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Optimization of Performance Turbine/Compressor in The Gas Turbine Compressor For Oil And Gas

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Abstract- *Gas turbines mainly used in the power generators such as power generation and propulsion systems. Gas turbine mainly consists of three components namely turbine, compressor and combustion chamber. Turbine produces work from combine the compressed air in the compressor and heated inside the combustion chamber. Analyze performance of gas turbines depends on the thermodynamic properties such as temperature, pressure, air to fuel ratio and the Relative Humidity (RH). All the parameters are known then the thermodynamic analysis can be carried out for the gas turbine. In this research gas turbine are used for oil and gas circulation at Pertamina Gas Company regional of South Sumatra Indonesia (Pertagas). Pertagas Regional South Sumatra consist on three SKGs such as Benuang and Pendopo which has several engine components that serve to support the process of gas or fuel distribution. That component is gas turbine compressor and gas engine. This machine requires fluid water and oil to work properly. In addition to fluid, machine performance depends on the machine usage conditions and maintenance process. Performance machine can be known from the work efficiency of the machine and the amount of energy utilized. In this paper, experimental research is applied to calculated water consumption and oil, efficiency, energy utilization and vibration. The result shows that the amount of water and oil consumption is 36.8 water m^3 /month and 635 oil/month. The efficiency of turbine is 0.94-0.96 and energy utilization factor is 0.7.*

Keywords- Pertamina Gas, Oil and Gas, Turbine, Compressor, Efficiency, and EUF

I. INTRODUCTION

Indonesia has huge oil and gas resources. The management of oil and gas is controlled by state-owned company, namely PT. Pertamina. PT. Pertamina has a responsibility in managing and processing oil and gas resources in Indonesia from upstream to downstream. Processing of fuel oil and gas is done in several provinces such as PT. Pertamina Gas (Pertagas) Regional South Sumatra based in Palembang. Pertagas Regional South Sumatra consists of several SKGs namely Benuang and Pendopo.

In oil and gas processing, there are several engine components such as gas turbine and gas engine compressors. The gas turbine compressor consists mainly of three components: turbine, compressor, and combustion chamber as shown in Figure 1. Other components such as RH engines, pumps and others also have an important role for the performance of gas turbines. This engine component serves to drain the oil and gas. Turbine produces work from combine the compressed air in the compressor and heated inside the combustion chamber.

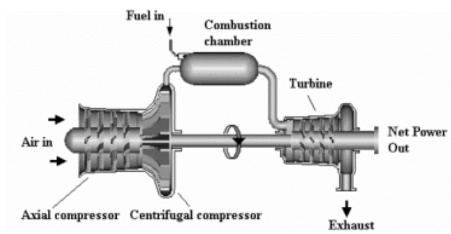


Figure 1. Gas Turbine Compressor

Analyze performance of gas turbines depends on the thermodynamic properties such as temperature, pressure, air to fuel ratio and the relative humidity (RH). After the parameters are known then the thermodynamic analysis can be carried out for the gas turbine compressor using the Brayton Cycle. In this paper, gas turbine compressor are used for oil and gas circulation at Pertagas SKG Benuang Regional of South Sumatra Indonesia. SKG Benuang has several engine components that serve to support the process of gas distribution. It includes turbines, compressors, pumps, RH engines and more. This machine requires fluid water and oil to work properly. Water is obtained from clean water and waste water treatment. Water use from sewage treatment is done to apply the 5R concept and at the same time maintain water availability. The oil used is NG lube, Turbo 68, Meditran S30 and T46. In addition to fluid (environmental conditions), machine performance depends on the machine usage conditions and maintenance process [1-8]. With increasing time operation, degradation of the compressor can be seen from performance decrease of compressor. The major cause of decreasing in the efficiency of compressor and air mass flow is fouling.

The main objective in this research is to get the performance of machine, efficiency machine and reliable energy utilization.

II. METHOD & MATERIAL

The test engines are gas turbine compressor 1 until 3 for gas circulation with the same properties and area research at Pertagas Company SKG Binuang Regional South Sumatra. Experimental method are used in this research with set up component consist gas engine compressor and gas turbine compressor as shown in Figure 2. Component of gas engine and turbine compressor can be seen in Figure 2 which consist on turbine, compressor, engine, air cooler, filter, turbo charger, valve, water cooler and water stand pipe.

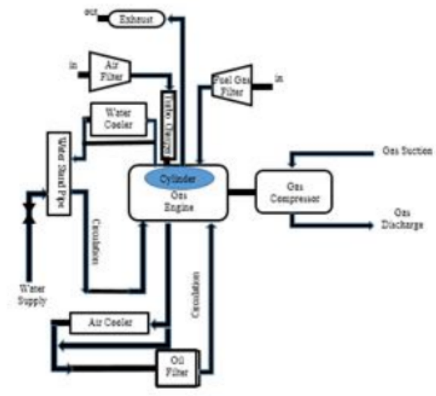
Calculated data by measuring rotation, temperature inlet and outlet of turbine and compressor, pressure inlet and outlite of turbine and compressor, and vibration value in the compressor system. Measuring data are done by using thermocouple, pressure gauge and vibration meter.

