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Performance Analysis Model Development for Mae Moh Coal-Fired Power Plant

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***Abstract*—**Electrification is a complex process and governed by various parameters. Modeling of power plant's target efficiency or target heat rate is often formulated and compared with the actual values. This comparison not only implies the performance of the power plant but also reflects the energy losses possibly inherited in some of related equipment and processes. The current modeling of Coal-fired Mae Moh power plant was formulated at the first commissioning. Some of equipments were replaced due to its life time. Relatively outdated for 20 years, the utilization of the model is not accomplished. This work has focused on the development of the performance analysis model of aforementioned power plant according to the most updated and current working conditions. The model is more appropriate and shows accuracy in its analysis. Losses are detected and measures are introduced such that reduction in energy consumption, related cost, and also environment impacts can be anticipated.

***Keywords*—**Performance analysis model, Power plant modeling, Target heat rate, Target efficiency.

I. Introduction

NORMALLY, the performance of Mae Moh power plant is evaluated from the plant heat rate. However, this factor does not indicate the suitability of plant operation. Therefore, the target heat rate which is the efficiently heat rate is selected as a factor for evaluating the plant performance. Thus, the actual plant heat rate should be closed to the target heat rate. The indicator for showing the variation of actual heat rate from the target heat rate is called the Station Thermal Efficiency Performance factor (STEP factor) which is the ratio of actual to target heat rates. Normally, the target heat rate was calculated when the power plant was commissioning. Since, at that time, the new equipments were installed and the performance of each equipment was extremely high. However, in case of Mae Moh power plant which having more than 20 years in operation, the deterioration of equipments is observed and it brings to get the increasing of heat consumption. Therefore, at present, the actual heat rate is far from that of the target and lower performance of power plant is obtained. This mean, the reference target heat rate is not suitable for current situation. Thus, the modification of target heat rate is necessary for Mae Moh power plant. In this work, Mae Moh power plant unit 8, a 300 MW coal fired power plant, is selected as a case study for tunings the target heat rate. The result of this study aims to serve the requirement of power plant.

There are many research works deal with the power plant performance, for example, Uson et al. [1] studied the parameter affecting the plant performance and found the degradation of main equipment is the main parameter for the decreasing of plant performance. Omen et al. [2] and Arauzo et al. [3] reported the variation of plant performance with the specification of fuel. Kopac et al. [4] investigated the effect of ambient temperature on the power plant performance. From the previous literatures, it can be conclude that there are many parameters affecting the performance of power plant. The main parameter is the deterioration of equipment. Therefore, in this research, this parameter is focused and the new model of target plant heat rate is also reported.

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II. Research Methodology

Fig. 1 shows the method for evaluating the STEP factor. It can be seen that the target heat rate actually can be calculated from 2 groups of correction factors which are the basic steam turbine heat consumption and the steam turbine exhaust pressure correction factors. Therefore, the shortest method for correcting the target heat rate is the improvement of all correction factors. In this work, the basic steam turbine heat consumption correction factor which is the main parameter affecting on the target heat rate is considered for improvement.

To finding out the basic steam turbine heat consumption correction factor, the thermal efficiency of steam turbine has to be calculated by simulate the power plant cycle on the simulation program called the Gate Cycle & Cycle Link. The detail of plant cycle is shown in Fig. 2. The up-to-date operation data is filled in the program and then calculate the thermal efficiency. By vary the interested parameter from the rated value, the %change in thermal efficiency could be evaluated and then the correction factor could be calculated from

$$Correction\ Factor = 1 + \left(\frac{\%Change\ in\ Thermal\ Efficiency}{100}\right) \quad (1)$$

It should be notice that the correction factor is find out for 3 step loads which are 100%, 80% and 60% from the rated load (300 MW).

