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Simulation For Performance Improvement of Omotosho Power Plant Using Inlet Air Cooler and Heat Recovery Steam Generation (HRSG) System

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Abstract

In this study Omotosho gas turbine plant was modified into three different configurations by incorporating Inlet air cooler and Heat Recovery Steam Generator (HRSG). The reason for the modification is to improve its performance. Aspen Hysys software was used to simulate both the simple (Omotosho) and the three modified gas turbine plants. The results reviews that the three modified gas turbine plants has higher thermal efficiency compare to the Omotosho gas turbine plant. There is thermal efficiency increase from 34.94% for the Omotosho gas turbine to 47.44%, 43.93% and 45.21% for the first, second and third modifications respectively. Also, there was increase in the power output from 114 MW for the Omotosho gas turbine to 157 MW, 143 MW and 147 MW for the first, second and third modifications respectively. The higher thermal efficiency of the modified gas turbine plants leads to specific fuel consumption reduction from 0.2116 kg/kWh for the Omotosho gas turbine to 0.1136 kg/kWh, 0.1683 kg/kWh and 0.1611 kg/kWh for the first, second and third modifications respectively. The reduction in the specific fuel consumption in the three modified gas turbine also lead to reduction of heat rate from 10304.27 kJ/kWh for the Omotosho gas turbine to 7588.89 kJ/kWh, 8195.51 kJ/kWh and 7963.43 kJ/kWh for the first, second and third modifications respectively. The emission rate of the three modified gas turbine plants are lower than that of the Omotosho plant thereby leading to reduction in global warming and ozone layer depletion. It was observed that the first modification has the highest overall performance, followed by the third modification then finally the second.

Keywords: *Simple Gas Turbine, Modified Gas Turbine, Thermal Efficiency, Power Plant, Brayton Cycle, Aspen HYSYS software.*

1.0 Introduction

A gas turbine serves as a mechanism for converting heat energy into functional outputs, including mechanical shaft power or the high-speed thrust utilized in jet propulsion. Widely deployed for power generation across various regions worldwide, gas turbines operate effectively under diverse climatic condition. According to (Achimnole E *et al*, 2017), various cyclic arrangements have been proposed to enhance the net output and efficiency of a system. This study investigates the performance improvement of conventional gas turbine power plants by integrating spray coolers at the air intake and exploring alternative regenerator options. (Johnson R, 1998), provided an analysis of the theory and functionality of evaporative coolers in the context of industrial gas turbine applications. (Ondrayas I *et al,* 1991), explored the implementation of chillers at the air intake as a means to enhance gas turbine power in cogeneration plants, particularly during periods of elevated ambient temperatures. According to (Elliot J, 2001), a gain of 1 percent in output power can be attained for every 1.6°C reduction in the inlet temperature through the utilization of water chillers. (Anon A, 2002), stated that directing a controlled spray of water into the compressor inlet could lead to a 10-20 percent increase in net power output. (Kolp D *et al,* 1995) conducted an analysis on the impact of different forms of inlet air cooling and supercharging on a 40 MW General Electric LM6000 gas turbine. They demonstrated that reducing the inlet temperature by 28°C could enhance the net output power by 30 percent.(Depaepe and Dick 2001) provided a technological and economic evaluation of water recovery in steam-injected gas turbines. Their analysis revealed that injecting steam into the cycle enhances its thermal efficiency. However, excessive water consumption poses a significant drawback. The installation of water condensers incurs initial and operational costs, with payback periods ranging from 1.5 to 9.5 years.

(Cohen. C *et al*, 1996), described the conventional application of the regenerator, utilizing exhaust gases, with the final stage turbine serving as the heat source. The recuperated heat is typically utilized to pre-heat the compressed air between the compressor and combustor. (Bathe W, 1996) and (Khartchenko N, 1998) propose various methods, including combined cycle and cogeneration applications, as alternative approaches. The performance of gas turbine is severely constrained by temperature variations, particularly in hot and humid regions like sub-Saharan regions such as Nigeria. The rise in inlet air temperature becomes notably pronounced during hot weather, resulting to a significant reduction in the power output of the gas turbine. This reduction occurs due to the inverse relationship between power output and ambient temperature, aggravated by the increased specific volume of air drawn in by the compressor. Both the efficiency and power output of gas turbines exhibit variations based on ambient conditions, as highlighted by (Kurt H *et al,* 2009).

These variations have a significant impact on electricity generation, fuel consumption, and plant incomes. To address this challenge, the technique of cooling the air intake to the compressor has been widely adopted, as discussed by (Khaledi H *et al*, 2005).

The injection of water into the inlet duct of a gas turbine has also become a widely accepted method for air inlet cooling, commonly known as inlet fogging, as described by (Mohammed A *et.al,* 2021).

As a result, this process also lowers the compressor inlet temperature, thereby recovering lost power output, enhancing efficiency, and reducing specific fuel consumption and net heat rate. Additionally, the research indicates that thermal efficiency tends to decrease with an increase in ambient temperature, as noted by (Hyun M *et.al,* 2018).

Research findings indicate also that ambient temperature has the most pronounced impact on both gas turbine inlet temperature and the pressure ratio. There also illustrated that a 10°C rise in the compressor air inlet temperature results in a 1% decrease in gas turbine power output as highlighted by (Barzegaravaal H *et al,* 2011).

In addition to the IAC and STIG methods used to improve the performance of simple gas turbine plants, other researchers have explored the use of additional turbines for performance improvement. (Aadel A, 2015) conducted research using numerical methods, modeling the power system with two combustion chamber in addition to IAC and STIG. The retrofitting method resulted in an efficiency improvement from 30.5% to 43% and increased power output from 22 MW to 33.5MW, as revealed by software simulations. Numerous studies has been conducted on different modifications of the simple gas turbine plants to improve their performance using Aspen Hysys software, both in Nigeria and globally, and it gave very good result, this is to show that Aspen Hysys software is a good engineering software to be used for gas turbine and other engineering simulation. Some notable examples includes, (Hayder J *et al.* 2023), there carried out analyzes on the performance of gas turbines in power plants employing a high-pressure fogging system. (Mohammed A *et al,* 2021), carried out a study using Aspen plus simulation to enhance the performance of the Al-Khayrat power plant through the implementation of a heat recovery steam generation (HRSG) system. (Ijeoma C *et al,* 2019), uses Aspen Hysys to simulate gas turbine plant using evaporative cooler.

(Saleh S *et al*, 2018), worked on a project focused on enhancing the performance of gas turbine power plants through the utilization of turbine inlet air-cooling (TIAC) technologies in Riyadh, Saudi Arabia. (Anoop K *et al,* 2018), conducted an analysis to improve the performance of a simple gas turbine cycle by implementing vapor compression inlet air cooling. (Hyun M *et al,* 2018), participated in a project focused on enhancing the performance of gas turbine combined cycle power plants by implementing dual cooling of the inlet air and turbine coolant through the utilization of an absorption chiller. (Achimnole E *et al,* 2017), conducted simulations for a gas turbine power plant incorporating a high-pressure fogging air intake cooling system. (Alaa A *et al,* 2016), worked on a project aimed at improving gas turbine performance by employing various integrated turbine inlet cooling techniques. (Alklaibi A *et al,* 2016), conducted a thermodynamic analysis of a gas turbine with an air bottoming cycle. (Ejiroghene and Oghenero 2016), conducted simulations for the air inlet cooling system of a gas turbine power plant. (Thamir K *et al*, 2011), carried out a study aimed at improving gas turbine performance by implementing various inlet air cooling systems. But all this work are not in comparison to the use of inlet air cooling (IAC), steam injection gas turbine (STIG), regenerator and additional combustion chamber, and also not in the comparison of the use of inlet air cooling (IAC), steam injection gas turbine (STIG), regenerator, additional combustion chamber and additional turbine.

