SIGMA
JURNAL TEKNOLOGI PELITA BANGSA
Vol. 12 No. 3 September 2021 p-ISSN: 2407-3903 e-ISSN: 2407-3903
Diterima, 23 Agustus 2021 | Direvisi, 08 September 2021 | Dipublikasikan, 28 September 2021

THE ROLE OF GAS TURBINE IN UTILIZING EARTH GAS AND OIL AS A POWER ENERGY GENERATOR; PROBLEM AND SOLUTION

Ari Yuneldi

Department of Information Technology Engeneering Fakulty Pelita Bangsa University
ariyuneldi1202@gmail.com

Abstract

The existence of gas turbines has an important role in generating energy, this tool utilizes gas and oil fuels to produce energy that is ready for use. Gas turbines continue to experience modifications and developments from year to year so that they can be used effectively and efficiently in their operation. Various technologies are developed to be able to generate electrical energy to the maximum by modifying and combining one working principle with other work principles. Whatever the facts are as sophisticated as any technology that is developed still has weaknesses and shortcomings so it requires more time to be able to produce a quality product. Therefore we need a process of innovation and problem solving in order to overcome this problem by providing alternative solutions to the shortcomings that exist so that the technology used can generate various benefits and minimize the risk of loss. In this report there are several alternative solutions for technology and generator components that are expected to provide little input and solutions so that among some of the shortcomings can be minimized.

***Keywords**: Gas turbines, electrical energy, energy generation technology, gas and petroleum, alternative solutions*

1. INTRODUCTION

Power plants in combined cycles have several important components including electricity generators, steam turbines, condensers, heat changes and gas turbines. Gas turbines play an important role in generating energy to produce electricity. The gas turbine itself began in early 1791, a patent from John Barber about steam turbines depicting liquids and gases as a potential energy source. "John Barber discovered what could be considered a gas turbine where gas produced from hot coal is mixed with air, compressed and then burned. This produces a high-speed jet engine about the radial blade on the turbine wheel rim. John Barber's idea, and previous activities (impulse steam turbine Giovanni Branca-1629, Leonardo da Vinci -1550 smoke factory, and Alexandria in the 130 BC BC-steam turbine reaction).

Although the gas turbines described by these early visionaries are now more appropriately called 'turbo-expanders' there is no evidence that any of these ideas were ever applied to hardware that worked until the late 19th century. The first half of the 20th century the development of gas turbines continued slowly. Constraints on manufacturing capability and availability of high-power, high-temperature resistant materials for use in compressors, turbines and combustion components. As a result of limited compressor pressure ratio, turbine temperature and low efficiency. To overcome the temperature limits of turbines, steam and water injection to cool fuel and turbine materials are used extensively. In 1905, the first gas turbine and compressor unit built by Brown Boveri was installed at Marcus Hook Refi Nery from the Sun Oil Company near Philadelphia, PA. This turbine provides 5,300 Kilowatts (KW) (4,400 KW for hot pressurized gas and 900 KW for electricity). Brown Boveri also built the first power plant turbine to generate electricity at Neuchatel in Switzerland. The following is a picture of the turbine unit he founded,

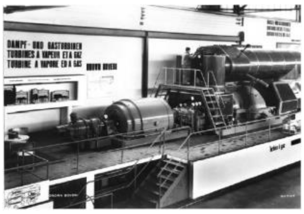
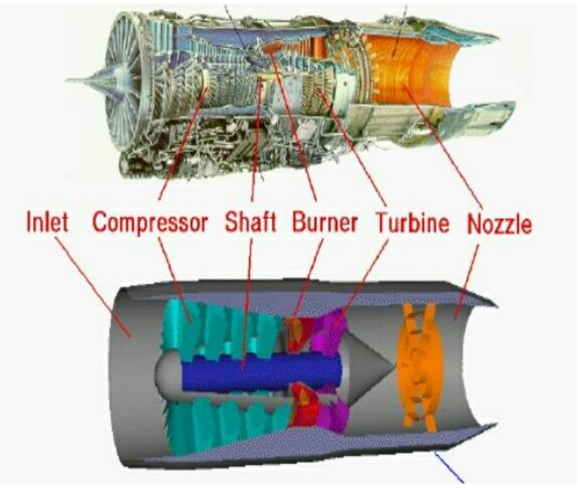


