© SEP 2026 | IRE Journals | Volume 10 Issue 3 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I3-1723191

Manufacturing and Installation of Aero Derivative Gas Turbine – In line with the Nigerian Industrialization Project

SHAIBU EROMOSELE. MENG, MNSE
University of Port Harcourt, Department of Mechanical Engineering

Abstract- Manufacturing is one of the critical stages in industrialization. The three layer knowledge graph of concept, model and decision layer was proposed for the manufacturing of aeroderivative gas turbine. The major components studied and billed for manufacturing are compressor, combustor, high pressure and free power turbine. The engine shall be multi-shaft engine with free spinning turbine, called free power turbine. This implies that the gas generator shaft shall be different from that of the low-pressure turbine shaft. The aero derivative gas turbine shall be compact in nature. Performance requirements of high-power output and safe operation are key consideration. Ceramic matrix composite CMC, high temperature alloy, gray and nodular iron materials shall be employed. Investment casting, foundry, forging welding technologies and Computer Integrated manufacturing system has been investigated for utilization in the manufacturing process.

Key words - Manufacturing, turbine, concept. Model, decision, engine, compact

I. INTRODUCTION

The bedrock of developed countries is science, technology, engineering, industrialization, research and development. Developing nations has the option to key into the aforementioned and progress their economy or be an import dependent nation, while their economies suffer. Most of the developed nations have either done research and development of aero derivative gas turbine or acquired the technology, by technology transfer transaction. Nigeria does not fall into any of the category at the moment. Limited work has been done on aero derivative gas turbine in Nigeria, even upon its critical nature in the Nigerian industrialization effort

Therefore, this research is dedicated to the manufacturing of four major components of aero derivative gas turbine in the Nigeria industrial space (compressor, combustor, high-pressure and low-pressure turbine). This shall create employment opportunities for more Nigerians with visible improvement in power generation, oil and gas exploration at reduced cost, thereby creating foreign exchange savings from importation of these equipment into the country. This research will also increase literature in this critical cost consuming section of the industry.

II. LITERATURE REVIEW

Chang et al (2025) presented that digital twin technology involves complex integration of data from sensors and controllers (temperature, pressure, wear and tear, production line process update and system adjustment within set limit). It is found to be very useful in industry 4.0 and smart manufacturing process. But there is a gap in complex data integration. Therefore, it is pertinent to resolve this shortfall of complex data integration and real time data flow associated with digital twin technology in manufacturing process. This resolution was done by introducing a three-layer knowledge graph. The three layer knowledge graph is a structured representation of real-world information by referencing and describing entities, attribute and relationships. It is classified into three categories of:

1. Concept layer – it is the foundation, the core, the encyclopedia of the multilayer industrial production knowledge. It is done by systematizing data into knowledge network. It contains rules, dictate the types of rules, determine interrelationship among these rules, their constraints and the rules application. The concept layer specifies domain, element within the domain and relationship in the network

2. The model layer aligns physical and digital data, it represents the rules and constrain contained in the concept layer and execute detailed digital modeling of information, geometry, regulation, physical and process characteristics during the production process. It focuses on specific product models.

3. The decision layer reference the model and real time data for decision making. It is the practical implantation of the model layer in the real word. Optimization of production process, risk management and maintenance forecasting activities are done here
This novel structured representation of knowledge was tested in turbine blade production process and it proved to be very effective and reliable with significant improvement in error reduction.

The digital twin technology is very supportive in improving manufacturing efficiency, production quality, cost management, waste management, production process, real time monitoring of production equipment and early decision making.

Biao et al (2024) opined that precision cutting is of paramount importance during aero engine components manufacturing. Any cutting technique that is as precise as possible wins the day in engine components production. Component like gears, blades, discs and shafts are made of high strength toughness alloys, intermetallic, ultra high strength steel, titanium alloys and nickel based super alloys. Machining components made of these material selections is usually very difficult. Again, applying immense cutting forces and elevated temperature has the propensity to compromise components integrity properties. This could result to early wear, tear, reduced efficiency or even outright failure. To reduce or eliminate this occurrence, the energy assisted cutting technologies is explored and integrated into machining operation. These technologies are laser assisted machining, cryogenic (low temperature science) cooling and intelligent machining monitoring technologies. Some of the energy assisted cutting or machining technologies are the ultrasonic vibration assisted cutting and electric energy assisted cutting.

