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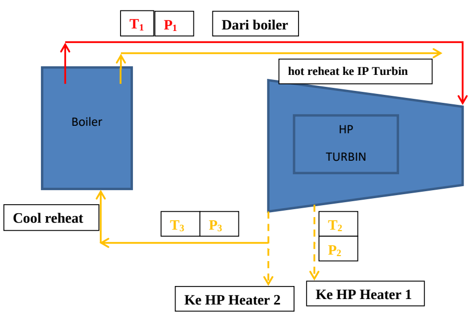
TURBINE PERFORMANCE ANALYSIS IN THE HIGH PRESSURE HEATER (HPH) CONDITION NOT OPERATING

Ni Ketut Caturwati.[a], Yusvardi Yusuf[a*], Imron Rosyadi[a]

[a] Department of Mechanical Engineering, Faculty of Engineering, Universitas Sultan Ageng Tirtayasa, Cilegon, Banten, Indonesia

*Corresponding author: yusvardi.yusuf@untirta.ac.id

Graphical abstract



Heat Balance HP Turbine Diagram

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Abstract

Turbines are one important component in a power plant. The function of the turbine is to utilize the potential energy contained in the steam which is then converted into kinetic energy by the nozzle, then the kinetic energy is converted again into mechanical energy in the turbine blade and shaft rotation. In a rankine cycle after the steam comes out of the Low Pressure Turbine (LPT), the steam will change in phase from gas to liquid by passing through the condenser. The condensate water is heated again through a Low Pressure Heater (LPH) until finally it is heated again to the High Pressure Heater (HPH) before entering the boiler. But whether the performance of the turbine if when the HPH is not operating will decrease. In this study, an efficiency calculation will be carried out between the condition of the HPH operating and the condition of the HPH not operating, as well as finding coal consumption in both conditions. Based on the study, turbine efficiency did not show any significant difference between the condition of the HPH being in operation and the HPH not operating, that is 94.07% for the condition of the HPH to operate and 93.72% for the condition of the HPH not operating. While coal consumption at the time the HPH was operating was 164 Ton / h and at the HPH not operating was 170 Ton /h.

Keywords: Turbine; High Pressure Heater; Coals

Abstrak

Turbin adalah salah satu komponen penting dalam suatu pembangkit listrik. Fungsi turbin adalah untuk memanfaatkan tenaga potensial yang terkandung dalam uap yang selanjutnya diubah menjadi energi kinetik oleh *nozzle* (nosel), lalu energi kinetik tersebut diubah lagi menjadi energi mekanis dalam putaran sudu dan poros turbin. Di dalam suatu siklus rankine setelah uap keluar dari *Low Pressure Turbine* (LPT) maka uap tersebut akan mengalami perubahan fasa dari gas ke cair dengan melewati kondensor. Air kondensat tersebut dipanaskan lagi melalui *Low Pressure Heater* (LPH) hingga akhirnya dipanaskan lagi ke *High Pressure Heater* (HPH) sebelum masuk ke *boiler*. Namun apakah unjuk kerja turbin jika pada saat HPH tidak beroperasi akan mengalami penurunan.

Dalam penelitian kali ini akan dilakukan perhitungan efisiensi antara kondisi HPH beroperasi dan kondisi HPH tidak beroperasi, serta mencari konsumsi batubara pada kedua kondisi tersebut.
Berdasarkan penelitian, efisiensi turbin tidak menunjukkan adanya perbedaan yang signifikan antara kondisi HPH sedang beroperasi dan HPH tidak beroperasi, yaitu sebesar 94.07 % untuk kondisi HPH beroperasi dan 93.72 % untuk kondisi HPH tidak beroperasi. Sedangkan konsumsi batubara pada saat HPH beroperasi adalah 164 Ton/h dan pada HPH tidak beroperasi adalah 170 Ton/h.

Kata kunci: Turbin; High Pressure Heater; Batubara
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1.0 INTRODUCTION

A power plant consists of various components that work in parallel and continuously. The smooth operation of each component must be guaranteed because each component in the generator is interconnected. Just like a turbine is an important component in a power plant. The function of the turbine is to utilize the potential energy contained in the steam which is then converted into kinetic energy by the nozzle, then the kinetic energy is converted again into mechanical energy in the form of rotation of the turbine blades and shaft. [8]

The UBOH Lontar PLTU is still relatively new therefore it is still full of disturbances everywhere. Especially when the High Pressure Heater (HPH) is not operating. Therefore, in this final assignment, we will discuss comparing when HPHs are operational and when HPHs are not operational. Remembering that this PLTU can still operate even if the HPH is not operating. [9][10].

2.0 METHODOLOGY

The research was carried out directly at PLTU UBOH Lontar using quantitative methods, namely by taking data related to this research, then the data was processed using calculation formulas.