Analyze data is follow the Brayton Cycle as shown in Fig. 2. Which the results is efficiency of turbine, energy utilization factor (EUF) of turbine and compressor and velocity of compressor. The efficiency of turbine is get by applying the law of thermodynamics follow the Eq. 1 which assumed that the mass and specific heats of fluid is same value for heater and cooler:

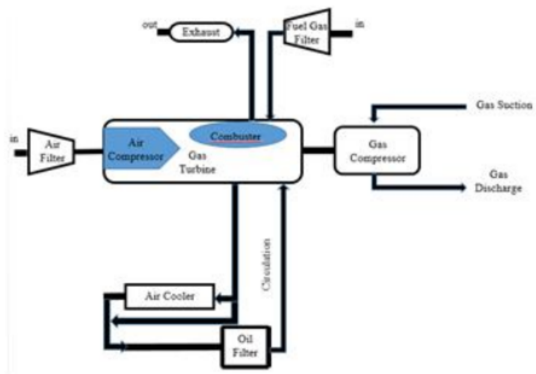
$$\eta = 1 - \frac{(T_4 - T_1)}{(T_3 - T_2)} \quad (1)$$

Pressure compression ratio (r_p) and temperature ratio of turbine and compressor is follow the Eq. 2:

$$r_p = \frac{P_2}{P_1} \text{ or } r_p = \frac{P_3}{P_4} \text{ and then } \frac{T_3}{T_4} = \frac{T_2}{T_1} \quad (2)$$



a. Gas Engine Compressor System



b. Gas Turbine Compressor System

Figure 2. Schematic of Circulation Turbine and Compressor System

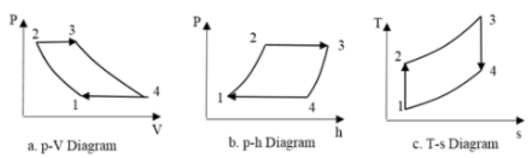


Figure 3. Brayton Cycle

The Brayton cycle is used to analyze the gas turbine systems in the circulation oil and gas at Pertamina Company and Figure 3 shows the P-V diagram, and the Temperature-Entropy (TS) diagram representation of an ideal Brayton cycle. In Figure 3 show that condition from point 1 to point 2 the water is isentropical compress and the heat is supplied at constant pressure from point 2 to point 3. At point 3 to point 4 the water is isentropically expanded. Since compression process and expansion process made increasing entropy due to losses inside the machines. Also the process from point 2 to point 3 happen the pressure drop. Hence, the overall performance of the gas turbine highly. The efficiency of gas turbine and energy utilization factor (EUF) of turbine and compressor can be calculated by using the schema in Figure 4.

Table 1. Consumption water and oil

day	Water (m^3)	Oil (T46+NG Lube)
30	36.8	635

Table 2. Data of Turbine and Compressor 1

Flow (mmscfd)	Temp Suction of Comp. (F)	Temp Discharge of Comp. (F)	Cp (Btu/lbm °F)	γ	$(\gamma-1)/\gamma$	rp	Pin of Turbine (Psig)	Pout of Turbine (Psig)	Tin of Turbine (F)	Tout of Turbine (F)	Power of Turbine (HP)	η	EFU
59	79	112	1.008	1.5	0.33	1.12	169	54.1	112	837	794	0.95	0.07
58	79	112	1.008	1.6	0.38	1.14	168	54.5	107	828	804	0.96	0.07
58	79	112	1.008	1.7	0.41	1.15	168	54.7	110	839	798	0.96	0.07
58	79	112	1.008	1.8	0.44	1.17	168	54.4	110	837	790	0.96	0.07
58	80	113	1.008	1.9	0.47	1.18	168	54.3	114	843	787	0.95	0.06
58	82	114	1.008	2	0.50	1.18	166	53.8	121	846	763	0.95	0.06
58	84	114	1.008	2.1	0.52	1.17	166	53.2	128	858	746	0.94	0.06
58	83	114	1.008	2.2	0.55	1.19	167	53.2	124	858	749	0.94	0.06
59	83	114	1.008	2.3	0.57	1.20	166	53.2	124	853	768	0.94	0.06
58	81	111	1.008	2.4	0.58	1.20	169	53.2	127	858	743	0.94	0.06
59	81	111	1.008	2.5	0.60	1.21	169	53.4	118	848	766	0.95	0.06
59	80	112	1.008	2.6	0.62	1.23	169	53.9	115	843	771	0.95	0.06

