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Effect of the Maintenance Strategy on the Performance and Efficiency of the Gas Turbine Unit: A Review

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ABSTRACT

With the intense competition characterizing the volatile power sector, the gas turbine industry is currently facing new challenges of increasing operational flexibility, reducing operating costs, and improving reliability and availability while mitigating environmental impact. In this complex and changing sector, the gas turbine community can meet a range of these challenges by developing highly accurate, computationally accurate and efficient diagnostic and warning systems to assess engine health. Recent studies have shown that monitoring engine gas path performance remains the cornerstone for making informed decisions in the operation and maintenance of gas turbines. Describes a newly developed engine performance monitoring methodology, diagnostic and forecasting techniques. The inception of performance monitoring and its evolution over time, the techniques used to generate a high-quality dataset using adaptive engine model performance, and the effects of computational intelligence techniques on enhancing the implementation of engine fault diagnosis are reviewed. Furthermore, recent developments in alarm technologies designed to enhance the maintenance decision-making scheme and the main causes of gas turbine performance degradation are discussed to facilitate the identification of unit faults. Gas turbine diagnostics and forecasts are one of the most important key technologies to enable the transition from scheduled maintenance to maintenance status in order to improve engine reliability and availability and reduce life cycle costs to organize, evaluate and identify patterns and trends in the literature as well as identify research gaps and recommend new research areas in the field of gas turbine performance-based monitoring.

1. INTRODUCTION

Renewable energy sources are seen as viable alternatives to fossil fuels for both the current and future needs of energy. In this work, we present a method for comparing five distinct kinds of renewable energy sources for the generation of electricity using a multi-criteria analytical hierarchy decision-making process: wind energy, biomass, concentrated solar power, geothermal energy, and solar photovoltaic [1].

Since there has been more pressure in recent years to raise the amount of renewable energy sources in electricity generation, developing geothermal energy may be possible now places that were not profitable Poland is currently implementing this method by using low temperature geothermal resources routinely for heating leisure activity places. However, research is ongoing regarding geothermal energy as a source of electricity. Using the first rule of thermodynamics, we determined that the system's power output and efficiency would be 10.5% and 1.79 MWe, respectively. Moreover, by applying the Second Law of Thermodynamics, we calculated a thermal efficiency of 29.0%. As a result of this, the design of a two-stage axial turbine was developed in response to feedback from the customer and cycle parameters. As a result of our investigation [2].

Power plants using dry steam: It is the most popular form and creates electricity by pouring hot steam from a reservoir of hot water directly into a turbine, which drives an electric generator attached to it. Once the hot steam has passed through and circulated to the turbine, it is condensed into water and then injected back into the earth through a well.

Electricity production requires the use of power plants. Due to how desirable they are for power generation given their low cost to power ratio, gas turbine power plants have attracted a lot of interest among the numerous types of power plants. The principal energy source utilized to produce electrical energy typically affects the types of generating stations. There are various parts for generating stations.

Gas producing stations, outdoor power plants Diesel fuelling stations, hydroelectric, tidal, wind, and solar power facilities [3]. Currently now, gas-steam combined cycle plants are the most productive and environmentally friendly power generation facilities. There was a potential for up to 60% thermal efficiency. The intricate, exorbitantly expensive, and precise parts that make up a gas turbine operate under conditions of extremely high gas pressure and temperature. Deterioration or failure has a significant impact on the engine's performance. The performance of a gas turbine is significantly influenced by the combustion chamber, compression, and turbine performance. 1-straightforward gas turbine, 2-Recovery cycle gas turbine, 3-Combined gas turbine, 4-Hybrid power stations [4].

Gas turbine is a rotating internally flammable vehicle in which the working fluid is continuously entered and passes through three basic stages: the stage of compression, the stage of heating, and the stage of expansion to produce the power necessary to operate the load. Gas turbines are used to power generators, ships, and racing cars, and are used in jet engines. Most gas turbine systems consist of three main parts: Air compressor, combustion, gas turbine [5].

Gas units entered the field of electric power generation since the beginning of the century in the past, it was mainly used to cover peak loads and fill in the resulting shortage The increasing demand for energy, there are several types of electric power plants as follows: 1. Steam power plants, 2. Gas generating stations, 3. Hydropower stations, 4. Tidal-dependent generation stations, 5. Nuclear power plants, 6. Wind power plants, 7. Solar power stations [6].

In order to improve the materials used to make the turbine parts' resistance and resistance to environmental factors like corrosion, much study has been conducted on these materials [7-10].