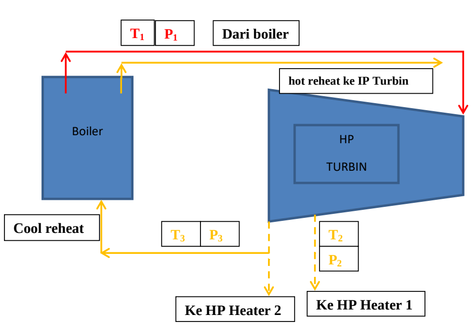

Figure 1. Heat Balance HP Turbine Diagram

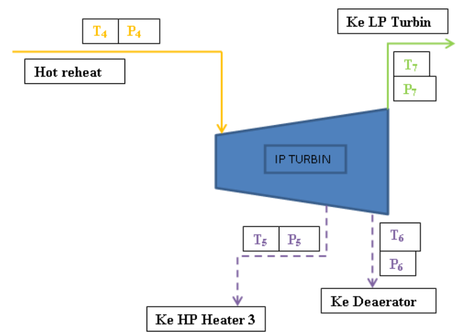

Figure 2. Heat Balance Diagram IP Turbine

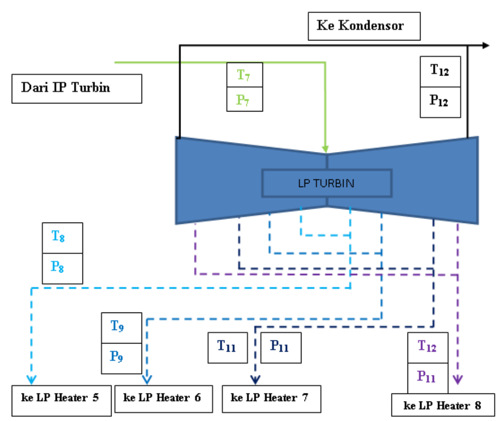

Figure 3. Heat Balance Diagram LP Turbine

From the Turbine Heat Balance Image above, temperature and pressure data can be obtained according to the conditions.

3.0 RESULTS AND DISCUSSION

HP HEATER ON CONDITION

Tabel 1. HP Turbine Steam Condition

no	h_a (kj/kg)	h_i (kJ/kg)	Temperature (^{0}C)	Pressure (Mpa)	Flow (kg/s)
1	3398.89	3398.89	538	16.67	271.16
2	3151.73	3135.94	391.3	6.205	20.51
3	3033.39	3015.24	323.9	3.755	22.08

Tabel 2. IP Turbine Steam Condition

no	h_i (kj/kg)	h_a (kJ/kg)	Temperature (⁰C)	Pressure (Mpa)	Flow (kg/s)
4	3539.07	3539.07	538	3.37	222.78
5	3332.05	3333.61	437.1	1.732	11.37
6	3113.02	3115.06	327.5	0.789	17.51
7	(hi') 3110.02	3112.39	326.06	0.773	196.81

Tabel 3. LP Turbine Steam Condition

no	h_i (kj/kg)	h_a (kJ/kg)	Temperature (⁰C)	Pressure (Mpa)	Flow kg/s
7	3112.39	3112.39	326.06	0.773	196.81
8	2992.99	2993.79	265.2	0.461	7.19
9	2869.7	2870.9	201.5	0.26	7.015
10	2747.46	2749.01	137.7	0.137	6.65
11	2606.18	2658.24	89.2	0.068	12.65
12	2580.81	2651.51	85.1	0.058	163.41

HP HEATER OFF CONDITION

Tabel 4. HP Turbine Steam Condition

No	Temperature (⁰C)	Pressure (Mpa)	h_a (kJ/kg)	h_i (kJ/kg)	Flow (kg/s)
1	538	16.67	3398.89	3398.89	232.08
2	389.4	6.02	3150.44	3132.54	0
3	330.3	3.886	3046.31	3026.16	0

Tabel 5. IP Turbine Steam Condition

No	Temperature (⁰C)	Pressure (Mpa)	h_a (kJ/kg)	h_i (kJ/kg)	Flow (kg/s)
4	538	3.47	3538.09	3538.09	226.61
5	443.3	1.869	3345.28	3343.84	0
6	333.5	0.856	3126.24	3124.26	17.44

Tabel 6. LP Turbine Steam Condition

No	Temperature (⁰C)	Pressure (Mpa)	h_a (kJ/kg)	h_i (kJ/kg)	Flow (kg/s)
7	330	0.839	3119.22	3119.22	212.49
8	270.7	0.5	3003.96	3002.86	7.82
9	206.4	0.282	2879.85	2878.38	7.62
10	141.9	0.148	2756.62	2754.76	7.22
11	91.2	0.073	2661.55	2609.07	14.1
12	86.2	0.06	2653.41	2578.35	175.84

