In the crude oil tank, a tripled-pipe concentric heat Exchanger is used to preheat the crude oil before it is transferred to the drum for heating at higher temperature required for the product separation before they are collected.

The soot that is generated in the cause of this process is collected by the Chimney and transferred through piping connection to a concentric heat exchanger in the crude oil tank. The soot temperature reduces at this point and is sent to the CCFPT (water wash) to wash off the soot, while the gas is collected in a tank and used as fuel to heat up the crude oil in the crude oil separation tank.

The estimated production capacity of a modified process of artisanal refining is 30000 barrels/day

The Strength of Materials and Specifications for the components of the modified process are as follows:

Metal material for distillation column and Chimney -

i) Stainless steel has the capacity to always go back to normal use after a fire incident (Euro Inox,

2014), hence, soot fire resistant, anti-rusted stainless steel with a life span of about 70 years is recommended.

ii) The suggested Stainless-steel material should be:

A product of EN1856-1, with an operating temperature of 450 ^{o}C. It should withstand a high-pressure rating of 1.2 – 1. 25 atm and resistance to wet condensate, soot fire and corrosion. It should also have good material thickness.

3.2 Chimney

The chimney Box compartment will be 6 nos sheet as seen in Plate 8. Internally welded flanged and bolted sections

i. Each with 2 no. Lifting points.
ii. 1 no internal ladder for full height of chimney.
iii. Tight flanges.
iv. Internal surface treatment of the shell and liners by degreasing wire brushing followed by the application of heat resistant aluminum paint is recommended.

The dimensions and specifications of all operational components are subject to the desired production capacity.

Considering various corrosion inhibition options available (Izionworu *et al.*, 2019) The following corrosion treatment will be provided for the metal surfaces:

Blast cleans to SA 2.5 followed by the application of 1 x 80 microns alkyd first coat, 2 x 40 microns and alkyd finishing coats with a total thickness of coating approximating 160 microns. The coating serves as the corrosion inhibitor.

4. CONCLUSION:

The researchers suggest the following as practical answer to the disastrous artisanal process currently in use for crude oil refining that discharges massive particulate matter – soot into the environment:

i. Legalize artisanal refining in Nigeria with products sold to practitioners who over time with research will advance the process to a modular refinery.
ii. Modification of Current Artisanal process by provision of simple chimney and other component parts.
iii. Soot slurry should be collected in a tank and treated. A simple water treatment line that will become an associated component of the artisanal refining process is recommended. In the meantime, soot slurry should be treated at the water treatment plant in Port Harcourt Nigeria.
iv. Provide level 3 Health Safety and Environment (HSE) training for artisanal refinery operators.
v. Vehicular emissions monitoring and control with strict conditions should be enforced.
vi. Rather than burn illegally refined petroleum products, tank farms for storage of seized petroleum products should be established while the modified process is implemented.
vii. All foods should be covered in homes and markets and transparent display units should be used by all food dealers. All surfaces should be cleaned regularly, and personal hygiene encouraged through regular advocacy.
viii. The establishment and equipment of the state-of-the-art cardio-respiratory centre to manage and diagnose all forms of cardio-respiratory conditions will be of great advantage to residents of each State in the Niger Delta region. Similarly, a cancer treatment centre in the region will raise the bar on the standard of medical treatment services and set stage for anticipatory medical intervention for existing health condition resulting from black soot inhalation.
ix. There should be massive tree planting in the State by individuals who own buildings and properties in the cities

, to absorb carbon dioxide (CO_2), and the control of other potentially harmful gases such as sulphur dioxide (SO_2), carbon monoxide (CO). Trees sequester carbon, removing CO_2 and other greenhouse gases, and it moderates surface temperatures through albedo (solar radiation). It is a fact that a mature canopy tree absorbs enough carbon and releases enough oxygen to sustain two human beings. Government and its regulatory authorities should drive this course.

x. Asphalt production process in the State should incorporate gaseous emission control methods in their operations.

xi. Again, since it is difficult to further breakdown the resulting atmospheric residue to derive vacuum products by continuous heating under atmospheric condition without straining the furnace and fouling of both the heating medium and product settler, and a future decline of efficiency of the heater this study recommends further research on a local alternative to manage the resulting Heavier Fractions which at the moment will be treated at Port Harcourt Refinery, Port Harcourt Nigeria.

5. ACKNOWLEDGEMENTS:

We wish to acknowledge the 2020/2021 set of Final year students of Chemical/Petrochemical Engineering department for their contribution during development and review of the modified process.

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PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON NEWVIEWS IN ENGINEERING AND TECHNOLOGY (ICNET) MAIDEN EDITION, FACULTY OF ENGINEERING, RIVERS STATE UNIVERSITY, PORT HARCOURT, NIGERIA.
27th October 2021
Available online at https://conference.rsujnet.org/

Paper number: ICNET2021-004

Determination of Variability in Hourly and Tilled Area Tractor Fuel Consumption during Harrowing Operations

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ABSTRACT

Fuel is an essential product used by all farm machinery during their operations. In this study, field experiments were carried out to determine the variability in hourly and tilled area tractor fuel consumption during harrowing operations. An experimental plot of 138 m by 50 m (6900m^2) area was cleared and divided into three blocks of nine sub-blocks. Each of the blocks was marked out in 2 m by 50m for different treatments. Alleys to the plot of dimensions of 1m by 50m were provided. The equipment and tractor used for the tillage operations were DFM 100CD fuel flow meter, disc harrow and Swaraj 978FE. Soil-implement-machine parameters (draught, moisture content, bulk density, tractor forward speed, harrowing depth, width of cut), time and tractor fuel efficiency parameters (hourly fuel consumption (FC_h) and tilled area fuel consumption (FC_{ta}) during harrowing operations were determined. The experimental data obtained were analysed statistically by means of analysis of variance (ANOVA), and Coefficient of variation (CV). The results obtained revealed that increased in the soil-machine-implement parameters increased in line with hourly and tilled area fuel consumption (FC_h and FC_{ta}). ANOVA results also showed significant difference with 95 % and highly significant at 99 % confidence levels and coefficient of variation (CV) of (a) 0.55 % and (b) 11 %; and (a) 0.18 % and (b) 0.13 %, which confirmed that experimental error was low and reliable. Generally, the variability in tractor fuel consumption during harrowing operations are influenced by variations in the soil-implement-machine parameters and thereby become the determining factors to reduce fuel consumption.

Keywords: Farm Mechanization, Harrowing, Hourly Fuel Consumption, Tillage, Tilled Area Fuel Consumption

Cite This Paper: Ekemube, R. A., Nkakini, S. O., Igoni, A. H., & Akpa, J. G. (2021). Determination of Variability in Hourly and Tilled Area Tractor Fuel Consumption during Harrowing Operations. *Proceedings of the International Conference on New-views in Engineering and Technology Maiden Edition*, Faculty of Engineering, Rivers State University, Port Harcourt. Nigeria, 27th October, 2021, ICNET2021-004, 56 – 66.

1. INTRODUCTION:

Harrowing is a process of tilling the soil after ploughing operations. This is a secondary tillage operation that can be accomplished with the aid of a secondary tillage implement called disc harrow. It is projected to create a refined soil condition. According to Ekemube *et al*. (2020) reported that for optimum crop yield in agricultural mechanization, pulverization by harrowing. This secondary implement reduces operating depth and is less aggressive than primary tillage implement. The utmost used implement types for tillage in the preparation for planting are harrows in conventional field operations (Stolf *et al.*, 2010). In most cases, these secondary implements are functional as both in primary and secondary provision. Furthermore, the most often considerable used for soil preparation with disc

harrow is the weed control, plant residues management, soil aeration and improvement of porosity, a good preparation of seedbed and improving soil physical conditions (Stolf *et al.*, 2010). Peça *et al.* (1998) reported that the 24-disc implement performed better both in terms of work rate and fuel consumption per unit of worked area, though by a small difference, relative to the 20-disc harrow, making the larger implement a better choice. Also, engine rotational speed and the effective work speed may be decision making questions in the harrowing operation (Correia *et al.*, 2015). Also, from their finding that the increase in effective speed reduces harrow work depth up to 26%, going from 17. 7 to 13.1 cm. This result is tillage with compromised value, being only rapidly equipped. Serrano and Peça (2008) carried out a field test under real conditions of field work revealed that the draught required for trailed disc harrows increased as the forward speeds increased from 3 and 9 km/h. Nkakini and Douglas (2013) recommended tillage speed of 2.22 m/s as the best forward speed for harrowing in loamy sand soil for drawbar pull.

Ekemube *et al.* (2020) recommended that forward speed and harrowing depth should be a determining factor to curtail expenses on fuel consumption during harrowing operation. It has been observed in literature, that for each of tillage operations (ploughing, harrowing and ridging), fuel consumption rates rise linearly with time and area covered (Ikpo & Ifem, 2005). They reported that ploughing operation which has need of more energy than others used up the highest fuel consumption and the lowest work rate. The traditional tillage pattern needs a smaller amount fuel and time for tillage operation compared to circuitous and straight alternation pattern that would reduce the cost of production (Sarkar *et al.*, 2016). The research by Shah *et al.* (2016) has shown that fuel consumption and operation cost was more by disc harrow as compare to combination of cultivator + disc harrow. From their findings, they recommended that the use of combination of cultivator + disc harrow followed by disc harrow could make better seedbed in clay loam soil. Abbouda *et al.* (2001) reported that the wider track widths combinations and higher water ballast levels showed no significant differences (at 5% level) of fuel consumption with trailed disc harrow, that this might be caused by the absence of the dynamic load transfer to the rear wheels during work by the freely floating disc harrow. According to Correia *et al.* (2015) the choice of 220 rad/s (2100 rpm) rotation and 3.65 km/h permits fuel economy and higher worked area amount per unit time, which are desirable outcomes to lessen operational costs. Similarly, Correia *et al.* (2015) uses 220 rad/s (2100 rpm) engine rotation with disc harrow in performance tillage operation in clay soil to enhance lower fuel consumption and higher effective field capacity. They observed that the difference is that, there was a reduction in depth of work and the power required on the bar improved and lower engine rotation speed makes available higher working depth and decrease power in the traction bar.

Serrano (2007) stated that as with other implements, fuel consumption in harrowing operation could be attained based on fuel consumption per hectare measurement, which is the key technical indicator in the agricultural machinery efficiency use assessment. So, he stated that this demonstrated the contribution of the several variables that affect fuel supplied to the engine transformation effectiveness, during the work done by the implement. Tavares *et al.* (2012) used a harrow in conventional tillage system to describe the operating fuel consumption is 20.9% lesser when compared to reduce tillage system using chisel. Ekemube *et al.* (2020) researched on the assessment of tractor fuel consumption as influenced by tractor forward speed and depth during harrowing operation, their result revealed that increase in both forward speed and harrowing depth causes fuel consumptions increase during harrowing. Kheiralla *et al.* (2003, 2004) in their studies of an evaluation of power

and energy requirements for both powered and draught implements. They posited that the disc harrow was the best energy efficient implement in terms of fuel consumption and specific energy followed by the rotary tiller, disc plough and mouldboard plough.

It has been in literature that tractor's fuel consumptions are affected by many parameters during tillage operation, these include type and structure of soil, climate, tractor type, tractor size and tractor-implement relationship. There is dearth of information on the variability of tractor's fuel consumption during harrowing operation; there is still work to be done on this area considering two aspects of tractor fuel efficiency parameters (TFEPs) (hourly fuel consumption (FC_h), and tilled area fuel consumption (FC_{ta}). The aim of this study is to determine the variability in tractor fuel efficiency parameters during harrowing.

2. MATERIALS AND METHODS:

2.1 Experimental Site

The map of the experimental area is displayed in figure 1. This experiment was carried out on May 12th, 2021 at the Rivers State Institute of Agricultural Research and Training (RIART) farm at Rivers State University, Port Harcourt, Nigeria (latitude of 4° 49′ 27″ N, and longitude of 7° 2′ 1″ E). The group balanced block design (GBBD) was the experimental design used. A farm size of 138 m by 50 m (6900 m^2) was divided into three plots of 9 sub-plots each. Each sub-plot of 50m by 2m was marked with a 1m alley. The sub-plot was provided for different treatment options and with a space of 2 m between each block and 1 m at the sides of the outer blocks

2.2 Tractor and Implement Specifications

A two-wheel drive tractor Swaraj 978 FE (Swaraj, India) was used for this study (Plate 1). The tractor has a total weight of 3015kg, engine horsepower of 72 hp and lifting power of 2200 kg. Front and the rear tires were 7.5–16, 8 ply and 16.9 – 28, 12 radials respectively. An 1800 mm wide mounted-type disc harrow with disc diameter of 508 mm of disc plough (Baldan Implementos Agricolas, Brazil) with 9-disc bottom mounted on a gauge wheel was used for the experiments (Plate 2). Also, a DFM 100CD fuel flow meter (Technoton Engineering, Belarus) has nominal fuel pressure 0.2 MPa, maximum fuel pressure 2.5 MPa, minimum kinematic viscosity 1.5mm^2/s, maximum kinematic viscosity 6.0 mm^2/s, minimum supply voltage 10 V and maximum supply voltage 45 V (Plate 3).

Plate 1: The Swaraj 978 FE Tractor (Swaraj, India)

Plate 2: The Disc Harrow (Baldan Implementos Agricolas, Brazil) used in this Study

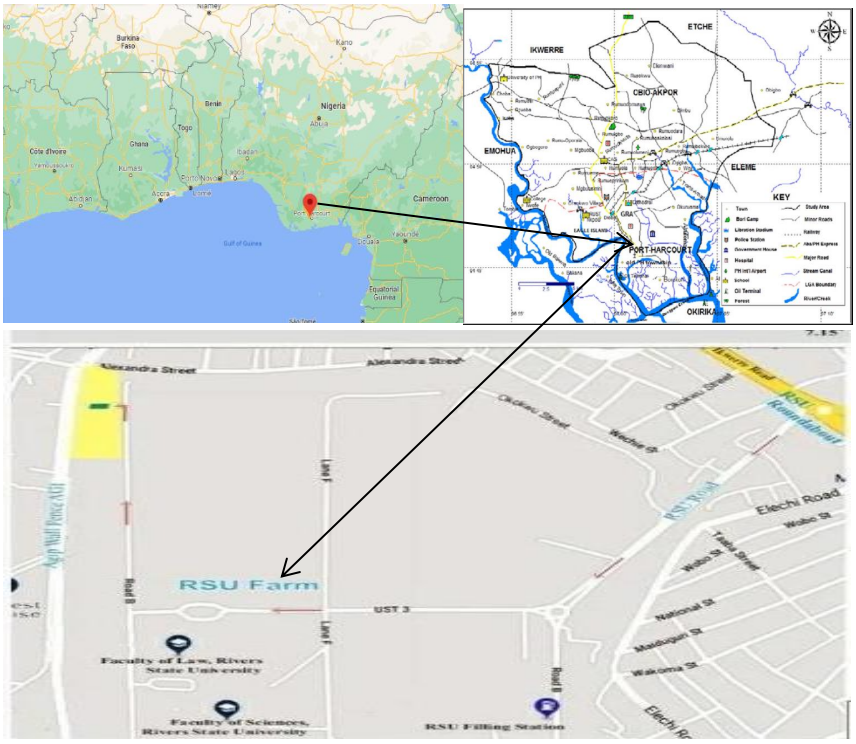

Figure 1: Map of Nigeria, Port Harcourt Metropolis and River State University (Source: Google Map, 2021).

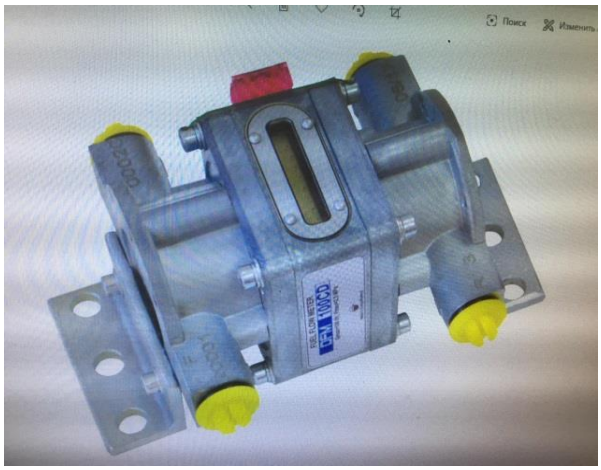

Plate 3: DFM 100CD Fuel Flow Meter (Technoton Engineering, Belarus) used in this Study

2.3 Experimental Procedure

Prior to harrowing operations, soil core was used for obtaining the soil sample from the depth of 0 - 15 cm at random in the field to determined textural classification of the soil, moisture content and the bulk density. The collected soil samples were taken to the laboratory for analysis. The parameters such as textural classification of the soil was determined by hydrometer method and the gravimetric (i.e., oven dry method) was used for soil moisture content determination (Nkakini, 2015). Also, the bulk density was determined using core method prior to tillage operation (Walter et al, 2016).

The disc harrow was attached to the tractor and levelled using the top links of the tractor in order to reduce parasitic forces. Then, harrowing depths

were determined by setting the level control of the lifting mechanism (three-point linkage height) to lower the disc harrow to the desired harrowing depth. Tractor forward speeds were determined by selecting a particular gear that gave the desired speed. This was done in a practice area in advance for each test plot to maintain the desired treatment. The harrowing depth measurement was done by placing the meter rule from furrow bottom to the surface of the harrowed land, while the width of cut was measured by placing a steel tape from one side of the furrow wall to the other end. Time was determined with a stopwatch set at zero before each operation. Draught force was determined using the formula represented below (ASAE, 2000):

$$D = F_i[A + B(S) + C(S)^2 WT] \quad (1)$$

D = Implement Draught force, N;
F = dimensionless soil texture and adjustment parameter;
i = 1 for fine, 2 for medium 3 for coarse;
ABC = machine specific parameter;
S = speed (Km/h);
W = machine with or number of rows (m);
T = depth (cm).

The digital method of measuring the quantity of fuel used was adopted to determine tractor fuel consumption. During this process, the use of DFM fuel flow meter was employed to measure fuel consumption. The metre was mounted on the fuel line between the tractor's fuel tank and the pump. At the end of each test operation the data was taken from the fuel flow meter as display information, switching is performed by light touch to the top cover of fuel flow meter by iButton key. Similar method has been adopted by Sumer *et al*. (2010); Spanolo *et al* (2012); Lopez-Vazquez *et al*. (2019); Ivanov (2019). Mathematically, hourly and tilled area fuel consumptions were deduced by expression in Equations (2 and 3) (Shafaei *et al*., 2018):

$$FC_h = \frac{T_{fc}}{h} \quad (2)$$

Where:
FC_h = Hourly fuel consumption (L/h);
T_{fc} = Tractor fuel consumption, L;
h = Working hour, h.

$$FC_{ta} = \frac{10 \times T_{fc}}{V \times W \times E \times h} \quad (3)$$

Where:
FC_{ta} = Tilled area fuel consumption, L/ha;
T_{fc} = Tractor fuel consumption, L;
V = Forward speed, Km/h;
W = Implement width, m
E = Implement field efficiency, %;
h = Working hour h

2.4 Statistical Analysis

Analysis of variance (single factor ANOVA) is the statistical method used to analyze the data in this research based on the F-test and to help achieve suitable error terms with single probability risk to determine if the means measured are totally different and if the differences are away from what is ascribed to chance or experimental error (Table 1) (Gomez & Gomez, 1983)

3. RESULTS AND DISCUSSION:

3.1 Soil textural class

The particle size distribution (PSD) analysis of a 102g air-dried soil before tillage operations indicated soil particles of various sizes, including sand (9.60 %), silt (8.80 %) and clay (83.60 %) in the soil. Result showed that the soil texture was loamy sand according to the United State Department Agriculture (USDA) textural classification of soil (Figure 2).