2. GAS TURBINE MAINTENANCE

Maintenance is the process of keeping a gas unit's mechanical components safe and long-lasting, as well as maintaining the production capacity intended for a gas unit. There are different sorts of routine maintenance, and each type is carried out on a certain component of the gas unit depending on the number of hours the generating unit has been running and the fuel used in the combustion process. Each type needs to be able to do maintenance, which necessitates the availability of a skilled and effective engineering and technical team as well as the necessary spare parts, tools, and unique mechanisms.

After the Second World War, there was an immediate desire to create novel methods for schemes that are characterised by giving an integrated picture of maintenance, determining the sequence and precedence, and also specifying the time required to complete these operations [11]. This allowed for the creation of an accurate timetable for the start and end times of each of these maintenances, which led to the emergence of big and complicated initiatives. The critical path approach is regarded as one of the most essential ways in planning and controlling large tasks and of utmost importance in determining the quickest route in terms of cost and completion of the project, measurement of wasted time, and related statistical calculations change.

Fast et al. [12] concluded that operating a gas turbine, like any main engine, requires a periodic inspection program that is carried out on it after certain hours of its operation (between 4 to 10,000 working hours). Where the manufacturer of the turbine determines the hours that it operates before opening its parts for comprehensive maintenance and it is (from 20 thousand to 30 thousand working hours) (Figure 1).

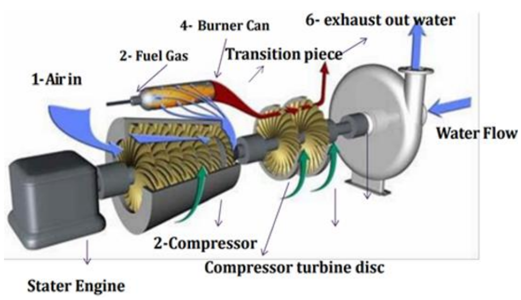

Figure 1. The diagram shows the operating mechanism of the gas turbine engine [6]

Mo et al. [13] provided preventive maintenance procedures. The degradation of the core element (represented by the Wiener model) and the control are responsible for poor control performance, and to achieve this goal, they developed a dynamic and random model to characterize the controller features in order to reduce the expected maintenance expenditure which is the direct effect of how well the controls work. The optimization results reveal the compromise between predicting repair costs and downtime based on stakes of validations, and their significance. Finally, a performance-based maintenance management model can save money in the long run by replacing CBM checks and maintenance.

Zhao et al. [14] observed according to the high cost of the components of the It is evident that these priceless components are maintained from all the initiatives that are spent up until the end of the program, which in most cases amounts to thousands of dollars. influences that lead to their damage or reduce their life, and they are preserved by performing the correct maintenance of all components without exception. Types of maintenance performed on a gas turbine, Partial maintenance or periodic inspection, Comprehensive maintenance.

Zhou et al. [15] established multi-tiered maintenance Schedule model that includes the following steps: unit life forecast, system-wide maintenance planning and decision-making, all of which are evaluated based on their impact on cost and availability. Maintenance costs can be decreased by between 27.7 and 25.1% with the help of the proposed technique based on the most suitable time window., Through the use of multi-objective maintenance scheduling, uptime for machines can be raised by 1.6%. it's just a 0.68 percentage point increase in maintenance expense. Because of the intricate interconnections between compressor units.

Salilew et al. [16] used a powerful and productive file, and adaptable maintenance strategy greatly enhances stability in product CBM (Disorder Maintenance) is an approach of routine upkeep based on the evaluation of a machine's present state experts can monitor the gas turbine's state and predict where problems will arise. This will make it possible for them to proactively choose the best maintenance solution, which in turn increases systems reliability and availability and reduces maintenance cost (Figure 2).

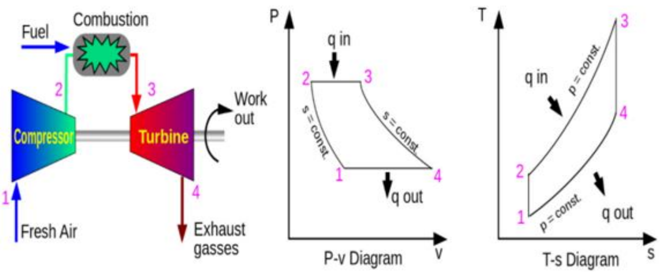

Figure 2. Gas turbine unit diagram and Brighton cycle

In the study [17], monitoring of engine gas path performance has proven to be critical a thorough examination is provided herein. This article's goal is to give a high-level introduction to of the literature on performance-based monitoring for gas turbines, organise and assess the existing literature, and find patterns and trends (Figure 3).