Figure 1. The First Industrial Gas Generators in the World

As for the 3,500 KW unit, which was commissioned in July 1949, it is a simple cycle gas turbine consisting of fifteen-stage axial compressors, six straight-current burners placed around the unit, and a two-stage turbine.
In the first world war the gas turbine was made too large. Following the work of A.C. Rateau, Stanford Moss developed the exhaust driven turbo-charger (1921), which led to the use of a turbo-charged piston engine aircraft during the Second World War. In 1919, the British Air Ministry came to Dr. W.J. Stern, Director of the South Kensington Laboratory, to see the possibility of gas turbines for airplane propulsion. Dr. Stern stated that the idea could not be implemented so it was modified several times finally in 1937, with funds from Power Jets Ltd., the Whittle machine (designated WU for the Whittle Unit) built by British Thomson-Houston Co. from Rugby successfully tested. The Whittle WU machine consists of a double entry centrifugal compressor and a one-stage axial turbine.
So long is the history of the development of gas turbines and steam turbines with several modifications and improvements so that they can only be used. As a gas turbine generator has several important components that can support the work of gas turbine itself. The important parts of the gas turbine are the diffuser (helping the diffusion process), compressor (a tool that serves to compress), burner section (combustion between fuel and air), turbine and nozzle. these parts can be seen in the following figure,



Pict 2. Components of gas turbine

2. THEORY

Ericsson Stirling Cycle and Cycle

The otto cycle and the diesel cycle can both change internally, but cannot be completely reversed or irreversible. Therefore, the efficiency of both cycles will always decrease from the efficiency of the Carnot cycle. In order for the cycle to approach the Carnot cycle, heat addition and rejection must be done isothermally. The point here is that the event changes the state of the gas when the temperature is constant or constant. The Stirling cycle has a graph of the relations of speeds and temperature-time, for more details, consider the following graph,

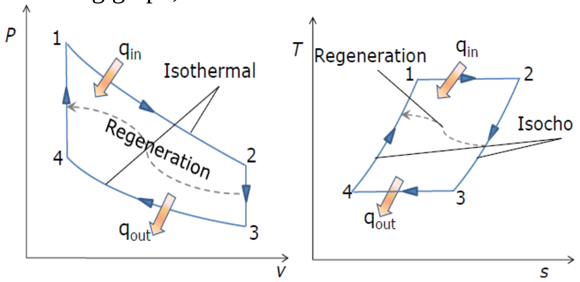
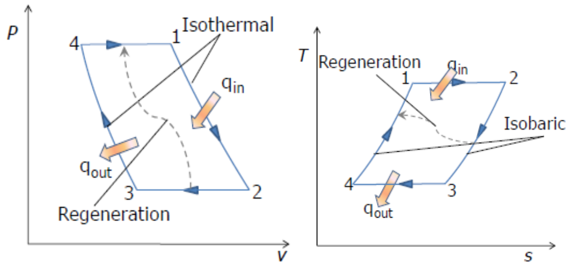


Chart.1 (a) Speed Pressure (b) Temperature Against Time
Meanwhile, the Ericsson cycle has a graph of relations of speeds and temperature-time as well, for more details, look at the following graph,

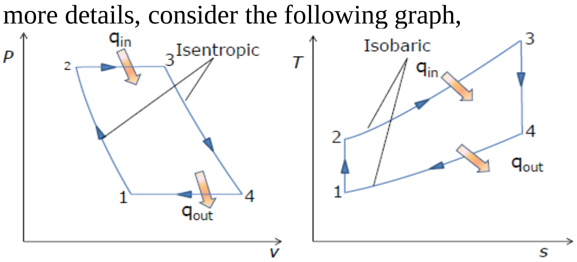


Graph.2. (a) Velocities (b) Time-Temperature

So for the Stirling cycle and Ericsson both are reversible. Reversible means here is the gas properties in thermodynamics where the gas changes can return to its original form. The efficiency is the same as the efficiency of the Carnot cycle between the same temperature limits. This cycle is difficult to realize quickly but provides significant advantages. The regeneration process in this cycle can increase the efficiency used in many modern cycles to improve efficiency.