Table 1: Analysis of Variance of Data for Group Balanced Block Design

Sources of Variation	Degree of Freedom (df)	Sum of Square (SS)	Mean Square (MS)	Computed F	Tabular F 1%	Tabular F 5%
Replication	r – 1	Replication SS	Replication MS			
Group	s – 1	Group SS	Group MS	$\frac{Group\ MS}{Error\ (a)\ MS.}$		
Error (a)	(r – 1) (s-1)	Error (a) SS	Error (a) MS			
Group A	t/s – 1	Group A SS	Group A MS	$\frac{Group\ A\ MS}{Error\ (b)\ MS}$		
Group B	t/s – 1	Group B SS	Group B MS	$\frac{Group\ B\ MS}{Error\ (b) MS}$		
Group C	t/s – 1	Group C SS	Group C MS	$\frac{Group\ C\ MS}{Error\ (b) MS}$		
Error	s(r-1)(t/s-1)	Error (b) SS	Error (b) MS			
Total	(r)(t) -1	Total SS				

d (depth), S (speed), W (width), ρ_b (bulk density), CI (cone index), D (draught), MC (moisture content), FC_h (hourly fuel consumption), FC_{ta} (tilled area fuel consumption)

Table 2: Mean Results of Field Test Performed during Harrowing Operation

Parameters								
d, m	**S, Km/h**	**W, m**	**ρ_b, g/cm^3**	**CI, N/cm^2**	**D, N**	**MC, %**	**FC_h, L/h**	**FC_{ta}, L/ha**
0.0 9	5.00	1.50	1.42	164.06	3818.88	17.92	3.04	6.15
	7.00	1.50	1.42	164.06	4133.38	17.92	4.19	6.67
	9.00	1.50	1.42	164.06	4447.87	17.92	4.29	6.80
0.12	5.00	1.50	1.53	214.84	5346.43	18.50	4.37	8.86
	7.00	1.50	1.53	214.84	5786.73	18.50	6.08	9.61
	9.00	1.50	1.53	214.84	6227.02	18.50	6.20	9.85
0.15	5.00	1.50	1.65	253.91	6873.98	18.60	6.54	13.33
	7.00	1.50	1.65	253.91	7440.08	18.60	9.09	14.52
	9.00	1.50	1.65	253.91	8006.17	18.60	9.30	14.76

d (depth), S (speed), W (width), ρ_b (bulk density), CI (cone index), D (draught), MC (moisture content), FC_h (hourly fuel consumption), FC_{ta} (tilled area fuel consumption)

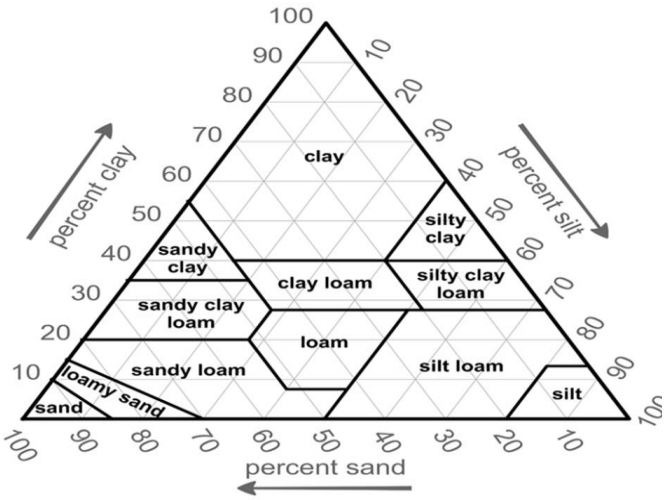

Figure 2: USDA Soil Texture Triangle

Field test parameters including tractor draught (D), forward speed (S), harrowing depth (d), moisture content (MC), bulk density (ρ_b), and width of cut (W) were evaluated (Table 1). From table 1, results showed that the increase in the values of the field test parameters increased the tractor fuel efficiency parameters (TFEPs) (hourly fuel consumption, FC_h), and tilled area fuel consumption, FC_{ta}). Therefore, fuel consumption is affected by draught, tractor forward speed, harrowing depth, width of cut, bulk density and moisture content. Therefore, tractor fuel consumption rate increases in line with time and tilled area. This is in agreement with the findings of Ikpo and Ifem (2005).

3.2 Hourly Fuel Consumption

Figure 3 shows the results of hourly fuel consumption during harrowing operation. The hourly fuel consumption readings were presented in Table 1 during harrowing operation. These were measured with the use of fuel flow meter. Parameters such as draught, cone index, forward speed, tillage depth, bulk density and moisture content that affect the variability of hourly fuel consumption during harrowing operation were measured before, during and after the operation. The increase in the aforementioned parameters increase fuel consumption during the process of harrowing but the draught influences the fuel consumption with the combinations of the tillage depth and forward speed in Table 2. From the experimental results, it was observed that increasing the tractor forward speed, travel time for an assumed distance reduces and as a result, time reduction will result in the hourly fuel consumption increase. Also, depth influenced hourly fuel consumption more than any other parameters that were tested in this study. This is in line with the findings of Leghari *et al.* (2016b); Nasir (2016); Almaliki *et al.* (2016a).; Shafaei et al. (2018); Nkakini and Ekemube (2020) and Ekemube et al. (2020). The variation in hourly fuel consumption was observed with increase in draught, cone index, tillage depth, forward speed, bulk density and moisture content. The standard error bar showed a statistically significant different which revealing its mean reliability treatment (Figure 3). Also, ANOVA results show that there are statistically significant at 95 % confidence level and highly significant at 99 % confidence and coefficient of variations (CV) (a) is 0.55 % and (b) 0.11% respectively, which revealed that the experimental errors were low and reliable (Table 3).

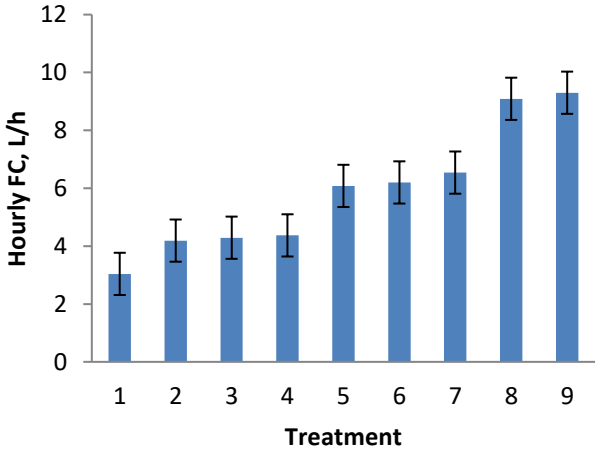

Figure 3: Variability of Hourly Fuel Consumption during Harrowing

Table 3: Analysis of Variance (Group Balanced Block Design) for Data in Table 1 (FC_h)

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	Computed F	Tabular F 5%	Tabular F 1%
Replication	2	0.002489	1.2445E-03			
Treatment group	2	91.5678	45.7839	43,8333.32**	6.94	18.00
Error (a)	4	0.0004178	1.0445E-03			
Treatment within group A	2	2.895	1.4475	32,589.12**	3.88	6.93
Treatment within group B	2	6.2874	3.1437	70,777.48**	3.88	6.93
Treatment within group C	2	14.1642	7.0821	159,446.89**	3.88	6.93
Error (b)	12	0.000533	4.441667E-05			
Total	26	25376.49				

*Significant, **Highly Significant, ^{ns} No significant, CV (a) = 0.55%, CV (b) = 0.11%

Table 4: Analysis of Variance (Group Balanced Block Design) for Data in Table 1 (FC_{ta})

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	Computed F	Tabular F 5%	Tabular F 1%
Replication	2	0.003822	0.001911			
Treatment group	2	269.4781	134.739	433,089.70**	6.94	18.00
Error (a)	4	0.001244	0.000311			
Treatment within group A	2	0.7098	0.3549	1,998.31**	3.88	6.93
Treatment within group B	2	1.6002	0.8001	4,500.56**	3.88	6.93
Treatment within group C	2	3.5186	1.7593	9,896.06**	3.88	6.93
Error (b)	12	0.002133	0.000178			
Total	26	275.3139				

*Significant, **Highly Significant, ^{ns} No significant, CV (a) = 0.18%, CV (b) = 0.13%

3.3 Tilled Area Fuel Consumption

The key technical indicator in the assessment of agricultural machinery efficiency for fuel consumption could be attained based on fuel consumption per hectare measurement (Serrano, 2007). Figure 4 shows the results of tilled area fuel consumption during harrowing operation. The tilled area fuel consumption readings were presented in Table 1 during harrowing operation. These were measured using fuel flow meter. Parameters such as draught, cone index, forward speed, tillage depth, bulk density and moisture content that affect the variability of fuel consumption during harrowing operation were measured before, during and after the operation. The increase in the aforementioned parameters increased fuel consumption during the process of harrowing but the draught influenced the fuel consumption with the combinations of the tillage depth and forward speed (Table 2). From the experimental results, it can be observed that the depth influenced fuel consumption more than any other parameters that were tested in this study. This is in line with the findings of Leghari *et al.* (2016b); Nasir (2016); Almaliki *et al.* (2016a); Nkakini and Ekemube (2020); and Ekemube *et al.* (2020). The variation in fuel consumption was observed with increase in draught, cone index, tillage depth, forward speed, bulk density and moisture content. The standard error bar showed a statistically significant different which revealed its mean reliability treatment (Figure 4). Also, ANOVA results shows that there is statistically significant at 95 % confidence level and highly significant at 99 % confidence and coefficient of variations (CV) of (a) is 0.18 % and (b) 0.13% respectively, which revealed that the experimental errors were low and reliable (Table 4).

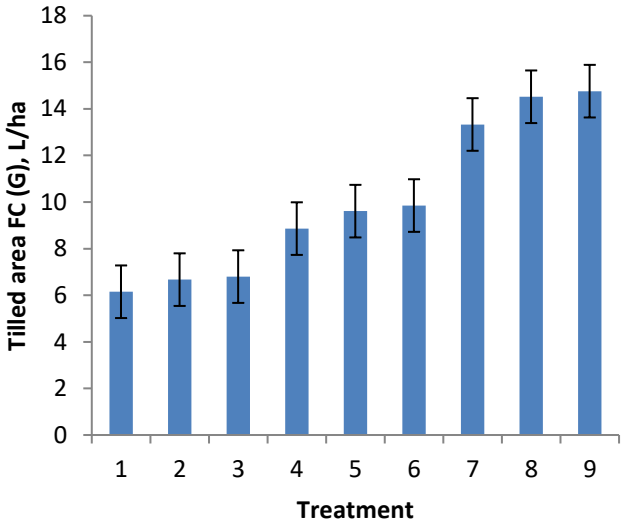

Figure 4: Variability of Tilled Area Fuel Consumption during Harrowing

4. CONCLUSION:

Determination of the variability in tractor fuel efficiency parameters (TFEP) (hourly and tilled area fuel consumption) in the course of harrowing operation has been studied. The findings led to the following conclusions:

(i) The incresae in soil-implement-machine parameters (draught, forward speed, harrowing depth, width of cut, bulk density and moisture content) in course of harrowing operations cause increment in hourly fuel consumption;

(ii) Similarly, incresae in soil-implement-machine parameters (draught, forward speed, harrowing depth, width of cut, bulk density and moisture content) in course of harrowing operation causes increment in tilled area fuel consumption;

(iii) In addition, the incresae in tractor fuel consumption rate increases in line with working hour and tilled area;

(iv) Variations in the soil-implement-machine parameters cause the variability in hourly and tilled area fuel consumptions.

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PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON NEWVIEWS IN ENGINEERING AND TECHNOLOGY (ICNET) MAIDEN EDITION, FACULTY OF ENGINEERING, RIVERS STATE UNIVERSITY, PORT HARCOURT, NIGERIA.
27th October 2021
Available online at https://conference.rsujnet.org/

Paper number: ICNET2021-005

Waste Chicken Feathers as Sorbents for Hydrocarbon and Non-Hydrocarbon Spills

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ABSTRACT

As man continues to depend on petroleum and its products, the tendency of oil spills occurrence is inevitable. Focusing on oil spill prevention is important but the potential for human error and equipment failure is inherent in the exploration, production, transportation and storage of petroleum and its products; so, it is equally necessary to develop devices for oil spill clean-up. Oil spill remediation is achieved using chemical, biological or physical processes to sorb oil from the surface of contaminated water. This study investigates the use of waste chicken feathers as sorbents for oil clean-up which is a physical process. The sorption capacity of waste chicken feathers was experimented on water contaminated with vegetable oil, peanut oil and engine oil. The experimental results showed that waste chicken feather mats have a very high oil sorption capacity of 20.59g for Vegetable oil/g of sorbent and low water sorption capacity of 0.98g of water/g of sorbent and are highly oleophilic and hydrophobic. Waste chicken feathers when used for oil spill clean-up, only interacts with the oil at the surface of oil/water mixture, it does not sink or mix with the water below and is not prone to degrading in the water when left for a long period. The waste chicken feather also showed vegetable oil recoveries of over 48.62% at a pressure of ~2,000 N.m^{-2}. Similar ranges were also recorded for peanut oil and Engine oil. A saturation time of about 120 seconds was observed for waste chicken feather for all peanut oil, vegetable oil and Engine oil.

Keywords: Waste Chicken feathers, Sorbents, Oil spill remediation, Oleophilic, Hydrophobic.

Cite This Paper: Chinwah, K., & Gift-Onyesoh, J. (2021). Waste Chicken Feathers as Sorbents for Hydrocarbon and Non-Hydrocarbon Spills. *Proceedings of the International Conference on New-views in Engineering and Technology Maiden Edition*, Faculty of Engineering, Rivers State University, Port Harcourt. Nigeria, 27th October, 2021, ICNET2021-005, 67 – 75.

1. INTRODUCTION

The exploration and production of crude oil activities provide great revenue for the global economy but the negative impact of oil spill remains a major concern for the oil and gas industry (Ifelebuegu & Chinonyere, 2016). Numerous spills have occurred in recent years. In November 2011, nearly 6,000 liters of oil were leaked into Campos Bay, Brazil, and this polluted an area of 163 km^2 and required a massive clean-up operation (Silva *et al.*, 2014). In the same year, the Bonga oil field spilled 1.1 million liters of crude oil (35,000 barrels) and contaminated a coastal strip of nearly 200km at the Nigerian coast (Sam & Prpich, 2017).

Oil spills can occur from non-hydrocarbon geographical setting: i.e., from natural disasters, households, and manufacturing or production companies. These equally have negative impact on the marine ecosystem and the environment. In some developing countries, when oil is spilled in water or on land, the physical and chemical properties of oil change progressively. The spilled oil contributes an undesirable taste and odor to drinking water and causes severe environmental damage (Nwadiogbu, Ajiwe, & Okoye, 2016). It was observed that local palm oil processing companies are sited close to water bodies (Olaleye & ., 2004). Most times, Palm oil plantation will have agricultural runoff into surrounding water bodies that can lead to bioaccumulation and toxic blooms, which could have an adverse effect in the aquatic ecosystem and reduce the drinking water quality for surrounding communities (Ng, 2017).

Oil spreads when spilled, whether on land or water. Oil spills are critical and urgent because they are unexpected and can cause enormous damage to the aquatic environment and marine life. Thus, must be contained quickly before they cause long-term disaster (Luciano Peske Ceron, Marcelo Zaro, Kevin Pilger, Thalles Augusto Brutti Marques, & Pablo Copes Tonin, 2018).

To control its spreading from polluting the environment, there is the need for containment and recovery. Containment of an oil spill refers to the process of confining the oil in order to stop it from spreading to other areas. That is, to redirect the oil to an area where it can be treated or recovered. Recovery is major step in removing oil from the environment. In the removal of oily contaminants from water, several methods are used; they include solidification of the oils, bioremediation, gravity separation, electro flotation and physical techniques such as natural recovery, skimmers and sorbents (Tesfaye, Sithole, & Ramjugernath, 2018).

Sorbents recover oil through either adsorption or absorption. Sorbents have been used for oil spill clean-up over the past years and they are grouped into three classes; natural organic, inorganic sorbents and synthetic organic sorbents (Lim & Huang, 2007). The removal of oil by sorption have been observed to be one of the most effective techniques for the complete removal of spilled oil under ambient conditions (Hussein *et al*., 2011). Organic materials such as feathers are inherently hydrophobic (water repelling) and oleophilic (oil attracting) thus, they absorb oil. Absorbents which are oleophilic and hydrophobic in nature, come out as a good controller of oil spills (Saurabh *et al*., 2015).

Feathers have a hollow structure and contain barbs and barbules, responsible for a high surface area. The oil retention on feathers is influenced by the intermolecular bonds between the hydrocarbons in oil and feather keratin (Kelle & Eboatu, 2018). Oil sorption is determined by the surface chemistry and microstructure of feathers. The presence of disulfide crosslinks from cysteine and predominant non-hydrophilic amino acids in the chain sequence give chicken feather keratin a hydrophobic character (Mendez-Hernandez, Salazar-Cruz, Rivera-Armenta, Estrada-Moreno, & Chavez-Cinco, 2018). Keratin fibers are strictly non-abrasive, low density, biodegradable, renewable, eco-friendly, insoluble in organic solvents, hydrophobic behavior, warmth retention and cost effective too (Bansal, Singh, Gope, & Gupta, 2017).

Chicken feathers are agricultural waste that is available in most countries with a high consumption of poultry. The consumption of poultry is increasing globally due to the rapid growth rate of chickens and the relatively low costs associated with poultry farming. Europe consumes ~14,013,000 tonnes of poultry per annum (AHDB, 2018). Global poultry consumption is expected to increase to ~14.9 kg/person/year by 2023 (Mottet & Tempio, 2017). Applications for waste feathers are limited compared to other natural fibres such as wool, hemp and sisal. Waste poultry feathers produced in the UK are processed by autoclaving to form feather-meal, a low-value, low-grade, protein-rich animal feed currently exported to Eastern Europe and Russia (Meeker & Meisinger, 2015). In Nigeria, chicken feathers constitute a major agricultural waste. They are usually disposed of in uncontrolled dumpsites, landfilled or burned.

The utilization of this agricultural waste can provide an effective, low cost, abundant and environmentally friendly oil sorbent with comparable performance to conventional sorbents. This research assesses the potential for chicken feather to be used as a sorbent for the removal of oil spills of both hydrocarbon and non -hydrocarbon origin from contaminated waters. Currently, the most common materials used for oil sorbents are commercial polypropylene which has good oil sorption capacities of 15-25g.g-1 and good oil/water selectivity because of their oleophilic - hydrophobic properties (Wu et al., 2014). The performance of the chicken feather is compared to commercially available polypropylene by investigating the microstructures, oil sorption capacity, water sorption capacity and oil recovery potential. The barriers to their commercial development are also highlighted and recommendations proposed.

2. MATERIALS AND METHODS

2.1 Materials

The materials used for this study are whole chicken feather, polypropylene pads, and three different oils: engine oil, vegetable oil and peanut oil.

2.1.1 Whole Chicken Feather

Chicken feathers (see Fig 1) obtained from a major UK poultry facility were washed using a 5% hydrogen peroxide solution containing an industrial scouring agent (M-SCOUR EF-5, Regency FCB). The sample was treated with 1% disinfectant solution (Dupont Virion S), and washed twice using industrial feather cleaning soap.