Kumar et al. [18] have created a framework for big data analytics that enhances condition-based maintenance (CBM), improves forecasting precision, and optimises the maintenance schedule in order to quantify the uncertainty in the remaining life expectancy. CBMs will improve equipment reliability, which will lead to lower maintenance costs, through the efficient use of monitoring information and condition predictions. An extensive set of data produced by a sophisticated simulation file of a gas turbine propulsion station is used to apply the experimental results. According to the comparison analysis, the method used in the suggested framework outperforms more traditional methods in terms of Statistical performance and accuracy rate indicators (Figure 4).

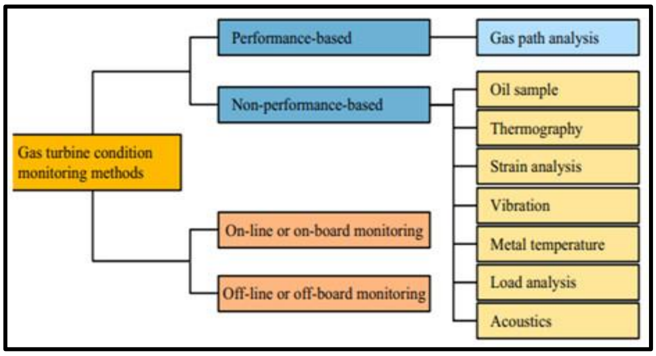

Figure 3. Diagram of methods for monitoring gas turbine condition

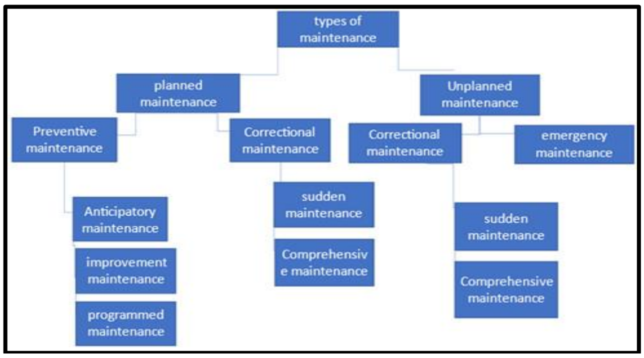

Figure 4. The types of maintenance in a gas turbine

Pérez-Ruiz et al. [19] explained gas turbine maintenance by using the principle of variable structural classifications to account for all conceivable risk events. , fault categorisation, multiple-class boundaries, and the skew error scheme, we find that (a) no single method outperforms all others across the entire array of diagnosing circumstances; (b) the prevalent level of specific diagnostic precision largely depends on the fault identification used; and (c) the major effect of fault intensity border is the fault categorization used. found. Because of (a) the proposed boundary's greater realism in contrast to simpler borders and (d) the inclusion of real deviation noise, the proposed method achieves a far higher level of precision than its predecessor.

Fentaye et al. [20] discuss the effects that cause problems in gas turbines and with the aim of determining the nature of the defects that cause gas turbine losses, and the gas path defects that contribute the most to this loss, and most of the components revolve around these defects, and before moving on to discuss the many obstacles that stand in the way of accurate diagramming of gas paths and the most important features that a conservative fault-finding technique must require. So far, we look at the different defective diagnostic techniques and summarize their benefits and drawbacks. Diagnostic tools based on artificial intelligence (AI) and its met heuristic (Figure 5).

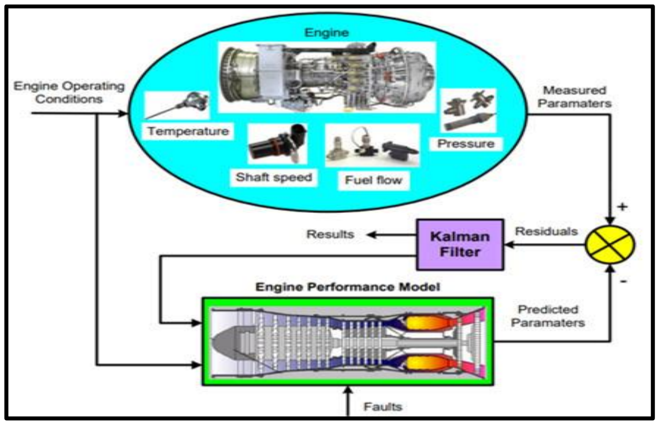

Figure 5. The graphic shows a GT gas path diagnosis using a Kalman filter [14]

3. THE EFFECT OF TEMPERATURES, TYPE OF FUEL, AND TYPE OF FILTERS ON THE STATION

The effects of these problems on the performance of all three major components include fouling and corrosion, two of the most significant and efficient sources of performance degradation in gas turbines. Components such as gas generator turbines, power turbines, and compressors are researched. Analyses are done on how they affect the overall effectiveness of the system. The inlet air temperature has a significant impact on gas turbine performance. The mass flow through a gas turbine affects its power output. Due to the less thick air, energy production is specifically reduced during hot days. A 1°C rise in intake air temperature results in a 1% drop in energy output, when the ambient temperature is high, which typically occurs during peak power, the gas turbine's power is increased through effective intake air cooling.

