FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA

BRIDGING DOMAINS WITH BLADES: GAS TURBINE ENGINES FOR SUSTAINABLE ENERGY AND PROPULSION ACROSS AIR, LAND, AND SEA

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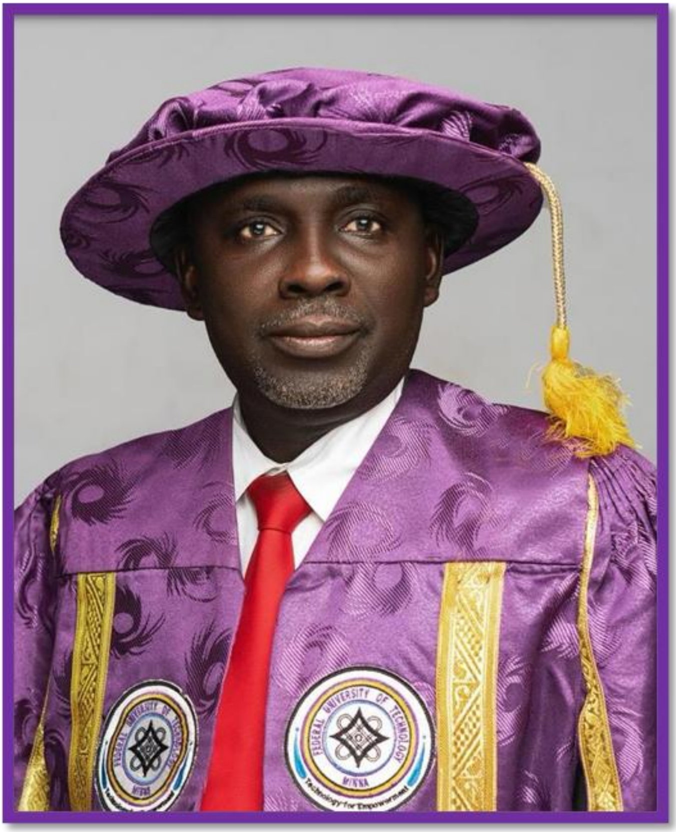

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Preamble

All praise and adoration are due to Allah, the Beneficent, and Merciful who had ordained today as my inaugural lecture day long before I was born. There could not have been a better day, Alhamdulillah. And may the peace and blessings of Allah be on our Noble Prophet Muhammad, his househood, Companions and those following his footsteps until the last day.

It is a great honour to stand before you to deliver the 123rd inaugural lecture of this great citadel of learning, one of the best specialized universities in Nigeria, Federal University of Technology, Minna.

Mr. Vice-Chancellor sir, Deputy Vice-Chancellors, Registrar, Bursar, the Librarian, Dean of Postgraduate School, Dean, School of Infrastructure, Process Engineering and Technology, Dean of Students Affairs, Deans of other Schools, Directors of Units and Centres, Professors and members of University Senate, other members of academic and non-academic staff, distinguished invited guests, the greatest FUTMINNA Students, ladies and gentlemen.

The title of this inaugural lecture is **Bridging Domains with Blades: Gas Turbine Engines for Sustainable Energy and Propulsion across Air, Land, and Sea.**

I would like to start by saying that “**ALL ENGINES ARE MACHINES BUT NOT ALL MACHINES ARE ENGINES**”

1.0 INTRODUCTION

Gas turbine engines, also known as combustion turbines, are versatile machines that are designed to convert the thermal energy of a fuel into some forms of useful power, such as mechanical (or shaft) power or a highspeed thrust of a jet through the process of combustion. They are widely used in various applications, including power generation, aviation, marine propulsion, and industrial processes. Gas turbines consist of several key components, including compressors, combustion chambers, and turbines, which work together to produce power efficiently. These components are shown in Figure 1. Figure 2 shows the gas turbine blades, a component which is exposed to tremendous thermal stress.

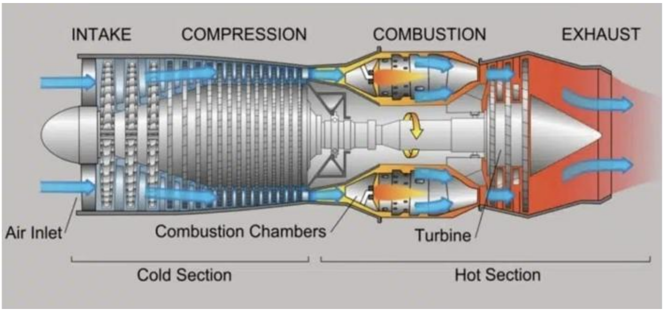

Figure 1: Gas Turbine Engine Components and Principle

Figure 2: Gas Turbine Blades

Gas turbine engine operate on the principle of the Brayton cycle as shown in Figure 3. This involves compressing air, mixing it with fuel, combusting the mixture, and then expanding the resulting hot gases through a turbine to produce power. The compressed air is first drawn into the compressor, where its pressure and temperature are increased. The high-pressure air then enters the combustion chamber, where it is mixed with fuel and ignited to produce a high-temperature, high-pressure gas. This gas is then expanded through the turbine, where it drives the turbine blades and generates mechanical energy. Finally, the exhaust gases are expelled from the turbine and can be used to produce additional power or for other purposes.

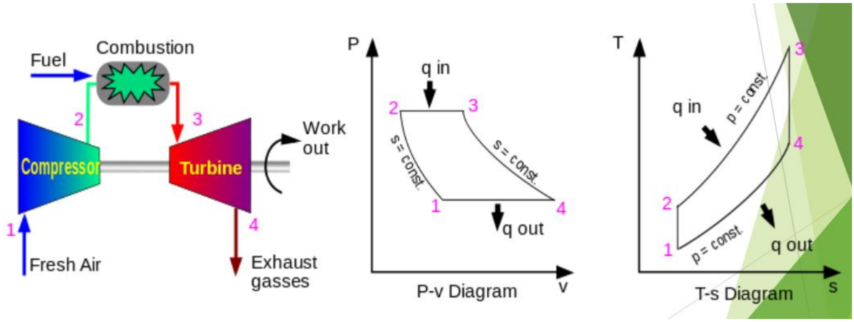

Figure 3: Gas Turbine and Brayton Cycle

Gas turbines are known for their high power-to-weight ratio, compact size, and rapid startup capabilities, making them suitable for applications where space and time are limited. They are also highly efficient, with modern gas turbines achieving thermal efficiencies of up to 40% or more in combined cycle power plants.

1.1. Evolution of Gas Turbines

The evolution of gas turbines spans over a century of technological advancements, from early experimental models to sophisticated systems powering modern industries. The journey of gas turbines began in the late 19th century with the pioneering work of engineers such as Sir Charles Parsons and Aurel Stodola.

In the early 20th century, gas turbines were primarily used in experimental and military applications, with limited commercial use due to technological limitations and high costs. However, significant progress was made during World War II, with the development of turbojet engines for aircraft propulsion, such as the famous Rolls-Royce Whittle engine in the United Kingdom and the Junkers Jumo 004 in Germany.

After the war, gas turbine technology continued to advance rapidly, driven by demand from the aviation industry and the emerging field of power generation. In the 1950s and 1960s, gas turbines were increasingly used in power plants, initially as peaking units and later in baseload and combined cycle configurations. This period also saw the introduction of industrial gas turbines for various applications, including oil and gas production, chemical processing, and cogeneration.

The 1970s and 1980s witnessed further improvements in gas turbine design and performance, with a focus on efficiency, reliability, and environmental performance. Advancements in materials, aerodynamics, and control systems led to the development of more efficient and environmentally friendly gas turbines, capable of operating at higher temperatures and pressures (Zhang, Wang, and Zhao, 2025).

In the late 20th and early 21st centuries, gas turbine technology continued to evolve, driven by concerns about energy security, environmental sustainability, and climate change. Innovations such as advanced combustion systems, inlet air cooling, and integrated gasification combined cycle (IGCC) technology have further enhanced the efficiency and flexibility of gas turbines, enabling them to meet the evolving needs of the energy industry (Morales, *et. al.,* 2024).

Today, gas turbines are at the forefront of energy generation and transportation, powering electricity grids, airplanes, ships, and industrial facilities around the world. With ongoing research and development efforts focused on improving efficiency, reducing emissions, and expanding fuel flexibility, gas turbines are expected to remain a vital component of the global energy landscape for years to come (Rahman, *et. al.,* 2024).

1.2 Significance of Gas Turbines in Modern Society

Gas turbines play a crucial role in modern society, providing power and propulsion for a wide range of applications. One of the primary uses of gas turbines is in electricity generation, where they are employed in both centralized power plants and distributed generation systems. Gas turbine power plants can be rapidly deployed and are capable of providing reliable electricity to meet the demands of growing populations and industries. They are also used in combined cycle power plants, where their exhaust heat is used to generate additional power through steam turbines, thereby increasing overall efficiency and reducing fuel consumption (Fadzli *et al.,* 2023).