The ultrasonic vibration assisted cutting (UVAC) employs the high frequency ultrasonic vibration application to either the work piece or cutting tool - by contact state change. Machining force and temperatures are reduced when contact state is altered. Higher ultrasonic amplitudes result to better and even surface finish of the work-piece. It is faster and less effort driven.

The second type of energy assisted machining technology is the electric energy assisted cutting (EEAC). This is used in aero engine component and precision instruments cutting. The EEAC is made up of two types. One type achieves material removal through electric discharge resulting from the gap between the electrode, the tool and work piece. For the other type, the material to be removed is dissolved by utilizing the work piece as an anode (electrode through which current flow into the device).

The third type of energy assisted cutting technology is the laser cutting (LC). This is also integrated into machining activity, majoring on the laser softening effect to reduce metal as desired. Other energy assisted cutting technologies are cold field assisted cutting, ultrasonic laser cutting, ultrasonic magnetic energy assisted cutting and ultrasonic electric energy assisted cutting

John & Sanjay (2021) presented that the GE LM2500 series aero derivative gas turbine has proven to be one of the most successful engines in its rank. Above three thousand units of this engine has been sold as still very competitive in the aero derivative market. It has unique attributes of flexibility, impressive reliability and availability, low emissions, operation flexibility and quick start-up.

During installation and operation, The LM2500 has a free spinning turbine, it is a multi-shaft engine. The gas generator shaft is different from that of the low-pressure turbine shaft. Meaning the GG and LPT are not mechanically connected. See below figure 2.8 below, the configuration of LM2500 with spinning turbine. Another quality of this turbine is the characteristic of compact installation arrangement due to designed size of the turbine and its auxiliary equipment, without compromising quality and safety.

© SEP 2026 | IRE Journals | Volume 10 Issue 3 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I3-1723191

See figure 2.9 below showing plan arrangements of seven aero derivative gas turbines in three acres of land measuring 135 X 90 Meters, with combined capacity of 250 MW output.

General Electric introduced an upgrade of LM2500 classified as LM2500XPRESS gas turbine generator. It is modularized into ten major components with ninety five percent completed at the factory prior to installation. The LM2500XPRESS is faster to install with minimum mechanical connections. This turbine can be used for simple cycle, combined cycle, cogeneration or combine heat power.