Brayton cycle

The Brayton cycle is a theoretical cycle for simple gas turbines. This cycle consists of two isentropic and two constant pressure processes. The combustion process is replaced by the addition of heat at a constant pressure from an external source or environment, while the discharge is replaced by rejection. The Brayton cycle itself was proposed by George Braytonin in 1870 for use in reciprocating machines. In this cycle, modern gas turbines when operating operate with engine speed, where these gas turbines operate in open-cycle or open cycle models, but can also be modeled as closed cycles using standard air assumptions.
It is not only the Ericsson cycle and the Stirling cycle that has a graph of the relations of velocities and temperature-time, but the Brayton cycle also has the same graph. For more details, consider the following graph,



Graph.3 (a) Velocities (b) Time-Temperature

The energy balance for a steady flow process can be expressed as:

$$\left(q_{in} - q_{out}\right) + \left(w_{in} - w_{out}\right) = \Delta h \quad (1)$$

The heat transferred to and from fluid work can be written as:

$$q_{in} = h_3 - h_2 = c_p\left(T_3 - T_2\right)$$
$$q_{out} = h_4 - h_1 = c_p\left(T_4 - T_1\right) \quad (2)$$

The thermal efficiency of the Brayton cycle is ideal assuming a large cold air standard is:

$$\eta_{th,Brayton} = \frac{w_{net}}{q_{in}} = 1 - \frac{q_{out}}{q_{in}} = 1 - \frac{T_4 - T_1}{T_3 - T_2} = 1 - \frac{T_1\left(T_4/T_1 - 1\right)}{T_2\left(T_3/T_2 - 1\right)} \quad (3)$$

Based on calculations and for now in the gas cycle the turbine has an efficiency of approximately the size 0.40. Processes 1 - 2 and 3 - 4 are both isentropic where when $P_2 = P_3$ and $P_4 = P_1$ then apply,

$$\frac{T_1}{T_2} = \left(\frac{P_2}{P_1}\right)^{(\gamma-1)/\gamma} = \left(\frac{P_3}{P_4}\right)^{(\gamma-1)/\gamma} = \frac{T_3}{T_4} \quad (4)$$

Substituting the equation into thermal efficiency, so that it is simplified to become,

$$\eta_{th,Brayton} = 1 - \frac{1}{r_p^{(\gamma-1)/\gamma}} \quad (5)$$

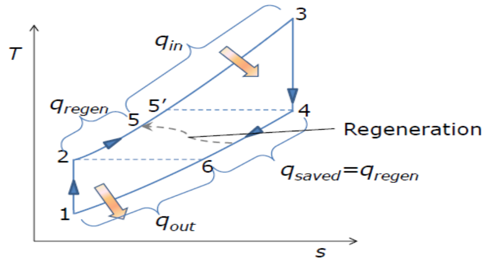
Or it can be written in the form of the following equation,

$$\eta_u = 1 - \frac{1}{\beta_c^{\left(\frac{k-1}{k}\right)}} \quad (6)$$

Where, $r_p = \frac{P_2}{P_1}$ it is a pressure ratio. The thermal efficiency of the Brayton cycle is a function of the cycle of pressure comparisons and comparisons of heat specifications.

Brayton Cycle with Regeneration

Regeneration can be done by using melting hot air from the turbine to heat the outflow of the compressor. Where the thermal efficiency of the Brayton cycle increases as part of the heat and the rejected one is reused. Regeneration decreases the heat input requirement (fuel) for the same work result. The graph of the temperature-time relationship of the Brayton Cycle with regeneration can be seen in the following figure,



Graph 4. Ericsson Regeneration Time

The highest temperature that occurs in the regenerator is at temperature four (T4).
The air will leave the regenerator at a lower temperature, namely temperature five (T5).
In the ideal case the air coming out of the regenerator at the inlet temperature of the four temperature exhaust gas (T4).
Actual and maximum heat transfer applies:

$q_{regen,act} = h_5 - h_2$ dan $q_{regen,\max} = h_{5'} - h_2 = h_4 - h_2$

The extent to which regenerators approach ideal regenerators is called the term effectiveness (ε) whose value can be determined through,

$$\varepsilon = \frac{q_{regen,act}}{q_{regen,\max}} = \left(\frac{h_5 - h_2}{h_4 - h_2}\right) \quad (7)$$

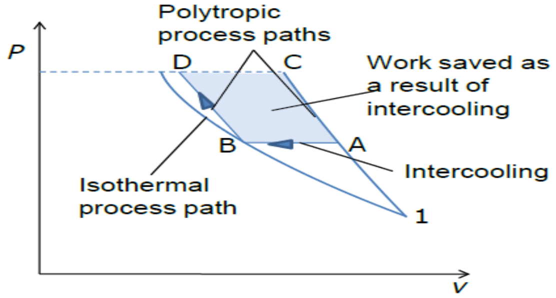
Based on the assumption of cold air standards, the thermal efficiency of the Brayton Cycle is ideal with regeneration is,

$$\eta_{th,regen} = 1 - \left(\frac{T_1}{T_3}\right)\left(r_p\right)^{(\gamma-1)/\gamma} \quad (8)$$

Thermal efficiency depends on temperature and pressure ratio.

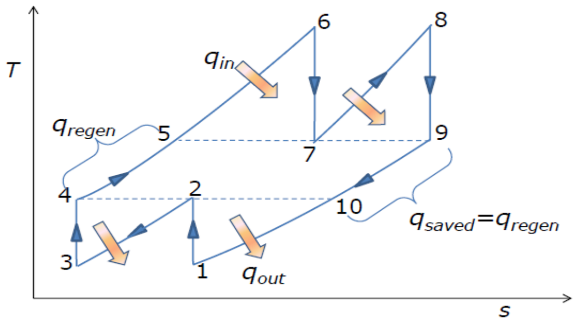
Brayton cycle with *Intercooling*, *Reheating* dan *Regenerating*

The work of the gas turbine cycle is the difference between the output of the turbine work and the input (input) of the compressor. This can be improved by reducing the work of the compressor or by increasing the intensity of the work of the turbine or both. The work needed to compress the gas between two specific pressures can be reduced by performing a gradual compression process and cooling the gas between multi-stage compression with intercooling. Likewise, the work of the turbine can be improved by multi-stage expansion by reheating. Because the number of compression and expansion stages increases, the process approaches the isothermal process. The combination of intercooling and reheating can significantly increase the work results of the Brayton cycle. The following is the Brayton cycle with intercooling, reheating, and regenerating,



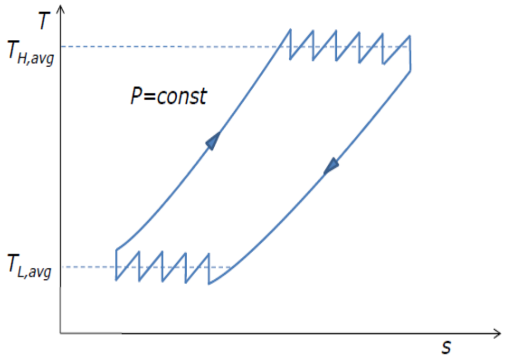
Graph 5. Brayton Cycle-Speed Intercooling, Reheating and Regenerating

Enter work into the first stage compressor (1AC process) and the second stage compressor with intercooling (1ABD process). While for graphs or temperature-time diagrams of gas cycle turbines are ideal with intercooling, reheating, and regenerating seen in the following graph,



Graphic 6. Temperature- Brayton Cycle Time Intercooling, Reheating and Regenerating

The working output of a gas turbine cycle increases as a result of intercooling and reheating. But intercooling and reheating reduce thermal efficiency unless it is accompanied by regenerating, this is because the intercooling decreases the average temperature when heat is added and reheating increases the average temperature when heat is rejected. As the number of compression and expansion stages increases, the Brayton cycle with intercooling, reheating, and regenerating approaches the Ericsson cycle. As in the following graph,