In addition to electricity generation, gas turbines are widely used in the aviation industry to power aircraft. Jet engines, which are a type of gas turbine, propel airplanes by drawing in air, compressing it, mixing it with fuel, and combusting the mixture to produce thrust. Gas turbines offer high power output and efficiency, allowing airplanes to travel long distances quickly and efficiently. They are essential for commercial air travel, military operations, and emergency services, such as medical evacuation and firefighting.

Gas turbines also play a vital role in maritime transportation, where they are used to power ships and boats. Marine gas turbines provide propulsion for various types of vessels, including cruise ships, cargo ships, and naval vessels. They offer advantages such as high power density, low emissions, and fuel flexibility, making them well-suited for marine applications. Gas turbine-powered ships can travel long distances at high speeds while minimizing environmental impact and fuel consumption.

Furthermore, gas turbines find applications in industrial processes, such as oil and gas production, chemical manufacturing, and cogeneration. They provide reliable power for onsite operations, enabling industries to maintain productivity and efficiency. Gas turbines can also be integrated with other energy systems, such as combined heat and power (CHP) plants, to maximize energy efficiency and cost savings.

Overall, gas turbines are integral to modern society, providing power, propulsion, and energy solutions for a wide range of applications. Their versatility, efficiency, and reliability make them indispensable in meeting the energy needs of today and the challenges of tomorrow.

2.0 GAS TURBINES APPLICATION IN THE AIR -AVIATION

Gas turbines have revolutionized aviation, playing a central role in the development of modern aircraft propulsion systems. They are the driving force behind jet engines, providing the high thrust-to-weight ratio and efficiency required for commercial, military, and recreational aviation. (Jones and Brown, 2022).

2.1 Aircraft Propulsion Systems

Aircraft propulsion systems have undergone significant evolution since the early days of flight, with gas turbines emerging as the dominant technology for powering modern aircraft. The development of gas turbines in aviation is closely linked to the rise of jet engines, which have replaced piston engines in almost all high-performance and commercial aircraft (Smith *et al.,* 2021). Figure 4 shows an aircraft with exploded gas turbine view.

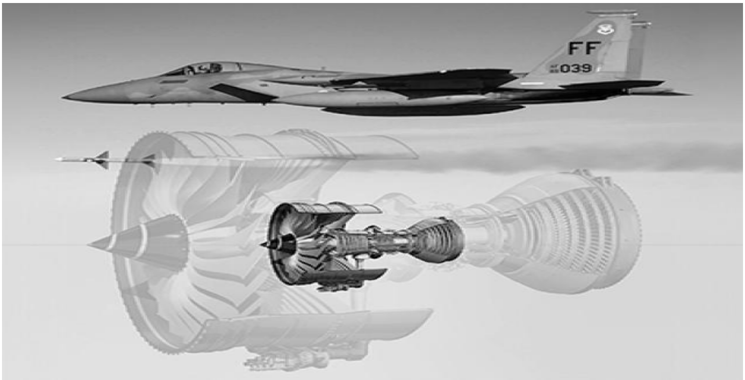

Figure 4: An Aircraft with Gas Turbine Engine *(Smith* et al., *2021)*

2.2 The Basics of Gas Turbines in Aviation

A gas turbine engine, commonly referred to as a jet engine, operates on the principle of the Brayton cycle. The process involves compressing incoming air, mixing it with fuel, igniting the mixture, and then expelling the exhaust gases at high speed to produce thrust. The core components of a jet engine include:

- **Compressor:** Located at the front of the engine, the compressor draws in ambient air and compresses it to high pressure. This increases the air's density and temperature, preparing it for efficient combustion.
- **Combustor:** In the combustor, the compressed air is mixed with fuel and ignited. The resulting combustion produces high-temperature and high-pressure gases.
- **Turbine:** A series of rotating blades extract energy from the expanding gases. Part of this energy drives the compressor, while the remainder is used to produce thrust.
- **Nozzle:** The nozzle accelerates the exhaust gases as they exit the engine, converting thermal energy into kinetic energy and generating thrust.

2.3 Types of Jet Engines

Several types of jet engines are used in aviation, each optimized for different performance requirements (Williams *et al.,* 2021):

- **Turbojet Engines:** These are the simplest jet engines, producing thrust by directly expelling exhaust gases from the turbine. Turbojets are highly efficient at high speeds but are less suitable for lower speeds and altitudes, making them more appropriate for military and supersonic aircraft.
- **Turbofan Engines:** The most common engine type in commercial aviation, turbofans use a large fan to draw in air, with a portion bypassing the core engine. This bypass improves fuel efficiency and reduces noise, making turbofans ideal for airliners.
- **Turboprop Engines:** These engines combine a gas turbine with a propeller, where the turbine drives the propeller to provide most of the thrust. Turboprops are especially efficient for regional and short-haul flights.
- **Turboshaft Engines:** Similar to turboprops but designed to drive a shaft rather than a propeller, turboshaft engines are widely used in helicopters and other rotary-wing aircraft

2.4 Concorde Aircraft

The Concorde was a masterpiece, the gold standard of aviation engineering. It checked all the boxes: aesthetics, design, speed, luxury, and innovation. Which is why, after over 50 years, it remains one of the most iconic aircraft ever built. The Concorde was the first turbojet-powered supersonic airliner to enter service flying passengers across the Atlantic at twice the speed of sound. Concorde was powered by four Rolls-Royce/SNECMA Olympus 593 turbojet engines mounted in pair under the wings as can be seen in Figure 5.

Figure 5: Concorde Aircraft

The Concorde was a revolutionary supersonic passenger aircraft developed jointly by British Aircraft Corporation (BAC) and Aérospatiale of France. Entering commercial service in 1976 and retired in 2003, the Concorde remains an icon of aerospace engineering. It could cruise at over twice the speed of sound—Mach 2.04 (approximately 1,354 mph or 2,180 km/h)—dramatically reducing transatlantic flight times to just under 3.5 hours (Aviation Week Network, 2022). A recent review highlights how Concorde's remarkable achievements continue to inspire modern supersonic transport research, with new designs targeting efficient cruise speeds between Mach 1.2 and Mach 2.2 while addressing noise and sustainability challenges (Hutchinson, *et al.,* 2021).

Technically, the Concorde was a delta-wing, turbojet-powered aircraft optimized for high-speed, high-altitude flight. It featured four Rolls-Royce/Snecma Olympus 593 afterburning turbojet engines, each producing around 38,050 pounds of thrust (169.3 kN) at takeoff. These engines were derivatives of military-grade powerplants, adapted for civil aviation and capable of sustained supersonic cruise at altitudes around 60,000 feet. The afterburners provided additional thrust during takeoff and the transonic phase of flight before being throttled back for efficient supersonic cruise. Aerodynamically, the Concorde's slender delta wing design was essential for maintaining lift and stability at supersonic speeds. However, such a wing generated less lift at low speeds, requiring a steep angle of attack during takeoff and landing. To enhance pilot visibility during these phases, Concorde employed a distinctive droop nose mechanism—an articulating nose cone that could be lowered to improve the cockpit's field of view and raised during cruise for optimal aerodynamics.

Concorde's structure was built primarily from high-temperature aluminum alloys—specifically, Hiduminium R.R. 58 (also known as AU2GN)—which offered exceptional strength and resistance to creep and thermal stress at the sustained skin temperatures experienced during supersonic cruise (Nasir, *et al.,* 2012). Figures 6 and 7 shows Airbus 320 and Boeing 787 aircrafts. They are both subsonic flights with cruise speeds ranging from 900 to 950 km/h. Figure 8 shows a prototype of a fighter jet named KAI KF-21 *Boramae* (young hawk) developed by South Korea with indonisia as a development partner. The aircraft is due for production in 2026.

Figure 6: The Airbus A320

Figure 7: Boeing 787 Aircraft

Figure 8: KAI KF-21 Boramae

KF-21 has several prototype undergoing testing. The production is set for 2026 by South Korea

2.5 Trends in Jet Engine Technology

The aviation industry continues to evolve, with innovations in jet engine technology aimed at enhancing performance, efficiency, and environmental sustainability (Anderson *et al.,* 2022). Key trends include: Increased Fuel Efficiency, Reduction of Emissions and Noise, Electrification and Hybrid Propulsion, Advanced Aerodynamics and Engine Integration, Sustainable Aviation Fuels (SAFs), Digitalization and Predictive Maintenance.

Gas turbine engines have transformed aviation by powering modern aircraft with high efficiency, reliability, and performance. With ongoing advancements in fuel efficiency, emissions reduction, hybrid-electric propulsion, and digitalization, the future of jet engine technology is poised to meet the challenges of sustainability and environmental responsibility. As the industry continues to innovate, the integration of sustainable aviation fuels and advanced manufacturing techniques will be key to achieving the ambitious environmental targets of the coming decades.

3.0 GAS TURBINE ENGINES ACROSS THE SEA (MARINE APPLICATIONS)

Gas turbine engines have emerged as a prominent propulsion system in the marine industry due to their numerous advantages, including high power-to-weight ratio, compact size, fuel flexibility, and lower emissions. The applications of gas turbines in the marine environment includes propulsion systems for naval vessels, commercial ships, and offshore platforms. This presentation takes into account the design considerations, performance characteristics, operational challenges and future trends in gas turbine utilization at sea.