Memon et al. [21] investigated the thermal efficiency of a gas power plant (Brighton cycle) to determine the impact of fuel turbine and compressor input temperature on plant efficiency and carbon dioxide emissions. They discovered that low compressor input temperature and high gas turbine input temperature produce the cycle's best performance.

Matjanov [22] investigated the effects of environmental conditions on the performance of a gas turbine power plant in Tashkent with a capacity of (MW 28.1). He demonstrated that power decreased from 34.2% to 32.0% at 45°C, and it was suggested to use an absorption cooler to cool the air entering the compressor using three different exhaust gas heat sources, including solar energy and heat recovery generator exhaust gases, in order to increase gas turbine efficiency. The usage of heat recovery generator was found to be both technically and economically superior than using exhaust gases in the absorption chillier, which also requires huge regions for solar collectors.

Mendeleev et al. [23] studied the effect of adding a humidification system to the gas generation unit for the air entering the compressor in order to reduce its temperature, especially in the summer season when the air is dry as a result of the change in its density and humidity at different temperatures, where a comparison was made for a unit Simple gas generation with the gas generation unit with the humidification system. They noted that the efficiency of the unit in which moisture is added to the incoming air is higher than the unit that does not contain the humidification system.

The energy produced increases by (7-9 MW) when the air entering the unit is humidified.

Ahmad [24] conducted a theoretical analysis of the first and third units of the Baiji gas station, with the first unit using (LFO) fuel and the third unit using (HFO) fuel. He discovered that as the load increases, the fuel consumption drops. For example, at 20 Mw, the fuel consumption is roughly 0.765 m3/Mw.hr. When the unit is operating at close to its maximum energy capacity for diesel fuel, the percentage starts to drop off and becomes 0.35 m3/Mw.hr. The price for heavy fuel rises by 15%. The thermal efficiency is 48% for the first unit and 51% for the third, implying that utilizing diesel fuel increases the real unit's efficiency by 4%.

Burnes and Camou [25] studied the effect of fuel composition on the performance of a gas turbine engine, and how different fuel types (natural gas and crude oil) affect the output characteristics of power turbine engines and highlighted the benefits of using fuel that contains high percentages of Hydrogen and carbon, including higher energy, higher more effectiveness and reduced carbon emissions, as well as the problems of the combustion process that must be taken into account such as self-ignition, reflux, explosion, and combustion instability, which become more obvious when changing hydrogen and carbon, and the researchers concluded that increasing the proportion of H_2 in fuel results more efficient H_2 combustion effects ,while Low H/C fuels lower ignition temperature are typical, and the results showed that natural gas is better than fossil fuels in this study.

Cai et al. [26] conducted a numerical analysis of a sulphur-containing natural gas-fueled power plant. This power plant was constructed to investigate the effects of sulfide concentration on a system's performance. Three different diluents, including gas, were used. Recycled flue and H_2O and CO_2 to cool down combustion temperature, increasing H_2S fuel concentration will diminish system efficiency. The results demonstrate that the use of recycled flue gas in sulfur-rich natural gas used to fuel energy plants can boost energy efficiency and reduce their environmental impact as the hydrogen sulfide content rises from 1 ppm to 1% vol.

In order to determine the best types, sizes, and stages of filters, Wilcox et al. [27] carried out a study on the procedure for filtering the air that enters the gas turbine system. They came to the conclusion that the environment in which the gas turbines operate has a significant impact on the filtration system to be used. The pollution in the area is another factor. The air will determine the filters that are employed. In order to properly choose the filters to be utilized, it is crucial to ascertain the type and volume of impurities; consequently, temporary and seasonal fluctuations must also be taken into account.

Wilcox et al. [28] studied the filtration process of compressed air for gas turbines in high-humidity environmental conditions when using high-efficiency filters and their effect on the thermal performance of the gas unit, because moist air can carry drops of water with it. As a result, moisture may build up these soluble contaminants and carry them through the filter to the gas turbine inlet where they may cause damage to the gas turbine. Sometimes, drops of water or some particles smaller than (10) microns can pass through these filters, especially if they are not designed to drain water. For instance, salt can cause heated corrosion in the turbine section since it is soluble. So they showed that it is important to use many filtration processes to reduce the amount of water in the incoming air. It has also been proven that a group of these devices was efficient in eliminating liquid particles larger than (3) microns. Mechanical filtration, however, cannot get rid of some water vapour and particles in the air that are smaller than three microns.