This study utilized Aspen Hysys version 11 software for the modeling and simulation of both the simple gas turbine and three modified gas turbine configurations. The simulated results for the simple gas turbine were subsequently compared to the practical performance data obtained from actual experiments or operational data of the gas turbine

Aspen Hysys software stands out as a potent engineering simulation tool extensively applicable in modeling and simulating various processes within petroleum, chemical and power plant domains. It empowers engineers to design, construct and simulate diverse chemical processes, employing commonly used equipment and devices such as regenerators, chemical reactors, pumps, air coolers, compressors, separators, expanders, distillation columns, heat recovery steam generators (HRSG), mixers, and other essential components as discussed by (Ijeoma C *et al,* 2019).

Aspen Hysys software is proficient in executing a broad spectrum of calculations, particularly in the field of chemical engineering. These calculations encompass aspects like mass and energy balances, mass transfer, vapor-liquid equilibrium, chemical kinetics and reactor design, heat transfer, and fractionation. Additionally, the software is capable of generating results that closely approximate real-world conditions, adding a significant level of realism to the simulation outcomes.

2.0 Materials and Method

2.1 System Description of the Study Area

This research centers on the Omotosho generation station (Phase II), which is a gas turbine facility owned by the Niger Delta Power Holding Company (NDPHC) in Nigeria. Located in Omotosho within the Okitipupa local government area of Ondo State, the power plant is equipped with four GE frame machines. Each machine has an individual installed capacity of 125 MW, leading to a cumulative installed capacity of 500 MW for the entire plant. Due to the high power generation in this gas turbine plants and a low thermal efficiency, there is a need to modify the gas turbine plant so as to increase the overall efficiency and also the power output for better performance and revenue generation. The gas turbine is modified into three different configurations and there are described below.

2.1.1 System Description of the First Modified Gas Turbine Plants (MGTP 1)

In Figure 1, the depiction illustrates the integration of a simple gas turbine system with a regenerator, inlet air cooler (IAC), steam injection gas turbine (STIG), and a low-pressure turbine and Figure 2 shows the flow chat of the modified gas turbine plant in Aspen Hysys simulation interface. This specific configuration is termed the single-shaft gas turbine with two turbines. In this design, both turbines are connected on the same shaft and operate sequentially

The process begins with atmospheric air entering the air cooler, where its temperature is reduced before flowing into the compressor. The cooler air increases the density which enables a higher flow rate through the compressor. The lowered inlet air temperature plays a crucial role in creating more favorable conditions for the compressor, resulting in improved compressor performance, higher power output, and overall efficiency of the gas turbine plants. Additionally, this design helps enhance compressor durability by reducing thermal stresses on the compressor components.

The air having undergone cooling in the air cooler, advances to the compressor and the compressor is responsible for compressing the incoming air before entering the combustion chamber. The compressed air then traverses a regenerator, where its temperature is increased with the aid of exhaust gas from the turbine. Following this the hot air from the regenerator is blended with steam generated from the heat recovery steam generator (HRSG). This blend is directed into the combustion chamber, where it combines with fuel and undergoes combustion, resulting in the generation of high-temperature, high-pressure gases.

The high-pressure turbine, situated as the first turbine in line, is linked to the same shaft as the compressor. It extracts energy from the high-pressure gases exiting the combustion chamber. Following this, the low-pressure turbine follows on the same shaft, extracting additional energy from the lower pressure gases that have already passed through the high-pressure turbine. This configuration finds common use in various applications such as aircraft engines, marine propulsion, combined heat and power systems (CHP), power generation, hybrid power systems, experimental and research applications, and certain industrial applications. Its suitability is particularly notable in scenarios where factors like simplicity, safety, adherence to environmental regulations, weight considerations, and cost efficiency are paramount.