3.1 Gas turbine engines at sea: where they shine

Marine gas turbines (MGTs) offer unmatched power-to-weight ratio, compactness, rapid start, low vibration, and high specific power—traits prized in naval combatants, high-speed craft, some cruise ships, and in offshore energy where tight topside footprints matter. Their main trade-off is part-load efficiency versus medium-speed diesels, which naval designers typically address with combined or hybrid architectures that keep turbines near efficient operating points. Recent studies highlight how modern ship electric architectures and battery-assisted hybrids help exploit gas-turbine strengths while curbing fuel burn and signatures (Park and Kim, 2024).

3.2 Propulsion architectures that pair well with gas turbine engines

Nowadays, gas turbine engines are used in many different configurations to fulfil the wide range of modern propulsion requirements (Armstrong, 2020). Classical mechanical combinations— the combined cycle diesel or gas turbine (CODOG) systems depicted in Figure 9 utilise a gas turbine for high power requirements and a diesel engine for low power activities. A single diesel engine and a single gas turbine at high speeds power each propeller in a combined diesel and gas turbine (CODAG) system as depicted in Figure 10. Other configurations include combined diesel and gas turbine (COGAG), diesel-electric and gas-turbine boost (CODLAG) and diesel-electric or gas-turbine boost (CODLOG)—let ships cruise economically on diesels or electric motors and sprint on turbines. The rising alternative is integrated electric or hybrid-electric propulsion: turbines (and/or diesels) drive generators feeding propulsion motors and ship service loads through a common bus, often with batteries to buffer transients and enable quiet low-speed operation. Recent naval design analyses show battery-diesel hybrid electric systems can cut fuel by over 20% compared with traditional mechanical layouts (Park and Kim, 2024).

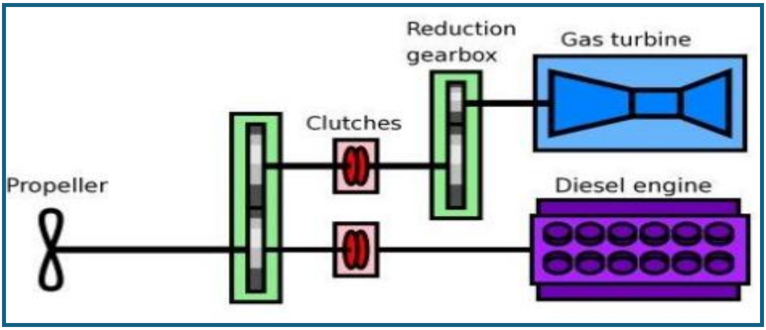

Figure 9: Combined Diesel or Gas Turbine (CODOG) Arrangement

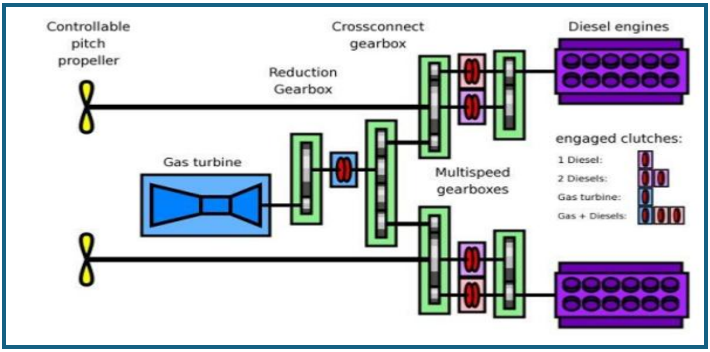

Figure 10: Combined diesel and Gas Turbine (CODAG) Arrangement

Figure 11: NNS ARADU

The Nigerian Navy Ship (NNS) Aradu shown in Figure 11, is powered by two Rolls-Royce Olympus TM3B gas turbines as part of its CODOG (Combined Diesel or Gas Turbine) propulsion system, which also includes two MTU diesel engines.

3.3 Combined Gas turbine Electric and Steam (COGES) and other bottoming cycles at sea

To lift cycle efficiency, several marine platforms adopt COGES (Combined Gas turbine Electric and Steam): a heat recovery steam generator (HRSG) captures turbine exhaust to make steam for a small steam turbine driving a generator on the same bus. Dynamic simulation shows COGES improves fuel consumption and responsiveness for cruise and naval profiles compared with simple-cycle gensets (Hao *et al.,* 2023). Retrofit assessments on Royal Navy frigates confirm notable CO_2 and fuel reductions compared with diesel-dominant baselines (Profir *et al.,* 2024). More advanced cycles such as supercritical CO_2 bottoming units are also being explored for compact waste-heat recovery, offering potential efficiency gains with smaller machinery than steam (Tzanos *et al.,* 2024). Related techno-economic work on ORC bottoming in shipping further validates the promise of turbine exhaust recovery at sea (De Ferri *et al.,* 2023).

3.4 Fuel pathways and emissions compliance

On regulated routes and in Emission Control Areas, international marine organization (IMO) Tier III NO_x limits and tightening GHG targets drive fuel and combustor choices. Aeroderivative turbines burning distillates or natural gas can use dry low-NO_x premixed combustors or water/steam injection to meet NO_x targets (Kimonivasilis *et al.,* 2021). Broader maritime decarbonization studies underscore the trade-space: LNG cuts CO_2 intensity but has upstream methane-slip concerns; for deep decarbonization, hydrogen-capable combustors and ammonia-ready turbines are key research areas. Recent reviews show hydrogen can be blended or fully substituted in modern gas turbines, with work underway to marinize these capabilities (Nazari *et al.,* 2022) Offshore energy: power and mechanical drive

Beyond ships, MGTs are workhorses on offshore platforms and FPSOs, where they generate power and mechanically drive large compressors and pumps. Greenhouse-gas inventories for FPSOs reveal that turbine combustion sources dominate total emissions, motivating efficiency upgrades, waste heat recovery (WHR) integration, and carbon-capture retrofits (Acevedo Blanco and Gallo, 2024). Electrification of offshore platforms using shore power is another strategy, though compact turbine/WHR systems remain vital for remote assets.

3.5 Reliability in the marine environment

Salt, spray, and aerosols make filtration and anti-fouling critical for marine turbines. Compressor fouling from salt-laden air degrades pressure ratio and efficiency; high-efficiency, pulse-cleanable filters and disciplined on-condition washing preserve output and fuel economy over long deployments (Niraula *et al.,* 2018). Field studies demonstrate that improved inlet protection directly translates to longer maintenance intervals and lower life-cycle costs, both for navies and offshore operators.

3.6 What's next

The near-term trajectory is clear: pair gas turbines with electric architectures, batteries, and WHR to harvest efficiency without sacrificing power density, ramp-rate, or footprint. For blue-water navies, CODLAG/CODLOG and integrated electric propulsion with turbine "sprint" blocks provide mission flexibility and growth margin for future high-energy weapons. For offshore and commercial tonnage, COGES/WHR, advanced controls, and selective fuel shifts (e.g., LNG or hydrogen-ready combustors) can deliver compliant, resilient, and compact power where mass and space are at a premium (Hao *et al.,* 2023; Park and Kim, 2024).

3.7 Gas Turbines in Land Applications

Gas turbine engines are very important components in modern energy and industrial systems, widely valued for their compact size, high power-to-weight ratio, and fuel flexibility, and reliability. Since its invention in the 20th century, gas turbines have developed into incredibly effective devices that can power industrial operations, drive mechanical systems in oil and gas sector, and generate electricity.

Power generating, oil and gas operations, and other industrial processes are some of the land applications of gas turbine engine.

i. Power Generation

One of the primary land applications of gas turbines is in electricity generation. Gas turbine engines are a critical component in modern energy generation, offering a flexible and efficient method for converting fuel into electricity. Gas turbines are integral to power plants, particularly in the context of electricity generation and have become an essential part of the global energy infrastructure. Their operation is based on the Brayton cycle, a thermodynamic process where air is compressed, mixed with fuel, and then ignited. The combustion gases expand rapidly, driving a turbine that is connected to a generator, producing electricity. This process is highly efficient and can be quickly adjusted to meet varying electricity demands. Gas turbines are employed in:

- **Simple Cycle Power Plants**: These plants operate with high thermal efficiencies at large scales and are suited for peak-load operations due to fast start-up times. Figure 12 shows a **s**imple cycle gas plant and Figure 13 shows a single-cycle/two shafts gas turbine.