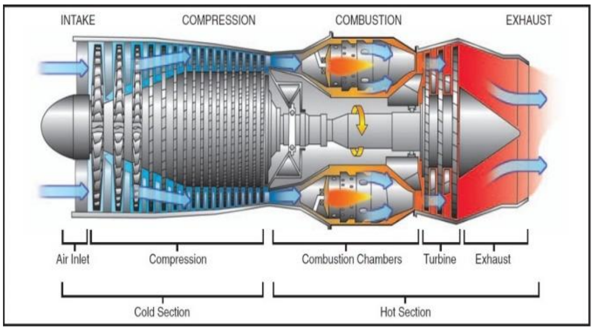


Graphic 7. Temperature-time -> Ericsson cycles

So the working principle of a gas turbine simply applies one cycle, like the Brayton cycle. If a gas turbine has a complex system in generating energy then it can apply more than one cycle and a combination of various other plants.

3. METHODOLOGY

The working principle of a gas turbine is that when air enters it will be compressed with a compressor and heated through combustion energy from fuel [12]. First of all, the air enters the compressor through the inlet (air inlet). Then on the compressor there is suction and increase in air pressure so that the air temperature also increases. After that the compressed air goes into the combustion chamber and then here fuel or fuel is sprayed from the remnants of the fossil that has been processed and then mixed with the air so that the combustion process occurs. This combustion process takes place in a state of constant pressure so that it can be said that the combustion chamber is only to raise the temperature. Then the combustion gas is flowed to the gas turbine through a nozzle that directs the flow to the turbine angles [13]. For more easily the above process can be shown by the following figure:



While the power produced by the gas turbine is used to rotate the compressor and rotate other loads such as an electric generator. After passing through the gas turbine, the results will be discharged out through the exhaust (exhaust). In the basic concept of physics, the gas turbine works based on the Ericsson cycle, Stirling and the Brayton cycle. In this cycle various processes occur as above so that they can generate electrical energy.

4. RESULTS AND DISCUSSION

Electric Energy Generation Technology

The turbine generation technology in producing electrical energy is by configuring a gas turbine through heat recovery (HR) and Steam Generator (SG). Gas turbines work with constant pressure in the form of an open cycle engine characterized by the thermodynamic cycle of Brayton. The main gas turbine hardware subsystem includes compressors, combustion chambers and expansion turbines. The figure below shows the gas turbine technology configured for Combine Heat and Power Technology (CHP). The CHP system includes a gas turbine in the form of a device to drive an electric generator with exhaust gas used to produce steam in a steam generator or Heat Recovery Steam Generator (HRSG) [21].

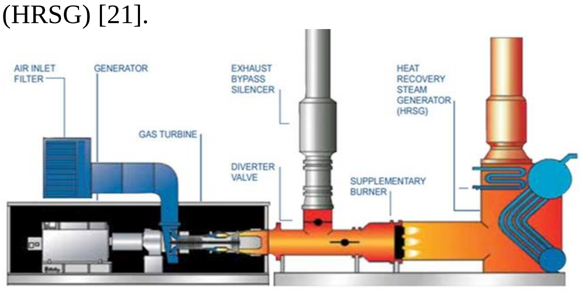
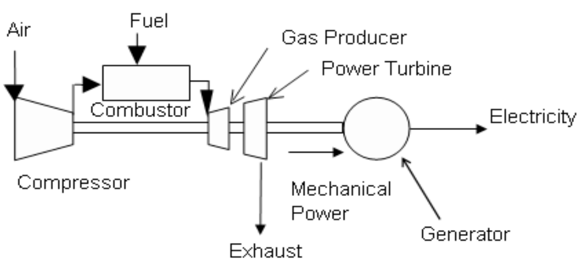