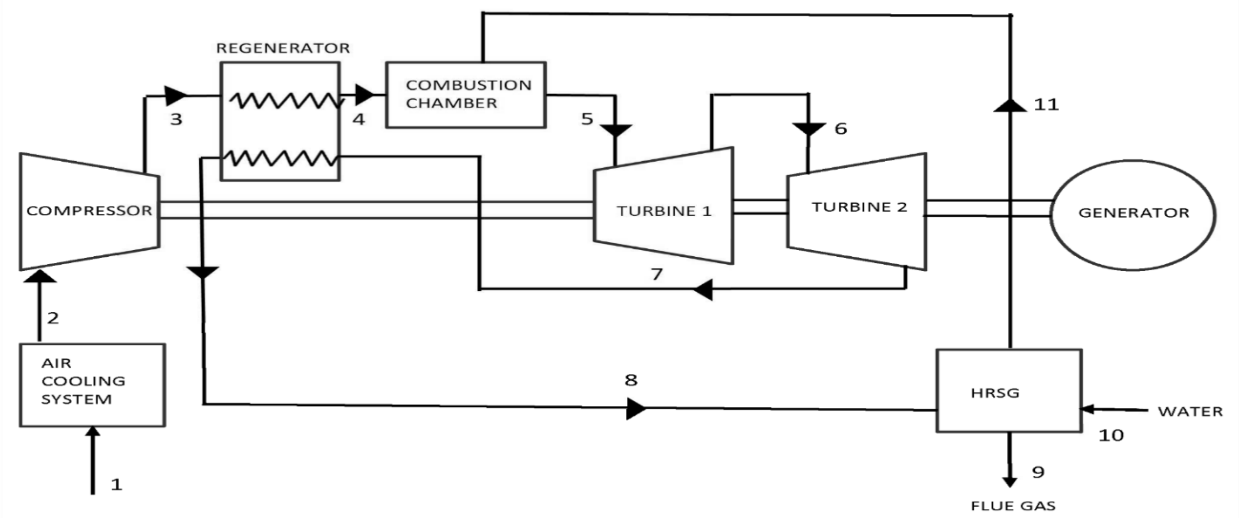


Figure 1: Block Diagram of MGTP 1

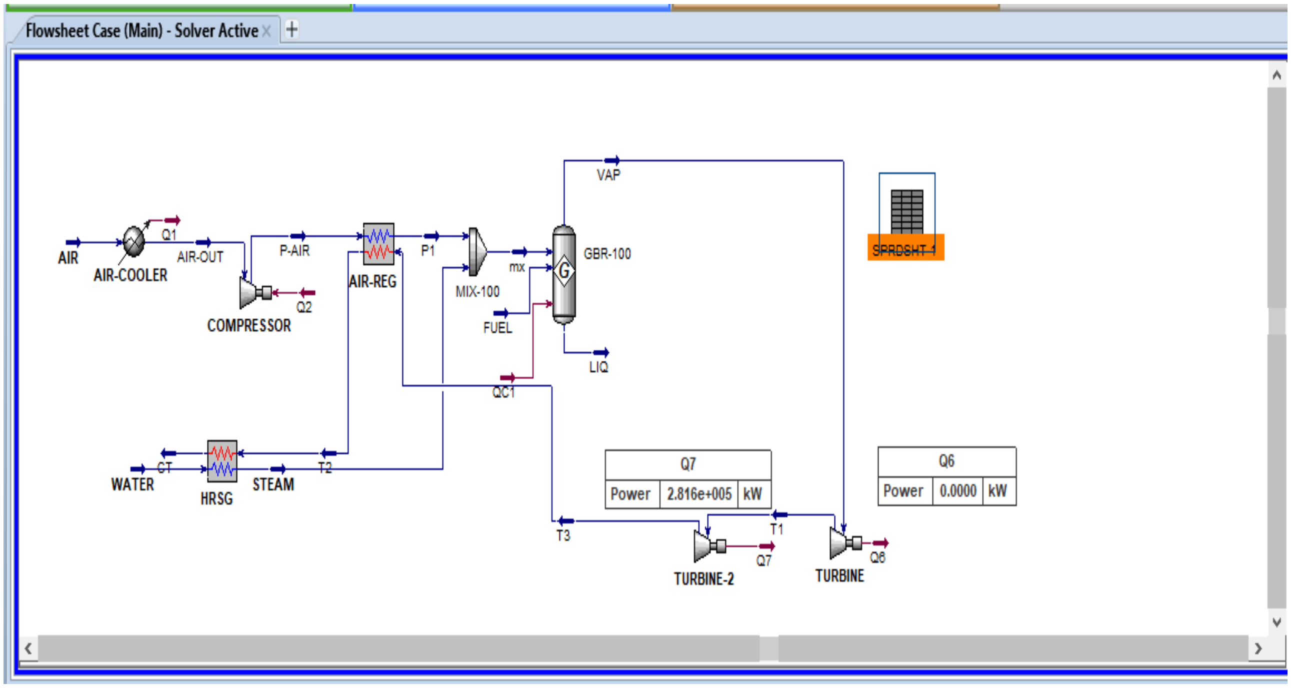


Figure 2: Flow Chat Model of MGTP 1

2.1.2 System Description of the Second Modified Gas Turbine Plant (MGTP 2)

Figure 3 depicts the second modified gas turbine plant, incorporating multiple improvements compared to the simple gas turbine configuration and Figure 4 shows the flow chat of the second modified gas turbine plant in Aspen Hysys simulation interface. This dual combustion chamber setup comprises a compressor, combustion chamber, turbine and generator. Additionally, it features supplementary components such as steam injection, inlet air cooling, a regenerator, and a converging combustion chamber.

Here is a detailed explanation of the MGTP 2:

i. Inlet air cooling system: the atmospheric air first enters the air cooler, where its temperature is lowered before being directed to the compressor. This cooler, denser air allows for a higher flow rate through the compressor, improving its performance and overall efficiency of the gas turbine. Lowering the inlet air temperature also enhances compressor durability by reducing thermal stresses on its components.
ii. Compressor and regenerator: the compressed air from the compressor is directed to the regenerator, where heat from the high-temperature exhaust gases is recuperated and transferred to the incoming compressed air. This pre-heating process is crucial for enhancing thermal efficiency and power output. The outgoing hot air from the regenerator serves as the heat source for the heat recovery steam generator (HRSG).

iii. Heat Recovery Steam Generator (HRSG): The HRSG generates steam from the recovered heat, which then mixes with the compressed air in a mixer before it enters the first combustion chamber (Regular Combustion Chamber). The regenerator and HRSG contribute to enhanced efficiency, power output, fuel savings, and reduced emissions, making the plant more environmentally friendly compared to a simple gas turbine.

iv. Dual combustion chambers: the first combustion chamber (Regular Combustion Chamber) involves fuel addition so as to initiate the combustion process. The combusted gas then proceeds to the second combustion chamber (Converging Combustion Chamber). The dual combustion chamber design offers advantages such as temperature control, independent optimization of pressure ratios, improved compression efficiency, increased turbine efficiency and reduced mechanical stress, improved reliability, fuel flexibility, emission control, and effective thermal management.

v. Turbine: the combusted gases from the second combustion chamber drive the turbine, turning its blades and generating power. The hot exhaust gas from the turbine is redirected to the regenerator, closing the cycle.

This dual combustion chamber configuration is widely utilized in various applications, including power generation, industrial processes, the oil and gas industry, combined heat and power systems (CHP), hybrid power systems, experimental and research applications, as well as aerospace and aviation. It is particularly suitable for scenarios where simplicity, safety, compliance with environmental regulations, weight considerations, and cost efficiency are crucial factors.

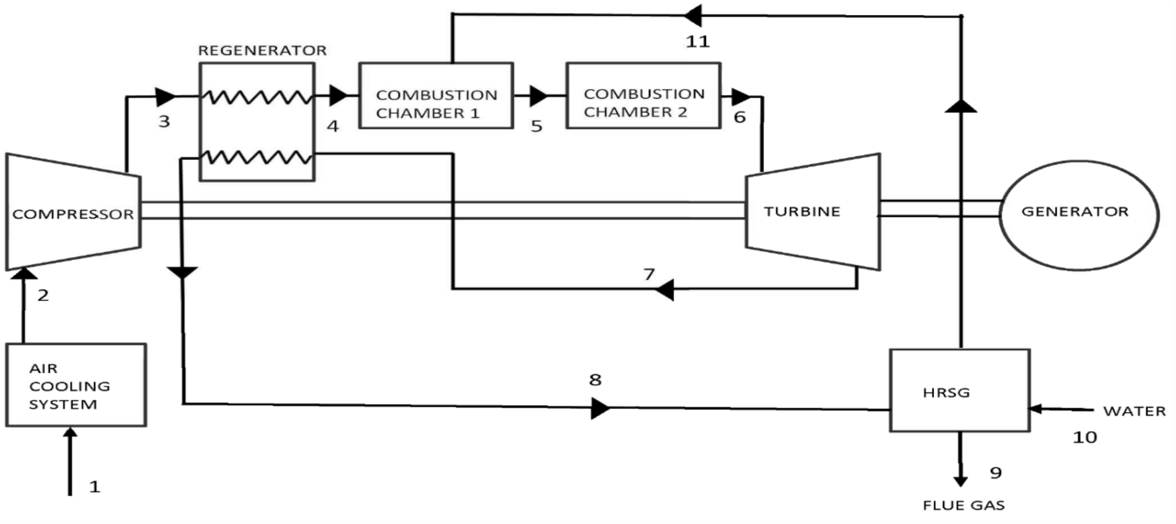
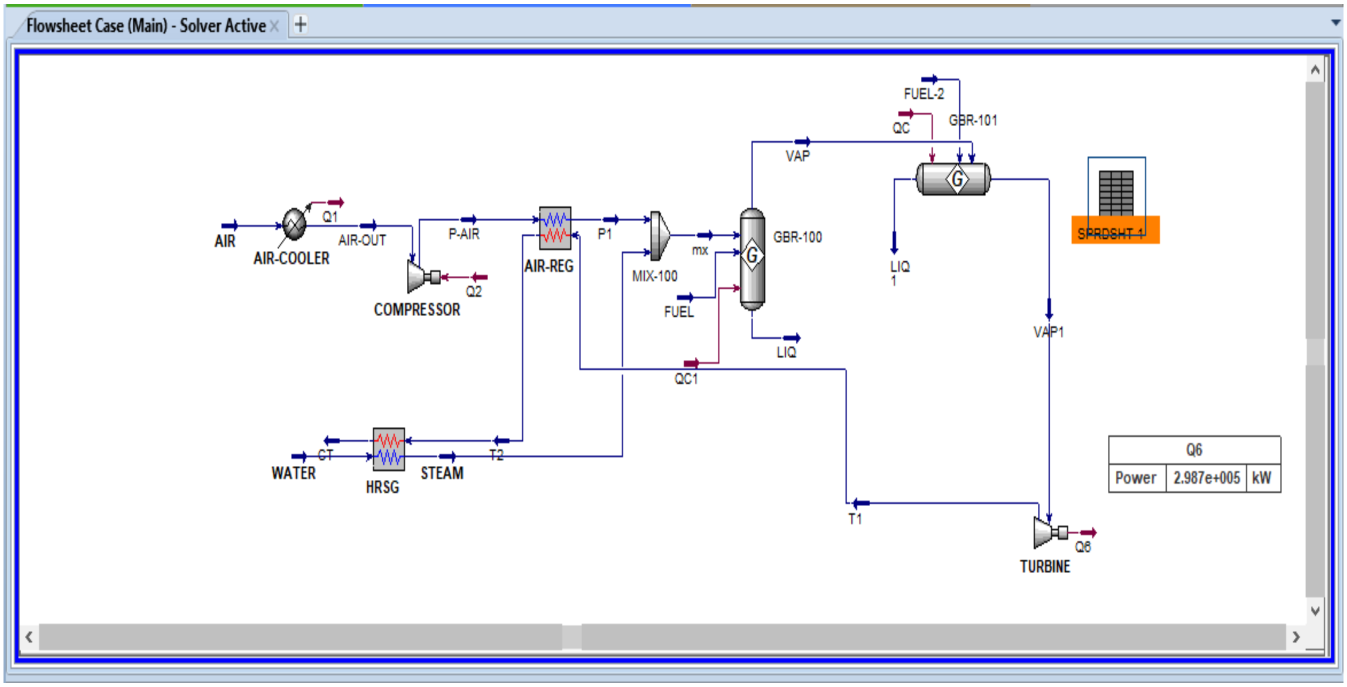