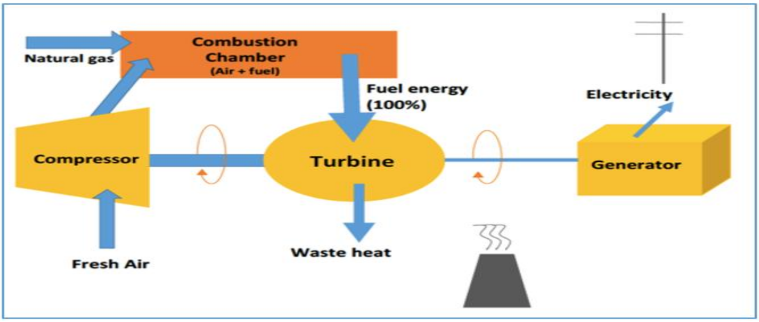

Figure 12: This is a Schematic Diagram of a Simple Cycle Gas Plant

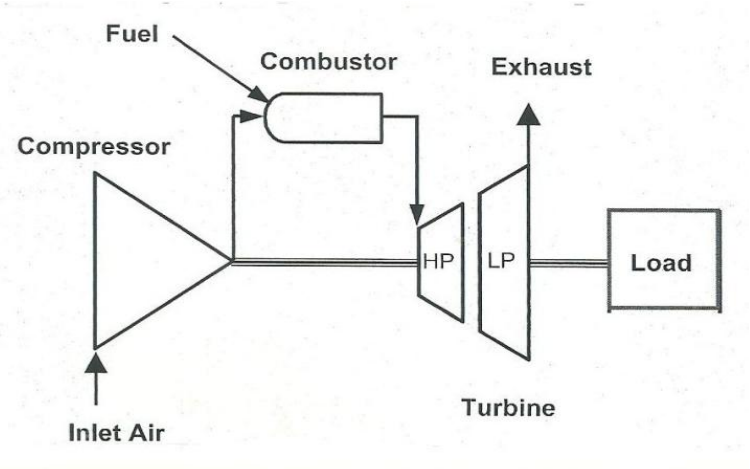

Figure 13: Schematic Diagram for a Single-cycle/Two Shafts Gas Turbine

- **Combined Cycle Power Plants (CCPPs)**: By using a Heat Recovery Steam Generator (HRSG), waste heat from the gas turbine is used to produce steam, which drives a steam turbine. This setup significantly improves overall efficiency, often exceeding 60%. Figure 14 shows a schematic diagram of combined cycle power plant.

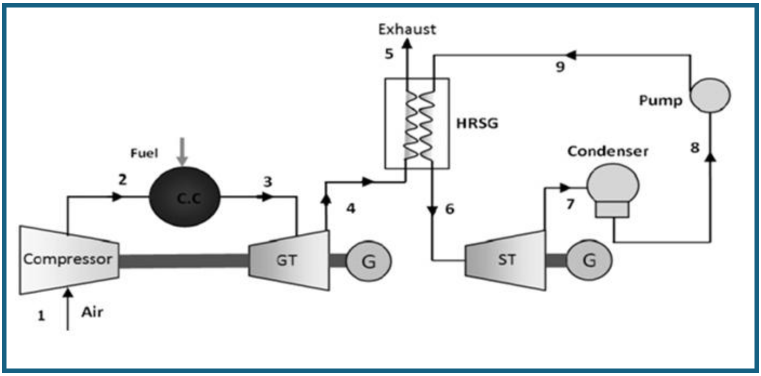

Figure 14: Schematic Diagram of Combined Cycle Power Plant

ii. Oil and Gas Industry

Gas turbines play a critical role in the oil and gas industry, particularly for mechanical drive

purposes, where they convert thermal energy from fuel combustion into rotational mechanical power. This mechanical power is then used to drive key equipment such as compressors, pumps, and generators in various segments of the oil and gas value chain from upstream exploration and production to midstream transportation and downstream refining. Gas turbine engines are widely used as prime movers for pumps in crude oil and refined product pipelines and also in Offshore platforms for supplying compact and reliable power and mechanical energy in remote environments. One of the most prominent applications of gas turbines in this sector is natural gas pipeline compression, natural gas loses pressure as it travels through pipelines over long distances. To maintain flow rates and pressure levels requires compressor stations.

4.0 MY CONTRIBUTIONS

4.1 Challenges of Blades of Gas Turbine Engine

Damages to **blades of aero and aeroderivative gas turbine engines** are among the most critical maintenance and safety issues in aviation and other applications of gas turbine because the blades operate under **extreme mechanical, thermal, and aerodynamic stresses.** Many aviation accidents are caused by the failure of aircraft engine components, and engine blades are especially vulnerable to high-cycle fatigue fracture in severe working environments as well as to impact damage caused by foreign objects.

4.2 Optimization of the cooling process in gas turbine blades

Gas turbines operate in extremely difficult working settings since they are frequently installed in remote areas like jungles, deserts, offshore platforms, and Floating Production Storage and Off-loadings (FPSOs). The performance and dependability of a gas turbine are threatened by operational conditions and harsh environmental factors such as offshore and coastal salt aerosols, large concentrations of pollutants such as sand, dust, and shot debris from drilling, and extreme weather conditions. The operating environment of gas turbines, such as the high levels of airborne particulate, salt ingress, and high operating temperatures, are some of the difficulties experienced by aeroderivative gas turbine engines in the petroleum sectors. The contemporary gas turbine engines function at elevated temperatures to raise their efficiency and performance; however, the turbine blades' material melting point might be exceeded by the high temperatures since the melting point of most blade materials are in the range of 1200°C to 1500°C (Geddes *et al.,* 2022). This situation most often leads to the breakdown of the interior components. Thus, this research optimised the cooling process in gas turbine blades using the

Computational Fluid Dynamics technique to develop a numerical code for temperature distribution modelling in a cooled turbine blade and a lifing model for gas turbine blades, and also simulating and optimizing the gas turbine cooling process. Figure 15 shows a new and an in-service damaged blades.

Figure 15: Gas Turbine Blades: (A) – a new turbine blade, (B) – the in-service damaged one (Orah *et. ai.,* 2019)

A numerical model - an alternating direction implicit (ADI) scheme, was adopted to develop numerical codes for temperature distribution predictions within the blade metal walls in this research. At the same time, the convective heat transfer coefficient of the cooling process was determined by employing the Newton's law of cooling equation.

The variation in temperature within the blade metal relating to time is shown in Figure 16. The convective heat transfer process yielded a mean blade metal temperature of about 400°C. This is within safe, operable temperature for the blade life sustainability which is good, and it conforms with the studies of Boyce (2012) which stipulated that blade metal temperature must be maintained below 704°C because blade metal temperatures exceeding 790°C are susceptible to hot corrosion. Figure 17 indicates the 3-D plot of the temperature distribution across the nodes within the blade metal in relation to time.

It signifies that the temperature distribution in all the nodes was significantly uniform in each time duration. It implied a convective cooling process since the air cools the blades as it moves through the cooling channels.

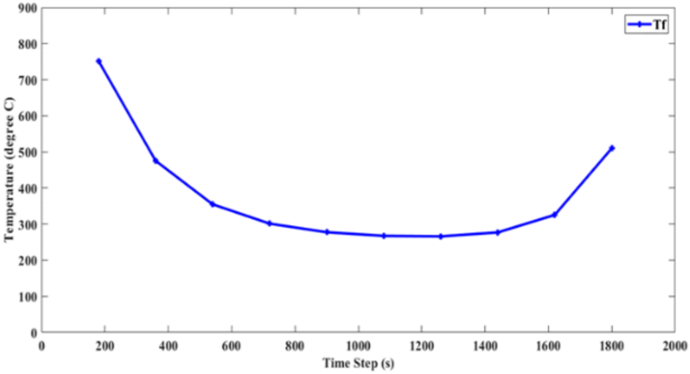

Figure 16: Temperature Distribution Curve for the Blade in relation to Time

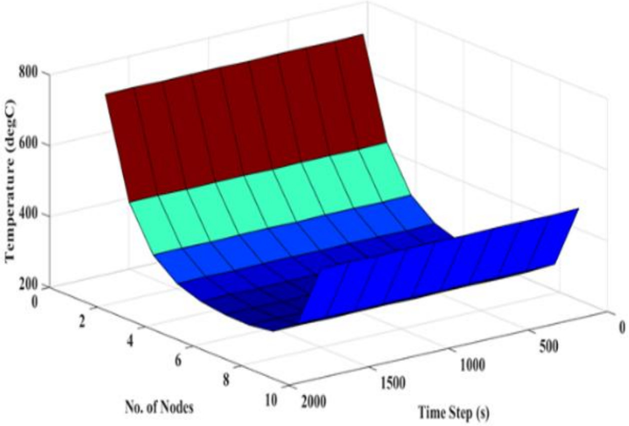

Figure 17: 3-D Temperature Distribution Plot varying with number of nodes and time

A numerical model - an alternating direction implicit (ADI) scheme, was adopted to develop numerical codes for temperature distribution predictions within the blade metal walls in this research. At the same time, the convective heat transfer coefficient of the cooling process was determined by employing the Newton's law of cooling equation. On the other hand, a lifing model for blade life estimation was also developed using the damage summation equation. However, oxidation and creep damage mechanisms were examined through the Kadioglu-Sehitoglu Thermomechanical Fatigue (TMF) damage frameworks. Furthermore, the dynamic model of an aeroderivative gas turbine was used to simulate and optimise the cooling process in the gas turbine blades. The modelling scheme was implemented using the Tools for Modelling and Analysis of Thermodynamic Systems (TMATS) in MATLAB routine. The results obtained showed that the mean blade metal temperature was 400°C with a heat load of 991.25W and heat transfer coefficient of 195.54W/m^2.K for the cooled turbine blade, and the estimated blade life was found to be 64,200 hours for aeroderivative gas turbine engines applied for land-based and marine based operations with fatigue and oxidation as the main factors affecting TMF life in a gas turbine blade. The results also revealed that mass flow rate has a significant effect on the cooling effectiveness of the blade than the ambient temperature. The mass flow rate yielded an average cooling effectiveness of 50 %, while ambient temperature yielded an average cooling effectiveness of 40 %. Optimal values of 5°C (278K) were obtained for the ambient temperature and 8.5kg/s for the mass flow rate for an effective cooling process. However, it suffices to note that a 2-D convective heat transfer analysis was done in this study, therefore, a 3-D approach involving blade thickness for convective heat transfer should be considered to allow for robust generalization.