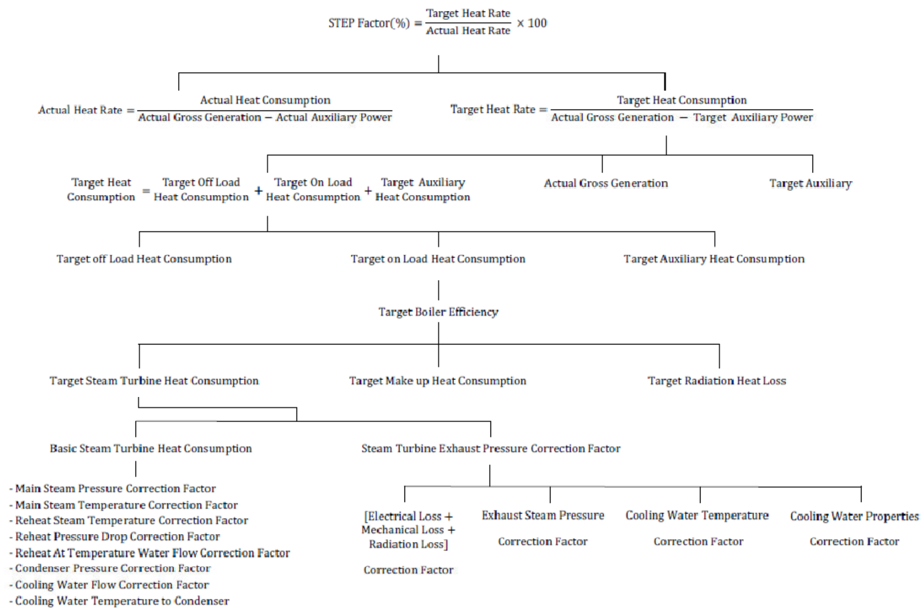

Fig. 1 Calculation diagram for STEP factor

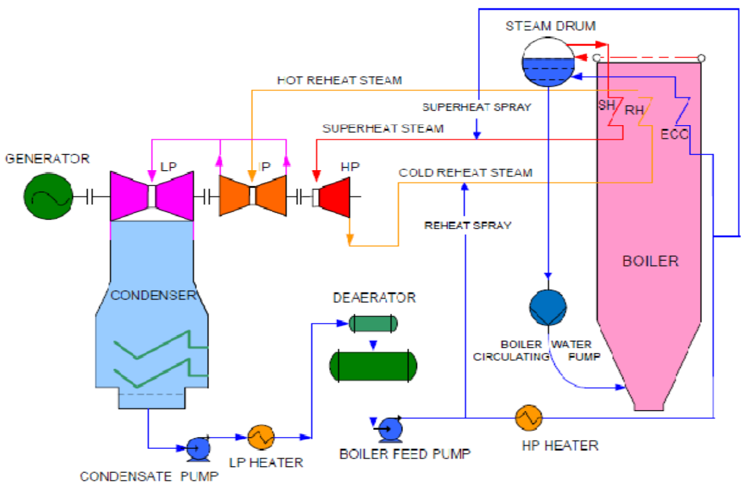

Fig. 2 Power plant cycle for 300 MW

III. Results and Discussion

To understanding the methodology for finding out the new correction factor, the cooling water flow to condenser correction factor is selected for describing the methodology. From the simulation program, the cooling water flow to condenser is varied from the rated value (8.5m^3/s) and then calculates the thermal efficiency of steam turbine. After that, the %change in thermal efficiency of steam turbine is evaluated by compared with that of rated value. Fig. 3 shows the %change in thermal efficiency of steam turbine at various cooling water flow to condenser. The correction factor can be calculated from (1) and the calculation result for 60%, 80% and 100% loads is shown in Fig. 4.

Following the description methodology, the correction factors for basic steam turbine heat consumption are shown in Table I. Comparison with the correction factor from the commissioning state shown in Fig. 5; it is found that the present correction factor differs from that of previous one.