Figure 3: Block Diagram of MGPT 2



Q6		
Power	2.987e+005	kW

Figure 4: Flow Chat Model of MGTP 2

2.1.3 System Description of the Third Modified Gas Turbine Plants (MGTP 3)

Figure 5 illustrates the configuration of the third modified gas turbine plant. And Figure 6 shows the flow chat of the MGTP 3 in Aspen Hysys simulation interface. While a basic gas turbine typically comprises a compressor, combustion chamber, gas turbine, and generator. The system depicted in the figure is enhanced with several components. These include a steam injection gas turbine, an inlet air cooling system, a regenerator, a low-pressure turbine, and a converging combustion chamber.

The operational sequence begins with atmospheric air entering the air cooler, where its temperature is reduced before flowing into the compressor. The cooler air, being denser, allows for higher flow rate through the compressor. This reduction in the inlet air temperature contributes to maintaining more favorable conditions for the compressor, resulting in improved performance, higher power output, and overall efficiency of the gas turbine plant. Additionally, this design helps enhance compressor durability by minimizing thermal stresses on the compressor components.

The cooled air, having undergone compression by the compressor, is directed to the regenerator. The regenerator plays a vital role in recovering the heat from high-temperature exhaust gases and transferring it to the incoming compressed air. Subsequently, the preheated air is combined with steam generated from the heat recovery steam generator (HRSG) in a mixer. The combined mixture is then directed to the first combustion chamber, known as the regular combustion chamber.

The heat source for the HRSG is supplied by the exit hot air from the regenerator. The inclusion of the regenerator and HRSG in the modification contributes to an increased power output and thermal efficiency. Moreover, this design aids in fuel conservation, emission reduction, making the overall plant more environmentally friendly in comparison with the simple gas turbine. Fuel is introduced into the conventional combustion chamber during the combustion process, and the resulting mixture is subsequently directed to the second combustion chamber, referred to as the converging combustion chamber

The advantages of incorporating dual combustion chambers are substantial. The dual combustion chamber plays a crucial role in temperature control by distributing the combustion process between the two chambers. This division enables more effective management of the working fluid temperature. Additionally, the dual combustion chamber allows for independent optimization of the pressure ratio in each chamber, thereby enhancing overall compression efficiency.

Furthermore, the utilization of dual combustion chambers contributes to increased turbine efficiency, reduced mechanical stress, improved reliability, fuel flexibility, emission control, and enhanced thermal management. In this configuration, the high-pressure turbine is positioned as the first turbine in line and it connected to the same shaft as the compressor. This integrated design enhances the overall performance and efficiency of the gas turbine plant.

The high-pressure turbine extracts energy from the high-pressure gases exiting the combustion chamber. Following this, the low-pressure turbine, positioned on the same shaft, continues to extract energy from the lower pressure gases that have passed through the high-pressure turbine. This modification brings about operational flexibility, allowing for efficient load distribution, an increase in thermal efficiency, and a reduction in emission rates. The integrated design of the dual turbine system enhances the overall performance and environmental sustainability of the gas turbine plant.

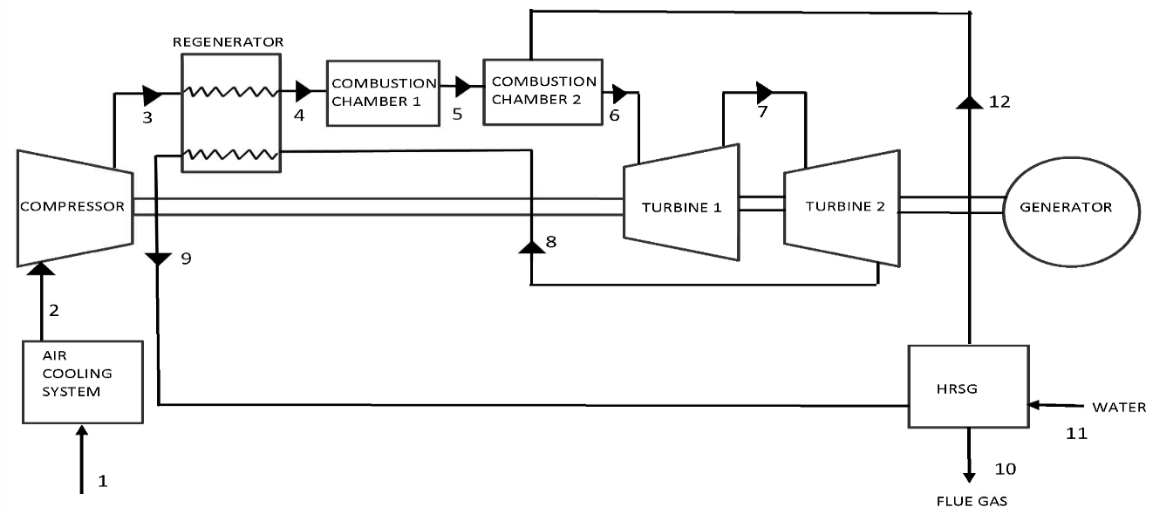
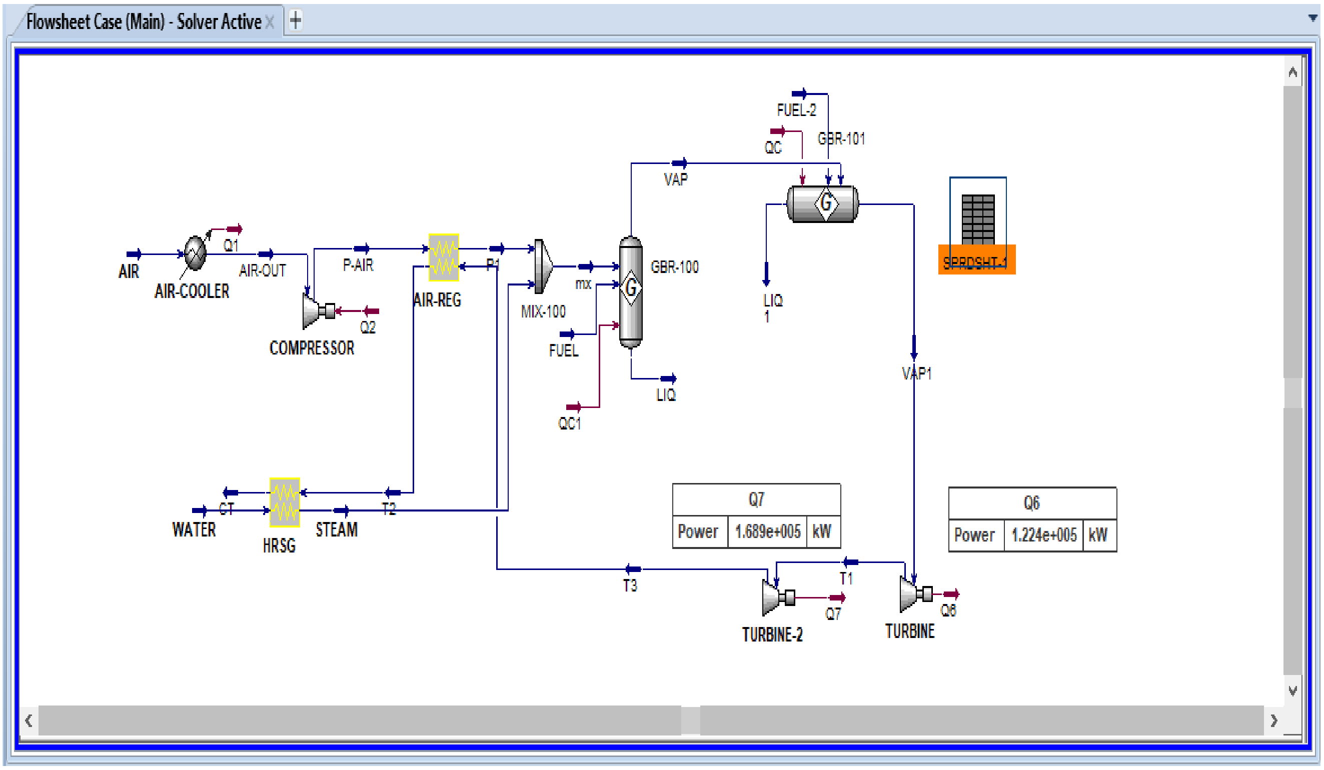