4.3 Impact of Component degradation in Gas Turbine Performance

Component degradation is a very common problem associated with operating industrial gas turbines. The hot gas component of the gas turbine engine comprises the burner, the turbine stages, and the exhaust nozzles/ducts. However, the turbine blades experience high thermal and mechanical loading (Orah, et al., 2021). In some location, compressor fouling is due to large amount of mixture of sand and oil in engine operating environment. Particularly, in the desert, the weather is highly sandy and dusty most times, therefore, this problem becomes even more obvious when gas turbines operate in the desert. In a dusty and sandy environment the fine particles mixed with vapour may enter the engine and deposit on the compressor blades. Meanwhile, degradation could also be as a result of ageing. Sometimes, combustion chamber got stacked with the impurities from the fuel and also the turbine creep life is reduced as a result of thermal stress. However, the resultant effect of all these is degradation. The purpose of this research is to study the effect of degradation on gas turbine performance. The study involves the analysis of operating parameters for Siemens gas turbine engines model SGT 5 – 2000E coded GT11 and GT21 in the power stations. The parameters considered were ambient temperature, exhaust temperature, combustion chamber pressure and turbine entry temperature, GT 11 is degraded while GT 21 is newly installed engine both in the same location at Geregu I and II power stations in Ajaokuta, Kogi State in the North central part of Nigeria. Simulations were carried out using Gas turb 11 simulation software, results of engine performance parameters were compared. A case study shows that due to component degradation, the TET increased to 1322.67K, the fuel flow increased by 8.49% and power falls by 7.14%. The analytical approach has shown to be very useful and could be applied to similar gas turbine engines used in power generation station as well as other industrial application. However, the method used in this research work can be adopted by the maintenance engineers to monitor the trend of components degradation in gas turbine engines for maintenance reliability.

Figure 18: Degraded Turbine Blade Tips. (Nasir, *et. al.,* 2016)

Figure 19 shows the power output of a newly installed and degraded engine. The two engines were meant to operate on base load at output of 145MW. From Figure 19, below, it could be observed that as a result of component degradation, the degraded engine could not achieve the expected output at base load while the newly installed engine could even achieve above the expected Megawatt if the operating conditions are favourable.

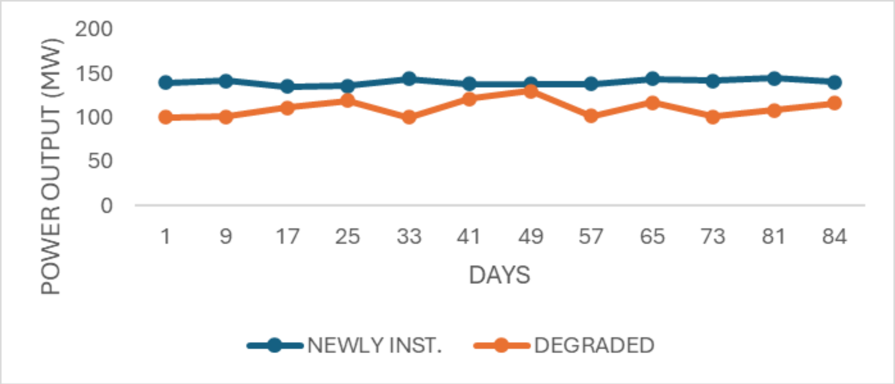

Figure 19: Power Output of a Newly Installed and Degraded Engine

The graph compares **power output (MW)** of **a newly installed gas turbine** and a **degraded gas turbine** over an operating period of approximately **85 days**. It clearly illustrates both the **magnitude** and **pattern** of performance degradation.

- The **newly installed turbine** maintains a relatively **stable output band of about 135–145 MW**, with only minor fluctuations attributable to ambient conditions and normal operational variability.
- The **degraded turbine** operates at a **significantly lower output level**, typically between **100 and 130 MW**, and exhibits **larger fluctuations**.

This immediately indicates that degradation affects not only **average power output** but also **operational stability.**

Using approximate values from the Figure 19,

- **Average new turbine output: ≈ 140 MW**

- **Average degraded turbine output: ≈ 110–115 MW**

The average power loss is $\Delta \mathbf{P} \approx \mathbf{25 - 30\ MW}$

The percentage degradation is $\frac{\mathbf{25}}{\mathbf{140}} \times \mathbf{100} \approx \mathbf{18\%}$

The o**bserved degradation-induced power loss is approximately 15–20%,** which is consistent with **moderate-to-severe compressor and hot-section degradation** in industrial gas turbines without recent major maintenance.

4.3.1 Economic Implication of the power loss

From the power loss of 25 MW and annual operating hours of 8000 hours,

$$\text{the average annual energy loss} = 25\ MW \ \times 8000\ h = 200{,}000 \frac{MWh}{year} = 2 \times 10^8 kWh/year$$

The electricity price in Nigeria ranges from ₦ 40 - ₦ 60 per kWh, computed using both boundary values.

Case 1 — ₦ 40 per kWh

$$Revebue\ loss = 2 \times 10^8 \times 40 = ₦8{,}000{,}000{,}000 = ₦8\ billion\ per\ year$$

Case 2 — ₦ 60 per kWh

$$Revebue\ loss = 2 \times 10^8 \times 60 = ₦12{,}000{,}000{,}000 = ₦12.0\ billion\ per\ year$$

Direct revenue loss from turbine degradation in Nigeria is on the order of ₦ 8–₦ 12 billion per annum, assuming 25 MW of lost capacity and 8,000 operating hours.

4.4 Development of a Complex Model for Gas Turbine Application in Natural Gas Pipeline Network

Natural gas being the cleanest fossil fuel today is receiving tremendous rise in demand for both industrial and domestic energy requirements. The availability of natural gas requires it to be transported from the production area through pipeline in most cases to the consumers; this requires compressor station mostly driven by gas turbine (Nasir *et. al.*, 2012). The development of gas pipeline system requires important data such as appropriate pipe sizes, gas rate, required delivery pressure, appropriate compressor and gas turbine sizes. The investment for the pipeline and compressor station is capital intensive and therefore the techno-economic and environmental risk assessment tool to rapidly assess a natural gas pipeline project becomes imperative. Figure 20 shows a natural gas pipeline.

Figure 20: Natural Gas Pipeline (Nasir et al, 2012)

Figure 21 shows natural gas pipeline infrastructure compring injection, partial delivery, compressor and final delivery stations.

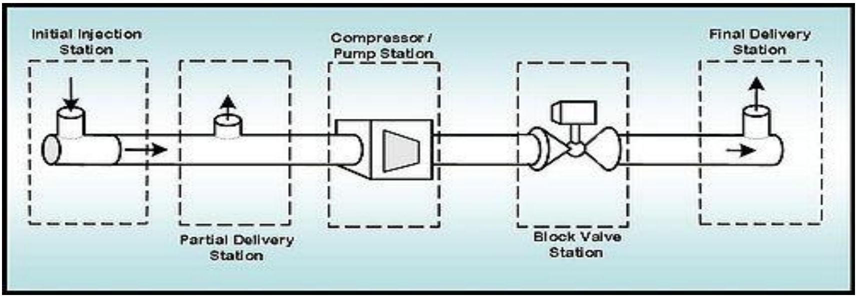

Figure 21: Natural Gas Pipeline Infrastructure (Nasir, *et al.*, 2013a)

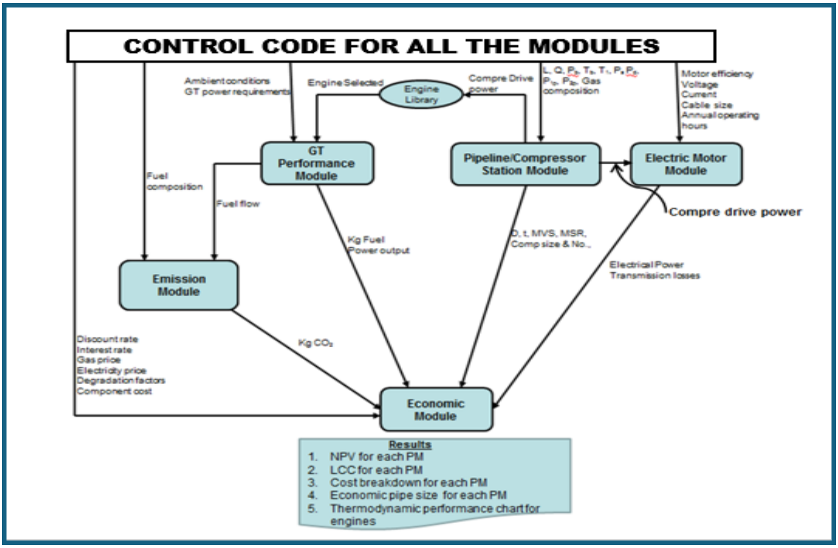

Figure 22:TERA Model for Pipeline Methodology (Nasir, 2013)

Figure 22 presents the development of a **single, unified analytical framework** that simultaneously evaluates technical performance, life-cycle economics, environmental impact, and risk exposure.
This integration is still limited in many pipeline compression studies.
Techno-economic and environmental risk assessment framework was developed to evaluate and compare **gas turbine–driven**

compressors and **electric motor–driven compressors** for natural gas pipeline transportation. This methodology represents a **robust, decision-oriented framework** that advances both academic understanding and industrial practice in natural gas pipeline compression by integrating technical modeling, economic evaluation, environmental assessment, and risk analysis into a single coherent approach.