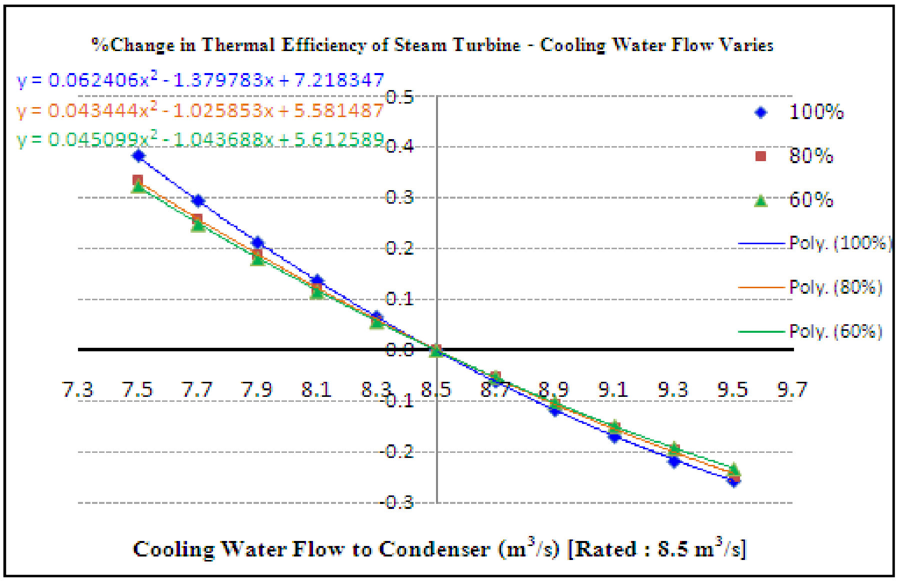

Fig. 3 The %change in thermal efficiency of steam turbine at various cooling water flow to condenser

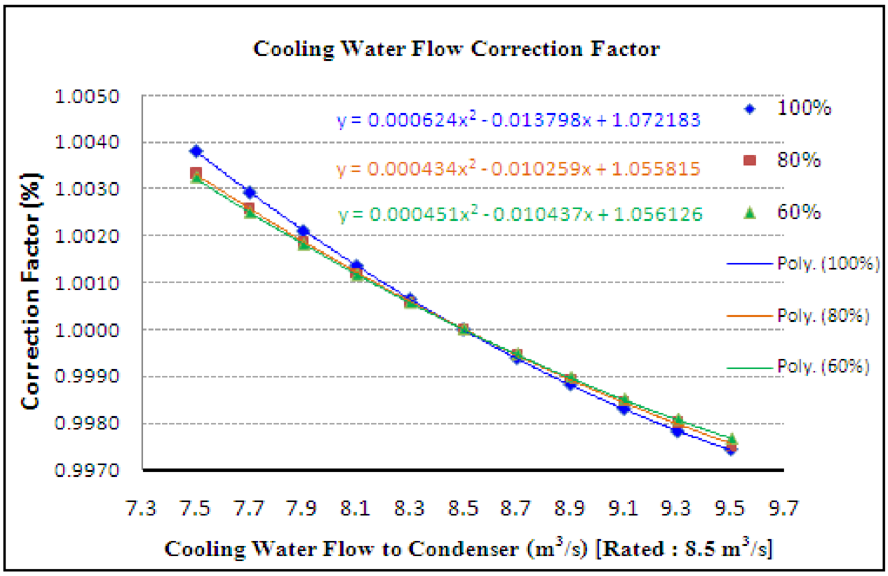

Fig. 4 Correction factor at various cooling water flow to condenser

TABLE I
CORRECTION FACTOR EQUATION

Parameter (x)	Correction Factor (y)		
	100% Load	80% Load	60% Load
1. Main Steam Pressure	$y = 0.000005x^2 - 0.002107x + 1.202801$	$y = 0.000006x^2 - 0.002364x + 1.217425$	$y = 0.000003x^2 - 0.001259x + 1.123961$
2. Main Steam Temperature	$y = 0.000001x^2 - 0.000819x + 1.293192$	$y = 0.000001x^2 - 0.000867x + 1.309874$	$y = 0.000000x^2 - 0.000639x + 1.248581$
3. Reheat Steam Temperature at Intercept valve	$y = 0.000000x^2 - 0.000353x + 1.183463$	$y = 0.000000x^2 - 0.000619x + 1.250200$	$y = -0.000000x^2 - 0.000143x + 1.127745$
4. Reheat Pressure Drop	$y = 0.000001x^2 + 0.000806x + 0.992615$	$y = 0.000008x^2 + 0.000656x + 0.993393$	$y = 0.000008x^2 + 0.000542x + 0.994408$
5. Reheat At temperature water flow	$y = 0.000644x + 0.999997$	$y = 0.000882x + 1.000000$	$y = 0.001072x + 0.999990$
6. Condenser Pressure	$y = 5.557859x^2 - 0.395348x + 0.997418$	$y = 6.146461x^2 - 0.159024x + 0.975645$	$y = 2.139689x^2 + 0.869947x + 0.919937$
7.Cooling Water Temperature to Condenser	$y = 0.000132x^2 - 0.005407x + 1.047972$	$y = 0.000155x^2 - 0.006092x + 1.049241$	$y = 0.000175x^2 - 0.006233x + 1.037889$
8. Cooling Water Flow to Condenser	$y = 0.000624x^2 - 0.013798x + 1.072183$	$y = 0.000434x^2 - 0.010259x + 1.055815$	$y = 0.000451x^2 - 0.010437x + 1.056126$