Fig 1 Waste Chicken Feathers

The cleaned feathers were dried using a modified tumble dryer. The dried feathers were shredded in batches using a Rapid 2040 granulator with a 5mm mesh.

2.1.2 Polypropylene Pads

The Polypropylene pad used in this study was sourced from Darcy co. U.K. This material is oleophilic and hydrophobic with a high oil absorbency and usually used as a suitable oil absorbent for domestic and industrial use.

2.1.3 Oil

Three types of oil representing hydrocarbon origin and non-hydrocarbon Origin were used to evaluate the oil sorption potential of waste chicken feather. The viscosity and density ranges of the different oils are given in Table 1.

Table 1: Viscosity and Density Values for Engine, Vegetable and Peanut Oil

Type of Oil	Viscosity (m.Pa.s)	Density (g/cm^3) at 20^{o}C
Engine	60	0.885
Vegetable	40	0.918
Peanut	40	0.912

(Oil Data extracted from Burkle GmbH, 2021)

The three oils, engine oil, vegetable oil and peanut oil were bought from stores in the UK. TOTAL company, Lidl and Morrison stores respectively in the United Kingdom.

2.2 Methods

2.1.3 Physical Characterization

The Physical characteristics, morphological and chemical characteristics were evaluated. The appearance and surface of waste chicken feathers and polypropylene mat was evaluated using scanning electron microscopy (SEM). The images were taken with Hitachi TM4000Plus. The samples were dried at 40^{o}c for about 12 hours; and then vacuumed for 5 – 10 minutes before starting the analysis.

2.1.4 Water Contact Angle

This analysis provides information about the wettability of the material. A Kruss drop shop Analyzer (model DSA 100S) was used at a temperature of approximately 20^{o}C. During each test, 5 ɥ of deionized water or vegetable oil were dropped onto the sample surface. Samples used for this test include whole chicken feather and polypropylene pads. The surface of the samples needs to be as flat as possible to obtain clear result from this analysis. In preparation, the samples were presented using 2.3 kg cement blocks for 24 hours to increase the flatness of their surface.

2.1.5 Dynamic Water-Sorption Test

Dynamic degradation (Water-sorption test) test was carried out to determine water take-up and the oleophilic properties of waste chicken feathers and polypropylene pads under dynamic conditions. Samples of the sorbent are cut into squares, weighed and then placed in I litre jars filled with water and sealed. The container is mounted on a shaker table, set at a frequency of 150 cycles per minute at duration of 15 minutes. After 15 minutes, the content is allowed to settle, and observations recorded for the condition of the adsorbent and the water. The water sorption capacity is calculated according to equation (ASTM, 2018).

$$Water\ Sorption\ Capacity\ \left(\frac{g}{g}\right) = \frac{Water\ Retained\ (g)}{Initial\ Mass\ of\ Sorbent\ (g)} \quad (1)$$

So = Initial Dry Sorbent weight
Swt = Weight of the sorbent sample at the end of the test
Sw = (Swt-So)
Sw = Net water Sorbed

2.1.6 Oil Sorption Study

The procedure for the study of oil sorption capacity followed the ASTM F 726-06 method, for both the short test and the long test. The sorption experiments were conducted in a static system at room temperature of about 20 ± 4^{O}C.

Short test: 30 ml of Engine oil was poured into a one-liter glass beaker containing 700ml tap water, to obtain oil films of about 3ml thickness on the water surface. This process was repeated for the other two oils used and this was done in triplicates. The sorption material was cut, weighed and placed in the beaker for 15 minutes. Subsequently, after 15 minutes, the sorbents were removed from the beaker with a sieve and drained for two minutes.

Long test: 30 ml of Engine oil was poured into a one-liter glass beaker containing 700ml tap water, to obtain oil films of about 3ml thickness on the water surface. This procedure was repeated for the two oil and this was done in triplicates. The sorption material was cut, weighed and placed in the beaker for 24 hours. Subsequently, after 24 hours, the sorbents were removed from the beaker with a sieve and drained for two minutes.

Finally, the weight of the sorbent was noted again. The mass of the retained oil is the difference between the final and initial weight of the sorbent. The oil sorption capacity was calculated using

$$Oil\ Sorption\ \left(\frac{g}{g}\right) = \frac{Oil\ Retained\ (g)}{Initial\ Mass\ of\ Sorbent\ (g)} \quad (2)$$

Q= Sorption Capacity

St = Total mass of the sorbed samples

So= Initial mass of the sorbed materials

2.1.7 Saturation Time

The saturation time was observed for the three oils using the ASTM F-726-06 method for the short test. However, the sorbent was removed from the beaker and left to drain every one minute for a total contact time of fifteen minutes. The weight after each two-minute interval was noted and the sorption capacity calculated to model the saturation curve.

2.1.8 Oil Recovery

$$Oil\ Recovery\ (\%) = \frac{Oil\ Recovery\ (g)}{Oil\ Retained\ (g)} \cdot 100\ \% \quad (3)$$

The oil recovery for waste chicken feathers and polypropylene pads was investigated. After the sorbent was saturated with oil, the weight was noted. Subsequently, the sorbent was compressed in a container using a 2.3kg cement block and weighed again. The difference between the weight of the saturated sorbent and the weight after compression is the mass of oil that could be recovered (oil recovery in grams). The percentage of oil recovery was calculated according to equation **Error! Reference source not found.**.

3. RESULTS AND DISCUSSIONS

3.1 Characterization of the materials

Morphological structures of Chicken feather fractions: From the SEM image we see more clearly that chicken feathers comprise of three distinct units, the rachis, the central shaft of the feather; the barbs and tertiary smaller structures and the barbules. These indicate a large surface area. have a rough surface with hollow microstructure (or lumen) as seen in Fig 2. hollow structures observed in the chicken feathers enable the binding of the feather mats to the oil surface. Rough morphology of sorbent materials and entangled pore structure contribute to oil retention (Wahi, Abdullah, Shean, Choong, & Ngaini, 2013). The dense surfaces waste chicken feathers observed and the small gaps in the structure are assumed to increase their hydrophobicity (Tesfaye et al., 2018).

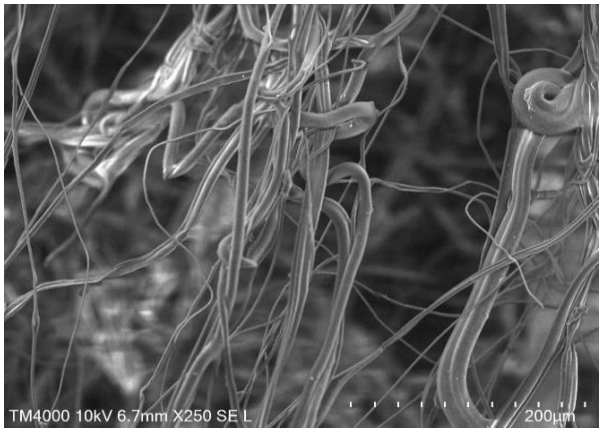

Fig 2 SEM image of polypropylene pad

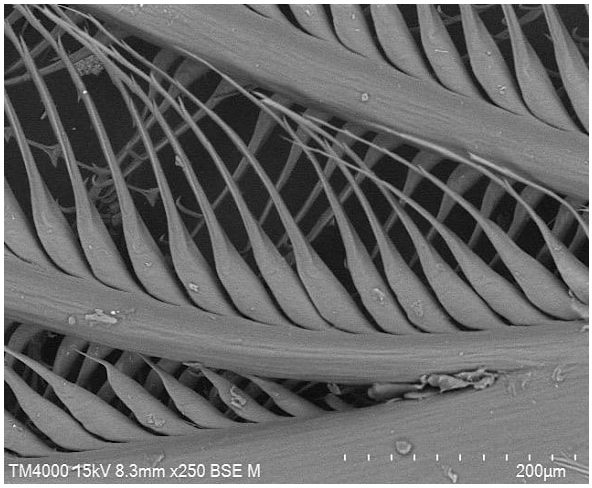

Fig 3 SEM image of a whole chicken feather showing barbs, barbules and hooks branching out from the rachis

As stated in Radetic *et al.* (2008), the most important qualities to consider when selecting oil sorbents include high sorption capacity, good buoyancy, adequate oil retention and reusability. The hydrophobicity and oleophilic properties of feathers result from high keratin content with desulphated bonds.

3.2 Water Contact Angle

The result of the contact angle shows hydrophobicity and oleophilicity for the whole chicken feathers and the polypropylene pads (see Table 2). When the contact angle is above 90 degrees, the solid is said to have a poor wetting potential and termed hydrophobic.

Table 2: Contact Angle for Polypropylene Pads and Whole Chicken Feathers

Sample	Water Contact Angle
Polypropylene Pads	136°
Whole Chicken feathers	119°

It has been reported that the wettability of a solid surface depends on two factors: the topographical microstructure and the surface chemical composition (Barthlott & Neinhuis, 1997; Zhang, Li, Liu, & Jiang, 2013).

3.3 Dynamic Water Sorption Capacity

The experimental results show that waste chicken feather mats have a very low water sorption capacity of 0.98g of water/g of sorbent even though polypropylene pads absorb less water of 0.40g of water/g of the sorbent (See Fig 4).

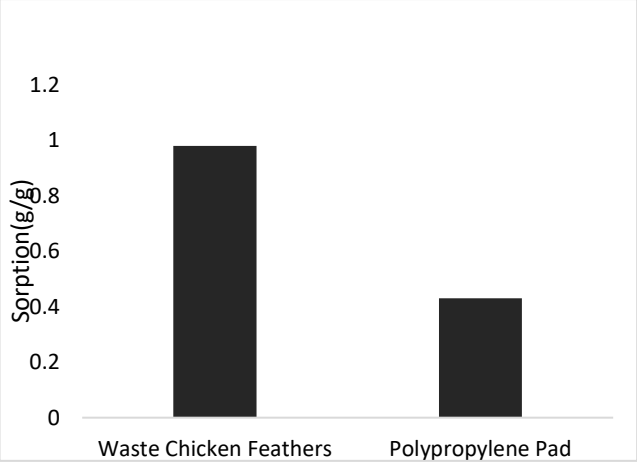

Fig 3.3: Water Sorption capacity of waste chicken feather and polypropylene pad

The result revealed that they are both highly hydrophobic and an important characteristic when selecting good sorbents. This will mean that the waste chicken feathers when used for oil spill cleaning, will only interact with the oil at the surface of oil/water mixture, it would not sink and mix with the water below and will not be prone to degrading in the water when left for a long period

3.4 Oil Sorption Capacity

The sorption capacities of waste chicken feathers for vegetable oil, peanut oil and engine oil under static conditions after 15 minutes are presented in Fig 4(a). It was observed that there is no major difference between the 15 minutes sorption time and the 24 hours because the saturation time was reached in less than 20 minutes and the waste chicken feather has higher sorption than polypropylene pads for all the different oils. The sequence from the highest to the lowest was vegetable oil, peanut oil and Engine oil. The sorption capacity for peanut oil was 20.59g/g about one and a half times greater than the polypropylene pads which was 13.04g/g. The results confirmed the report that Chicken feathers have an oil sorption capacity of about 16.2 $g.g^{-1}$ (Tesfaye et al., 2018). Consequently, waste chicken feathers and polypropylene pads provide practical advantages for introduction to and extraction from oil spills.

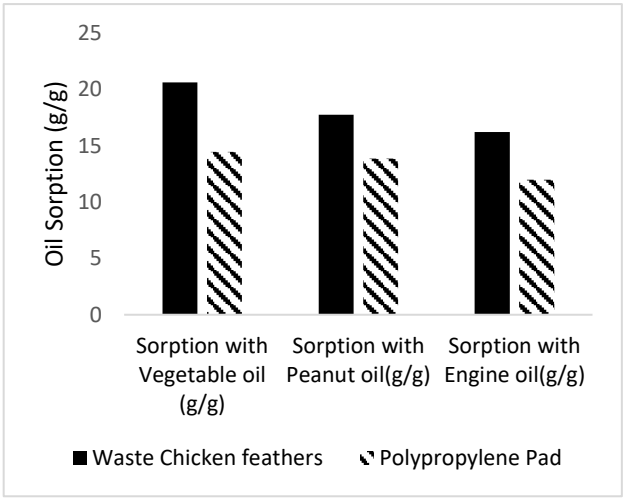

Fig 5 Sorption capacities of waste chicken feather and polypropylene using vegetable oil, peanut oil and engine oil

3.5 Saturation Time

Fig 6 illustrates the sorption time increase from 60s to 720s. A time of 720s resulted in a maximum Vegetable oil sorption capacity of 15.53 (g/g) for chicken feather. For all the three oils, it was observed that the initial two minutes was very rapid and then the rate of sorption reduced. The initial fast adsorption may be because of the initial adsorption onto the surface of the material and subsequent penetration into the microscopic voids. The slow uptake in the later stages may be because of less available sites for active sorption. This may be due to the oleophilic and hydrophilic nature of the chicken feather. This observation relates to the trend reported in Osamor & Momoh (2015) research on the use of coconut coir as a sorbent to remove vegetable oil and diesel oil from saltwater.

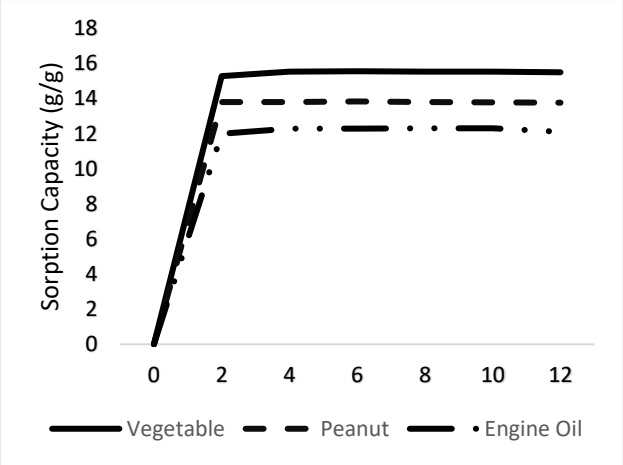

Fig 6 Saturation curve of waste chicken feathers in vegetable, peanut and engine oil showing that the waste chicken feathers were saturated within the first two minutes of being exposed to oil.

3.6 Oil Recovery

Waste Chicken feather showed oil recoveries of over 48.62% using vegetable oil at a pressure of approximately 2,000 $N.m^{-2}$ as seen in Fig 7. Some higher values of up to 95 % have been reported in the literature (Tesfaye et al., 2018).

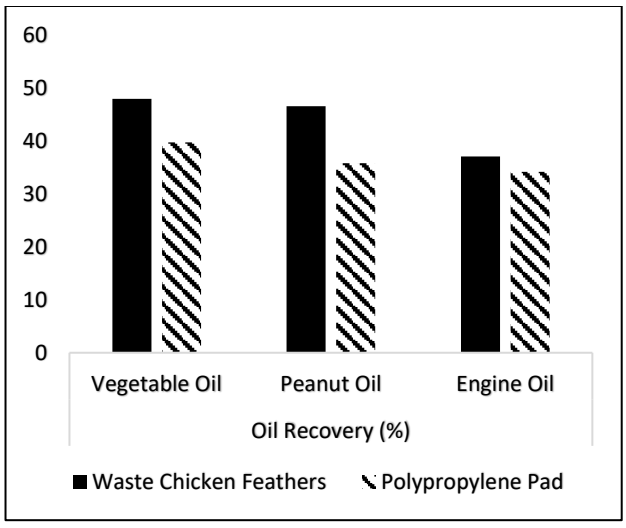

Fig 7 Oil recovery in percent for waste chicken feathers and polypropylene pads

It was observed that the oil recovery of waste chicken feather was higher for polypropylene pads. The porous structure of waste chicken feathers enables the oil to be retained in voids, this contributes greatly to the high oil recovery and this oil is therefore easier to recover by using pressure.

4. CONCLUSION

This study confirms the potential of chicken feather waste to be used as a sorbent to clean up oil spill arising from vegetable oil, peanut oil and engine oil. It studied the science of sorption and its applicability in the cleanup of oil spill.

The research indicates that chicken feather mats can be used for cleanup of non-petroleum sources of oil as well as petroleum derived oil. Therefore, both petroleum and non-petroleum origin spills can be addressed by using Chicken feathers are a local abundant resource and their use is a cheaper, practical solution to address problematic oil spills in Niger Delta Communities in Nigeria.

This will also solve the waste management challenge of this agricultural waste because waste chicken feathers have limited disposal options thereby establishing a circular economy for the agricultural waste. The oil loaded feathers can be used to generate biogas because it has biochemical methane potential.

Future studies include characterization of chicken feather using IGC-SEA (Inverse Gas Chromatography- Surface energy analyzer) and Dynamic vapor sorption. Factors such as converting feathers to mats, fiberisation machinery or commercial packaging for clean-up will impact the likelihood of local manufacturing of chicken feather sorbents.

5. ACKNOWLEDGEMENTS

The authors appreciate the financial and technical support received from: Total Energies, Surface Measurement Systems and Metaspec limited.

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PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON NEWVIEWS IN ENGINEERING AND TECHNOLOGY (ICNET) MAIDEN EDITION, FACULTY OF ENGINEERING, RIVERS STATE UNIVERSITY, PORT HARCOURT, NIGERIA.
27th October 2021
Available online at https://conference.rsujnet.org/

Paper number: ICNET2021-006

Intelligent Technique for Incipient Fault Localization in Power Transmission Lines

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ABSTRACT

Power transmission lines are often bedeviled with the occurrence of faults that leads to the disruption of power flow and distress in the performance of the entire power system. The incipient fault localization in power transmission lines is an emerging area of power system research that elucidate the determination of fault prior to the actual fault occurrence using appropriate fault signatures. In this research, an approach based on neural intelligence and resonance theory of transmission lines is proposed for the effective detection of likelihood of a fault in transmission line (TL). The approach was applied for the localization of TL faults in a section of the Nigerian 330-kV power transmission network. Time domain simulations considering the dynamic fault resistances in a continual power monitoring system were performed. The results showed that the proposed system had good line localization predictive response and could be considered a promising approach for further studies on the incipient TL fault localization.

Keywords: Power system, Transmission Line, Fault localization, Fault Prediction, Resonance

Cite This Paper: Wokoma, B. A., Idoniboyeobu, D. C., Ahiakwo, C. O., & Braide, S. L. (2021). Intelligent Technique for Incipient Fault Localization in Power Transmission Lines. *Proceedings of the International Conference on New-views in Engineering and Technology Maiden Edition*, Faculty of Engineering, Rivers State University, Port Harcourt. Nigeria, 27th October, 2021, ICNET2021-006, 76 – 82.

1. INTRODUCTION:

Power system have for long been berserk with the burden of maintaining a continuous state of uninterrupted energy supply. However, due to various degrees of faults, the tendency to maintain the much-needed power stability status quo has been unachievable. Thus, ongoing researches focus on overcoming the various faults possible in power transmission lines considering specifically the insulation degradation (Negrão *et al.*, 2013; Stefenon *et al.*, 2020), the short-circuit line faults and localizations (Tayeb *et al.*, 2011; Roostaee *et al.*, 2017; Jembari *et al.*, 2019; Mustari *et al.*, 2019; Li *et al.*, 2019), and the power network component faults such as in transformers (Contreras-Valdes *et al.*, 2020).

While these approaches have proven particularly useful, there have still been the problem of faults leading to catastrophic failures in some instances thereby requiring the preventative actions. As a follow up to this challenge, the incipient determination of faults is currently gaining traction. Thus, researchers find out that it is better to identify the fault earlier through real time monitoring systems considering variety of fault signatures (Andresen *et al.*, 2018).