4.4.1 Design and Off-design Performance Module

In carrying out gas turbine design point simulations, a pressure ratio, component efficiencies and maximum cycle temperature are selected to achieve a required engine performance. The design point simulation determines the thermal efficiency and airflow rate for a given power demand. The modelling and performance simulation of gas turbine engines of simple cycles, but of different configuration and output power, were carried out using TURBOMATCH. Model results of gas turbines of 40.7MW Simple Cycle Two Shaft (SCTS) model and a 33.6 MW Single Spool Simple Cycle model (SSSC) are presented.

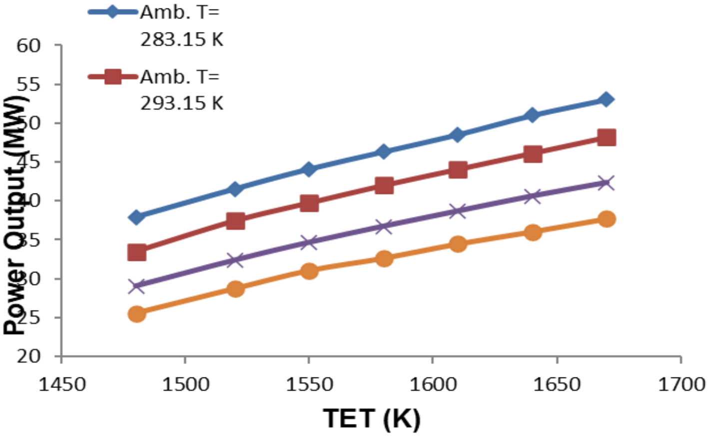

Figure 23: Power Output against Turbine Entry Temperature (TET) for 40.7 MW SCTS

From the trend in Figure 23, the power–temperature relationship is approximately linear over the normal operating range.

- **TET range:** approximately **1100 K to 1500 K**
- **Power output range:** approximately **30 MW to 40.7 MW**
- An increase in TET of about 100 °C results in an increase in power output of approximately 3.0–4.0 MW.
- This corresponds to an average power sensitivity of about 0.03–0.04 MW/°C (i.e., 30–40 kW per °C) and each 10 °C increase in TET yields roughly 0.3–0.4 MW additional power, highlighting why TET control is a critical lever for short-term power augmentation, even though with implications for component life and maintenance costs.

This sensitivity reflects the increase in turbine specific work with higher firing temperature, while compressor work remains nearly unchanged. However, at higher TETs, the effective gain per degree may reduce slightly due to cooling air extraction and thermal limits.

4.4.2 Material and Cooling Limits

- Turbine blade metal temperature limits (~1050–1150 K)
- Advanced cooling allows gas temperatures >1400 K
- Each **10 K increase in TET can reduce blade life by ~15–20%** if unmitigated

For Economic Implications

Assuming:

- Capacity factor = 0.9
- Electricity value = ₦ 60/kWh

An increase of **100 K TET** gives ≈ **2.7 MW additional power**

Annual energy gain=2.7×0.9×8760 ≈ 21,300 MWh
Annual revenue gain≈21,300×60=₦ 1.28 billion/year

This highlights why OEMs aggressively pursue higher TET through materials and cooling innovation. TET remains the single most influential parameter for power uprating in simple-cycle gas turbines

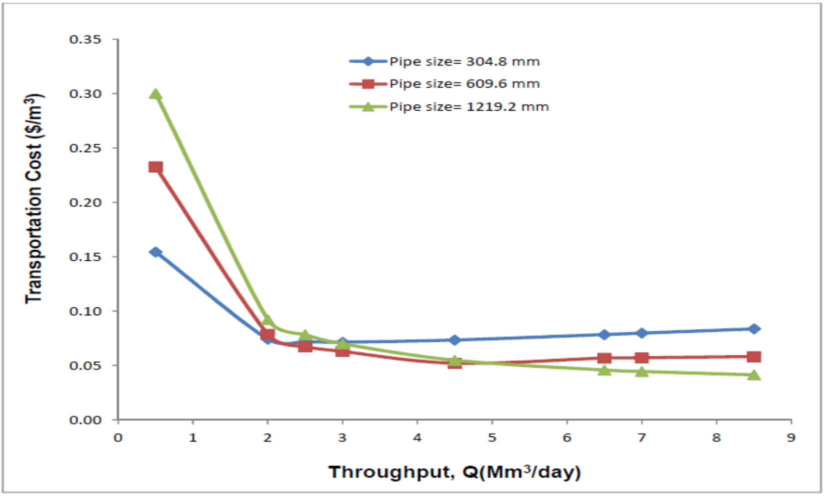

Figure 24: Cost Per Unit of Gas Variation with Throughput for Different Pipe Sizes

Figure 24 shows a pronounced inverse relationship between **cost per unit of gas transported** and **throughput** for all pipe diameters. At low flow rates, unit costs are high due to poor utilization of capital-intensive infrastructure. As throughput increases, unit costs decline sharply, reflecting strong economies of scale.

- At **low throughput (<2 Mm³/d)**:
    - The **smallest diameter** pipeline (304.8 mm) has the **lowest cost** because its capital cost is lowest.

    - For a throughput of 0.5 Mm³/day, the economic pipe diameter is 304.8 mm (12″), yielding a transportation cost of \$0.15/m³ (\$3.95/GJ). Despite being the minimum-cost option, this value far exceeds typical pipeline transport benchmarks, clearly indicating that long-distance interstate transportation at this flow rate is uneconomical (Nasir, *et. al.,*2013b).
    - Larger diameters have higher fixed costs that are inefficient at low volumes.
- At **moderate throughput (~2–6 Mm³/d):**
    - All diameters converge to similar unit costs because increased flow allows better utilization of pipe capacity.
    - This suggests an **economically optimal flow range** where choice of diameter is less sensitive.
- At **high throughput (≥7–8 Mm³/d):**

- The **largest diameter** (1219.2 mm) shows the **lowest transportation cost**, since bigger pipes reduce frictional loss and compressor work despite higher capital cost.
- Smaller pipes become increasingly expensive per unit volume due to compressor energy and operational costs.

This pattern reflects the pipeline cost optimization trade-off: using a larger diameter increases capital cost but reduces *variable cost* (energy and compression), while a smaller diameter saves capital at the cost of higher operational expenditures (Nasir *et. al.,* 2013b)

4.5 Optimization of Compressor Station Location and Power Plant Sizing

Optimization is an act, process, methodology or procedure(s) used to make a system or design as effective or functional as possible. It could involve maximizing or minimizing a function called the objective function, subject to certain constraints imposed on the variables of the function. The objective function and constraints can be linear or nonlinear; the constraints can be bound constraints, equality or inequality constraints, or integer constraints. Figure 25 shows the optimization process.

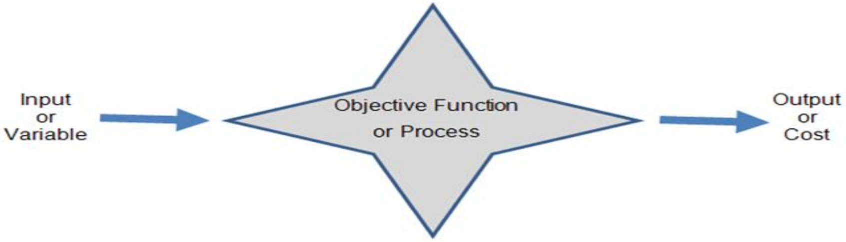

Figure 25: Optimization Process

Genetic Algorithms (GA) which are part of the group of Evolutionary Algorithms (EA) are direct, parallel, stochastic methods for global search and optimization, which imitates the evolution of the living beings, described by Charles Darwin.