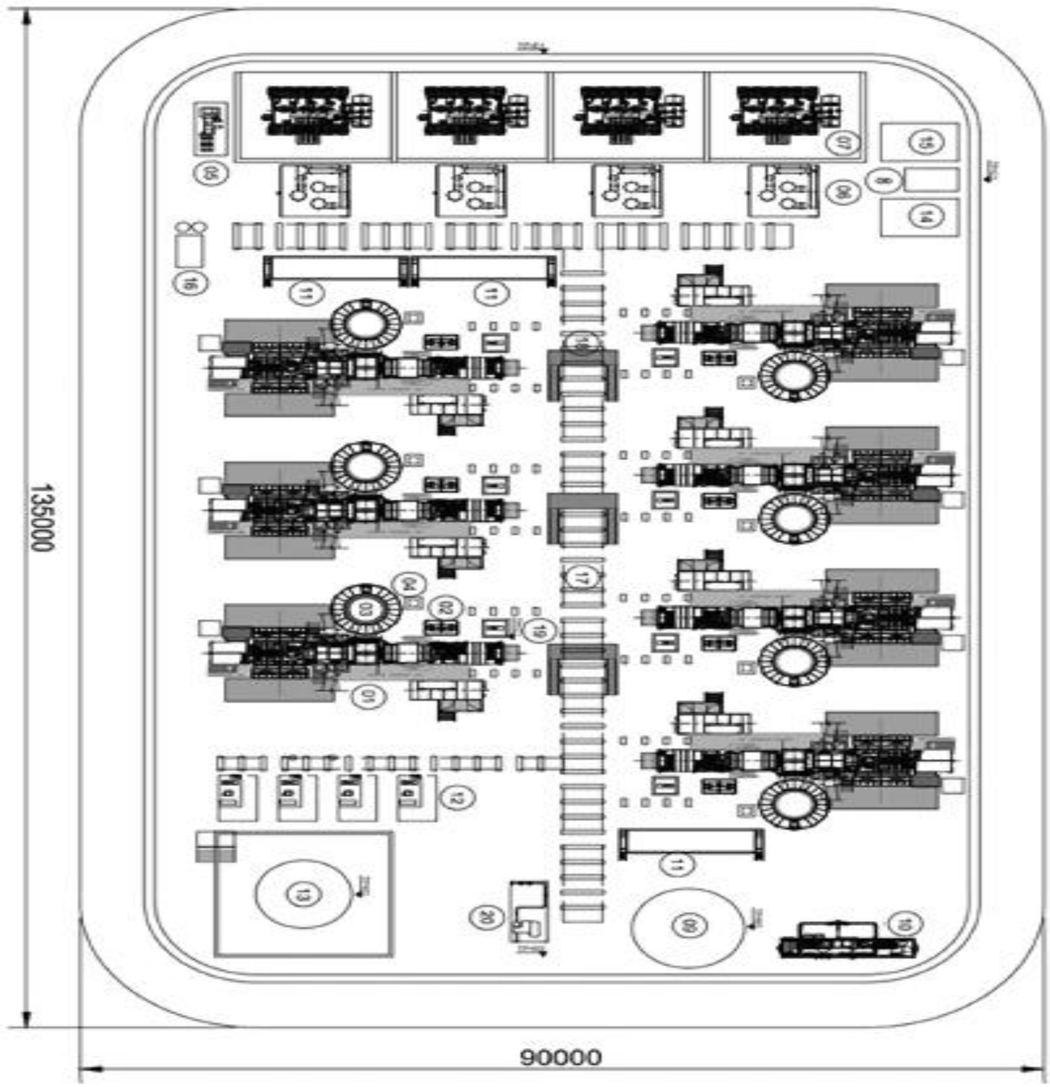

Figure 2.9: Plan arrangements of seven aero derivative gas turbines in three acres of land measuring 135 X 90 Meters (John & Sanjay (2021)

Yu (2018) opined innovative materials - alloy and gradient materials, polymeric, carbon plastic and materials made from special additive in combination with improved technology - use of open motor and gear fan to improve engine reliability. Gas Turbine fan blade, with high cooling efficiency and other components parts are manufactured from miscellaneous innovative materials as this is critical to achieving improved Gas Turbine Engine reliability. These improvement on engine manufacturing is also focused at weight reduction, noise reduction and corrosion resistance of components parts and systems. The Aero Gas Turbine Engine operating condition and performance is monitored locally and remotely to

© SEP 2026 | IRE Journals | Volume 10 Issue 3 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I3-1723191

ensure abnormalities are detected and corrected early to increase reliability.

Frank, et al (2015) indicated that upgrade decisions are offshoot of research and development, based on the need for improvement in manufactured product, service delivery, safety and quality. Customer satisfaction is assured with properly conceived and managed upgrade decisions and processes.

Aero turbine upgrade can be on the power turbine stage 1 and 2 components parts (blade and vane) using 3D aerodynamic tools. Upgrade can also be in the power turbine compressor stages (increase or modification). Upgrade has also been done in control system from MkIV to MKVe control package for better machine user interface management, increases availability and reliability. According to this paper, upgrade resulted to increased power output, machine performance, efficiency, and customer satisfaction. innovation, creativity and change are basic necessities for any entrepreneur who want to remain competitive in the present-day business world.