4. TRANSACTIONS AND DESIGN METHODS (PRACTICAL, THEORETICAL, SIMULATION)

Gas turbines are subjecting to various types of degradation If they are not processed in time, it may lead to failure of the production capacity of the power plants and increase Maintenance expenses. vigilance performance monitoring is large part of the CBM plan, which helps reduce maintenance costs and improve the service life of components. It includes Detect, isolate and identify defects that also occur In gas turbine components or their metering system. Over the years, there have been different strategies for detecting errors which developed by using performance-based and non-performance Current methods of diagnosis, studies and analysis of gas turbine components. It is important to know the plant performance parameters and to diagnose faults early to predict the missing part and this helps in reducing maintenance costs, preventing unplanned outages and evaluating different schedules.

Rahman et al. [29] carried out a parametric analysis of the effect of gas turbine power on thermodynamic performance by changing the operating the thermal efficiency and compressor performance of gas turbines are influenced by a number of variables, including pressure ratio, air-to-fuel ratio, and ambient temperature. operation, power, particular fuel consumption, and heat rate), where the MATLAB program was used to create the gas turbine performance model programming. The findings demonstrated that thermal efficiency is significantly influenced by pressure ratio, ambient temperature, and air-to-fuel ratio. In addition, thermal efficiency and power output linearly decrease with increasing ambient temperature and air-to-fuel ratio. Yet, the specific fuel consumption and heat rate rise linearly as the ambient temperature and the air-to-fuel ratio increases.

Sahu [30] described a gas turbine core component with good heat air layer blade cooling and examined how operational conditions affected heat efficiency. This combines the utilization of compressor thermal performance (to cooling the blade). The pinion air cooler specifications are determined by the turbine temperature differential and the permissible temperature of the blade material. a lot of the time. According to the data, for a specific set of repetitive exposure (rpc = 20, TIT = 1500 K, hAC = 88%, and hGT = 90% with an air mass flow rate of 500 kgsec), the investment cost flow Rate (Z), fuel cost rate (Cf), total cost flow rate (CT), and super efficiency are all $0.6334/sec.

In the study [31], faults are simulated by altering the turbine and compressor characteristic curves to alter the health metrics (flow capacity and isentropic efficiency) of each GT element. Compression fouling model findings are compared to publicly available experimental data, with good outcomes indicating a sufficient level of model reliability in estimating the variance of measured parameters. Each 10% drop in jet engine loads necessitates a fault insertion procedure to identify the fault signatures in part-load situations. The fault profiles exhibit varying sensitivities to load changes, as shown by the simulated findings.

Hashmi et al. [32] conducted an analytical study. on the synergistic influence of fouling and variable external circumstances on gas turbine performance. Different conditions have been accounted for in the study by dividing it into four groups: The first variant has intake air cooling, the second variant does not, and the third variant employs a Varying Timetable for Inlet Vanes (VIGVs). in addition to (iv) not on a VIGV plan. Thermal efficiency and SFC, which had been declining due to fouling, were found to that integrating inlet air conditioning in order to increase the productivity of commercial gas turbines, a flexible geometric engine is being used. regions with hot, humid climates like the. Middle East and South - East Asia have improved after the implementation of the VIGV schedule (Figures 6, 7 and 8).

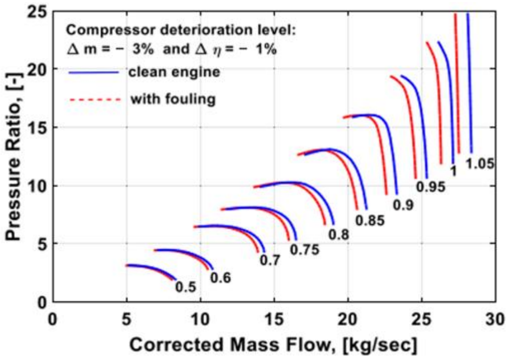

Figure 6. Illustration of the effect of pollution on the pressure ratio in the compressor map [32]

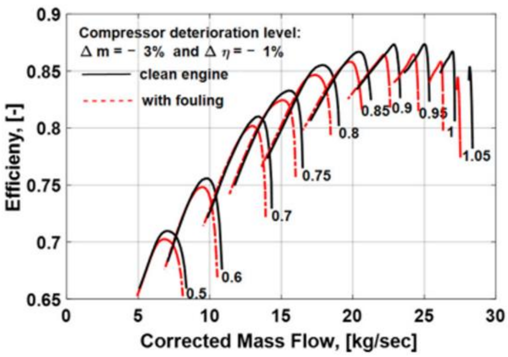

Figure 7. Illustration showing the effect of pollution on efficiency in the compressor map [32]