In this paper, a pragmatic transmission line (TL) monitoring and localization solution is proposed that follows from the theory of resonant frequencies in power transmission lines and neural predictive systems as found in mammalian brains. The idea behind this approach is to marry the continual learning capability of human brains with the sound principles of resonant transmission lines for effective monitoring and incipient localization of faults in power transmission lines and in real time. With the proposed approach, it

should be possible to determine the TL faults in advance and hence safeguard the power network from an imminent collapse.

2. MATERIALS AND METHODS:

This section describes the proposed transmission line (TL) resonance model as in section 2.1 and the neural prediction technique employed (see section 2.2). The TL resonance model includes the neural prediction logic in a combined incipient fault monitoring and prediction system.

2.1. Resonance Model of Transmission Line

The resonance model of a TL considering Single-Line-to-Ground faults is based on the equivalent pi connected circuit shown in Fig.1.

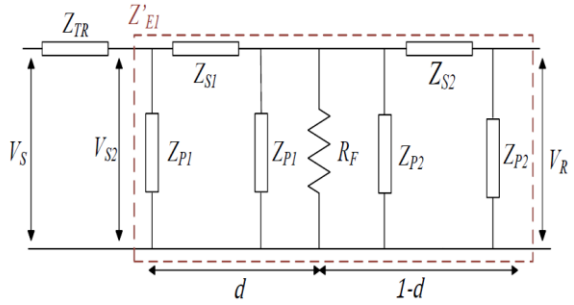

Fig.1. Transmission Line model for resonant studies in presence of SLG faults (Source: Govindarajan *et al.*, 2015).

In the model of Fig.1, the electrical parameters are distributed along the length of the TL. The core system line parameters of interest for include the line impedances, z, and shunt admittance, γ, which are computed according to equations (1) and (2):

$$z = R_x + j\omega L_x \quad (1)$$

$$\gamma = j\omega C_x \quad (2)$$

where,
R_x = Resistance of line per unit length
L_x = Inductance of line per unit length
C_x = Capacitance of line per unit length

If we consider a cable of length say l, the series and parallel impedances Z_s and Z_p are computed as in (Glover *et al.*, 2012):

$$Z_s = Z_c \sinh(\gamma l) \quad (3)$$

$$Z_p = \frac{\tanh\left(\gamma l / 2\right)}{Z_c} \quad (4)$$

where,
γ = line propagation constant
Z_c = line characteristic impedance

Without loading, the time-domain transfer function of the TL system may be represented as:

$$H_c = \frac{V_R}{V_S} = \frac{Z_P}{Z_S + Z_P} = \frac{1}{\cosh(\gamma l)} \quad (5)$$

Using s-function representation, equation (5) is re-modeled as:

$$H_c(s) = \frac{V_R(s)}{V_S(s)} = \frac{1}{\cosh\left(\sqrt{(R+sL)sC}\right)} \quad (6)$$

Finally, to obtain the resonant frequencies, s_{nc}, the roots of the denominator part in equation (6) have to be solved; the solution is as provided in equation (7).

$$s_{nc} = -\frac{R}{2L} \pm j\sqrt{\frac{((2n-1)\pi)^2}{4LC} - \frac{R^2}{4L^2}}, \quad n = 1,2,3,\ldots \quad (7)$$

Since at most times, $1/(LC) >> (R/L)^2$, the roots are approximated as in equation (8):

$$s_{nc} = -\frac{R}{2L} \pm j\frac{(2n-1)\pi}{2\sqrt{LC}}, \quad n = 1,2,3,\ldots \quad (8)$$

From equation (8), a resonant peak will appear when the TL real response frequency is equal to

the imaginary part. This follows from theory and the approximate resonant frequencies are (Lin & Holbert, 2009):

$$\omega_{rnc} \cong \frac{(2n-1)\pi}{2\sqrt{LC}}, \quad n = 1,2,3,\ldots \tag{9}$$

and,

$$f_{rnc} \cong \frac{(2n-1)}{4\sqrt{LC}}, \quad n = 1,2,3,\ldots \tag{10}$$

The models in equations (9) and (10) show that resonant frequencies will occur in odd multiples.

Thus, these models can be used to re-represent further higher dimensions in scale.

A real time systems level simulation model describing the aforementioned operation is as shown in Fig.3.1.

2.2. Neural Prediction Technique

The considered neural predictive approach is based on a theory called auditory machine intelligence (AMI) that utilizes the perception of humans to an odd-ball stimulus and intelligent processing in auditory cortex to form invariant predictions in time and space. This approach fundamentally includes the following (Osegi & Anireh, 2020):

i. A set of input detectors.
ii. A processing logic based on Change Detection (CD) and a Model Adjustment (MA) formula.
iii. A learning algorithm using Hebbian style reinforcement rules.

Using the aforementioned scheme, it is possible to generate continual predictions of a sequence of time-stepped inputs.

The architecture of the proposed AMI neural solution is as shown in Fig.2. In this architecture, mathematical formulas are labeled as an operator sign while functional modules and a trigger block define the key functional routines and time series attributes used in the control initializations of the AMI respectively. A Binary Encoder and Binary-to-Integer Transformer module are used to convert the set of input detectors labeled X_t, from a multivariate to a univariate time series. By default, a Change Detection (CD) mismatch processing function is enabled while the trigger control is set to 0. When a transition is needed from a univariate to a multivariate time series processing, the trigger is enabled and the Model Adjustment (MA) processing of X_t is activated. If the converse is the case, CD processing only is activated.

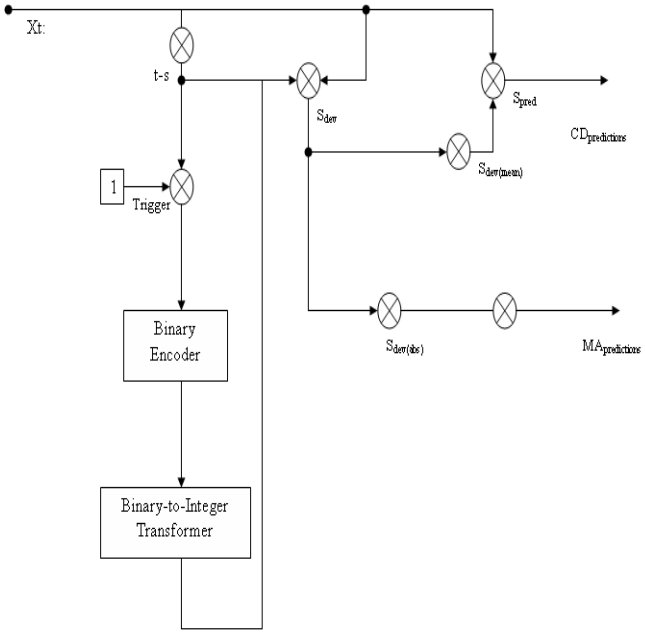

Fig.2. AMI Neural Architecture (Source: Osegi & Anireh, 2020).

The primary predictions of the Neural AMI solution are described by Phase-1 prediction equations and as follows:

First, we define a mean deviant point as in equation (11):

$$S_{dev(mean)} = \frac{\left(\left(\frac{\sum[S_{dev}]}{(n-1)}\right) + S_{deviant}\right) - 2}{n+1} \quad (11)$$

where,
n = number of data points in a temporal sequence
$S_{deviant}$ = the *(n-1) th* value of the temporal sequence
S_{dev} = the difference between $S_{deviant}$ and S_{stars}
S_{stars} = the *(n-2)th* values of the temporal sequence
S^* = sparse set of input sequences

Next a prediction is performed using equation (2):

$$S_{pred} = S_{deviant} + S_{dev(mean)} \quad (12)$$

where,

$$S_{deviant} = S_n^* - 1 \quad (13)$$

$$S_{stars} = S_n^* - 2 \quad (14)$$

The Neural AMI technique processing and learning functions are also as described in Algorithms 1 and 2 respectively.

Algorithm 1. AMI Processing Algorithm
1: Initialize S_{pred}, as prediction parameter, S_{stars}, as input sequences (standards) State, $S_{dev(mean)}$ as deviant mean, *j* as iteration counter.
2: *for* all s∈ *s.*S_{stars}, && j > 1, do
3: Compute $S_{deviant}$ and S_{stars} using equations (13) and (14)
4: $S_{dev} \leftarrow \|S_{deviant} - S_{stars}\|$ // deviations from standards
5: Compute $S_{dev(mean)}$ using equations (11)
6: Compute S_{pred} using equations (12) and (13)
7: Update $S_{dev(mean)}$ using Algorithm 2
8: *end for*

Algorithm 2. AMI Learning Algorithm
1: Initialize S_{pred}, as prediction parameter, S_{stars}, as input sequences (standards) State, $S_{dev(mean)}$ as deviant mean, $S_{diff\,(1)}$ as difference between

S_{pred}, $S_{deviant}$+1 and $S_{diff(2)}$ as difference between $S_{dev(mean)}$ and $|S_{diff(1)}|$, l_p as correction factor or bias.
2: *for* all s∈ *s.*S_{stars} do
3: if $S_{diff(2)} > 0$
4: $S_{dev(mean)} \leftarrow S_{dev(mean)} - |S_{diff\,(1)}|$ // Weaken deviant mean by a factor, $|S_{diff(1)}|$
5: elseif $S_{diff(2)} < 0$
6: $S_{dev(mean)} \leftarrow S_{dev(mean)} + |S_{diff\,(1)}|$ // Reinforce deviant mean by a factor, $|S_{diff(1)}|$
7: else
8: $S_{dev(mean)} \leftarrow S_{dev(mean)} + l_p$
9: end if
10: *end for*

3. RESULTS AND DISCUSSION:

In this section simulations are done in MATLAB/SIMULINK based on existing line parameters of the TL of a section of Nigerian 330kV network (Onitsha-Alaoji single circuit). A real time emulator for realizing the predictive fault localization functions is as shown in Fig.3. Table 1, shows the TL parameter specifications used to generate the results.

Parameter	Value/Specification	Unit
Line Length	138	km
Circuit type	Single	NA
Conductor cross-section	350	mm^2
Resistance	0.0390	Ω/km
Inductance	1.11	mH/km
Capacitance	912.06	uF/km

3.1 System Level Simulations - No Fault situation

Considering the detailed schematic in Fig.3, the simulation results is as presented in the graph

(Fig.4) showing prediction based on Neuronal Auditory Machine Intelligence (NeuroAMI) technique and approach of advanced technology in (Osegi & Anireh., 2020; Osegi *et al.*, 2020).

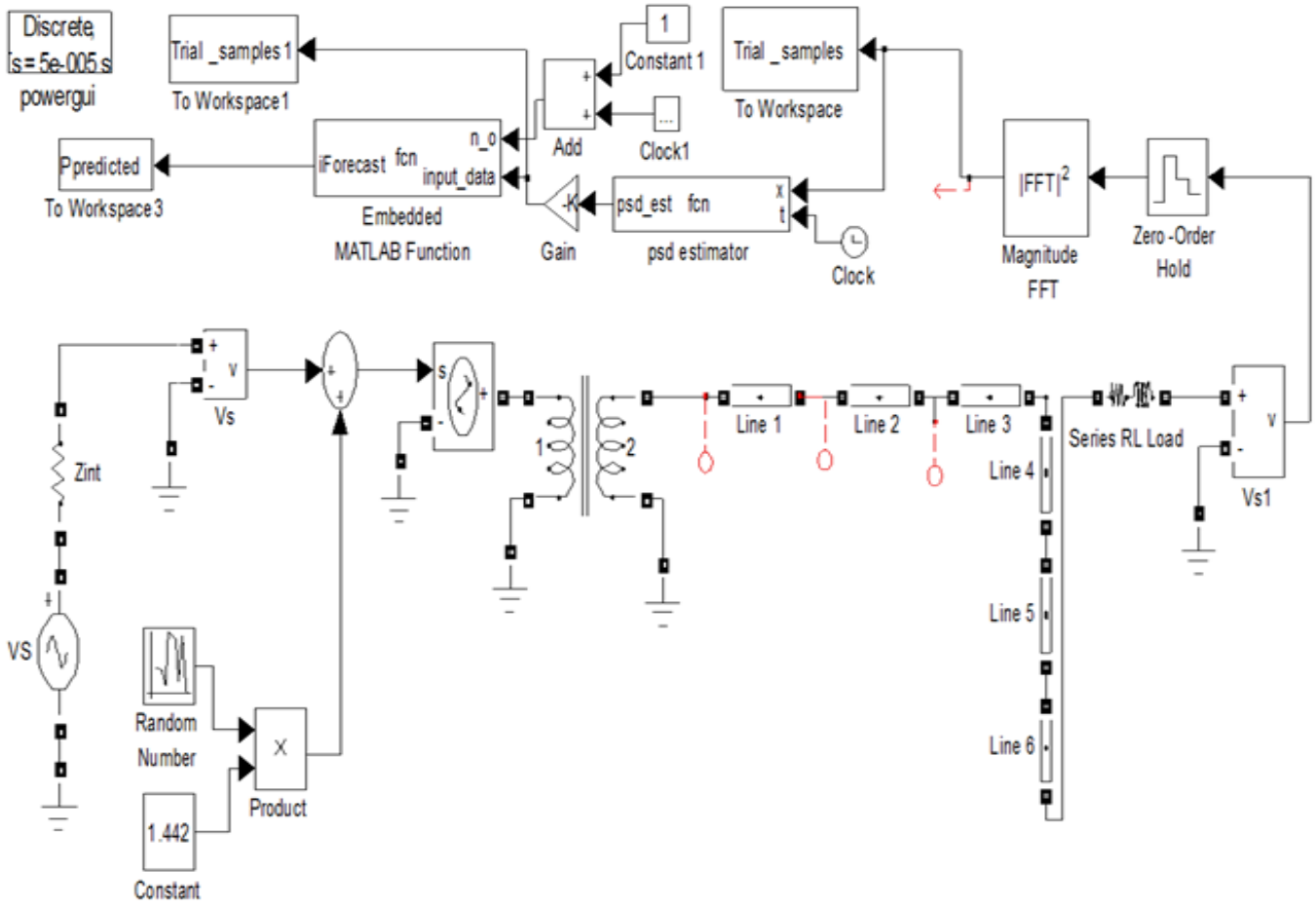

Fig.3. Detail schematic of the power transmission line for simulation studies.

3.2 System Level Simulations – Under Fault situation

In the case of a fault in the transmission line, we consider a fault after line 2 – see the schematic of Fig.4. This corresponds to a fault at location of 40km from the step-up transformer end and at a resistance of 0.1 Ω. The resulting simulation is as presented in the graph of Fig.5.

The results (response graphs) in Figures 4 and 5 are indicative of the close correlation between the actual PSD estimate and the predicted one. However, at peaks of about 25V/k-Hz, 27V/k-Hz and 35V/k-Hz, there are noticeable discrepancies in the actual vs. predicted estimates during faulted case (see Fig.5).

4. CONCLUSION:

This research paper has proposed a Neural auditory machine intelligence (AMI) approach

and simulation model to TL fault diagnosis in power system transmission network. It has also presented some initial results on the developed solution model and the results showed good predictive response of the considered approach.

Currently, this research work is ongoing at the Department of Electrical Engineering, Rivers State University, Nigeria. Future work will incorporate real-time embedded microprocessor relaying logic to further enhance the proposed model features. Also, the proposed approach should be applied to different line configurations considering the varieties of existing line length and considering the gradual variation of the fault resistances.

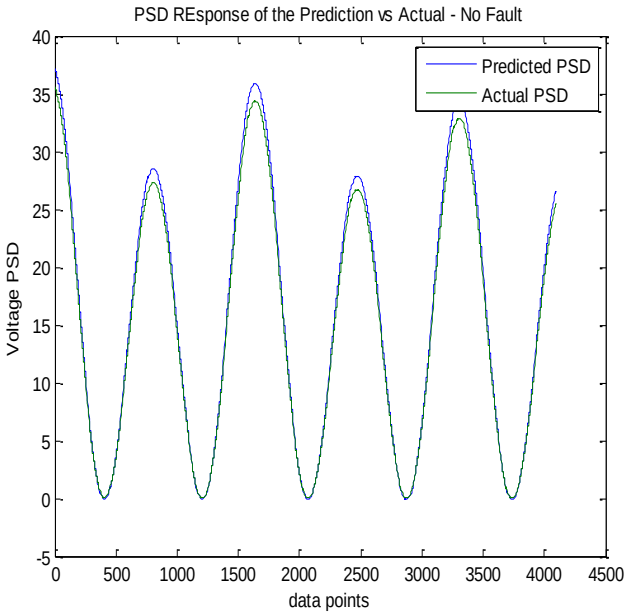

Fig.5. PSD prediction response compared to actual values under fault conditions.

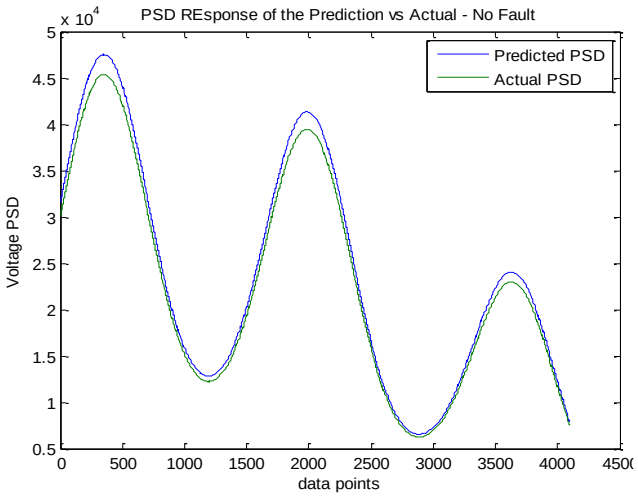

Fig.4. PSD prediction response compared to actual values during no-fault simulation

5. ACKNOWLEDGEMENTS:

Sincere thanks and acknowledgment go to Engr. Osegi, E. N. and Dr. Anireh, V. I. who assisted with code modifications for the simulations.

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27th October 2021
Available online at https://conference.rsujnet.org/

Paper number: ICNET2021-007

Design and Simulation of Real-Time Digital Audio System using LabVIEW

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ABSTRACT

This paper describes a real-time digital audio processing system that is designed and implemented using LabVIEW software on a 5-band graphic equaliser to help reduce poor quality of sound systems, this design seeks to address good quality, enhancement of audio systems and also provide high stereo music signal ranging from 48KHz to 200KHz, 16 bits. For an Analogue to Digital Signal Process (DSP), that involves equalization and filtering techniques that is commonly applied for digital audio enhancement and system performance. In terms of good and quality sounds the proposed system is designed to address it. Results were obtained and investigated and can be seen on the waveform graph in LabVIEW. The design and implementation of a 5-band graphic equaliser had different frequencies ranging from 20Hz to 16kHz. In this paper LabVIEW software will be used with a 32kHz sampling frequency for improved audio quality, where the proposed design was investigated, and results analysed.

Keywords: Filters, Equalizers, DSP, Digital Audio, LabVIEW, 5-Band.

Cite This Paper: Gobo, I. W., Ojuka, O. E., & Wokoma B. A. (2021). Design and Simulation of Real-Time Digital Audio System using LabVIEW. *Proceedings of the International Conference on New-views in Engineering and Technology Maiden Edition*, Faculty of Engineering, Rivers State University, Port Harcourt. Nigeria, 27th October, 2021, ICNET2021-007, 83 – 87.

1. INTRODUCTION

Today with the steady advancement in technology, systems have continuously improved with the aid of Digital Signal processing techniques popularly known as DSP, DSP comes as a result of Analogue to Digital conversion processes (ADC) and have led to improved systems which are now more reliable, efficient, flexible and more advanced in terms of system performance. (Gokhale *et al.*, 2005).