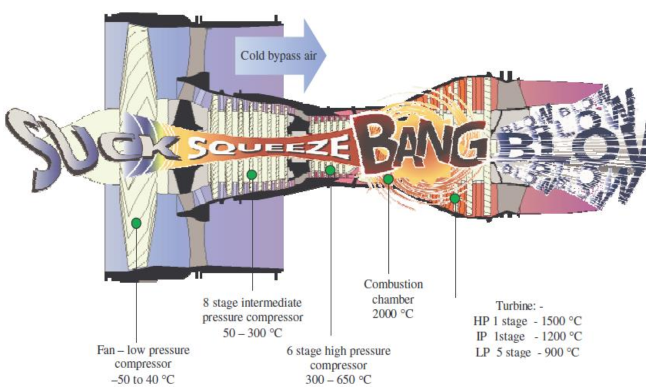
Figure 4. Configuring a Gas Turbine with Heat Recovery

In this technology, where the compressor heats and compresses the air in (Note the Picture) which is then heated further with the addition of fuel in the combustion chamber. A mixture of air gas and heat combustion

drives an expansion turbine, thus producing enough energy to provide shaft power to the generator or mechanical process and to drive the compressor. The power produced can be searched using the equation where the magnitude [22]. Furthermore, the power produced by the turbine expands and is used by the compressor whose value is proportional to the absolute temperature of the gas passing through the system. Therefore, it is advantageous to operate an expansion turbine at an institutional temperature that is in accordance with the economic material and internal blade cooling technology and to operate the compressor with the lowest possible air flow temperature. [21].
A higher temperature and pressure ratio can result in higher power efficiency, or a power-to-weight ratio. Thus, the general trend of gas turbine technology has been combined with higher temperatures and pressures. While these technologies increase machine production costs, the value is higher, in terms of greater power output and higher efficiency. Generation technology based on the image above can be seen structurally as in the following picture [21].



In addition, gas turbine technology was also developed by experts, as written by Petter Spittle in his journal Gas Turbine Technology, there are four processes in gas turbines, namely suck, squezee, bang and blow. The first occurrence of a suck event is that the air is sucked in through the fan on the front of the gas turbine engine. Furthermore, squezee or air occurs squeezed to atmospheric pressure many times. After that, the bang process occurs, namely the fuel is mixed with air for the combustion process and the last blow event occurs, hot air expands and is blown out from the back of the engine [23]. The following is an illustration of the process



Problem

Because the fuel comes from fossils (oil and natural gas), there is a tendency that one day will run out, because it will consume a lot of fuel, the water used in the combined cycle must go through a filtering process so there is no impurity, the turbine must be cleaned periodically because the filter in the inlet is very easy to dirty, giving rise to a more distinct sound, air pollution.

Alternative Solutions

Add a kind of fuel saver to the engine design, for example installing Power or X-Power on the fuel line. Where this power works with the principle of magnetic waves in the form of Active Ultra Magnetics without electricity which can be produced from the arrangement of several high-quality permanent magnet components, namely neodymium magnet. Through this wave the power of power can convert both BBM and BBG molecules into positively charged ions that are able to absorb oxygen in balance so that a perfect combustion process occurs in the combustion chamber. This can cause an increase in performance by achieving maximum torque at low speed and reducing exhaust gas pollution and can save fuel or CNG reaching 10% - 40%. Because this method can save fuel and reduce air pollution, this solution can be used to overcome the first and fifth problems above.

The problem can be in need of cleaner and better water, therefore on this channel you can use water filters automatically. One of them is a water filter in the form of hydro, where the Profex activated carbon from hydro can absorb dirty and problematic water. Then Profex can bind the dirt in the water so that the water produced is cleaner. The solution to the problem of turbine cleaning is that we can use good quality cleaning chemicals so that the gas turbine can work more optimally, for example using materials in the form of ProtoKlenz and TurboKlenz. ProtoKlenz is the most environmentally friendly gas turbine compressor chemical, the basic ingredient is water that can clean and wash gas turbine compressors with a safe and environmentally friendly operator. While TurboKlenz is a powerful and powerful chemical cleaner that can also be used to eliminate stubborn dirt conditions.

Because noise is one of the disturbing factors, sound absorbers are needed to reduce excessive noise. Previously maybe we should be able to analyze and find out the noise level of our engine like a gas turbine, after that we can find an alternative solution so that the treatment is right and works well. Alternative solutions offered we can use Rockwool and glass wool materials that can reduce sound intensity from resonance. The principle works can change vibration energy into heat energy due to collisions of molecules and is elastic and does not absorb water.