Leonardo & Luca (2014) presented that a manufacturer continued dominance and competitiveness in the aero derivative gas turbine business is anchored on research, development and uprade. Innovative thinking and creativity is critical. Companies are increasingly interested in advanced and record-breaking technology in gas turbine engine. It is recorded that Ansaldo Energia's AE64.3A emerged with record breaking performance after model upgrade, stepping up reliability and availability to 99% and 94% respectively.

III. MANUFACTURING OF AERO DERIVATIVE GAS TURBINE

This ADGT model shall be a multi-shaft engine with free spinning turbine. Meaning, the gas generator shaft shall be different from that of the low-pressure turbine shaft. There shall be no mechanical connection between the GG and LPT shaft. It shall be modular in nature.

The three layer knowledge graph shall be adopted for the manufacturing of this aero derivative gas turbine. It is an organized representation of information and data by referencing and describing entities, attribute and relationships. This is classified into concept layer, model layer and decision layer.

1. Concept layer - during the concept layer and as indicated in the preliminary design, reference technology was determined to be LM2500 + G5 aero derivative gas turbine. A further categorization into three major components of compressor, combustor and the turbines was done. Multilayer components were identified, their interrelationship, assembly and functions established. Theoretical background and operating principles were determined and referenced.

2. The model layer - in this layer, I represented and executed 35 MW and 48 MW aero derivative gas turbine preliminary design data in a digital modeling - depicting rules, constrains, characteristics, process, relationships and output. Effect of changes in air inlet temperature and increase in the number compressor stages from seventeen to eighteen were modeled, recorded and interpreted in relationship to financial gains.

3. The decision layer, shall reference the model and real time data for decision making. The aero derivative gas turbine modeled in layer two above shall be designed, manufactured, tested and put to use. Risk management and maintenance forecasting shall also be done.

The above three layers of manufacturing process has been tested in world class manufacturing environment and proven to be very successful with improved manufacturing efficiency, production quality, cost management, waste management, production process, real time monitoring of production equipment and early decision making (Chang et al 2025)

Manufacturing process shall be concentrated on three major components of the compressor, combustor and the turbine (both high-pressure and low pressure, bearing in mind the performance requirements of high-power output and safe operation. To achieve higher power output, attention shall be paid to atmospheric air inlet temperature and compressor stages. Computer

Integrated manufacturing system CIM shall be adopted at the right time

Materials to be used for this manufacturing are high-performance fiber for casings, blades, hoods, nacelles etc., ceramic matrix composite CMC - ceramic material reinforced with high strength and high elastic fiber with the capability to reduce wear, tear and crack propagation for turbine rotor and stator blades, turbine outer ring, combustion liners, turbine disk and other turbine components. High temperature alloy materials - single crystal super alloy and nickel based. It shall be continuous grain structure and contain refractive metals without boundary. It shall have high operating temperature. Directional solidification super alloy shall be developed by passing molten metal via temperature gradient at a controlled rate at operating temperature synonymous with the model and coating materials to improve temperature resistance of engine components around the hot section. Coating materials like titanium oxide, aluminum oxide shall be added to step up the turbine operating temperature capability in the hot section component. Investment casting shall be employed in production of aero engine components with complex structure as desired, which is by application of wax pattern and refractive ceramic material. Welding technique shall also be applied to about fifty percent of turbine components (Zijuan et al, 2025)

Furthermore, for the purpose of clarity, oxidizing CMC materials shall be used to manufacture the exhaust section - alumina and aluminosilicate. They shall be combined with various ceramics, metallic fillers and reinforcement to form these oxide CMC materials. Alumina and aluminosilicate are the based materials for oxide CMCs. Alumina shall be combined with boron carbide, silicon nitride, titanium dioxide filler to produce a reinforced material of oxide CMC with good creep and corrosion resistance properties

The turbine combustion section (blades, liners, transition duct and nozzles) shall be manufactured with non- oxidizing CMC materials. This is primarily due to better thermal and mechanical properties (George & Konstantinos 2023)