DSP systems can be used in different applications. These applications include real time processing of sound (audio), image processing, sonar and radar signal processing, noise cancellation, adaptive filtering, communication (in terms of encoding and decoding) etc. DSP allows signals to be converted and processed from its analogue to digital forms for better outputs. Presently, Digital signal processing DSP play a vital role in audio technology, in terms of manipulating and enhancing audio sounds, equalization techniques etc. (Tim et al., 2016)

2. MATERIALS AND METHODS

Filter design can be used to solve real life issues, where a filter can be designed and implemented to meet up a given task, one way is to select a real-life problem and design a suitable filter(s) for it. Digital Filters have so many applications, the proposed design is for an audio system that consist of 5-bands of different frequencies. A FIR filter

will be used for this system for audio enhancement, equalization, tone control, noise reduction and band splitting, where the FIR filter have different frequency ranges as mentioned previously (5-Band).

This design process involves the use of LabVIEW throughout the design process, first predetermined limit for the 5-band sliders were set. A band can be referred to as the spectrum of frequencies that are altered by a controller, for instance this, 5-band audio equalizer has 5 sliders.

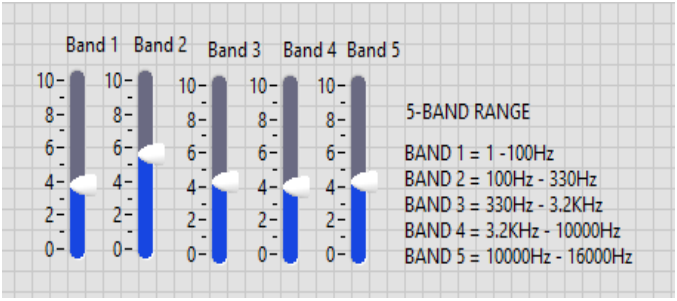

Fig. 1: 5-Band audio equalizer with different frequencies (front panel. LabVIEW).

These sliders can be used to change the effect on the audio signal by sliding it up or down. This system is designed to plot the filter characteristics of the FIR filter which where all linked together and were plotted in a graph (waveform) for the analysis of the proposed design.

In this design equalization technique is necessary, an equalizer is simply a special hardware or software that could adjust the gain of different frequency bands and characteristics of the signal (Jennifer, Jason et al., 2016) Equalizers makes use of filters for this purpose, each filter is used to pass a selected frequency band, the chosen frequency band can be enhanced or suppressed using an adjustable slider attached to the output of the corresponding filter (Cem, et al., 2018).

Note, as the filter order increases, the operation characteristics also increase, which shows an improvement in the filtering quality. hence, the design process started with high order of 3 for the equalizer.

All filters used for the 5-Band audio equalizers design where FIR filters, having different frequencies from 20Hz to 16kHz. And where split individually with the aid of the band splitting technique explained in Fig. 3. And the filter types are all band pass, a pass band filter is a type of filter that allows only the set band of frequencies to pass through and doesn't allow other frequencies that are not in that band range to pass. As seen in Fig. 2

3. RESULTS AND DISCURSION

From Fig. 3, the 4th FIR filter Band ranges from 3.2kHz to 10kHz, to filter a specific set of frequency, the filter type must be changed, here a band stop filter is used, it is the opposite of a Passband filter, which rejects certain band of frequencies, for this design, the band stop filter is used to stop a frequency of 5kHz, as this happens, the switch is turned on and a light emitting diode (LED), is used as an indicator.

Results Analysis:

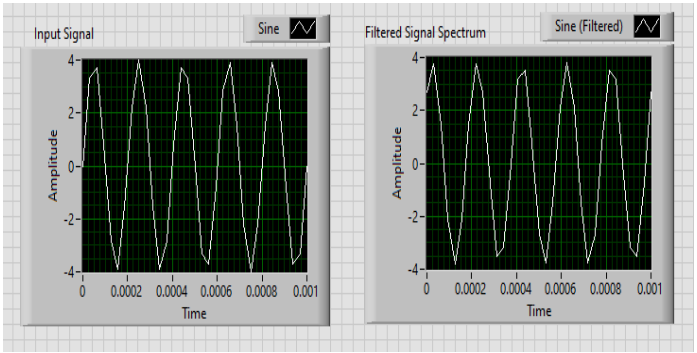

Fig. 3: Waveform shows signal of 5kHz Filtered.

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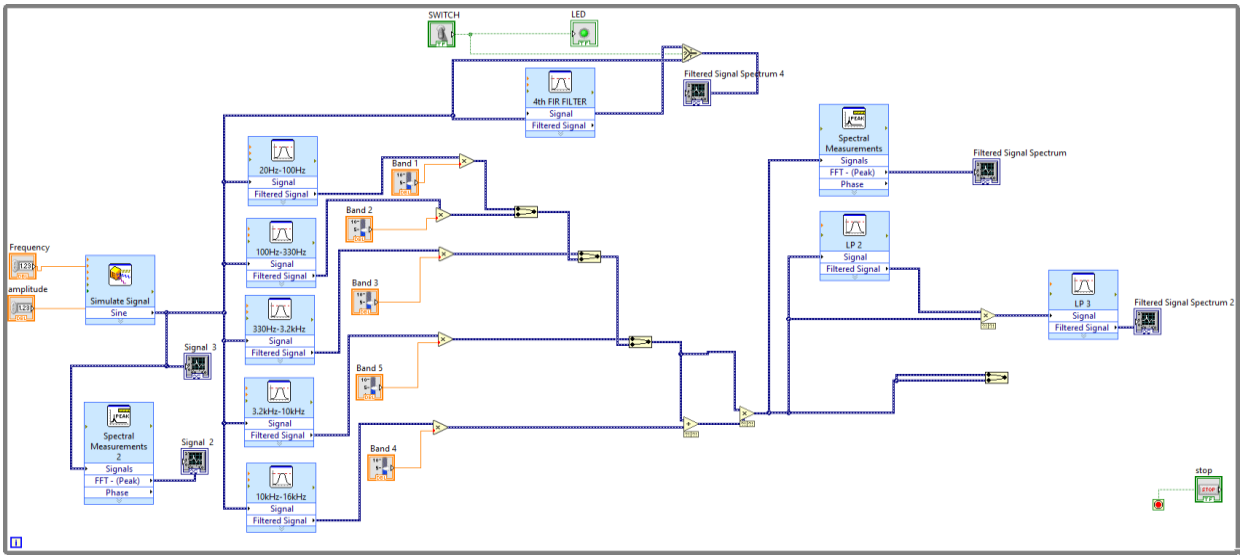

Fig. 2: Schematics of Designed 5-Band Audio Equalizer.

From the results seen above the 5kHz was filtered with different amplitudes and shows it was highly attenuated and displays the characteristic feature of a FIR filter of linear phase response.

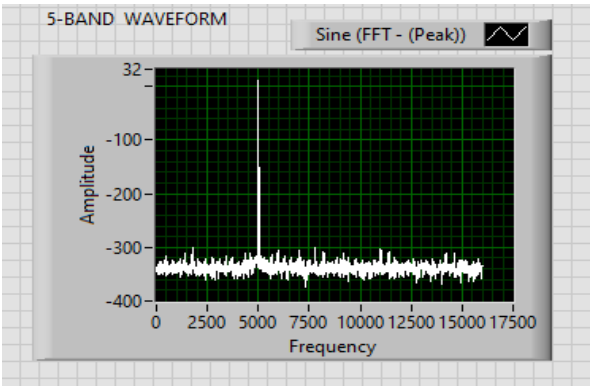

Fig. 4: Waveform shows the 5kHz Stopped.

To stop a frequency of 10kHz, applying the same technique as previously used, a band stop filter is needed.

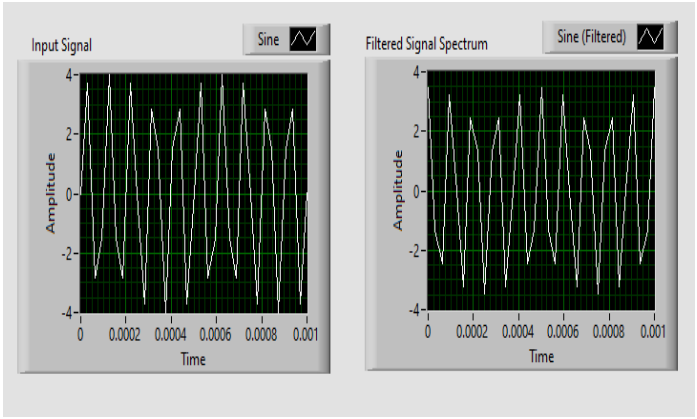

Fig. 5: Waveform shows a high attenuation and a linear phase response.

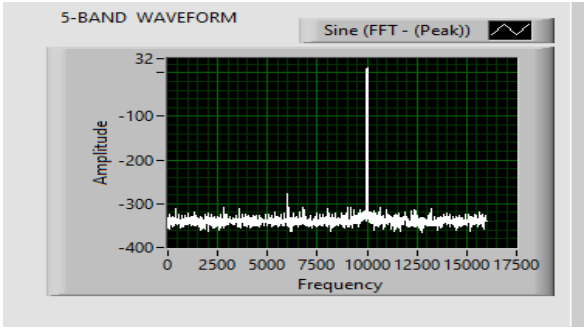

Fig. 6: Waveform shows 10Khz Stopped.

The 5th Filter is designed using a band pass filter having an increasing cut off frequency and is still a Finite impulse filter (FIR). For Digital equalization FIR is recommended because they

possess linear phases as seen from the results achieved above and tend to eliminate group delay distortions (Gabriel , et al., 2000) Distortions are generally unwanted signals introduced into the system. This proposed design for an audio system requires low noise, and good quality amplifications. For this design the LabVIEW front control panel includes switches, sliders, indicators (LED), graphical waveforms used to display the outputs of the components.

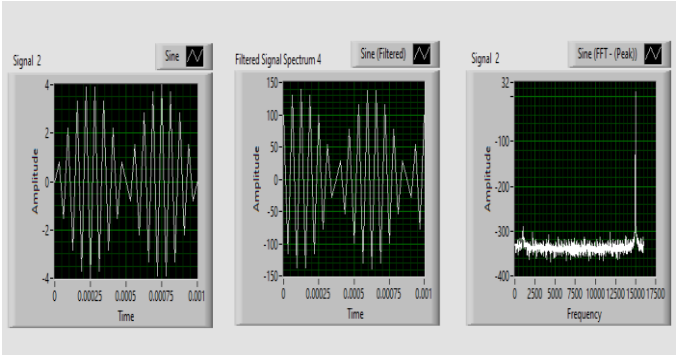

Fig. 7: When both Filters were removed.

From the analysis, so far filtering techniques help improve audio equalizer, good spectral selectivity also enhances a digital audio system, and equalizer technique also improve the system weakness, where different bands make the system more stable and flexible. Knowing that FIR filter response is generally determined by the set frequencies as seen in Fig. 7, where we had to set specific frequencies.

FIR filter frequency response is determined by a set of coefficients. The result analysis shows an impulse response of aligned signals which started at an amplitude of 0 (Zero) and when it was filtered had a start amplitude of 100 and continued its sequential signal processing.

4. CONCLUSION

A generalized understanding of a real-time DSP audio system was used to design and implement the system which involves the conversion process of an analogue to digital section, and a digital to analogue conversion process of an audio system. The design and implementation of a digital system was achieved where results were analyzed for a 5-Band audio equalized system which was done with the aid of LabVIEW for real time operation. From this proposed design of a Digital audio Equalizers has shown several advantages over analogue equalizers, in terms of quality, were analogue equalizers have issues like group delays, distortions, and inter band interferences making it hard to get a good frequency response.

With the use of DSP, it has made such audio technique to be more efficient, good, and improved quality, less distortions, different and flexile band selections which are easily controlled and has led to fast filtering techniques.

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PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON NEWVIEWS IN ENGINEERING AND TECHNOLOGY (ICNET) MAIDEN EDITION, FACULTY OF ENGINEERING, RIVERS STATE UNIVERSITY, PORT HARCOURT, NIGERIA.
27th October 2021
Available online at https://conference.rsujnet.org/

Paper number: ICNET2021-008

Gas Turbine Blade Reliability and Generator Optimal Estimation of Weibull Probability Distribution

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ABSTRACT

The increasing demand of electricity power supply and its availability is indispensable to manage economically following the rapid growth of population to energy consumption capacity which is a major concern making the electricity sector industries to experienced significant implication for power plant operation to provide basic energy services to the people particularly to the reliability of the engineering component under review To achieve this goal the study considered the application of reliability technique in order to analyse the activities of the failure times of ten identical gas-turbine blade of similar "make" and mode of operations subjected to the same conditions in Afam power station over a period of ten years, from the results obtained, the gas-turbine blades were in their wear-out period of reliable maintenance to give out efficient performance following to the reliability of the three parameter weibull distribution R(t) given as 0.60 this means that turbine blade actually required reliable maintenance. While, the failure rate of the turbine-blade $\lambda(t)$*:* $0.082577/hrs$*, the mean time to failure (MTTF): 13.55hours. The results obtained through the simulation of TPC windchill quality solution software estimated the parameters which shows suitable behaviour of the system components for early response for reliable maintenance. The reliability* $R(t)$*, failure rate* $\lambda(t)$ *and meantime to failure (MTTF) were successively computed. Conclusively, the probability that the gas turbine blades under investigation will continue to be operational in service without failures is about 70% while the mean time to failure of the gas turbine blade is about 14hours.*

KEYWORDS: Availability, Reliability, Electric Power, Weilbull Distribution

Cite This Paper: Braide, S. L. & Idoniboyeobu, D. C. (2021). Gas Turbine Blade Reliability and Generator Optimal Estimation of Weibull Probability Distribution *Proceedings of the International Conference on New-views in Engineering and Technology Maiden Edition*, Faculty of Engineering, Rivers State University, Port Harcourt. Nigeria, 27th October, 2021, ICNET2021-008, 87 – 99.

1.0 INTRODUCTION

Gas turbine-blade component reliability plays an important role in the performance of electricity power supply of power from the generating station which incidentally falls among the expensive equipment in the electricity power supply industry. Therefore, it is a necessity to guide and reduce the risk of failures and forced outages by system design engineer technique on the view to perform preventive repairs to improve the existing reliability of the system (Kang *et al.*, 2018). The gas turbine blade wear-out of failure has leads to high cost of electricity outages and customer dissatisfaction. Thus, evaluation and analysis of the behaviour of this

facilities/equipment requires strong knowledge about regular conditions of data collection in order to provide adequate information for effective system planning and operations. (Chen *et al.*, 2016)

The aim of this paper is to analyse the Gas turbine blade reliability and generator optimal estimation of the weilbull probability distribution. Energy utilization is the fundamental element for economic and social growth particularly in Nigeria. The migration of people from the rural–setting to urban cities as a form of socio-economic development constitute an over load in the network thereby charcterizing the process as a form of complex and robust challenging problems to solve mathematically. Power system comprises generation transmission and distribution network. Electric power is generated and distributed upto the point of utilization (consumer). In Nigeria the activities of transmission and distribution sector are characterized by constant outages due to system components failures as an interruption to the efficient power supply reliability. The cost of repairs, equipment's down time, idle labour, loss of output schedule delays and customer dissatisfaction are thereby affected in small, middle and large economic business operations.

The main objective of engaging preventive maintenance is to reduce the total cost of providing services. The cost analysis between breakdown and preventive maintenance can actually indicate the preferred alternative. Essentially to conduct a cost-analysis an information must be available relative to:

(i) Cost of breakdown
(ii) Frequency of breakdown
(iii) Cost of preventive maintenance to reduce or eliminate failures (otherwise preventive maintenance mean routine inspection and servicing).

However, it is designed to detect potential failure conditions and make correction that will prevent major operating difficulties. It is important to effect quick responses to machine service requirements that are known whose failures can be predicted with some level of accuracy. Preventive maintenance is desirable when it can increase the operating time of asset by reducing the severity and frequency of breakdown. Preventive maintenance might include cleaning, lubricating, inspecting, calibration, testing, critical part placement before failure or complete over-hauls.

2.0 MATERIALS AND METHOD

2.1 Materials

The materials used in this research include:

(i) Data of the facilities (maintenance records)
(ii) Data consists of times(t) to failure of ten identical gas turbine blades in the study case (Afam power plant)
(iii) Application of TPC windchil quality solutions software tool.

These data were collected from the Port Harcourt Electricity Distribution Company (PHEDC/Research Desk and operation, Maintenance Department). The data collected was implemented into governing equations to get information of the turbine blade failures in order to predicts/estimate the plan to reduce early failure rate (Balakrishnan & Kateri, 2008).

2.2 Methodology

A reliability research strategy was utilized for this review following to the reliability model described by three parameter estimation of gas-turbine blade performance which can adequately examine the failure times of gas turbine blade for ten similar units, under investigation and evaluation.

Essentially, the methodology was based on the following considerations:

(i) Collecting the frequency of turbine blade failure that results into outages and blackout
(ii) Determination of mean time to failure (MTTF) and failure rate
(iii) Determination of reliability function of the three parameter Weibull distribution.
(iv) Determination of unreliability that may either result into availability and unavailability.
(v) Examination of life cycle of the system components for efficient planning.

2.3 Computation of the characterised reliability-index and three parameter weibull distribution

Case 1: The Mean time to failure of the three-parameter weibull distribution (MTTF) is given by:

$$\text{MTTF} = \gamma + \eta\,\Gamma\left(1+\frac{1}{\beta}\right) \qquad (1)$$

where;

$$\left.\begin{array}{l}\gamma \geq 0 \text{ and } t,\ \beta,\ \eta > 0 \\ \Gamma(x) = \int_0^{\infty} e^{-x} x^{n-1}\end{array}\right\} \qquad (2)$$

η : Scale parameter

$\Gamma(x)$: Gamma Function

γ : Location parameter

β : shape parameter

t : Time

That is the term (MTTF) is applied to non-repairable points which operates under specified condition. It is otherwise the ratio of sum of time to failure of each component to the number of components under test.

Case 2: Mean time between failure (MTBF)

This is the term which is applied to repairable terms, which measure the average time that a particular equipment will fail and remain in service. MTBF of an equipment may be reduced to potential defects introduced by poor maintenance procedures.

Thus,

$$\text{MTBF} = \frac{1}{n}\sum_{i=1}^{n}\left(t_k..t_{k-1}\right) = \frac{t_n - t_o}{n} = \frac{t_n}{n} \qquad (3)$$

Since, $t_0 = 0$ at the beginning.

Then,

$$\text{MTBF} = \frac{\textit{Total operating time}}{\textit{No. of failures in that time}} \qquad `(4)$$

Case 3: Availability performance

Availability performance is the ability of an item to be in a state to perform a required function under a given conditions that is for a given instance of time or over a given time interval, this mean that;

(i) All items assumed operating conditions unless failed scenario.
(ii) The exception would have been standby redundancy but this scarcely exists power station because of high power supply demand.
(iii) The outcomes in the analysis are based on two fundamental rules for combining probabilities.
(iv) If A and B are two independent events with probabilities $\rho(A)$ and $\rho(B)$ of occurring, then the probability $\rho(AB)$ that both events will occur is the product;
$\rho(AB) = \rho(A).\rho(B)$ (5)
(v) Similarly, if two events A and B are mutually exclusive so that when one occurs the other cannot occur, the probability that either A or B will occur is:
$p(A\,B) = p(A) + p(B)$ (6)
(Datsiou & Overend, 2018)

Case 4: Failure rate

Failure may be either partial or complete, gradual or sudden it may be caused by inherent weaknesses or misuse. These failures can manifest in the following forms as; catastrophic failures, primary failure and secondary failures.