5. CONCLUSION

As a gas turbine generator has several important components that can support the work of gas turbine itself. The important parts of the gas turbine are the diffuser (a tool that helps the diffusion process), a compressor (a tool that serves to compress), a burner section (combustion between fuel and air), a turbine and a nozzle.

Ericsson Stirling Cycle and Cycle, Brayton Cycle, Brayton Cycle with Regeneration and Brayton Cycle with Intercooling, Reheating and Regenerating.

The turbine generation technology in producing electrical energy is by configuring a gas turbine through heat recovery (HR) and Steam Generator (SG). Gas turbines work with constant pressure in the form of an open cycle engine characterized by the thermodynamic cycle of Brayton. Gas turbine technology was also developed by experts, as written by Petter Spittle in his journal Gas Turbine Technology, there are four processes in the gas turbine, namely suck, squezee, bang and blow.

ACKNOWLEDGMENTS

Turbine generator has several important components that can support the work of gas turbine itself. This paper was written to provide a little knowledge and description to others. Thank you to all those who have helped in the writing of this report

REFERENCES

[1] Hassan, Mansoor-ul. 2014. *Power Generation Methods, Technique and Economical Strategy*. Saudi Arabia-Pakistan: International Technical Sciences Journal (ITSJ).

[2] Day, John. 1980. Engines—The Search for Power.

[3] Usher, Abott Payson. 1988. A History of Mechanical Inventions.

[4] Davy, Norman. 1914. The Gas Turbine.

[5] W. Judge, Author. 1950. Modern Gas Turbine.

[6] Jennings and W.L Rogers. 1953. Gas Turbine Analysis and Practice.

[7] America Encyclopedia

[8] geps@www.ge.com,. General Electric Power System.

[9] Gunston, Bill. 1995. The Develompment Of Jet and Turbine Aero Engines.

[10] Giampaolo, Tony MSME, PE. 1939. Gas Turbine Handbook: Principles and Practices. 3rd Edition. United State of America: The Fairmon Press, Inc.

[11] Saha, Ujjwal K. Jet Propulsion, Gas Turbine Cycles. Department of Mechanical Engineering Indian Institute of Technology Guwahati.

[12] Zohuri, B. 2015. Combined Cycle Driven Efficiency for Next Generation Nuclear Power Plants. Switzerland: Spinger International Publishing.

[13] Dietzel, F. 1992. Turbin, Pompa dan Kompresor. Edisi ke-3. Jakarta: Penerbit Erlangga. Hal 153.

[14] Bhaskar, dkk. 2017. Introduction to Aerospace Propulsion. Department of Aerospace Engineering.

[15] Eryahem, Mohamed. Dkk. 2014. Isotherm, Kinetic and Thermodynamic Studies for the Sorption of Mercury (II) onto Activated Carbon from Rosmarinusofficinalis Leave. American Journal of Analytical Chemistry: Scientific Research Publishing.

[16] Norton, D.John. 2016. The Impossible Process: Thermodynamic Reversibility. Department of History and Philosophy of Science Center for Philosophy of Science. University of Pittsburgh.

[17] U.S.P. Shet, dkk. 1999. Gas Power Cycles; Refrigeration Cycles. American: Standard Inc.

[18] Cengel, Y.A. And Boles, M.A. 2008. Thermodynamics: An Engineering Approach. 6th Edition. New York: McGraww-Hill.

[19] Tsai, Lauren. 2004. Design and Performance of a Gas-Turbine Engine from an Automobile Turbocharger. Massachusetts Institute of Technology: Department of Mechanical Engineering.

[20] Valentini, A. Gas Turbine Power Plant.

[21] U.S. 2016. Department of Energy, Combined Heat and Power Techonology Fact Sheet Series-Microturbine.

[22] Rahman, M, dkk. 2011. Thermodynamic Performance Analysis of Gas-Turbine Power-Plant. International Journal of the Physical Sciences Vol.6(14), pp. 3539-3550. University Malaysia Pahang.

[23] Sittle, Peter. 2003. Gas Turbine Technology. UK: Rolls-Royce plc, Ansty CV7 9 JR.