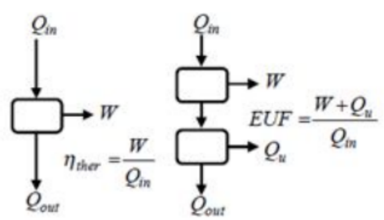


Figure 4. Efficiency and EUF Turbine and Compressor

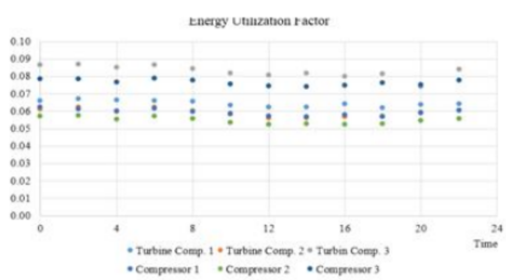


Figure 5. EUF Turbine and Compressor

III. RESULTS & DISCUSSION

The results of optimization of gas turbine compressor for oil and gas can be seen in the Table 1. Table 1 shows the value of water consumption which obtained from clean water and waste water treatment and consumption of oil for turbine and compressor is 36.8 m^3 /month and 635 oil/month.

Table 2 show that the data turbine and compressor for gas turbine compressor 1 such as temperature suction and discharge compressor, temperature inlet and outlet turbine, pressure inside and outside turbine, efficiency and energy utilization factor. As shown in Table 3 with flow of gas 58-59 mmscfd, temperature suction compressor is 79-84 F and discharge compressor is 112-114 F. Temperature and pressure inlet turbine is 107-128 F and 166-169 Psig. For temperature and pressure outlet for turbine is 828-858 F and 53.2-54.7 Psig. By using the Eq. 1 we get the efficiency of gas turbine compressor is 0.94-0.96 with the power of turbine is 743-808 HP and energy utilization factor 0.06-0.07. For gas turbine compressors 2 and 3 they have similar phenomena with gas turbine compressor 1 depending on the gas flow rate. Gas turbine gas compressor 3 having a lower gas flow rate than gas turbine compressor 1 and 2 is 45-46 mmscfd. This value causes the inlet is decreasing and outlet temperatures of the turbine become increase and also the EFU value become increase. High temperatures will increase turbine power where the greater the turbine power used then EFU value will be lower. Because the value of EFU is affected by the available power and power used. Figure 5 shows the EUF value for the gas turbine gas compressor 1-3 where the largest EUF value is obtained on the use of turbine gas compressor 3. High EUF is caused by the power used by the higher turbine gas compressor 3. For rotation of turbine and compressor can be seen at Figure 6, where the higher rotation contain on the gas turbine compressor 3. Gas turbine compressor 2 have the lower rotation compare with the gas turbine compressor 1 and 3. This cause the vibration value of gas turbine compressor 2 also is larger than gas turbine compressor 1 and 3 as shown in Figure 7. This is due to the low rotation of turbine and compressor will be cause the vibration level become high.

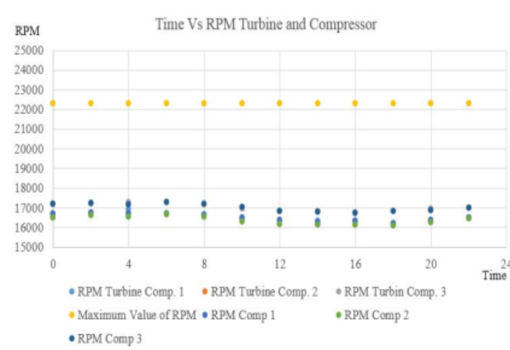


Figure 6. RPM Turbine and Compressor

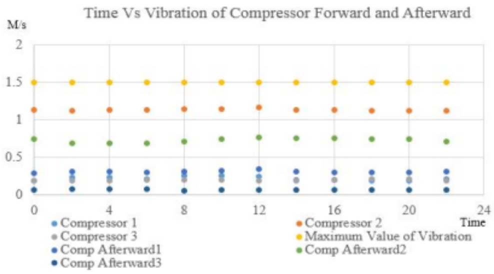


Figure 7. Vibration of Turbine and Compressor

IV. CONCLUSION

From experimental research to optimization of turbine and compressor utilization is obtain the result is a performance gas turbine compressor namely:

1. The amount of water and oil consumption is 36.8 water m^3 /month and 635 oil/month.
2. The efficiency of turbine and compressor work for gas turbine compressor 1 to 3 has 94-95%. This indicates that the machine is used very effective for oil and gas processing.
3. The value of EUF gas turbine compressor 3 is higher than the gas turbine compressor 1 and 2. This indicate the compressor 1 and 2 have more energy availability.
4. The value of rotation for gas turbine compressor 3 is higher compared to other gas turbine compressor. Where the lowest value rotation there is on the compressor turbine gas 2. The low rotation causes the vibration value of compressor 2 to be higher than the other compressor turbine gas.

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