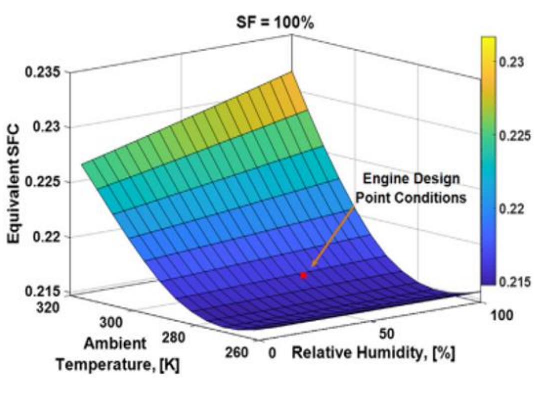

Figure 8. Graphic showing the effect of the parametric study on SFC at 100% contamination intensity [32]

Sidum et al. [33] studied the impact of turbine performance on compressor operating conditions. The power plant is situated in the Nigerian delta region's tropical rainforest. Factors affecting power output were identified, including compressor inlet temperature and humidity. According to the study, power production decreases as compressor inlet temperature rises. During operating, the compressor inlet temperature was 31℃, and the plant's net power production was 125.5 MW. who is significantly less the output was calculated to be 138.26 MW at a lower temperature of 18℃, which is very near to the projected rated capacity of 138.29 MW. It was also noticed that the thermal efficiency increased by 33.1% at the input air temperature of 31℃, and improved to 36.10% at 18℃. The investigation also revealed that the temperature drops from 31℃ to 18℃ increased power output by 0.78 percent per 10℃, lowering compressor inlet temperature. A total of 128.406 megawatts of energy were produced at a temperature of 31 degrees Celsius and a humidity of 80%, however, due to the effect of humidity on the functioning of the turbine. As comparison to the 125.5 MW obtained at the same temperature without taking humidity into account, this implies an increase of 2.096 MW or 1.67%. According to the results, compressor intake air temperature and turbine power output are inversely associated, and power output and humidity are also inversely related.

Meziane and Bentebbiche [34] performed digital simulations, we may adjust the amount of hydrogen added from 0% to 90% in 10% degrees., the combustion reaction scheme was simplified by using a GRIMECH 3.0 mechanism. By injecting the blended fuel at a consistent bulk flow rate, the exhaust is maintained when the blended fuel injection occurs at a constant velocity. distribution is more consistent. Additionally, both CO and NO emissions are decreasing steadily. Micro gas turbine power production may be reduced, however, if the average outlet temperature drops.

Pirvaram et al. [35] studied the combined cycle under conditions rich in fuel with the recycling of exhaust gases (ammonia) used as a “carbon-free” fuel, as it is a good carrier of energy, but it leads to the production of significant amounts of nitrogen oxides during the combustion process, and to avoid this problem is done Burning unburned hydrogen in a heat recovery steam generator and thus the hydrogen leaving the combustion chamber increases the system's thermal effectiveness and increases the energy produced, since emissions of nitrogen oxides can be reduced while maintaining efficiency. The ideal operating conditions for this process depend on the exhaust gas recirculation ratio, the turbine inlet temperature, and the permissible NOx concentration in the exhaust gas.

Hussain et al. [36] explain the importance of a pump widely used in the gas turbine machine's lubrication system, wherein space efficiency and dependability are paramount. This work examines the pump's characteristics from an operational standpoint and compares them to experiment results, finding a close match (within 5% variance). In this way, the approach can be utilised to make predictions about efficiency and wear. As a result of these findings, pump engineers to pick username pump's geometric characteristics and mechanical clearance based on needs.

Al-Dalwi and Vural [37] studied the effect of operating variables on the combined station (gas, steam) using simulation (HYSYS), and explained that the modelling was complicated as the cycle was simulated at the steady state. The closed cycle was more complicated due to the problems of material accumulation, and it was found that the solution to this problem is to put a tank for it to control the pressure and the flow of the steam cycle. They concluded that HYSYS simulation is not good with polymers, and neither of them was designed to simulate power plants, but it is considered useful for simulating hydrocarbons. A comparison was made for the results of the operational unit in the normal case, and the total efficiency was found (53%) with the simulation results amounting to (59%).

Enagi et al. [38] used of the ANSYS- (Computational Fluid Dynamics) simulation programme Simulations were run using models chambers layouts in terms of species transportation and quasi burning geometries and determine which was the most efficient. The parameters of the flame holder are 50 mm in diameter, the height of the chamber is 60 cm, and there are four apertures measures Sizes of 6-10 millimetres and a diluting region; these dimensions were chosen as the optimal chamber shape following optimization. In in order to assess the cabinet's efficiency, Stable combustion was achieved in the chamber's experimental test using LPG fuel, lowering carbon monoxide emissions to below 100 parts per million, and keeping turbine inlet temperature from surpassing 900 degrees Fahrenheit.