There is also an option of adopting foundry and forging technologies for turbine engine manufacturing. Gray and nodular iron shall be used for the manufacturing of casings, while low alloy steel shall be used for the manufacturing compressors and turbine (Brandt et al 2020)

IV. INSTALLATION OF AERO DERIVATIVE GAS TURBINE

The multi-shaft engine with free spinning turbine, modular in nature with majority of the components pre-installed off site. The aero derivative gas turbine shall be shock mounted for stability and noise reduction. It shall be totally enclosed for the purpose of both thermal and acoustic insulation. For accessibility and safety requirement, a rooftop hatch and two side doors shall also be installed. The two side doors shall be on the opposite sides of the engine.

The turbine compartment and exhaust shall have prefabricated installation mounts, slots and flange. The gas generator shall be equipped with three mounts at the compressor front frame (CFF) section to fit into the three mounts at the prefabricated structure on the compartment. The gas generator shall be bolted to the low-pressure turbine within the compartment at the compressor rear frame (CRF) and turbine mid frame (TMF). The gas turbine casing shall be bolted to exhaust casing at the turbine mid frame at one end and equipped with permanent flange at the other end for bolting to the permanent exhaust flange towards the flexible coupling and power generator at the turbine rear frame (TRF). The three mount on the gas generator, the flange bolting between the GG and LPT and the permanent exhaust flange towards the power generator provides the gas generator and the LPT ability to withstand axial, vertical and longitudinal loads. Rail track shall be incorporated into the engine compartment to keep the PT in position during and after installation process. The exhaust and inlet plenum shall be permanent structures serving dual purposes of operational and installation requirements. The gas turbine inlet plenum serves the purposes of air filtration and gas turbine housing. While, the exhaust system shall be the channel of burnt gas exhaust and also serve as gas turbine support.

V. CONCLUSION

Emphatically, manufacturing of industrial equipment starts with ideas, conceptualization, acquisition of knowledge, preliminary design, design and then manufacturing. Nigerian has abundant human and natural resources to execute manufacturing of industrial equipment and accessories. The missing links are ground breaking decisions and determination to grow our technology. It is critical at this point to toe the line of progress and advancement in technological breakthrough. Recommended model is the three-layer knowledge graph of concept, model and decision. This has been tested and utilized by industry giants as reviewed in the literature. Aero derivative gas turbine is the reference technology. Major components of interest are compressor, combustor, high pressure turbine and the free power turbine. Accessories shall be part of the second phase (starting system, utility system, firefighting system, lubrication system and control system).

REFERENCES

[1] John, M & Sanjay, S (2021). *Enabling Renewable Penetration Using the LM2500XPRESS*. GE Gas Power Aeroderivative Solution. GEA 33073.

[2] Biao, Z, Yufeng, W, Jianhao, P, Wenfeng, D, Xiaofei, L, Bangfu, W, Minxiu, Z, Jiuhua, X, Liangchi, Z & Raj, D (2024). Overcoming Challenges - Advancement in Cutting techniques for High Strength Toughness Alloys in aero engines. *International Journal of Extreme Manufacturing*. IOP

[3] Chang, S, Xin, T, Qi, J, Young, H, Tao, W & Dongsheng, J (2025). Digital Twin System for Manufacturing Process based on a Multi-layer Knowledge Graph Model. *Scientific Reports*. Nature

[4] Yu, A.N (2018). The Problem of Ensuring Reliability of Gas Turbine Engine. *IOP Conference Series: Material Science and Engineering*. Mater. Sci, Eng. 302 012082.

[5] Frank, A., Akash, B., Chrish, H., Hisham, A. (2015). Aerodynamic Turbine Upgrade for Gas Turbines. *Turbo Expo: Power for Land, Sea, and Air*. ASME

[6] Leonardo, T., Luca, A. (2014). Ansaldo Energia AE64.3A Gas Turbine Upgrade. *Proceedings of The Power-Gen Europe 2014 Conference*.