Therefore, failure-rate is related to both number of failures per unit time that is the number of items which fails in a given time depends not only on the quality of the item, hence;

(i) If the number of components in operation at the time of failure is Nr
Then failure –rate $\lambda(t)$ is given by;

$$\lambda(t) = \underset{\Delta t \to \infty}{Lim} \frac{1}{N_s} \times \frac{\Delta N_f}{\Delta_t} = \frac{1}{N_s} \times \frac{\delta N_f}{\delta t} \qquad (7)$$

Case 5: Operational availability

The operational availability (A_0) given as;

$$A_o = \frac{Up - Time}{Operating - Time} \qquad (8)$$

Thus,

Availability,

$$(A_v) = \frac{Available\ Hour}{Period\ Hour} \times \frac{100}{1} \qquad (9)$$

The significant measurement of the performance of a repairable system given as;

$$R(t) = \ell^{-}\left(\frac{t-\gamma}{\eta}\right)^{\beta}, t \geq \gamma \qquad (10)$$

Case 6: Reliability function of the three (3) – parameter weibull distribution is given as;

The three –parameters weibull failure rate function is given by;

$$\lambda(t) = \frac{\beta}{\eta}\left(\frac{t-\gamma}{\eta}\right)^{\beta-1}, t \geq \gamma \qquad (11)$$

Case 7: Weibull shape parameter(β)

The weibull shape parameter (β) is also known as the weibull slope. This is because the value of β is equal to the slope of a line in a probability plot.

(i) When the shape parameter, β < 1 (this means that the failure rate decreases)
(ii) When the shape parameter, β = 1 (this means that failure-rate is constant with time (t) and the distribution is equal to the exponential distribution)
(iii) When the shape parameter, β > 1 (this means that failure rate increases)

Case 8: Weibull scale parameter, η

That is increasing the value of η while keeping β constant has the effects of stretching out the probability density function (pdf). A change in the scale parameter (η) has the same effect on the distribution as a change of the abscissa scale. Since the area under a pdf curve is a constant value, the peak of the pdf curves will also decrease with increase of η (Yang & Nie, 2007).

Case 9: Weibull Location Parameter, γ

The location parameter, γ actually accounts for the subtraction (positive or negative) value that places the points in an acceptable straight line. changing the value of the location parameter γ , has the effects of pushing the distribution and associated function if (γ > 0) or to the left if (γ < 0).

Case 10: Prediction Performance of Weibull Distribution Model

The prediction accuracy of the model in the estimation of the turbine-blade failures with respect to actual values were evaluated based on the correlation coefficient R^2, root mean square error (RMSE) and coefficient of efficiency (COE) (Markovic *et al.*, 2009). These parameters are calculated based on the following equation as;

$$R^2 = \frac{\sum_{i=1}^{N}(y_i - z)^2 - \sum_{i=1}^{N}(x_i - z)^2}{\sum_{i=1}^{N}(y_i - z)^2} \qquad (12)$$

Similarly, the root means square error (RMSE) given as;

$$RMSE = \left[\frac{1}{N}\sum_{i=1}^{N}(y_i - x_i)^2\right]^{1/2} \quad (13)$$

The coefficient of efficiency (COE) given as;

$$COE = \frac{\sum_{i=1}^{N}(y_i - x_i)^2}{\sum_{i=1}^{N}(y_i - z)^2 -} \quad (14)$$

where y_i is the i^{th} actual data X_i is the i^{th} predicted data with the weilbull distribution (z) is the mean of the actual data, N is the number of observations.

Case 11: Reliability model of system component and weilbull-two parameter characterization.

The rate of failure and mean time between failure (MTBF) are the key parameters of reliability in the turbine blades evaluation which are estimated using weilbull distribution function and with available data for each part, since weilbull distribution technique is a vital tool used in the systematic modeling of failure rates, forecasting failures and in modeling of failure and fault-process stemmed from their aging.

The weilbull parameter would be determined using the least-square relationship as:

$$y_i = mx_i + c \;\; or \;\; x_i = In(t_i) \quad (15)$$

where; t_i is the independent age (year) of failed component in rank i.

Therefore,

$$y_i = In\ In\left[\frac{1}{1-F_i}\right] \quad (16)$$

From, (15) and (16) are the weilbull shape parameter (β) which can be calculated given as;

$$\beta = m = \frac{\sum_{i=1}^{N} x_i y_i - \frac{\sum_{i=1}^{N} x_i \sum_{i=1}^{N} y_i}{N}}{\sum_{i=1}^{N} x_i^2 - \frac{\left[\sum_{i=1}^{N} x_i\right]^2}{N}} \quad (17)$$

Similarly, the constant (c) given as;

$$C = \frac{\sum_{i=1}^{N} y_i}{N} - \frac{m\sum_{i=1}^{N} x_i}{N} \quad (18)$$

The life or scale parameter (α) can be determined given as;

$$\alpha = \ell^{-\left[\frac{c}{m}\right]} \quad (19)$$

(i) By the estimation of two-parameters technique for the prediction if the system behaviour of the component is according to the equipment – curve distribution.

(ii) Weibull probability distribution function f(t) shows probability of failure in certain time (t) given as;

$$F(t) = \left(\frac{\beta}{\alpha}\right)\left(\frac{t}{\alpha}\right)^{\beta-1} \ell^{-\left(\frac{t}{\alpha}\right)^{\beta}}; \; for \begin{cases} \alpha > 0 \\ \beta > 0 \\ 0 \le t <= \infty \end{cases} \quad (20)$$

(iii) The cumulative distribution function F(t), which shows the probability of failure in time (t) would be calculated as;

$$F(t) = 1 - \ell^{-\frac{t}{\alpha}^{\beta}}; \; for \begin{cases} \alpha > 0 \\ \beta > 0 \\ 0 \le t <= \infty \end{cases} \quad (21)$$

Essentially, reliability function R(t) which shows probability of remaining intact till the time (t) and the rates of failure λ(t) which can be expressed as;

$$R(t) = 1 - F(t) = \ell - \left(\frac{t}{\alpha}\right)^{\beta} \text{ or} \qquad (22)$$

$$\lambda(t) = \frac{F(t)}{R(t)} = \left(\frac{\beta}{\alpha}\right)\left(\frac{t}{\alpha}\right)^{\beta-1} \qquad (23)$$

From observation, the shape –parameter (β) affects the shape distribution curve that is when the shape parameter changed, the curve f(t) varies differently in shape. For example, if the curve turns to exponential distribution while β = 1

(i) That is the failure rate will be decreasing while β<1, means that the component is in the early failure state.

(ii) Similarly, when failure rate is constant while, β=1, the components is in the occasional failure condition. Incidentally, the failure rate is increasing while β>1 this means that the component is in the loss failure condition (Abbasi & Malik, 2016).

Case 12: The Mean and standard deviation of a weibull distribution evaluation

The mean and standard deviations are presented in terms of shape and scale –parameter given as:

$$\mu = \mu\Gamma\left(1 + \frac{1}{\beta}\right) \qquad (24)$$

and

$$\delta^2 = \alpha^2\left[\Gamma\left(1 + \frac{2}{\beta}\right) - \Gamma^2\left(1 + \frac{1}{\beta}\right)\right] \qquad (25)$$

2.4 Collection of Failure Time (t) of a Gas Turbine-Blades performance

Presentation of the failure time (hrs.) of a ten identical gas turbine–blades that are similar-make and similar –model while working under same stress conditions, stated as;

Table 1: The rating –order of turbine blade failures in time (hrs.)

Rank	Failure Time, (hrs.)
1	1047
2	1279
3	1340
4	1578
5	1598
6	1749
7	1804
8	1841
9	1847
10	1869
11	1879
12	1890
13	1939
14	1948
15	1949
16	1956
17	19087
18	1995
19	2004
20	2005
21	2047
22	2214
23	2287
24	2436
25	2439
26	2442
27	2581
28	2617
29	2926
30	2978

Sources: Research Desk/Maintenance Department Afam power Generating Station.

3.0 RESULTS AND DISCUSSION

3.1 Results

Table 1 shows that failure times (hours) of ten similar gas turbine blades performance reliability having identical configuration in the make and

model when subjected to the same stress level conditions under investigations were determined. The existing failures data is analyzed using weibull analysis software TPC windchill Quality solutions to obtain three-parameter weibull estimates of location, shape and scale parameters in order to produce the following weibull probability plot, probability density function (PDF) - plot, and 3D contour plot as presented in table 2, given as:

Table 2: Three (3) – parameter weibull estimates using windchill quality solutions application tool

Function	Shape – parameter (β)	Scale – parameter (η)	Location parameter (λ)
Probability	4.1652	33.6733	–3.1855
Reliability with time	4.1652	33.6733	–3.1855
Unreliability with time	4.1652	33.6733	–3.1855

The application of reliability evaluation of three-parameter weibull distribution, shows from the simulation results obtained in the TPC windchill software reliability application tool given as:

shape (β) = 4.1652

scale (η) = 33.6733

location (λ) = –13.1855

time (t) =16.1867 hours

Thus, the reliability function of the three-parameter weibull distribution given as:

$$R(t) = \ell - \left(\frac{t-\lambda}{\eta}\right)^{\beta}, \text{ for } t \geq \gamma \qquad (26)$$

Similarly,

The three –parameter weibull failures rate function is given by:

$$\lambda(t) = \frac{\beta}{\eta}\left(\frac{t-\lambda}{\eta}\right)^{\beta-1}, \text{ for } t \geq \gamma \qquad (27)$$

and

Mean-time to failure of the three-parameter weibull distribution is given as:

$$MTTF = \gamma + \eta + \left(1 + \frac{1}{\beta}\right), \text{ where } \gamma \geq 0 \text{ and } t, \beta, \eta > 0$$

that is,

$$\Gamma(x) = \int_0^{\infty} \ell^{-x} x^{n-1} \qquad (28)$$

where;

η : scale parameter

$\Gamma(x)$: gamma function

γ : location parameter

β : shape parameter

t : time

Thus, the reliability analysis for the weibull distribution parameters is determined and calculated as;

$$R(t) = \ell - \left(\frac{t-\gamma}{\eta}\right)^{\beta},$$

t = 16.1867hours

ℓ = 2.718

β = 4.1652

η = 33.6733

γ = –13.1855

$$R(t) = \ell^{-}\left(\frac{16.1867 - 13.1856}{33.6733}\right)^{4.1652}$$

or

$$R(t) = \ell^{-}\left(\frac{29.3723}{33.6733}\right)^{4.1652}$$

or

$$R(t) = \ell^{-}(0.872272)^{4.1652}$$

or

$$R(t) = \ell^{-0.56598} = 2.718^{-0.56598}$$

or

$$R(t) = \frac{1}{2.718^{0.56598}} = \frac{1}{1.7610695}$$

$$R(t) = 0.5678 \approx 0.60$$

Similarly, the failure rate is calculated as:

$$R(t) = \frac{\beta}{\eta}^{-}\left(\frac{t-\gamma}{\eta}\right)^{\beta-1} \quad for\ t \geq \gamma$$

$\beta = 4.1652$, $t = 16.1867$hrs

$\eta = 33.6733$ $\gamma = 13.1855$hrs

$$\lambda(t) = \frac{4.1652}{33.6733}\left(\frac{16.1867 - 13.1855}{3.6733}\right)^{4.1652}$$

or

$$\lambda(t) = 0.12369\left(\frac{29.3723}{33.6733}\right)^{3.1652}$$

or

$$\lambda(t) = 0.12369(0.872272)^{3.1652}$$

or

$$\lambda(t) = 0.12369 \times (0.648862)$$

or

$$\lambda(t) = 0.0802577\ /\ hours$$

Thus, the Mean time to failure (MTTF) of the three-parameter Weibull distribution calculated as;

$$MTTF = \lambda + \eta\ \Gamma\left(1 + \frac{1}{\beta}\right),\ for\ \gamma \geq 0\ and\ t, \beta, \eta > 0$$

$\gamma = -13.1855$, $\eta = 33.6733$

$\beta = 4.1652$, $\Gamma\ 1.2400 = 0.7940$

$$MTTF = -13.1855 + 33.6733\ \Gamma\left(1 + \frac{1}{4.1652}\right)$$ or

$$= +13.551102\,hrs$$

3.2 Discussion of Weibull Distribution Plot

Following to the presentation plot of figure 1 the probability of failure versus time are shown. The scope of the probability plot is seen to be decreasing at the beginning but as it gets to the end of the plot it is observed to be gradually increasing which is pushed to the right. Provided the value of the location parameter is positive.

Similarly, in figure 2, shows the plot of the probability density function (pdf) observed to be increasing at steady condition up to certain time, t =18hours but from this point further there is a sharp decrease. Subsequently, in Figure 3 which shows the reliability plot, it is observed to be initially very high at the beginning but over time becomes decreasing, which means that the gas turbine is aging with time that is there is a gradual drop in reliability. Similarly, figure 4, shows the plots of the failure rate which is increasing at a time (t). This indicates that gas turbine blade is tilting towards their wear-out period of reliable maintenance.

Figure 5, shows vivid presentation of the contour plot of 3D, from the plots it is observed that the values of the estimates of three-parameter weibull vary along the contour axes. Significantly, that is moving from the bottom of the location and shape parameters which increases gradually while the value of the scale-parameter observed to be slightly affected.