Zeinalpour et al. [39] conducted an analytical study to examine the sensitivity of gas turbine fuel consumption in relation to the turbine stage efficiency. It was discovered that if the first stage of the turbine's efficiency is enhanced from 82% to 84%, the engine's fuel consumption decreases by 1%. Cycle analysis showed that the sensitivity of fuel consumption to the efficiency of the turbine stage varied with different stage efficiency values. The findings demonstrate that fuel consumption is more sensitive to the efficiencies of the early stages and that the improvement of stages with a lower temperature has a greater impact on fuel consumption. It follows that the stage's impact on gasoline usage will depend on the temperature drop during that stage. Also, it was shown that as stage efficiency grows, so does the sensitivity of fuel use to that efficiency.

Ezzat and Dincer [40] proposed a new generation of joint power plants that run on ammonia only. Both an ammonia-fuelled gas turbine cycle (GTC) that uses hydrogen as a promoter and a solid oxide fuel cell are integral to the system's ability to generate electricity (SOFC). Using the RC's electricity, an ammonia electrolyzer creates hydrogen gas that can be used later. To do a thermodynamic analysis of the system, the laws of thermodynamics, both first and second, are being used. Additionally, the Exergy losses and destruction of the various integrated power plant units are calculated. Additionally, a thorough parametric study is conducted to examine how changes in environmental factors, operational parameters, and design choices affect total system performance as an entire. Overall, the multigenerational system has energy efficiencies of 58.72% and energy efficiencies of 50.66% (Figure 9).

The researchers used the MATLAB program to conduct an economic and environmental analysis of the gas-turbine plant, focusing on the overall cost and rate of carbon dioxide emissions, and the operating conditions were (compressor pressure ratio, combustion chamber inlet temperature, and the gas turbine temperature difference) [41]. The results showed that as carbon dioxide emissions rose, so did the cost of emission reduction. The results also demonstrated that the electrical energy efficiency of the cycle increases with the increase in the gas turbine entry temperature and the compressor pressure ratio. The economic analysis demonstrated that the higher energy efficiencies, the higher total cost rate. The results also demonstrated that the compressor pressure ratio and the gas turbine inlet temperature, the carbon dioxide emission rate decreases.

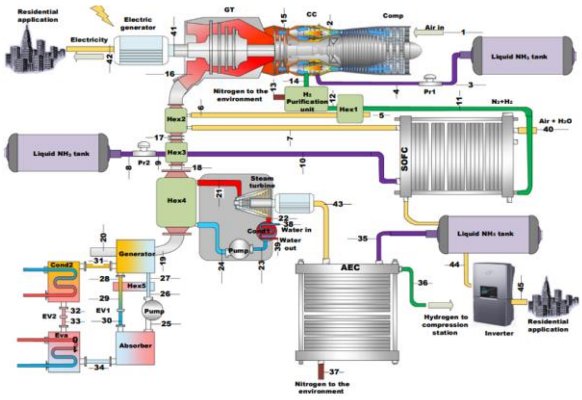

Figure 9. Schematic of the SOFC- GT based multigeneration system [40]

Feng et al. [42] reached the results, that the best values for the distributions of thermal conductivity and pressure ratio of the compressor produce the highest possible rate of gain without dimensions. The highest rate of dimensionless profit and the matching exergy efficiency have a cyclical relationship. Rates of maximal non - dimensional higher profit. when the temperature ratio of the heat reservoir (1), the price ratios of the heat exchanger (a and b), and the total inventory by means of thermal separators (UT) all rise. Exergy efficiency improves as a, 1, b, and UT drop and grow, respectively. The best value of the temperature ratio of the heat reservoir, 2, yields twice the maximum rate of dimensionless profit.

Salah et al. [43] studied the power and energy available for the gas power station in the town of Kirkuk with a rated capacity (MW 283.6) in order to assess the unit's thermal performance (K3) at the real environmental conditions of the station that included the external relative humidity, compression ratio, and outside temperatures by applying the first and second law of) thermodynamics using ChemCad simulations). The findings demonstrated that the thermal performance of the gas unit degrades as the ambient temperature rises; the unit's energy efficiency peaked at a temperature of 19.39 degrees Celsius (37%), but performance improved as the compression ratio rose.

Şöhret et al. [44] lay out the methods for evaluating systems in terms of external energy first in detail here. The following section provides a survey of the relevant literature. Literature reviews suggest that turbofans are more thoroughly studied than any other design of the gas turbine engine used in aviation. Advanced exergy analysis approach is applied to gas turbine engines for aeroplanes, both those using conventional fuel and those using alternative fuel, in order to better understand the interplay between the various parts.