The first step in the implementation of a GA is the establishment of an objective function. This is a function that calculates the fitness of each member of the population or simply the function to optimize. The optimization in MATLAB is set to minimize by default but in order to maximize an objective function, a negative is simply set to the function and it is minimized. In this research, the objective function which is the total cost pertaining to the application of gas turbine as a driver for pipeline compressor is meant to be minimized. The objective function is given in equation 6.1

$$Objective\ function = C_{GTCAP} + C_{GTFUEL} + C_{GTOM} + C_{GTEMISSION} + C_{COMPRESSOR}$$

The variable parameter used here is the available gas turbine power. The parameter varies between a minimum and a maximum with the intent of finding a gas turbine power that will yield the minimum total cost with due cognisance to the constraint of maximum allowable operating pressure (MAOP) of the pipeline which dictates the maximum gas turbine power.

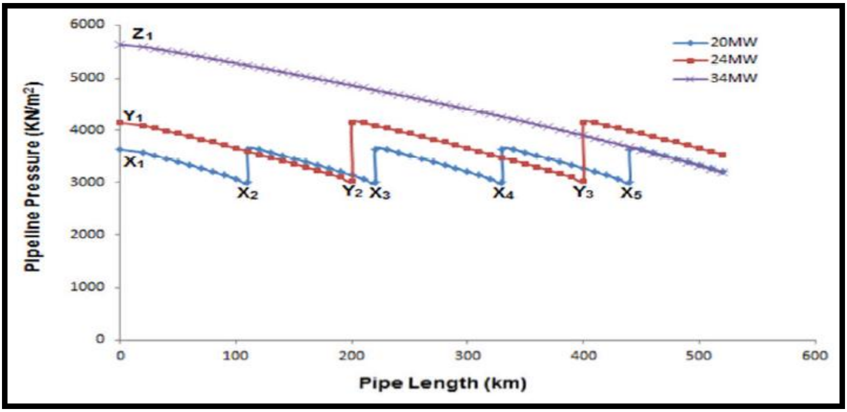

Figure 26: Pipeline Pressure Profile and Compressor Location for Varying Drive Power

Figure 26 illustrates how compressor station location and number vary with drive power along the 512 km pipeline. At 20 MW, a discharge pressure of 36.4 bar limits station spacing to about 110 km, requiring multiple stations (about five) to maintain the minimum operating pressure of 30 bar. Increasing the drive power to 24 MW raises the discharge pressure to 41.4 bar, thereby extending the spacing to about 200 km, but still necessitating additional booster stations. In contrast, a 34 MW compressor delivers a discharge pressure of 56.3 bar, allowing the gas pressure to remain above **30 bar** over the entire 512 km pipeline, thus requiring only one compressor station, with pressure reduction at the city gate. Overall, the results show that fewer high-power compressor stations are more economical and operationally efficient than many low-power units, particularly for long-distance pipelines.

Throughout the study, hydraulic balance was maintained and this makes it possible for all the compression equipment to be identical. This will reduce inventory of spare parts and minimize maintenance.

4.6 Investigation of Pressure Transients and Effects of Wave Propagations Due to Instantaneous Valve Closure in a Pipeline Transporting Premium Motor Spirit (PMS)

The study adopted a numerical simulation–based transient hydraulic analysis to investigate pressure surges and wave propagation in a pressurized petroleum pipeline transporting Premium Motor Spirit (PMS). The methodology is appropriate given that hydraulic transients are inherently unsteady phenomena that are difficult to capture analytically for complex pipeline networks.

The transient analysis was carried out using WANDA Transient **4.5.1210**, which is based on the Method of Characteristics (MOC)**.** The choice of MOC is technically sound, as it is widely regarded as the most robust and industry-accepted approach for solving the governing hyperbolic partial differential equations of unsteady flow in pipelines (Muhammad *et. al.,* 2020a).

Figure 27 represents a pressurised pipeline transmission system comprising a source, a driven compressor unit, intermediate control and isolation devices, and a downstream delivery section. The flow direction is left to right, as indicated by arrows.

The pipeline is discretised into sections (A–H), with pressure measurement points (P1–P4) and control elements strategically placed to monitor and regulate flow and pressure.

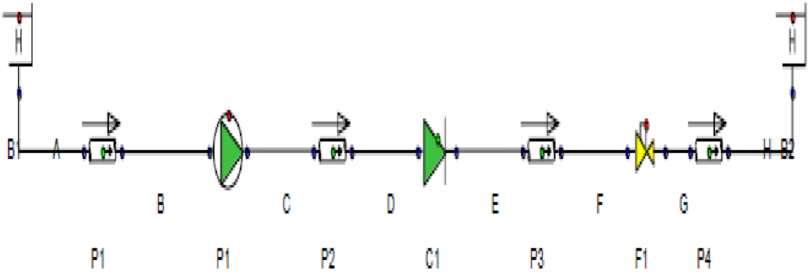

Figure 27:Pipeline Network System showing Nodes A-G

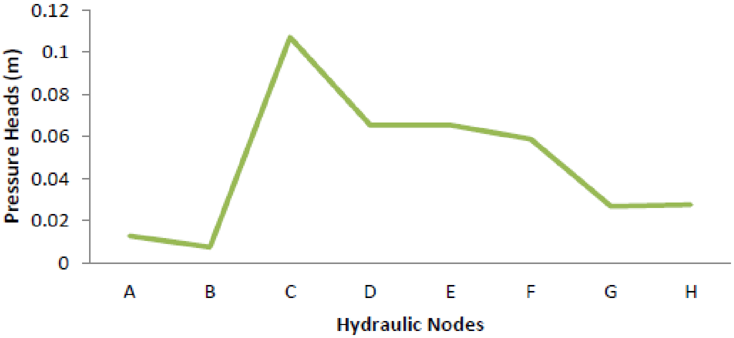

Figure 28: Pressure Heads at Various Hydraulic Nodes of the Pipeline

Figure 28 presents the pressure head (m) variation along discrete hydraulic nodes (A–H) of the pipeline. The profile reflects the combined influence of compression, frictional losses, throttling effects, and downstream demand conditions. The non-monotonic shape confirms that the system includes active components (e.g., a pump or compressor) rather than a purely gravity-driven or passive pipeline (Muhammad, *et. al.,* 2020b).

The pressure head distribution across nodes A–H clearly illustrates a pipeline system with centralized pressure boosting**,** followed by progressive energy dissipation toward the outlet. The hydraulic behaviour is consistent with well-designed pressurized PMS pipeline operation, where pressure is elevated strategically and allowed to decay in a controlled manner to meet downstream delivery requirements safely and efficiently.

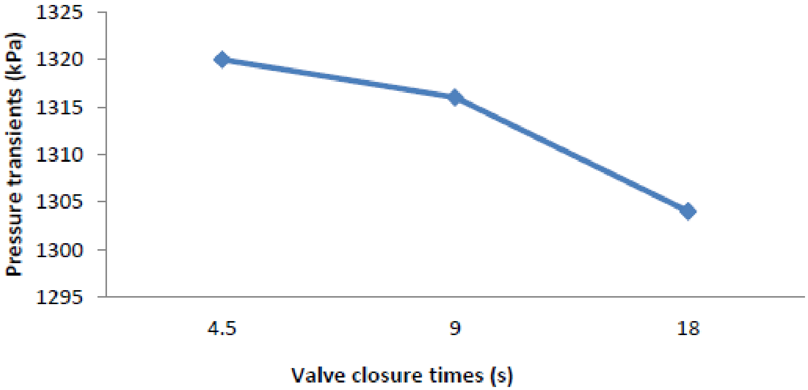

Figure 29: Comparison of pressure transient in the pipeline network at different valve closure times

The graph of Figure 29 depicts that pressure transients due to instantaneous closure of a gate valve in a petroleum pipeline transporting PMS reduces as the valve closure time increases. The transient analysis demonstrates that instantaneous gate-valve closure in a PMS pipeline generates **severe** pressure surges and depressions that propagate as elastic waves along the pipeline at the acoustic wave speed (~1160 m/s). These waves produce alternating high-pressure peaks (water hammer) and low-pressure troughs (cavitation)**,** with the most critical effects occurring near the valve and pump locations. Therefore, in a pipeline network, it is better to have a longer valve closure time so as to reduce or eliminate the possibility of pressure transients, column separation or the formation of cavitations voids that may eventually lead to pipeline failure.

CONCLUSION

In reflecting on *“Bridging Domains with Blades: Gas Turbine Engines for Sustainable Energy and Propulsion across Air, Land, and Sea,”* it is evident that the gas turbine engine remains more than just a machine of thrust and power, it is a symbol of human ingenuity, adaptability, and the quest for sustainable progress.

Mr Vice Chancellor sir, Distinguished ladies and gentlemen, the journey so far has shown that the true strength of gas turbine technology lies in our ability to understand and manage the complex thermal and mechanical realities that govern gas turbine blade performance, reliability, and operational lifespan. Therefore, from the foregoing, it indisputable that:

Quantitative modelling of degradation effects reveals that gas turbine inefficiencies translate directly into substantial economic losses, especially in power generation systems, thereby establishing degradation-aware performance monitoring as both an engineering and policy imperative.