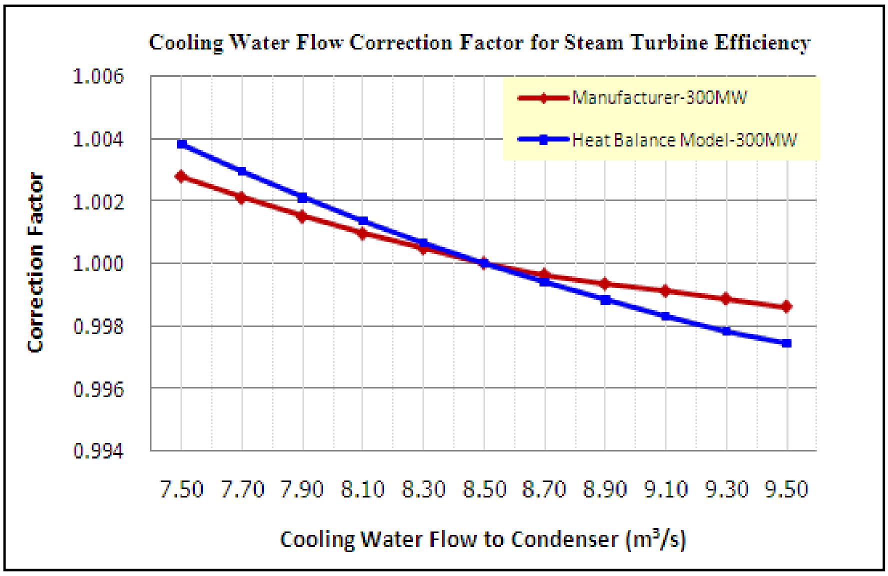

Fig. 5 Comparison of correction factor from commissioning state and present state

The validation of correction factor is done to find out the suitability for the power plant. The tested operation data from Mae Moh power plant unit 8 shown in table II is used for validation. It is found that the STEP factor calculated from the new correction factor is 100.13% with the standard deviation less than 0.44. Because of the new renovation of this power plant unit, therefore, this STEP factor value is acceptable for real application.

TABLE II
VALIDATION DATA FOR MAE MOH POWER PLANT UNIT 8

Measurement Value	Unit	Operating Condition		
		100%Load	80%Load	60%Load
$\dot{m}_{MS}$	kg/s	260.55	212.91	170.53
P_{MS}	Bar a.	161.00	159.09	151.98
T_{MS}	°C	535.24	521.89	496.81
$P_{FW\text{-}in}$	Bar a.	179.88	172.71	161.61
$T_{FW\text{-}in}$	°C	247.73	236.35	224.62
$\dot{m}_{RH}$	kg/s	219.53	180.10	145.69
P_{RH}	Bar a.	38.65	31.41	24.94
T_{RH}	°C	519.27	507.23	470.02
$P_{Cold\text{-}RH}$	Bar a.	41.32	33.45	26.63
$T_{Cold\text{-}RH}$	°C	333.11	317.33	286.63
$P_{RH\text{-}Spray}$	Bar a.	187.68	180.19	167.54
$T_{RH\text{-}Spray}$	°C	185.70	175.92	166.38
$\dot{m}_{BFP\ outlet}$	kg/s	247.99	199.86	154.72
$P_{sat\text{-}BFP\ inlet}$	Bar a.	10.87	8.85	7.08
$P_{BFP\ outlet}$	Bar a.	187.68	180.19	167.54
$T_{BFP\ outlet}$	°C	185.70	175.92	166.38

IV. Conclusion

Mae Moh power plant faces with the unacceptable of STEP factor calculated from the commissioning data because of the deterioration of power plant. The solution for this problem is to find out the new correction factor which matching with the status of power plant. From the research, it is found that the STEP factor calculated from the new correction factor is acceptable for a 300 MW Mae Moh power plant.

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