Figure 5: Block diagram of MGTP 3



Q7		
Power	1.689e+005	kW

Q6		
Power	1.224e+005	kW

Figure 6: Flow Chat model of MGTP 3

2.3.1 Modelling of the Simple Gas Turbine Plant (Omotosho)

The simple gas turbine cycle is known as the Brayton cycle. Here's an overview of the process: air initially enters the compressor, where it undergoes compression and heating. It then moves into the combustion chamber, where at constant pressure fuel combustion occurs raising the air temperature to a high level (T_3) which is a key step in the Brayton cycle. The subsequent high-temperature gases enter the turbine and it then undergo expansion to generate useful work, and then the exhaust gases exit the turbine which defines an open-cycle gas turbine engine. In Figure 7, the schematic diagram of a basic gas turbine is presented, while Figure 8 illustrates the flow chart of the simple gas turbine model. It is important to highlight that there is no pressure drop at the inlet and exhaust ducts. Furthermore, the assumed pressure drop across the combustion chamber is 2%. The simple gas turbine plant consists of the compressor, combustion chamber and turbine.

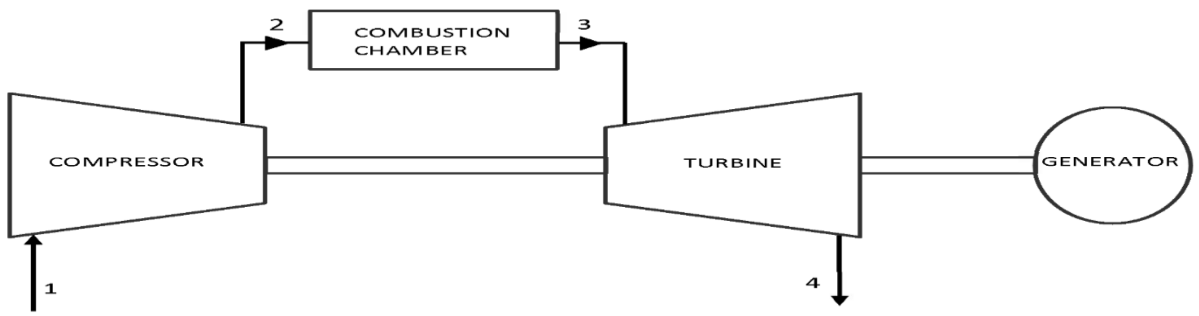


Figure 7: Block Diagram of Simple Gas Turbine Plant

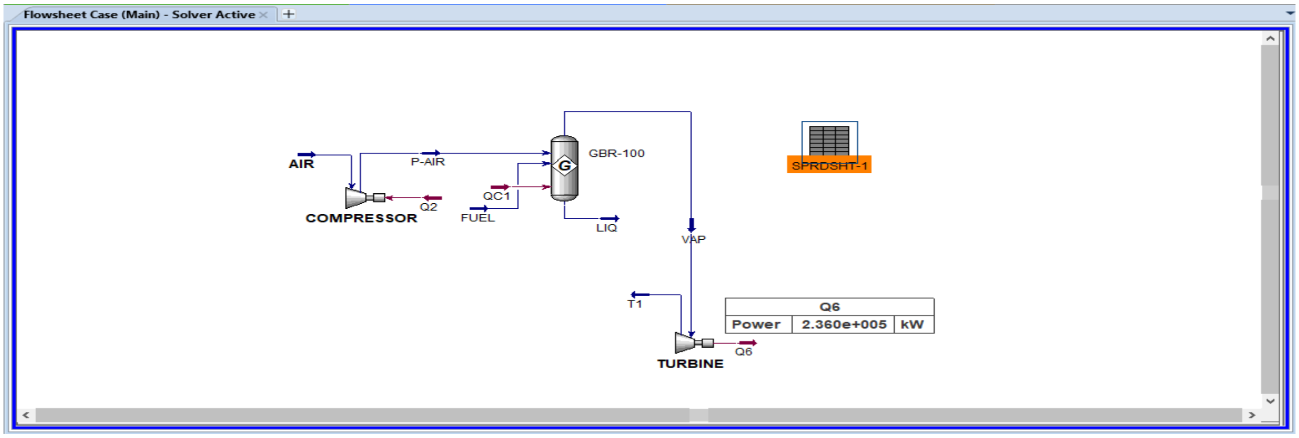


Figure 8: Flow Chat Model of the Simple Gas Turbine Power Plant

Table 1: Mass Composition of the Fuel

S/n	Composition	Weight Percentage
1	methane	0.8876
2	Ethane	0.0440
3	Propane	0.0257
4	n-butane	0.0084
5	n-pentane	0.0019
6	n-heptane	0.0018
7	n-hexane	0.0017
8	Nitrogen	0.0011
9	co_2	0.0196
10	i-butane	0.0055
11	i-pentane	0.0027

2.7. Data Collection

Operational data for the gas turbine unit at Omotosho power plant spanning from 2018 to 2022 were obtained from the daily turbine control log sheet. Statistical analysis was conducted on the daily average operating variables, and mean values were compiled for each month from January to December, as well as an overall average. Table 2 provides a summary of the operating parameters of a gas turbine unit based on the GE frame model used in this study. Subsequently, a thermodynamic analysis of the plant and its performance was conducted for both simple and the three modified gas turbine configurations.

Table 2: Operational Parameter of Omotosho Generation Station (Phase II) Gas Turbine Engine

S/No	Operational Parameters	Unit	Value
1	Ambient temperature, T_1	k	298
2	Compressor outlet temperature, T_2	k	607
3	Turbine inlet temperature, T_3	k	1473
4	Turbine outlet temperature, T_4	k	761
5	Exhaust gas temperature, Texh	k	761
6	Compressor inlet pressure, P_1	kPa	101.3
7	Compressor outlet pressure, P_2	KPa	1200
8	Pressure ratio	-	11.9
9	Mass flow rate of fuel	kg/s	6.7
10	Mass flow rate of air	kg/s	376.75
11	Power output	MW	125
12	LHV of fuel	KJ/kg	46670

13	Heat rate	KJ/kwh	10,200
14	Thermal efficiency	%	33.36

3. 0 Results and Discussion

3.1 Results

The simulated results obtained from Aspen Hysys software for the simple and the three modified gas turbine plants are presented. Figures 9 – 15 clearly shows the comparison between the output parameters of the simple and the three modified gas turbine plants. And the output parameters considered in this study are the thermal efficiency, specific fuel consumption, heat rate, emission rate, compressor power, turbine power and power output.