In searching for turbine efficiency, you must compare actual work (Timeal) with ideal work (Wideal). To calculate actual work, use actual enthalphi, namely by looking in the table by knowing the Temperature (T) and Pressure (P). Meanwhile, ideal work uses ideal enthalphi by knowing temperature and entropy. The incoming entropy must be the same as the outgoing entropy. If written, the efficiency formula is as follows:

$$\eta\ turbin = \frac{W\ aktual}{W\ Ideal} \times 100\%$$

the actual working formula is as follows:

$$W_{aktual} = (m_1)(h_{1a} - h_{2a}) + (m_1 - m_2)(h_{2a} - h_{3a})$$

$$W_{aktual} = (m_4)(h_{4a} - h_{5a}) + (m_4 - m_5)(h_{5a} - h_{6a}) + (m_4 - m_5 - m_6)(h_{6a} - h_{7a})$$

$$W_{aktual} = (m_7)(h_{7a} - h_{8a}) + (m_7 - m_8)(h_{8a} - h_{9a}) + (m_7 - m_8 - m_9)(h_{9a} - h_{10a}) + (m_7 - m_8 - m_9 - m_{10})(h_{10a} - h_{11a}) + (m_7 - m_8 - m_9 - m_{10} - m_{11})(h_{11a} - h_{12a})$$

The ideal working formula is as follows:

$$W_{ideal} = (m_1)(h_{1i} - h_{2i}) + (m_1 - m_2)(h_{2i} - h_{3i})$$

$$W_{ideal} = (m_4)(h_{4i} - h_{5i}) + (m_4 - m_5)(h_{5i} - h_{6i}) + (m_4 - m_5 - m_6)(h_{6i} - h_{7i}')$$

$$W_{ideal} = (m_7)(h_{7i} - h_{8i}) + (m_7 - m_8)(h_{8i} - h_{9i}) + (m_7 - m_8 - m_9)(h_{9i} - h_{10i}) + (m_7 - m_8 - m_9 - m_{10})(h_{10i} - h_{11i}) + (m_7 - m_8 - m_9 - m_{10} - m_{11})(h_{11i} - h_{12i})$$

So that efficiency is obtained when HPH is on and HPH is off

Tabel 7 : Turbine Efficiency

effisiensi Turbin	HP heater on	HP heater off
HP Turbin	95.2	94.59
IP Turbin	99.49	99.55
LP Turbin	87.54	87.02

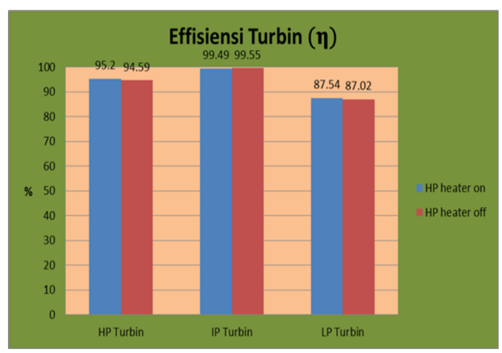

Figure 4. Comparison graph of the efficiency of each turbine with the HPH on and off condition

The efficiency of each turbine is determined by the total efficiency as follows:

$$\eta_{turbin} = \frac{\eta_{HP\ turbin} + \eta_{IP\ turbin} + \eta_{LP\ turbin}}{3}$$

the total efficiency is:

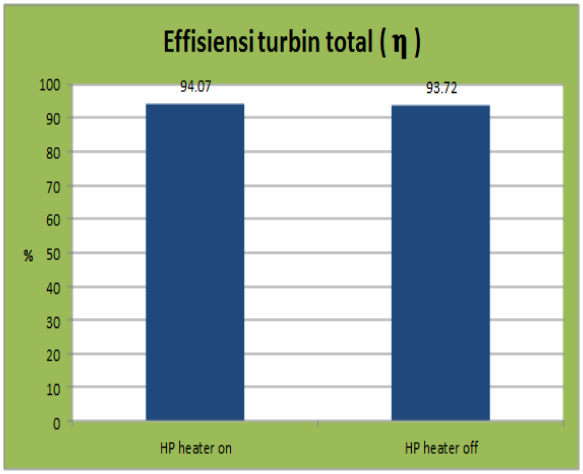

Figure 5. Total Turbine Efficiency Graph

4.0 CONCLUSION

Based on the discussion in the previous chapter, the following conclusions can be drawn:

1. Efficiency of each turbine when HPH is on: HPT = 95.2%, IPT = 99.49%, LPT = 87.54%

2. Efficiency of each turbine when HPH is off: HPT = 94.59%, IPT = 99.55%, LPT = 87.02%

3. The total turbine efficiency when HPH is on is 94.07%, while the total turbine efficiency when HPH is off is 93.72%, this efficiency is obtained at 100% loading.

4. The fuel consumption required when the HPH is on is 164 tons/h, while the fuel consumption when the HPH is off is 170 tons/h. Assuming boiler efficiency of 88%.

5. fuel consumption when the HPH is on for a day is 3936 tonnes, and when the HPH is off is 4080 tonnes.

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