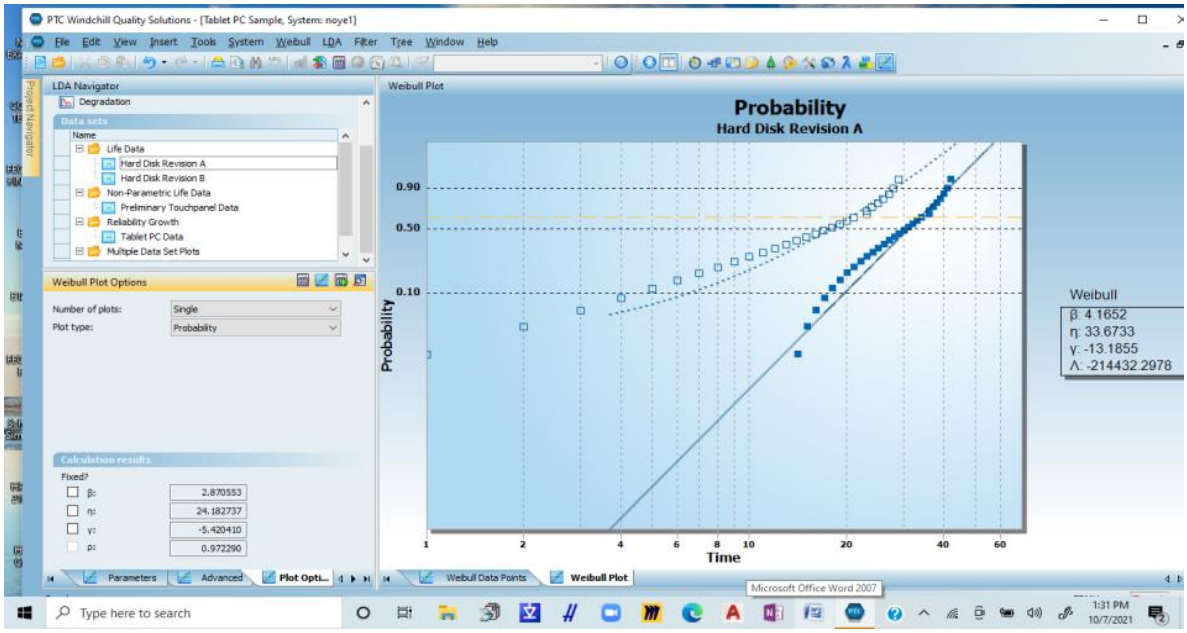

Figure 1: Probability plot against time, t in hours

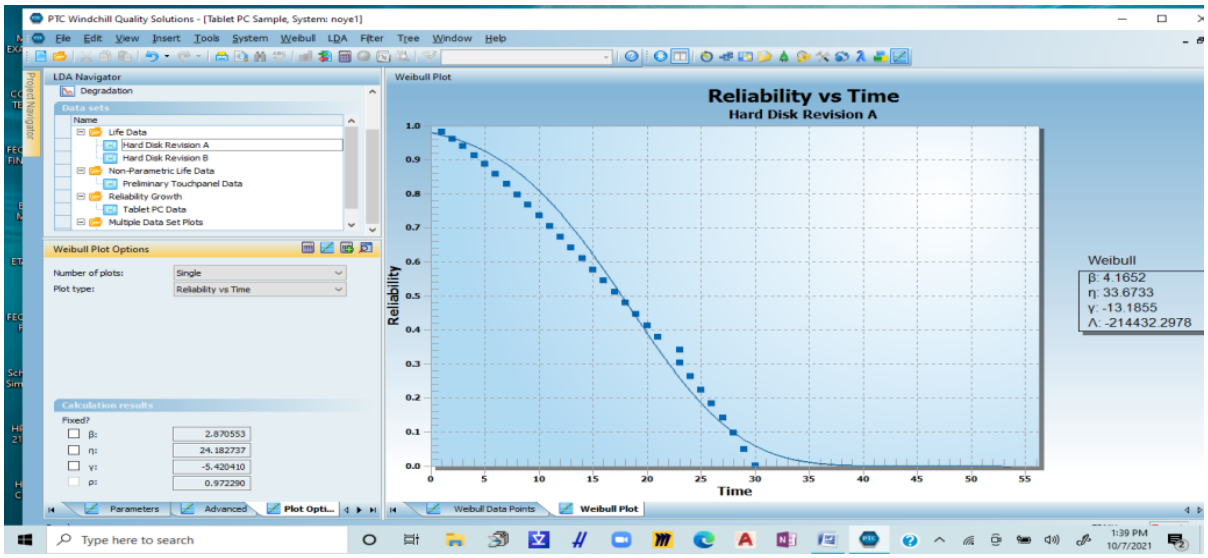

Figure 2: Reliability versus time in hours

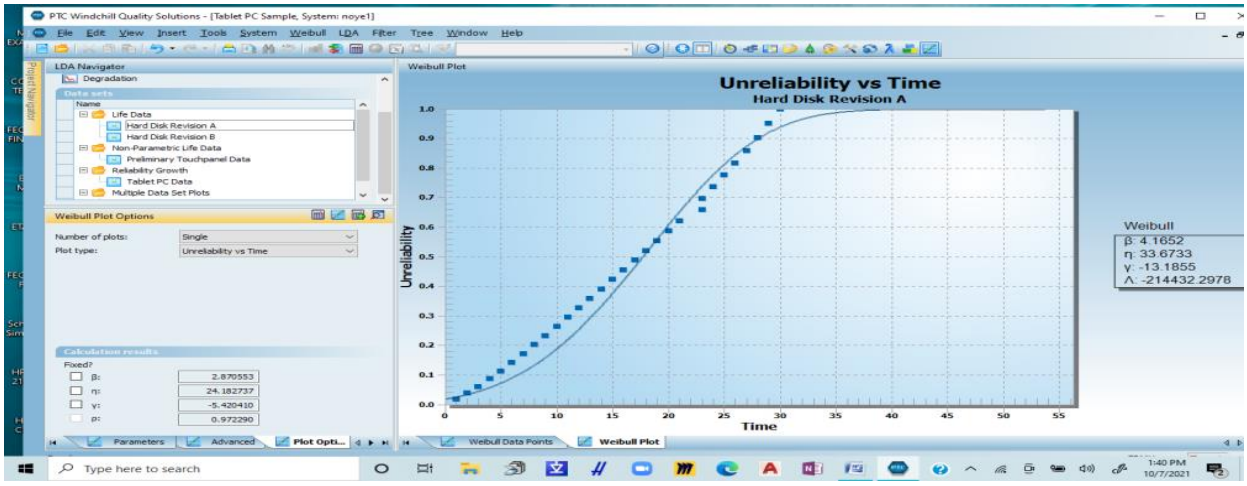

Figure 3: Unreliability versus time, (t) in hours

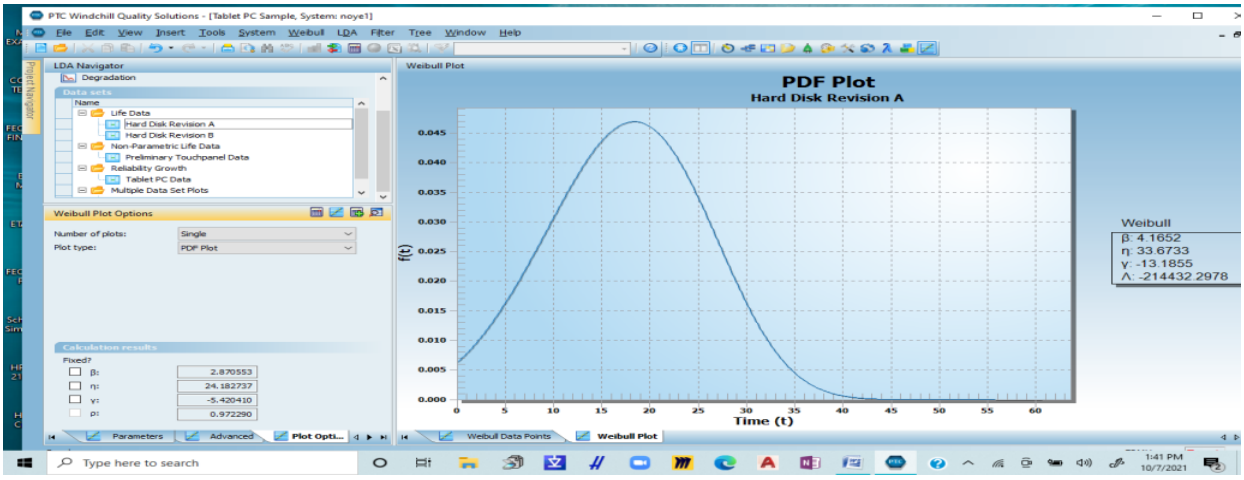

Figure 4: Probability density function (PDF), versus time (t) in hours

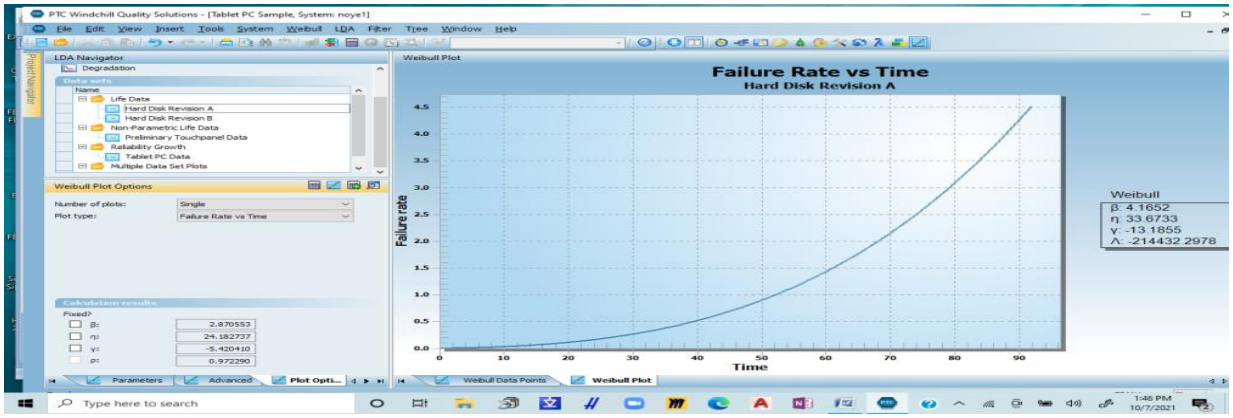

Figure 5: Failure rate versus time, t in hours

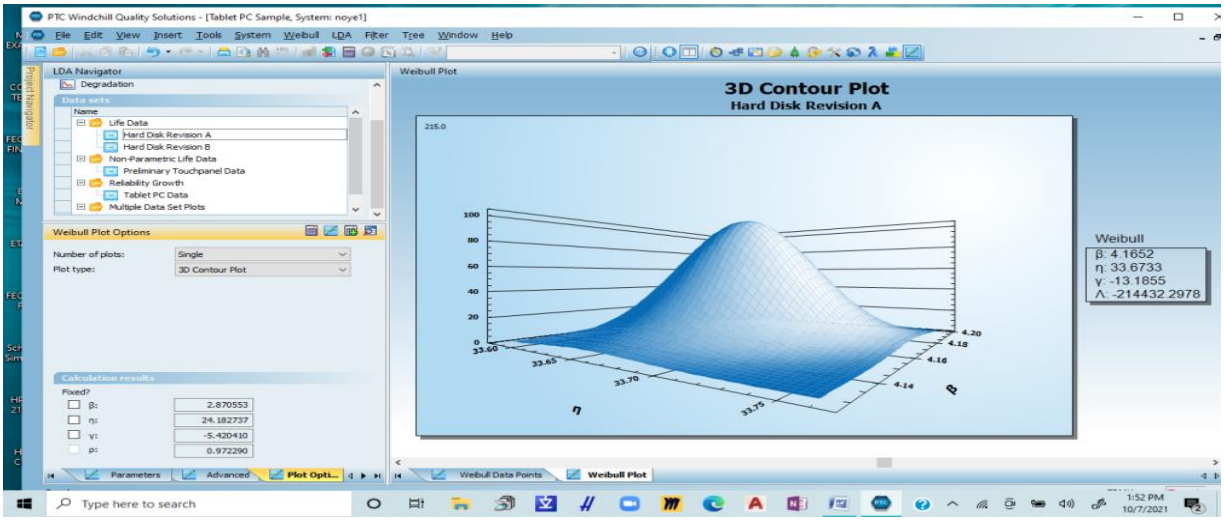

Figure 6: 3D Contour representation plot

Plate 1: Turbine-blade design configuration.

4.0 CONCLUSION

The analysis of the parameter estimation of Weibull distributions using reliability evaluation technique was formulated with implementation of the input data collected in the study case under investigation. The study evaluated the analysis of the failure times of ten similar turbine blade in an identical mode of operations using TPC windchill quality solution software in order to obtain the estimates of the three parameters of weibull (location, shape and scale parameters). The estimates were successfully obtained which represents the probability that gas-turbine blade existing state will continue to be operational in service without components failure which is about 70% reliability level, while the mean-time to failure to the turbine blades is about 14hours.

The results of the analysis evaluated indicates that the blades were tilting towards their wear-out

period of their numerical value of shape-parameter (β) which becomes 4.1652 that is greater than one. From the TPC windchill estimates obtained the reliability $R(t)$, failure rate $\lambda(t)$ and mean-time to failure of the blades are adequately computed.

This research paper is a lead study and a challenging area in widespread practice especially in the area of management of system components of power plant unit availability that should conform to local and international standard of operations. The following recommendation are strongly addressed to improve the existing reliability of power quality as:

(i) The electric power station should align in the development of equipment/components for specific operations and maintenance (O&M) procedures and program.
(ii) Energy demand and load growth should be monitored from the station, based on the following subsequent demand rate and frequency.
(iii) Electric power station should embrace the ideas or the use of dedicated high-profile software – package for analysis, estimate and evaluations.
(iv) Reliability indices and parameters analysis should give self-contained information to give a useful practical introduction to standard availability performance evaluations.

Wear-out period of system components (turbine blade) should be replaced and service immediately to avoid total breakdown of other facilities that may affects or attracts more cost to the machine (turbine power plant) etc.

5.0 ACKNOWLEDGEMENTS

The authors are graciously grateful to Prof. Taiwo Ademiluyi for her encouragement also from the Department of Electrical Engineering, Rivers State University (RSU) Port Harcourt for their general support, advice to make this paper a success. Thank you

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η : Scale parameter

$\Gamma(x)$: Gamma Function

γ : Location parameter

β : shape parameter

t : Time

PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON NEWVIEWS IN ENGINEERING AND TECHNOLOGY (ICNET) MAIDEN EDITION, FACULTY OF ENGINEERING, RIVERS STATE UNIVERSITY, PORT HARCOURT, NIGERIA.
27th October 2021
Available online at https://conference.rsujnet.org/

Paper number: ICNET2021-009

Incorporating Solar and Wind Energy Technologies in the Power Mix of a Proposed Power Structure

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ABSTRACT

In this work, the possibility of utilizing solar energy and wind energy for electricity generation in a proposed new power structure in Nigeria was examined. The wind and solar energy potentials of all the 36 states and the federal capital territory of Nigeria for electricity generation were assessed using data in the open literatures about selected locations in each state, usually, the state capitals. Using the levelized cost of electricity (LCOE) and the net present value (NPV) methods, the economic viability of the usage of both energy systems (solar photovoltaic (PV) system for solar energy conversion and wind turbines for wind energy conversion) were presented. Project life of 20 years at 9% discount rate together with electricity price of ₦55 per kW-hr ($0.1339 per kW-hr) was used for the analysis. While it is not economically viable to operate wind energy system in several states in the southern part due to low wind speeds, the reverse is the case in few other states such as Anambra and Enugu states. It is economically viable to operate solar PV system on commercial scale in several states in the southern part, but in the northern part, solar PV systems can be operated on commercial scale profitably in all the states, with Yobe state having the lowest LCOE. The LCOE as a function of the wind speed and the solar irradiation were obtained in this work. These relations can aid quick assessment of the economic viability of operating either energy system in any location.

Keywords: Levelized cost of electricity, Net present value, Solar energy, Solar photovoltaic, Wind Energy, Wind turbine.

Cite This Paper: Saturday, E. G., & Amafabia, D. M. (2021). Incorporating Solar and Wind Energy Technologies in the Power Mix of a Proposed Power Structure. *Proceedings of the International Conference on New-views in Engineering and Technology Maiden Edition*, Faculty of Engineering, Rivers State University, Port Harcourt. Nigeria, 27th October, 2021, ICNET2021-009, 100 – 110.

1. INTRODUCTION

The power sector of Nigeria is dominated by gas turbine power plants located mainly in the south-south geopolitical zone of the country, followed by hydropower power plants in the Northern region of the country (Saturday, 2021). There is inadequate power supply in Nigeria. This is not totally due to the low amount of installed power in the country which is less than 15 GW today (the electrical energy demand value as projected by different researchers ranges from some 17 GW to 50 GW using different economic growth scenarios (Ibrahim and Gokhan, 2018; Ezennaya *et al.*, 2014; Sambo, 2008). In the existing structure, power generation comes from power plants owned by the federal government, state governments and private individuals. Power transmission is solely in the hands of the federal government through the transmission company of Nigeria (TCN), while power distribution is achieved through eleven (11) electricity distribution companies (DISCOS) which are privately owned (Saturday, 2021; FGN, 2017). The inability of the DISCOS to improve their infrastructures and distribute all the power

generated and transmitted to their ends is a major problem in the existing structure. Power is in recurrent list in the Nigerian constitution, but the federal government plays major role in the power sector while some state governments has little or no contribution to the growth of the sector. A new structure was thus proposed to address these problems (Saturday, 2021). Details of both the existing structure and the proposed structure are provided in next section of this paper.

There has been clamour for injecting renewable energy-based power generation systems to the power mix. Much attention has been paid to wind energy and solar photovoltaic (PV) systems for power generation in Nigeria. As solar energy can come in small units, several homes have embraced it amidst the high installation cost complains. Also, several private organizations and state governments have gone into different solar energy projects for power production in Nigeria (REA, 2021; FGN, 2021; FGN, 2018). Wind energy has not enjoyed much usage as solar energy in Nigeria. This is because wind energy conversion systems do not come in little packages that could be easily purchased and installed by individuals.

In this work therefore, the existing power structure is x-rayed viz-a-viz the proposed power structure. This is followed by identification of the existing power installations across the country. The power demand of each state and the additional power need of each state in comparison with the available installed power will be estimated. The wind energy and solar energy potentials of selected locations in the various states as published by different researchers will be examined. With these values, power extracted from these two energy resources, and the economics involved in exploiting these energy resources will be carried out for all the states. The results will guide the various state governments in planning for solar and wind energy installations in areas not yet connected to the grid with high potentials of these resources.

1.1 The Nigerian Power Structure and a Proposed Structure

The existing power structure of Nigeria is shown in Figure 1

The existing structure consists of the power generators, the transmission company of Nigeria and the DISCOS in one hand which is basically concerned with grid-connected power and the Interconnected Mini Grids and Isolated Mini Grids which are driven by the Rural Electrification Agency. The federal government plays several roles through the federal ministry of power with its agency, the Nigerian Electricity Regulatory Commission, playing regulatory role in the sector. The Nigerian Bulk Electricity Trading company is also of the federal government charged with the responsibility of buying electricity from the power generators and selling same to the DISCOS.

In the proposed structure, each state will have power generating plants jointly owned with private organizations that will oversee the running of the plants. The Power plants owned by the federal government (partly sold today) that are connected to the national grid should sell power to those states with insufficient power generation while the federal government maintains the TCN. States with excess power production can sell power to other states through the national grid. Each state will have not less than two electricity distribution companies jointly owned by the state and private partners who will equally have shares in the power generating companies. The federal government will merely be an observer, supporter, and tax collector in the new structure. For areas far from

grid-connected power, the various state governments should exploit mini-grids using basically solar and wind energy systems in such areas if the potentials of these energy resources are appreciable in those areas. The move towards renewable energy utilization for power production should start from those areas.

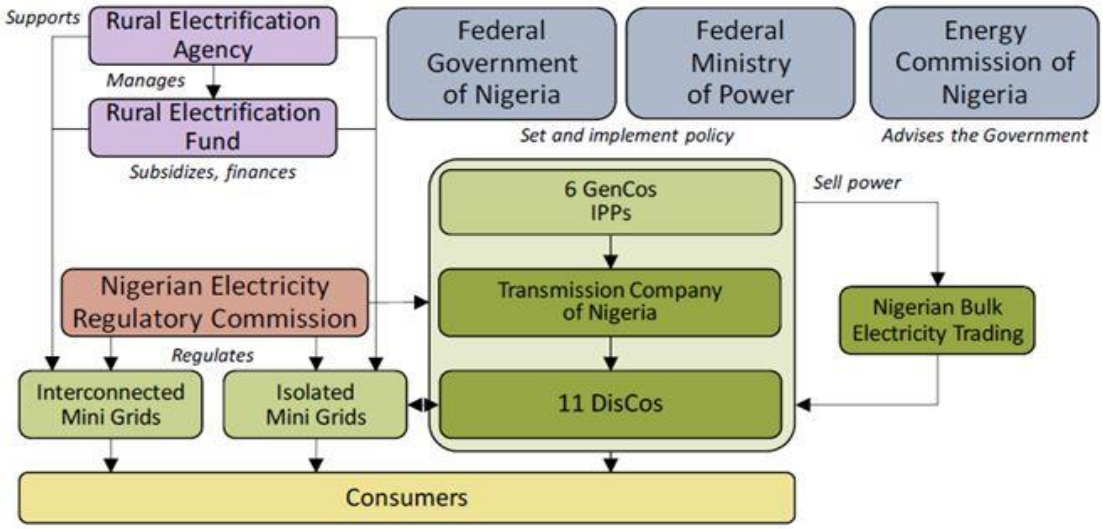

Fig. 1 The power sector structure of Nigeria (World Bank, 2017)

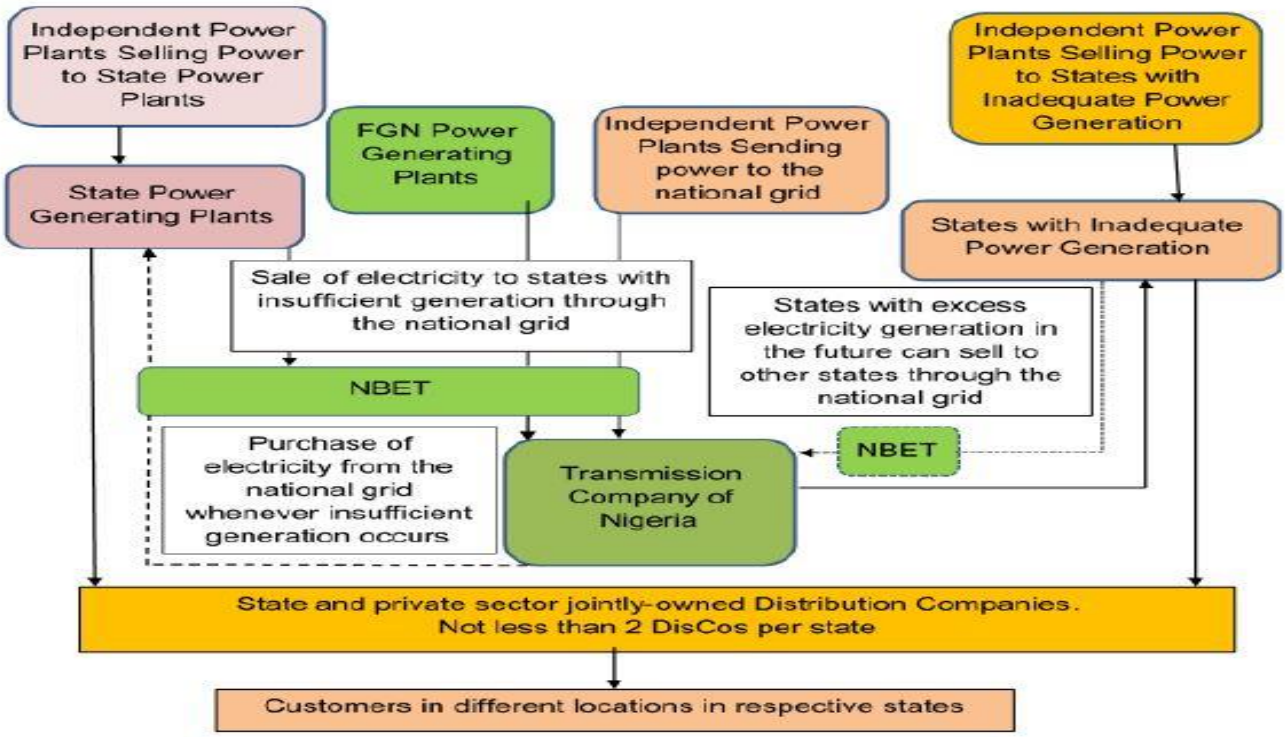

Fig. 2 Proposed structure of the power sector (Saturday, 2021)

2. MATERAILS AND METHODS

2.1 Power Plants in Nigeria and Total Power Installations in Various States

There are several power plants in Nigeria, and they are spread across the country. While the southern part of the country has basically gas turbine-based power stations, the northern part has a number of hydro power plants connected to the national grid. Before estimating the electrical energy demand of each state, it is necessary to know the total installed power capacity of power plants located in each state. Table 1 provides this information.