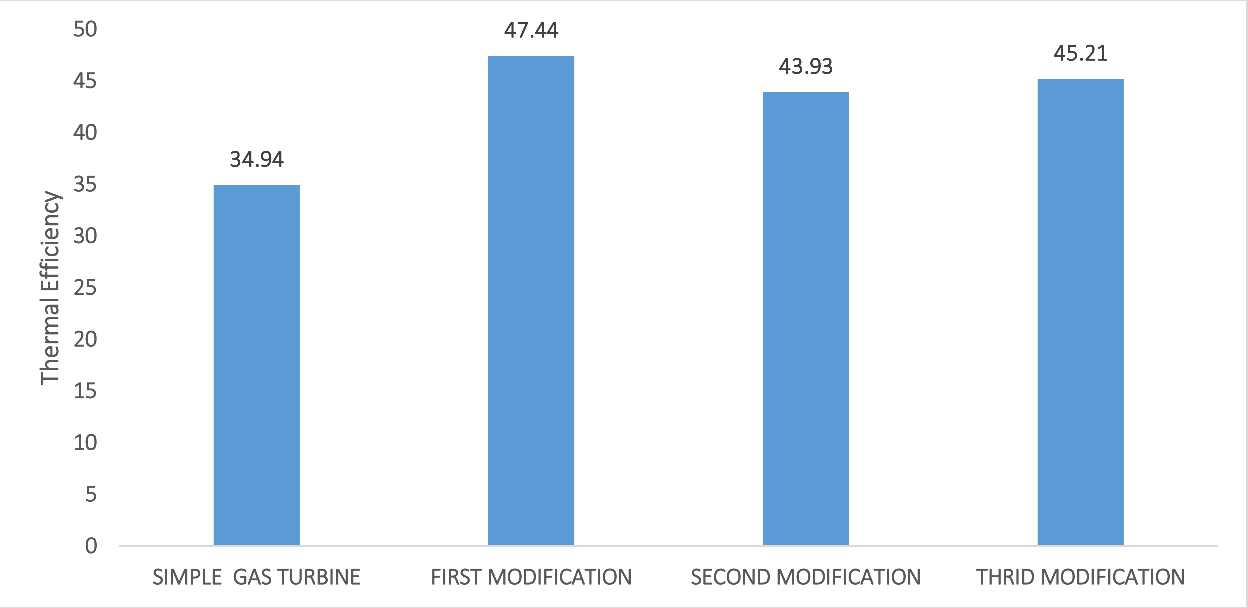


Figure 9: Simulated results obtained for the thermal efficiency of the simple and the three modified gas turbine plants.

Figure 9 shows that all three modified gas turbine power plants have higher thermal efficiency than the simple gas turbine. The first modification has the highest efficiency, followed by the third, and then the second. The differences among them lie in their configurations. The first modification includes one compressor, one combustion chamber, and two turbines. The second has one compressor, two combustion chambers, and one turbine. The third modification consists of one compressor, two combustion chambers, and two turbines. Figure 9 highlights significant thermal efficiency improvements across three modifications compared to the simple gas turbine. The first modification shows the highest increase at 12.5%, followed by the third modification at 10.27%, and the second modification at 8.99%. These findings underscore substantial enhancements achieved in thermal efficiency across all modifications relative to the simple gas turbine plant.

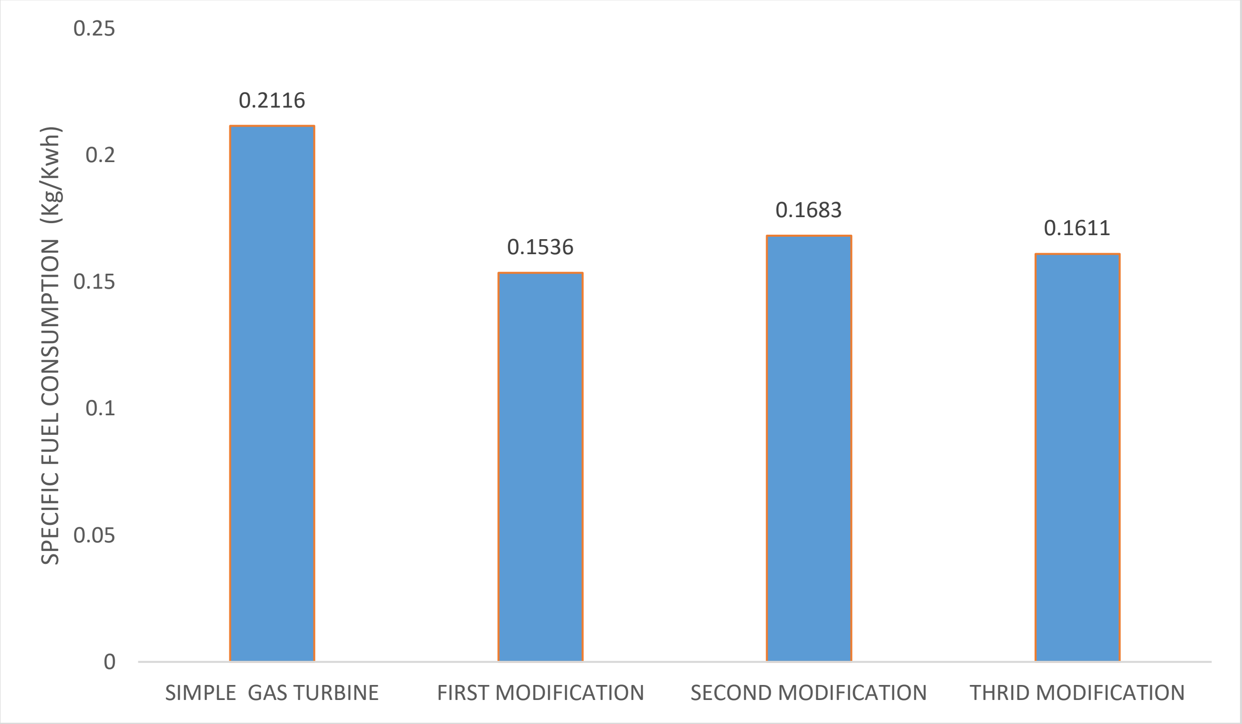


Figure 10: Simulated results obtained for the specific fuel consumption of the simple and the three modified gas turbine plants.

Figure 10 clearly indicates a substantial decrease in fuel consumption for all three modified gas turbine plants compared to the simple gas turbine plant. Notably, the first modification exhibits the lowest fuel consumption per hour, followed by the third, and lastly the second. The reductions in fuel consumption not only contribute to cost savings but also help in minimizing CO_2 emissions, thereby aiding in the global efforts to combat climatic change and mitigate depletion of the ozone layer.