Optimised cooling strategies, driven more by mass-flow control than ambient conditions, provide a practical pathway to extending blade life while maintaining high turbine entry temperatures, enabling improved performance without compromising component integrity

Integrated techno-economic and environmental modelling frameworks significantly enhance decision-making in gas turbine–driven natural gas pipeline and energy infrastructure, demonstrating that holistic system-level analysis yields superior outcomes compared with isolated technical optimisation

Across aviation, marine, and land-based applications, gas turbines remain unmatched in power density and operational flexibility, confirming their enduring relevance despite evolving energy and emissions constraints

Overall, this body of research affirms the gas turbine as a strategic bridging technology—technically, economically, and environmentally—supporting energy security, industrial productivity, and sustainable development across multiple domains

RECOMMENDATIONS

In order to mitigate potential and huge financial loss as a result of gas turbine engine degradation, real-time performance diagnostics in grid-connected gas turbines should be mandated, thermodynamic health audits at defined operating intervals is recommended and to incentivize predictive maintenance technologies through regulatory framework.

TET is the most influential parameter for gas turbine power augmentation. A 100 K increase may yield ≈2.7 MW additional output but significantly reduces blade life if not properly managed, therefore operational TET standards aligned with material and cooling limits should be established. Advanced blade materials and cooling research through targeted funding should be promoted..

To improved capital efficiency, reduced emissions exposure, and enhanced investment confidence, integrated techno-economic-environmental modelling should be made mandatory for major gas pipeline projects. And national guidelines for gas turbine vs. electric motor compression selection should be developed. Environmental risk metrics should be embed into energy infrastructure approval processes.

In order to maintain lower life-cycle costs, reduced operational complexity, and improved system resilience natural gas pipeline compression project, high-power compression station optimization for interstate gas transmission is encouraged, and hydraulic balancing to standardize equipment across networks should be promoted.

To eliminate severe pressure surges (water hammer), increasing risk of cavitation and structural damage in petroleum and gas pipeline, minimum valve closure time standards in petroleum and gas pipelines should be mandated and transient hydraulic analysis for new pipeline be an approval requirement.

To reduced fuel intensity, lower emissions, improved national energy productivity. conversion of simple-cycle plants to combined-cycle configurations should be encouraged and incentivize, waste heat recovery in offshore and industrial installations should be promoted and there should be intensive support for hybrid-electric propulsion research for marine applications.

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With the kind permission of the Vice Chancellor, I respectfully request that my beloved wife be allowed to stand while I make this acknowledgement as a token of public recognition of her immeasurable contribution to my life and career. I express my deepest and most heartfelt gratitude to my darling wife for her unwavering support, love, patience, and understanding. Through every challenge, late night, and professional commitment, she has stood firmly by my side with grace and steadfast faith. Behind every milestone I have achieved lies her quiet sacrifice, constant encouragement, and unshakeable belief in me. She has fully shared in the burdens and responsibilities of my academic career, and her support has been truly invaluable to this moment.

My darling, thank you for the love, understanding, laughter, and for raising our wonderful and well-behaved children. May Allah bless you abundantly. I love you more. Please sit.

To our beloved children — Al-Amin, Maryam, Aisha, Nasir, and Khadijat—you are my pride and joy. May Allah bless and guide you always. I also extend my sincere appreciation to Aunty Halima, Uncle Abdullahi, and family for their consistent support.

Distinguished ladies and gentlemen, I thank you all, and may Allah reward you all abundantly.

ALL ENGINES ARE MACHINES BUT NOT ALL MACHINES ARE ENGINES
MY VICE CHANCELLOR SIR, DISTINGUISHED INVITED GUEST, GREATEST FUT MINNA STUDENTS, LADIES AND GENTLEMENT

I AM DONE

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PROFILE OF ENGR. PROF. ABDULKARIM NASIR, FNSE, FNIMechE

Engr. Prof. Abdulkarim Nasir, NIMechE, is a distinguished Professor of Mechanical Engineering with about three decades of academic, professional, and research experience spanning Nigeria and the United Kingdom. He obtained his Bachelor of Engineering (BEng) in Mechanical Engineering and Master of Engineering (MEng) in Thermofluid, Power Plant, and Automotive Engineering from the Federal University of Technology, Minna (FUT Minna). It is worthy of note that Prof. Abdulkarim Nasir was the first and the only postgraduate student of the School of Engineering and Engineering Technology. FUT Minna in the 1993/94 academic session —a pioneering milestone in the university’s academic history.

He earned his PhD from the prestigious Cranfield University, United Kingdom, a specialist postgraduate institution, where his research focused on gas turbines and natural gas pipeline systems in the oil and gas industry. His doctoral work produced a novel, robust, coherent, and decision-oriented framework that significantly advanced both academic knowledge and industrial practice in natural gas pipeline compression. This groundbreaking research earned him the Outstanding PhD Research Award jointly conferred by the American Society of Mechanical Engineers (ASME) and the International Gas Turbine Institute (IGTI). In recognition of his exceptional research talent, he was endorsed by the

Royal Academy of Engineering, UK as having exceptional talent, leading to the award of a Global Talent Visa by the UK Home Office. The impact of his PhD research was such that it led to the establishment of a new research group at Cranfield University—TERA for Oil and Gas—further cementing his status as a trailblazer in the field. While at Cranfield University, Prof. Abdulkarim Nasir was elected President of the Cranfield Students' Association, becoming the only Black man who was a university president in the United Kingdom during that period.

To strengthen his pedagogical competence, Prof. Nasir obtained a Postgraduate Diploma in Education (PGDE) from the University of Ilorin. He has since demonstrated outstanding commitment to teaching and mentorship, having supervised over 100 undergraduate projects, more than 15 master's dissertations, and 8 PhD theses. His scholarly output comprises over 80 publications, including peer-reviewed journal articles, conference papers, and book chapters. He has presented his research at globally renowned platforms such as the ASME Turbo Expo in four different countries and won Best Poster Award during ASME Turbo Conference (2010) in Glasgow, Scotland. He has presented conference papers a couple of times at the World Congress on Engineering at Imperial College London.

Prof. Abdulkarim Nasir is a Fellow of the Nigerian Society of Engineers (FNSE) and a recipient of the Nigerian Society of Engineers Presidential Award for his immense contribution to the advancement of engineering practice, academic scholarship, research innovation, and the mentorship of the next generation of engineers. He is also a Fellow of the Nigerian Institution of Mechanical Engineers (FNIMechE) and a recipient of the Nigerian Institution of Mechanical Engineers Award of Excellent Achievement in Honour of his outstanding contributions to the development of the society, exceptional achievements in his field of expertise and relentless pursuits of excellence. He is a registered engineer with the Council for the Regulation of Engineering in Nigeria (COREN), a certified teacher with the Teachers Registration Council of Nigeria (TRCN), and a member of the International Association of Engineers (IAEng).

Beyond academia, he has made remarkable contributions to engineering regulation, accreditation, and professional development in Nigeria. He currently serves as Chairman of the National Technical Committee on the Development of Codes and Standards for Equipment in the Oil and Gas Industry under the Standards Organisation of Nigeria (SON). He previously served as Chairman of the COREN Training and Certification Committee and he is currently a member of the Engineering Accreditation Committee (EAC) of COREN. He has led COREN and NUC accreditation exercises across several Nigerian universities and currently serves as an external examiner for undergraduate and postgraduate programmes in multiple institutions. He is also the Chairman of the Engineering Residency Programme Development Committee of COREN.

Within the university system, Prof. Abdulkarim Nasir has served in numerous leadership roles, including Head of the Department of Mechanical Engineering and Deputy Dean of the School of Engineering and Engineering Technology at FUT Minna. He has also served as a departmental and school examination officer, academic adviser, and member of several strategic committees within and outside the university.

Professionally, he was Chairman of the Nigerian Society of Engineers (NSE), Minna Branch (2021–2023), he was also a Distinguished Member of the COREN Council representing the North-Central States, and currently represents Nigeria on the Board of the International Society of Air-Breathing Engines (ISABE), headquartered in Indianapolis, Indiana, USA.

Prof. Nasir is also an accomplished consultant and technical advisor. He has led feasibility studies for renewable energy projects, including UNIDO-funded mini-hydropower systems, and collaborated with the Nigerian Air Force on the design and testing of solid-fuel rockets. In 2008, he led the team that designed and successfully fired Nigeria's first indigenous solid-fuel rocket at the FUT Minna Gidan Kwano Campus.

A dynamic researcher, seasoned engineer, accomplished administrator, and proactive, results-driven professional, Prof. Abdulkarim Nasir is widely respected for his intellectual depth, leadership acumen, and commitment to national development. He teaches a broad range of undergraduate and postgraduate courses, including thermodynamics, fluid mechanics, heat and mass transfer, energy systems, turbomachinery design, thermal power systems, and fluidization. He is particularly admired for his engaging teaching style, dedication to mentorship, and ability to inspire future generations of engineers- qualities that reflect not only his professional excellence but also the strong values that underpin his family life.

Engr. Prof. Abdulkarim Nasir is happily married to Engr. Dr. Hauwa Talatu Abdulkarim, and they are blessed with children.

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