This work's goal is to do a thermodynamic analysis. of two operating Siemens V94.2 gas turbine (GT) units [45]. These units were chosen because they are performing far below their designed thermal efficiency, and because of their age, extensive retrofits would yield a low return on investment. The complete gas turbine thermodynamic process is simulated with the help of a numerical model built in MATLAB SIMULINK. Comparisons with operational data from the stations are used to verify the accuracy of the produced numerical results. The thermal efficiency has been increased by 30%, allowing for a maximum power output of 140MW. The results of a 6.0°C temperature rise, the power output dropped by 0.2%. To maximise thermal efficiency and power output, a graphical optimization is performed, wherein the parameters are presented on graphs. Conclusions and suggestions for improving rated power, electrical efficiency, provided.

Bianchi et al. [46] conducted a comparison in this paper comparing two energy return strategies that can be implemented in underutilized gas turbines -based Trash To-Energy (WTE) facility to boost the efficiency of trash to electricity transformation (GT). The repowered system can produce up to three times as much power as the original system, and its first law efficiency can reach as high as 36%. In addition, waste utilisation can be improved through integration with GT, leading to favourable results.

A study on enhancing the thermal performance of gas turbines was conducted in Malaysia with the goal of lowering the temperature of the air entering the turbines by employing mechanical coolers and simulation (using the GT Pro software) [47]. The findings demonstrated that adding an air cooling mechanism enhances system functionality and boosts energy output from (35 kW) to (44 kW).

Reine and Nader [48] provide a technical evaluation of several thermodynamic configurations of the ECGT system and explore the fuel economy potential of the EREV There are several types of ECGTs: the basic S-ECGT, the more complex DS-ECGT, the intercooled DS-ECGT, and the reheated DS-ECGT (DIRe-ECGT). Energy and technology analyses are carried out in order to evaluate the functionality of the system and power-to-weight efficiency at various temperatures. Based on the findings, the DIRe-ECGT-APU shows promise for use in EREVs due to its lower fuel usage compared to the other ECGT-systems studied.

Barakat et al. [49] introduced in the current work, a new hybrid cooling system a comparison to alternative intake air-cooling systems for gas turbines is shown and verified. Fogged up, an updated hybrid cooling system, and the earth-air heat exchanger are the various cooling systems. In total, three models are created: one for predicting the cooling capacity of the fog system, another for describing the thermal behaviour of the planet's surface hybrid system, and a third for calculating the state's energy efficiency. Furthermore, in regions when temperatures regularly exceed 30°C and relative humidity is less than 60%, the dual cooling system provides the most effective option.

Ibrahim et al. [50] analyzed the energy of simple Brighton Joule cycle in the electric power generation station The performance of the North Oil Company, which is situated in the northern part of Kirkuk, and the impact of changing ambient temperature of of the gas generation unit (which design capacity is 23.75MW) at standard conditions using Matlab program, they concluded. that while particular fuel consumption falls when ambient temperature rises, the unit's overall efficiency rises as temperature does.

5. CONCLUSIONS

To enhance the performance of gas turbine power plants, the current version includes developments in the intake air cooling system employed, the fuel type used, the cleanliness of the filters, and the timing of maintenance. where quality is achieved and gas turbine power plants' performance is improved by diversifying the maintenance system. The execution of the maintenance must take place at the designated periods and in accordance with the operating hours for each type of turbine if it is to be successful. The peak output of the gas turbine is increased when operating in hot weather thanks to the gas turbine intake air conditioning system.

There are four types of gas unit maintenance. Three of them are programmed maintenance. The first type is combustion chamber maintenance. the second one is the hot track maintenance and the third one is comprehensive maintenance. each maintenance has its materials and time (maintenance period). The fourth type is emergency maintenance, which leads to a sudden stop of the gas unit usually, it is the result of stopping one of the auxiliary devices (maintenance period) according to the type, location and weight of the device, some of which are in hot places that cannot be work on it until the place cools down. in all unit, there are two seasons for maintenance, the first in the fall (9, 10) and the second is in spring (4, 5) when the load on the electrical system is less due to the mild weather. as for the factors that affect the programmed maintenance, they are the spare materials, as they are not available in the warehouses or are delayed in their arrival from the manufacturer because they are ruling This leads to postponing maintenance to the next season, if available. If it is not available, the unit will be stopped from working. Currently, one of the solutions used in this field is the method of upgrading gas turbines using the improved gas path technology. This technology helps reduce the interval between maintenance operations required for gas turbines in the station, thus reducing breakdowns, enhancing the station's production and performance, and allowing each gas turbine to supply electricity to the grid at regular intervals. longer which will help reduce annual costs.

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