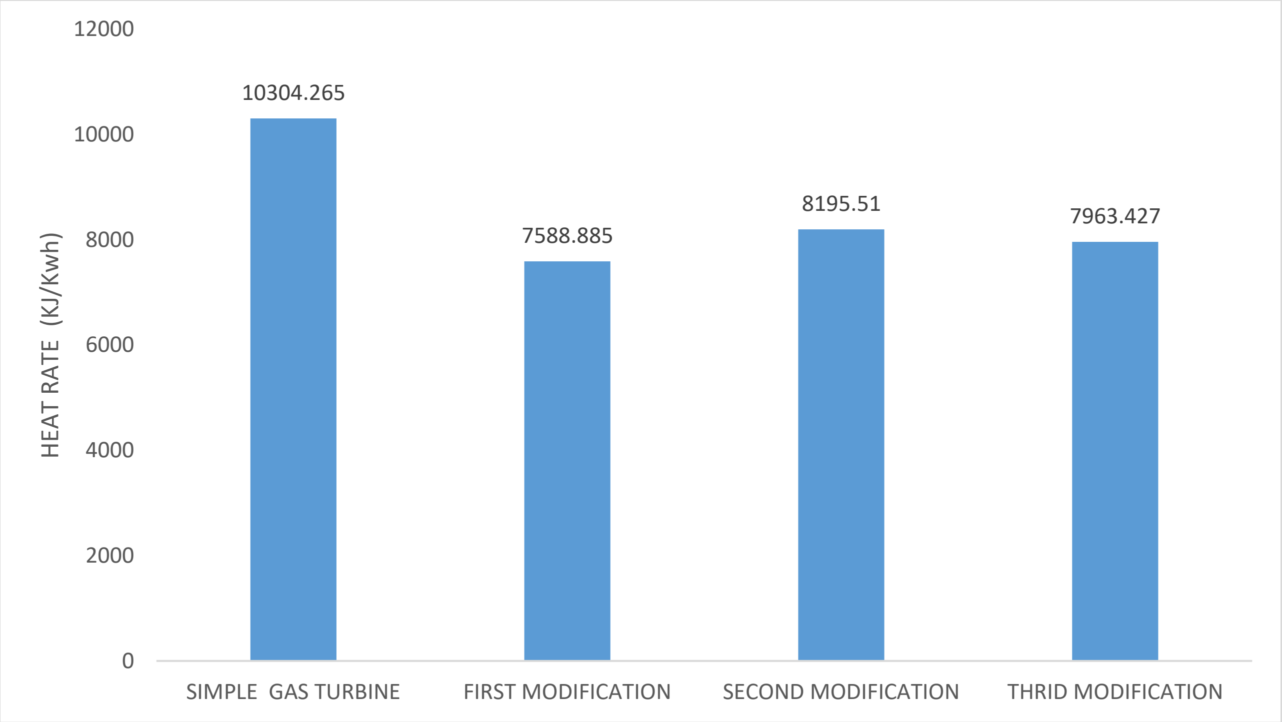


Figure 11: Simulated results obtained for the heat rate of the simple and the three modified gas turbine plants.

Figure 11 displays the simulated outcomes of heat rates for both the simple and the three modified gas turbine plants. Heat rate holds paramount importance in the overall thermal efficiency of gas turbine power plants. It is inversely proportional to the thermal efficiency, indicating that a decrease in heat rate is associated with an improvement in plant thermal efficiency, a reduction in specific fuel consumption, and a decline in emission rates. Heat rate stands out as a crucial metric for evaluating the efficiency of electrical generators or power plants engaged in the conversion of fuel into both heat and electricity. More precisely, it quantifies the amount of energy consumed by a power plant to produce one kilowatt-hour (kWh) of electricity. From Figure 11, it is evident that the first modification boasts the lowest heat rate, followed by the third, and lastly the second. These findings underscore the improved efficiency and reduced energy consumption achieved by the modified gas turbine plants.

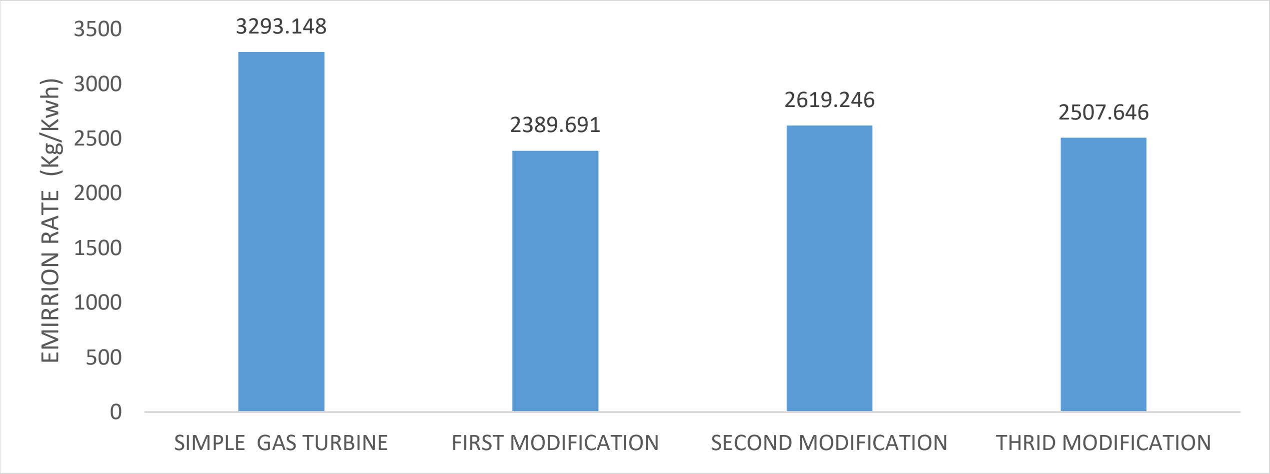


Figure 12: Simulated results obtained for the emission rate of the simple and the three modified gas turbine plants.

Figure 12 depicts the simulated emission rates for the simple and the three modified gas turbine plants, highlighting the significant impact of emission rates on the thermal efficiency of gas turbine power plants. Emission rate is inversely proportional to thermal efficiency and it plays a crucial role in influencing specific fuel consumption and heat rate. A decrease in emission rate corresponds to an increase in thermal efficiency, reduced fuel consumption, and improved heat rate. From Figure 12, it is evident that the first modification exhibits the lowest emission rate, followed by the third, and lastly the second. These findings underscore the substantial reduction in emission rates achieved by all three modifications, aligning with the goal of creating more environmentally friendly and efficient gas turbine systems.

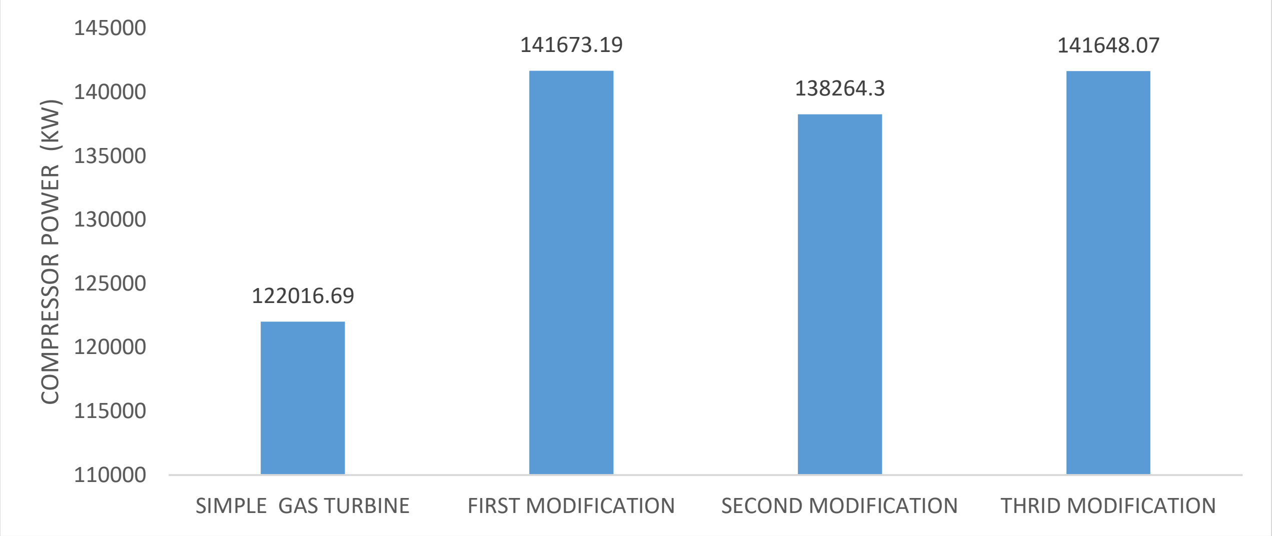


Figure 13: Simulated results obtained for the compressor power of the simple and modified gas turbine plants.