2.2 Power Demand of Various States in Nigeria

The demand for electrical power or energy of the various states is estimated here. Energy demand depends on the population and the level of economic activities or gross domestic product (GDP) of the locality in question. If the energy demand of one state is known, that of other states can be estimated by exploiting the population and GDP of the states as in (Saturday and Aderibigbe, 2020). In this case, an average electrical energy demand value of 1035 MW (Briggs & Ugorji, 2017) for Rivers State is used to estimate that of the remaining states exploiting Equation (1) (Saturday & Aderibigbe, 2020),

$$ED_s = \frac{GDP_s}{GDP_{rs}} \times \frac{POP_s}{POP_{rs}} \times ED_{rs} \qquad (1)$$

From Equation (1) ED_s , GDP_s and POP_s represent respectively energy demand, GDP, and population of the various states while ED_{rs}, GDP_{rs} and POP_{rs} are the respective values for Rivers State. Table 2 shows the GDP and population of the various states.

If an average value of the energy demand estimated by various researchers is to be adopted (in this case 33.5 GW), the energy demand of the various states will be scaled up or down to this value using Equation (2),

$$ED_{s\prime} = \frac{ED_s}{ED_T} \times ED_{av} \qquad (2)$$

Where $ED_{s\prime}$ is the adjusted value of the energy demand of each state, ED_T is the total energy demand of the various states obtained by summing all the ED_s values in Equation (1) while ED_{av} is the average energy demand value adopted ($ED_{av} = 33.5\ GW$)

2.3 Solar and Wind Energy Potentials in Nigeria and Extractable Energies

The solar and wind energy potentials of various locations in Nigeria have been studied by several researchers. The solar irradiation values of several places in Nigeria can be found in the works of Abdullahi *et al.* (2017) and Akorede *et al.* (2017). Like the potentials of solar energy in Nigeria, the wind energy potentials of different locations in Nigeria have been studied by several researchers (Idris *et al.*, 2020; Eboibi *et al.*, 2017; Okeniyi *et al.*, 2015). The potentials of wind energy come in the form of the average wind speed measured over several years. Table 3 shows the solar irradiation values and the average recorded wind speed values of different locations in Nigeria cutting across all the 36 states and the FCT. The annual mean wind speed data (at 10 meters height) was obtained from Akorede *et al.* (2017) (but those on asterisk were obtained from https://www.worldweatheronline.com/ado-ekiti-weather-averages/**ekiti**/ng.aspx at 6 meters height; replacing Ekiti in bold with any other location directs to the site for wind data in that location). The solar irradiation values were

obtained from Akorede *et al.* (2017), Abdullahi *et al.* (2017), Ikeagwuani *et al.* (2016) and Dike *et al.*, (2011).

Table 3: Solar irradiation and average wind speed values of different locations in Nigeria

State (Location)	Yearly averaged daily solar radiation (kWh/m^2.day)	Location in the state	Annual mean wind speed at 10m height (m/s)
Abia (Umuahia)	4.68	Umuahia	2.68*
Abuja FCT	5.39	Abuja	3.77
Adamawa (Yola)	5.774	Yola	4.16
Akwa Ibom (Uyo)	4.68	Uyo	2.55
Anambra (Awka)	4.825	Awka	2.08 *
Bauchi (Bauchi)	5.714	Bauchi	4.83
Bayelsa (Yenagoa)	4.175	Yenagoa	1.56*
Benue	5.077	Makurdi	2.42 *
Borno (Maiduguri)	6.4	Maiduguri	5.22
Cross River (Calabar)	3.925	Calabar	4.6
Delta (Warri)	3.748	Warri / Asaba	2.11 /2.16
Ebonyi (Abakaliki)	4.955	Abakaliki	2.39
Edo (Benin)	4.202	Benin	3.38
Ekiti (Ado Ekiti)	4.775	Ado Ekiti	2.77 *
Enugu (Enugu)	4.82	Enugu	5.73
Gombe	6.25	Gombe	2.53
Imo (Owerri)	4.146	Owerri	2.8
Jigawa	5.987	Dutse	3.47 *
Kaduna	5.672	Kaduna /Zaria	5.13 / 6.08
Kano	6.003	Kano	9.39
Katsina	4.766	Katsina	7.45
Kebbi	5.140	Yelwa	3.88

Table 3: Continuation

State (Location)	Yearly averaged daily solar radiation (kWh/m^2.day)	Location in the state	Annual mean wind speed at 10m height (m/s)
Kogi	5.035	Lokoja	2.92
Kwara (Ilorin)	5.23	Ilorin	5.04
Lagos (Ikeja)	4.256	Lagos Island	4.69
Nasarawa	5.170	Lafia	2.68 *
Niger	5.427	Minna	5.36
Ogun (Abeokuta)	4.258	Ijebu-Ode	3.62
Ondo (Akure)	4.485	Ondo (City)	1.77
Osun (Osogbo)	4.735	Oshogbo	3.33
Oyo (Ibadan)	4.71	Ibadan	3.86
Plateau	5.653	Jos	9.47
Rivers (Port Harcourt)	4.31	Port Harcourt	3.3
Sokoto	5.34	Sokoto	7.21
Taraba (Serti)	4.488	Jalingo	3.12 *
Yobe (Nguru)	6.660	Potiskum	5.25
Zamfara	5.150	Gusau	6.17

The amount of electrical energy extractable from either wind energy or solar energy depends on the capacity factor for both energy systems and the amount of wind speed for wind energy system and the solar irradiation value for solar energy extraction. For wind energy, wind turbines are used for extracting the energy and converting it to electrical energy. The available energy in the wind E_a and the amount of energy extractable E_e are given by Equations (3) and (4) respectively,

$$E_a = \frac{1}{2} \times \rho \times A \times v^3 \quad (3)$$

$$E_e = P_R \times Cf \quad (4)$$

where ρ, A, v, P_R and CF are the density of the air, area of turbine blades, the velocity of the wind, the rated power of the wind turbine and the capacity factor respectively. The capacity factor used in this work relates to the diameter of the turbine D and the wind speed given by Equation (5),

$$CF = 0.087 \times v - \frac{P_R}{D^2} \quad (5)$$

The turbine used in this work is AN Bonus wind turbine with diameter 60 m and rated power of 1 MW. The wind speed at the 60 m height has to be estimated (Saturday and Aderibigbe, 2020). From Equation (5), the least wind speed required to operate the turbine is 3.2 m/s.

The amount of energy to be installed $E_{in,s}$ and the number of turbine units required n (same power rating) are given by Equations (6) and (7) respectively (Saturday and Aderibigbe, 2020),

$$E_{in,s} = \frac{ED_s}{CF} \quad (6)$$

$$n = \frac{E_{in,s}}{E_e} \quad (7)$$

The actual land area required for wind turbine installation is much smaller than the entire area required as wind turbines are spaced wide apart. Using a convention of 60 acres (0.2428 km^2) of land per megawatt of electricity produced, the land area A_l required in square kilometer is given by Equation (8),

$$A_l = E_{in,s} \times 0.2428 \quad (8)$$

where the energy installed is expressed in megawatt. For solar PV systems, the amount of energy to be installed depend on the capacitor factor and the energy demand as in Equation (6), but the capacitor factor is expressed as (Saturday and Aderibigbe, 2020),

$$CF = \frac{E_a}{P_k} = \frac{365 \times P_r \times G}{8760} \quad (9)$$

where E_a is the solar energy extractable per unit time, P_k is the peak power of the solar PV system (peak power of 1 kWp is assumed in this case), P_r is the performance ratio (usually taken as 0.75), G expressed in (kWh/m^2/day) is the average daily global irradiance, 365 represents the number of days in a year while 8760 is the number of hours in one year. In some cases, the total amount of solar energy available per annum E_{ann} is needed and this is obtained using Equation (10),

$$E_{ann} = 365 \times P_r \times G \times P_k \quad (10)$$

The area of land required for solar energy installation $A_{l,s}$ is critical in solar PV system usage. The area can be estimated using Equation (11),

$$A_{l,s} = \frac{E_{in,s}}{P_K} \quad (11)$$

2.4 Economics of solar and wind energy utilization of the various states

Several economic parameters can be employed in adjudging the economic viability of any project. These include among others the payback period method, the discounted payback period method, the net present value (NPV) method, the internal rate of return or return on investment method, the levelized cost of electricity (LCOE) method (Saturday *et al.*, 2018). The LCOE method and the NPV methods are adopted in this work. The LCOE and the NPV are given respectively in Equations (12) and (13),

$$LCOE = \frac{IC + \sum_{i=1}^{n} \frac{AC_{O\&M}}{(1+r)^{-i}}}{\sum_{i=1}^{n} \frac{E_{in,s}}{(1+r)^{-i}}} \quad (12)$$

$$NPV = \sum_{i=1}^{n} \frac{NACF}{(1+r)^i} - IC \quad (13)$$

where n is the project life span (20 years was adopted in this work), IC is the cost of installing the system (in monetary value per kW or MW of electricity produced), $AC_{O\&M}$ is the cost of operating and maintaining the system annually, $NACF$ is the net annual cash flow which is the difference between the annual revenue which comes from the sale of generated electricity and the cost of operating and maintaining the system annually ($AC_{O\&M}$), and r is the discount rate. Onshore wind energy system is considered in this work and the installation cost varies between $1,200 per kW and $1,600 per kW (Wind Power Monthly, 2020). Since the values are on the downward trend, the lower value is adopted in this work. For a solar PV system, utility-scale system is adopted with installation cost of $1.44 per Watt (Fu *et al.*, 2018). The $AC_{O\&M}$ for wind energy system and solar PV system adopted in his work are ($27/MWh) and $0.001454 per kWh respectively. The price of electricity used in this work is ₦55 per kWh. A discount rate of 9% is adopted; this value is low but power projects are usually funded with funds borrowed at low interest rates hence the choice of low value here. Since the NPV represents the net present value, for two different states with different population values as well as energy demand values, for same wind speed, the state with higher energy demand will go with higher NPV value, suggesting that the project in that state is doing better, which is not true. To avoid this, the NPV per energy demand was used to judge the economic viability of operating the different energy systems in the various states.

2.4.1 The Relationships between the LCOE and the Speed and the Solar Irradiation

The LCOE depends on the wind speed for wind energy system and the amount of solar irradiation for solar energy system. The relationship between the LCOE and the independent parameter in each system can be obtained by curve-fitting the data obtained for the various states using curve-fitting capabilities in Microsoft Excel.

3. RESULTS AND DISCUSSION

Table 4 shows the energy demand value of the various states and the FCT viz –a –viz the amount of installed. The difference between the energy demand value and the available installed power will give each state government an idea of the additional power installation required if the state government takes over the ownership of the power installations in their states with or without private partnership. Plants proposed and those under construction are not included in Table 4; that information is in Table 1.

Table 5 shows the LCOE and the NPV per energy demand for wind energy system for the various states while Table 6 shows LCOE and the NPV per energy demand for solar energy system. For the wind energy system, LCOE and NPV were not evaluated for Bayelsa, Delta, Anambra, Ebonyi and Ondo states because the wind speeds in the selected locations are lower than the cut in speed of the selected wind turbine. For electricity price of ₦55 per kW-hr ($0.1339 per kW-hr), only four states in the southern part (Cross River, Enugu, Lagos, and Oyo) have LCOE value lower than the electricity price; all the other states have LCOE value higher than the electricity price hence goes with negative NPV. For the northern part, five states- Benue, Kogi, Nasarawa, Gombe and Taraba states have LCOE values higher than the price of electricity in Nigeria; all the other states and the FCT has LCOE values lower than the electricity price of $0.1339 per kW-hr. Generally, states which LCOE is higher than the price of electricity has negative NPV, indicating that it is

not economically viable to operate wind energy system in those states going by the current installation cost and electricity price if the aim is to make profit.

The LCOE and the NPV for solar energy system depends on the solar irradiation value for the various locations. For the southern states, the LCOE values obtained for nine of the states is lower than the price of electricity while for the remaining 8 states, the LCOE values are each higher than the price of electricity. Anambra state has the lowest LCOE value followed by Enugu state; for the NPV per energy demand, Anambra state has the highest value followed by Enugu state. These two states have solar irradiation values of 4.825 kWh/m^2-day and 4.820 kWh/m^2-day respectively which are the highest in all the states in the southern region. For the northern region, all the states have LCOE values lower than the price of electricity, indicating that it is economically viable to operate, in commercial scale, solar energy systems in the indicated locations in all the northern states. Yobe state gave the lowest LCOE value followed by Kano state.

For a given state, the LCOE values obtained from the two energy systems differ. For some states, wind energy systems are more viable while for other states, solar energy systems are more viable. For the southern part, there are more states with more viable solar energy utilization. In the northern part, 9 out of the 20 locations are more useful for solar energy utilization while the other 11 locations are more viable for wind energy utilization. Figure 3 compares the LCOE values of the states where solar energy utilization is more viable while Figure 4 compares the LCOE values of the states with more viable wind energy usage, all for the northern states

In using any energy system for the proposed power structure, the targeted locations should be those areas far from the national grid. The actual wind speed and solar irradiation values should be obtained and used. The results presented so far will give each state government a general picture of the solar energy and wind energy potentials in the state, as in many cases, the potentials in the selected locations (usually the state capitals) are not much lower than the highest obtainable in any part of the state.

The relationship between LCOE and the wind speed obtained by curve-fitting the data in Microsoft Excel has a correlation coefficient of 0.9909 (R = 0.9909) and it is given by Equation (14),

$$LCOE = -0.0008v^3 + 0.021v^2 - 0.1756v + 0.5397 \quad (14)$$

A polynomial of order 3 fit the data as the LCOE depends on the power available in the wind while the power available in the wind is proportional to the velocity in the wind raised to power 3. For solar energy system, the relation between the LCOE and the solar irradiation is given by Equation (15) with a correlation coefficient of 1,

$$LCOE = 0.57G^{-0.986} \quad (15)$$

From the above, it is more accurate to predict the LCOE value in solar energy system compared to wind energy system. Equations (14) and (15) can be easily employed to estimate the LCOE of wind and solar energy systems respectively and compare with the existing price of electricity to ascertain the economic viability of operating either system in the locality in question. It is pertinent to point out that, Equations (14) and (15) are applicable at a discount rate of 9%; at lower discount rate, the LCOEs obtainable will be lower, and vice-versa.

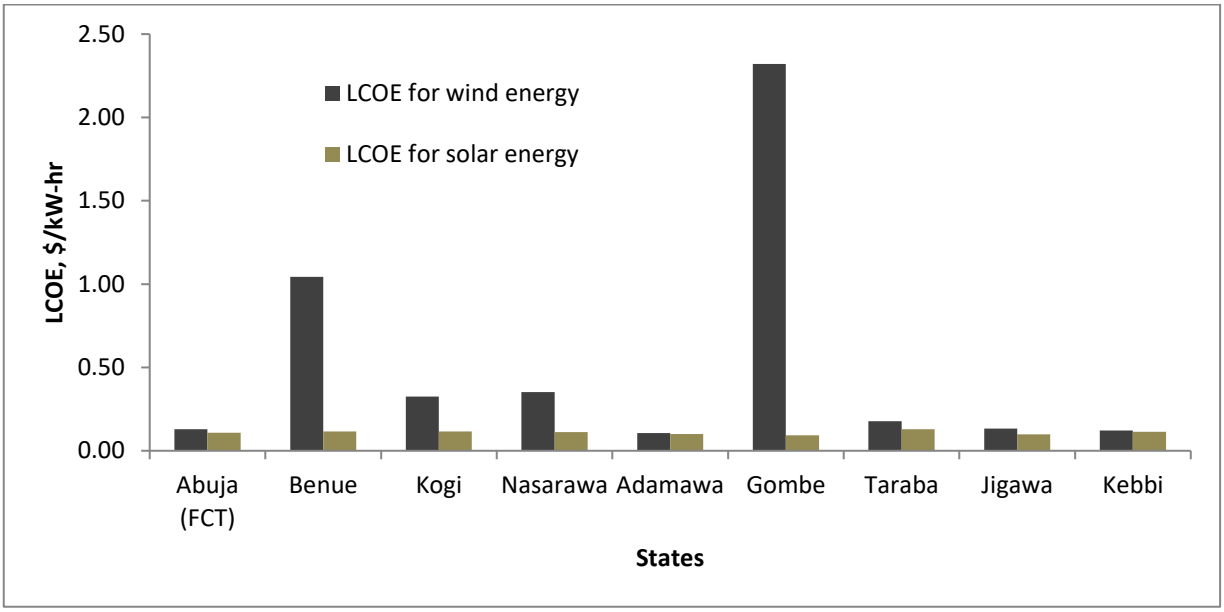

Fig. 3: Comparison of LCOE values from wind energy and solar energy systems for states with more viable wind energy utilization

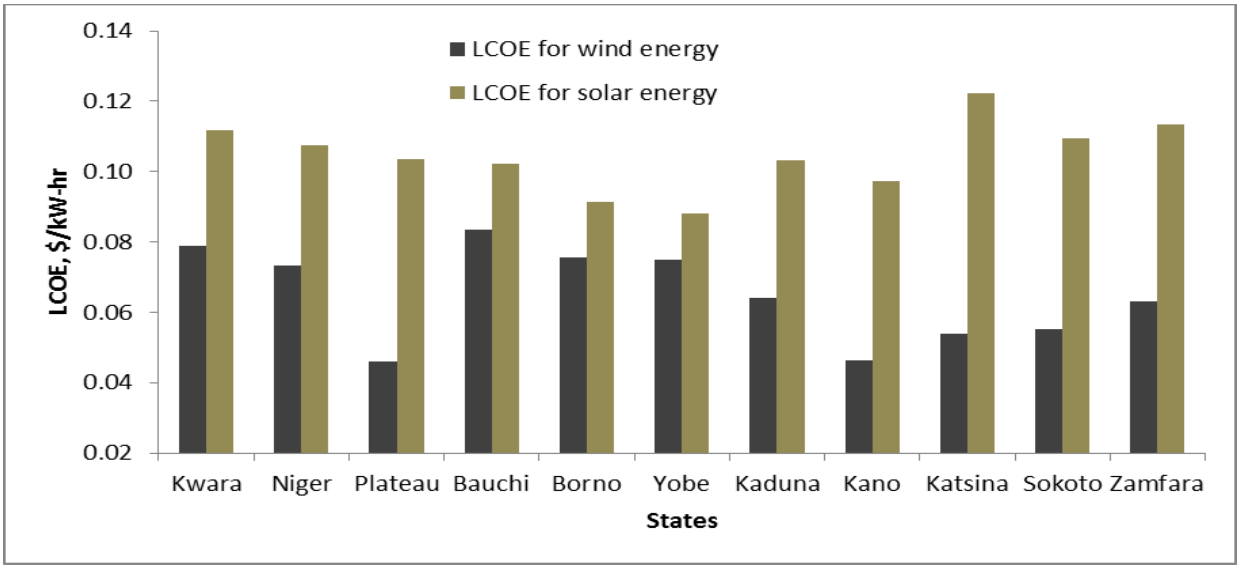

Fig. 4: Comparison of LCOE values from wind energy and solar energy systems for states with more viable solar energy utility

4.0 CONCLUSION

This study reveals the potentials of various states in Nigeria, in harnessing wind and solar energies as alternative sources of power generation in the country, splitting the analysis into the southern and the northern parts of the country. The wind energy potentials are economically viable in many of the states in the northern part while solar energy potentials are economically viable in all the northern states. In the southern part, few of the states can operate wind energy system profitably while it is economically viable to operate solar energy system in many of the states. The study presents the need to implement these two energy systems in a proposed power structure. Although the power sector has been facing several challenges, there is room for improvement if the proposed structure is implemented, where state governments will be involved in power generation, transmission and distribution in partnership with private organizations within their localities and sell excess power to neighboring states through the national grid. Concerted effort by the federal government is needed to achieve the desired progress in the sector. For each state, areas far from the national grid with appreciable wind and or solar energy potentials should be the starting points for the utilization of these energy systems to increase the renewable energy mix in our power sector

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