Figure 13 illustrates the compressor power of both the simple and modified gas turbine power plants. Compressor power in a gas turbine refers to the mechanical power needed to operate the compressor, playing a crucial role in the overall efficiency and performance of the gas turbine. Various factors, such as compressor design, efficiency, pressure ratio, and mass flow rate of air, can influence compressor power. As seen in the figure, the first modification exhibits the highest compressor power, followed by the third modification, and lastly the second. These findings highlight the variations in compressor power among the different modifications, emphasizing the significance of this parameter in the overall efficiency and performance of the gas turbine plants.

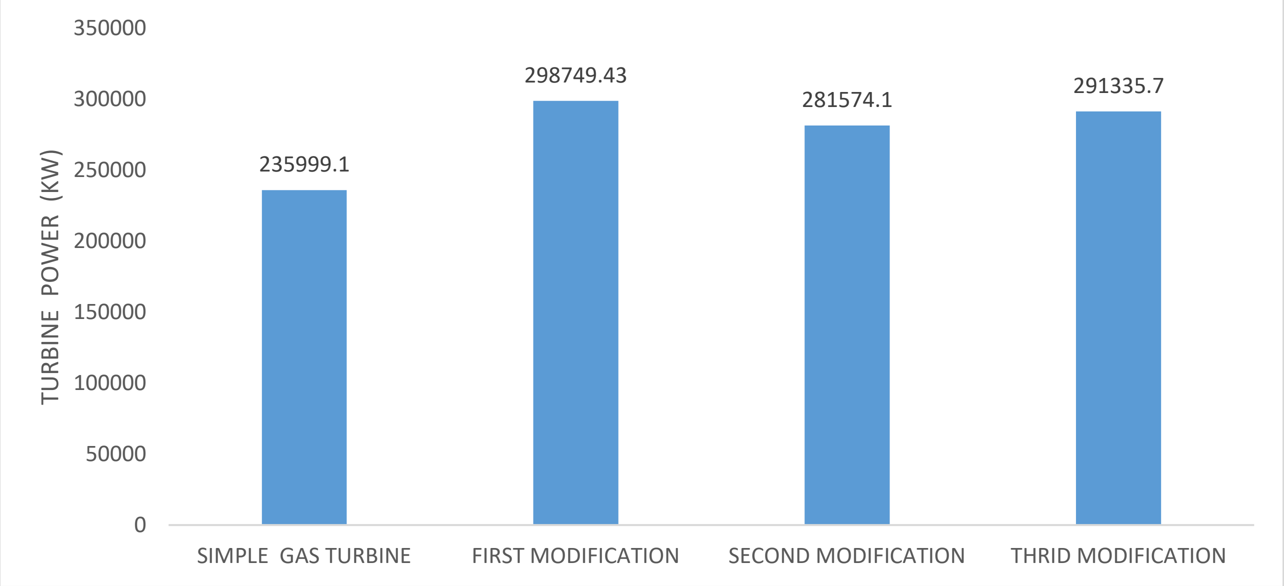


Figure 14: Simulated results obtained for the turbine power of the simple and modified gas turbine plants.

Figure 14 presents the turbine power of both the simple and modified gas turbine power plants. Turbine power in a gas turbine refers to the power output generated by the turbine, and it is a crucial factor influencing the overall efficiency and performance of the gas turbine. Various factors, including turbine design, efficiency, and fuel flow rate, can impact turbine power. As seen from Figure 14, the first modification exhibits the highest turbine power, followed by the third modification, and lastly the second. These findings underscore the variations in turbine power among the different modifications, emphasizing the significance of this parameter in the overall efficiency and performance of the gas turbine plants.

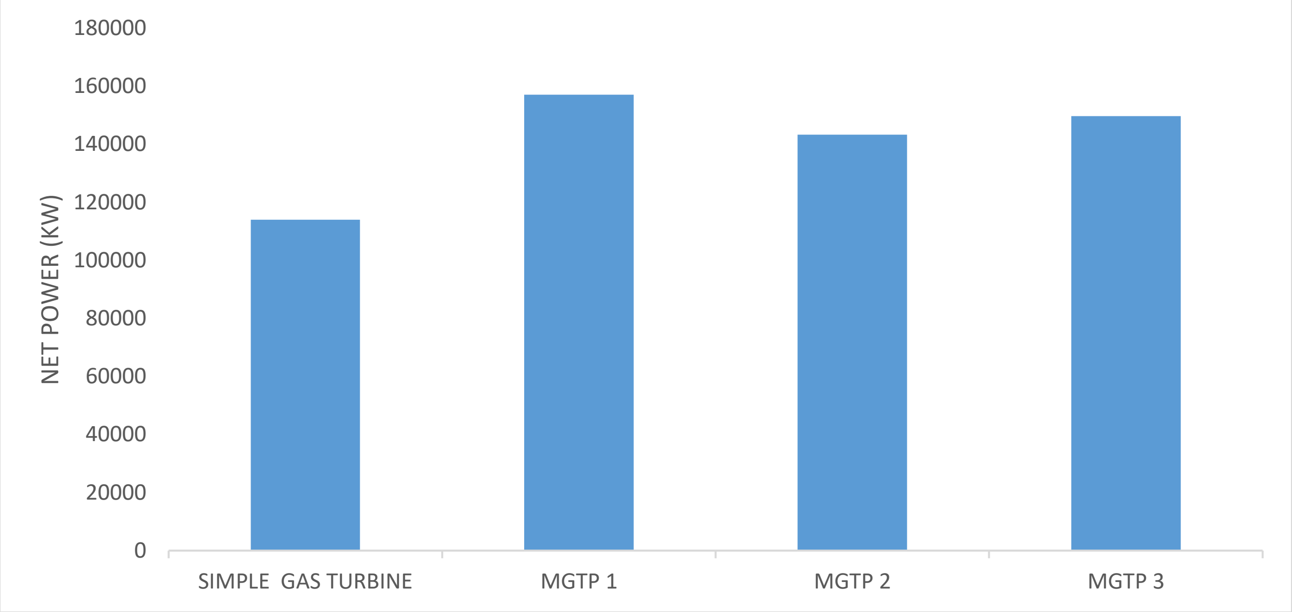


Figure 15: Simulated results obtained for the net power of the simple and modified gas turbine plants.

Figure 15 illustrates the net power of both the simple and modified gas turbine power plants. Net power in a gas turbine refers to the effective power output available for performing useful work after accounting for various losses and inefficiencies in the system. It represents the power delivered to external loads or applications and is a crucial factor in assessing the overall efficiency and performance of a gas turbine. several factors, including design, compression ratio, combustion efficiency, turbine inlet temperature, load conditions, environmental conditions, maintenance and wear, fuel quality, and overall system efficiency, can influence net power.

The first modification exhibits the highest net power or power output, followed by the third modification, and lastly the second. These findings underscore the variations in net power among the different modifications, emphasizing the significance of this parameter in evaluating the overall efficiency and performance of the gas turbine plants.

Conclusion

In this study, Aspen Hysys software was employed to model and analyze various performance parameters of the Omotosho gas turbine plant and the obtained results were compared with the operational data of the existing simple gas turbine. The comparison revealed a satisfactory agreement between the simulated results and the actual operational parameters, affirming the accuracy of the Aspen Hysys software in replicating the performance of the simple gas turbine.

Further investigation involved the modeling of the simple gas turbine into three distinct configurations, and all were subjected to simulation. The results from the simulations were then compared with those of the simple gas turbine. The key findings from the thermodynamic simulation are summarized as follows:

i. The thermal efficiency, compressor power, turbine power, and net power of the three modified gas turbine plants are higher in comparison to the Omotosho gas turbine plant.
ii. The specific fuel consumption, heat rate, and emission rate for all the modified gas turbines are lower than that of Omotosho gas turbine plant.
iii. In general, among the three modified gas turbines, the first modification exhibits the highest overall performance improvement, followed by the second and, finally, the third modification.

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