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Optimization of Prefill Mode to Increase Reliability of Gas Turbine 13E2 PT. PJB UP Muara Tawar

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Abstract: *Muara Tawar block V is constructed by PT. PLN (Persero) Power Plant Master Project of Java, Bali and Nusa Tenggara Networks based on contract No. 261. PJ / 041 / DIR / 2007 (Concerning Gas Fired Power Plant Extension Project). The plant use gas turbine type 13E2. Operational concept of gas turbine type 13E2 is regulating the amount of fuel that is divided from three fuel control valves and the operating pattern is in an area known as the pilot valve and premix valve which must be maintained stability of combustion shown by pulsation parameters. The prefill concept is used to avoid flame off when gas turbine loading often passes over point switch or back point switch. Prefill itself will momentary activate a pilot valve to fill the Fuel Distribution System (FDS) line from MBP43. However, prefill gives effect of high pulsation that trigger Gas Turbine experiencing PLS or derating. This effect can be overcome by improving the prefill concept and modifying the prefill system through Logic Advant, resulting in a more stable burning in the gas turbine burner.*
Keywords: *Gas Fired Power Plant, FDS, pilot valve, pulsation, prefill.*

I. Introduction

The utilization of gas turbines in power generation has increased in recent years and it will be increase up to medium level of application [1]. Muara Tawar Block V gas turbine system was designed to operate at peak or under load continuously in both open and combined cycle as per network requirement. Muara Tawar Block V power generation can generate 242.5 MW electricity (gross output). It come from the gas turbine generator alone about 161.5 MW and from the steam turbine is about 81 MW [2]. The reliability of a power plant to provide electricity to the electricity network is the most important task to ensure energy availability [3]. Gas Turbine type 13E2 consist of three fuel control valves to maintain mass and energy balances in burner system under pilot and premix valve. In order to maintain stable combustion, changing in the operating condition between the pilot valve and the premix valve are required and its known as switch over and switch back point. During this conditions the pulsation parameter should be monitored. If gas turbine operates in high load or above switch over point continuously, it tend pilot valve MBP43 cannot provide sufficient gas fuel to combustion system. Moreover, during the load decrease the operating condition will change to switch back point. It condition lead to mass unbalance and it can be very dangerous because the pilot valve must close immediately. Moreover, in this condition the pilot valve status is closed due to operation in high load. This condition trigger flame off and resulting the unit trip. The prefill concept is used to overcome this hazard and unscheduled shut down by the pilot valve in the MBP43 area pulse opening. However, prefill can also effect on the emergence of high pulsation that resulted gas turbine experienced PLS or derating.

II. Theory

Prefill is used to reduce the disturbance that may arise due to the changing of electricity load from high to low load and vice versa. Prefill is used to fill up the volume between Fuel Distribution System (FDS) to the burner [4]. This prefill is performed by opening the pilot valve or MBP43 in certain time to ensure the volume of the FDS until the burner fill up with approximately 20% of additional fuel. Mass unbalance occurs when the load is over the Switch Back Point (SBP) area. Therefore, the prefill on FDS pilot will not causing the flame off when SBP present.

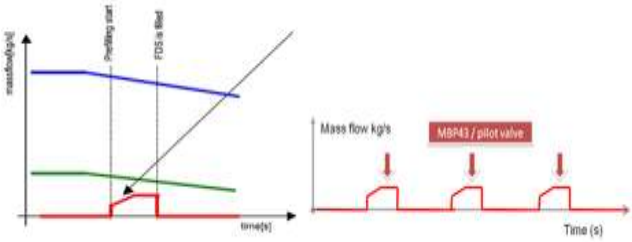

Figure 1. Prefill Concept

The prefill will be activated when the decrease in electricity load occurs. The prefill system will open the MBP43 control valve from the minimum mass flow rate and increase up to maximum mass flow rate gradually to fill up the volume between FDS to the burner. Gas turbine at Muara Tawar Block V mass flow rate was designed at 0.285 kg/s in maximum load and 0.250 kg/s in minimum load [5]. The prefill process will stop if any of the criteria are reached i.e. Delta TAT (Temperature After Turbine difference) reaches 5 deg C, or high pulsation reaches 35 mbar, or maximum prefill time has reaches 10 seconds.

III. Method

3.1 Analyze DEPP Prefill System of Gas Turbine

Logic prefill system is simulated under Advant Egatrol 8 software. Simulation on the logic include operation of pilot valve MBP43 and the operating pattern of the prefill system.

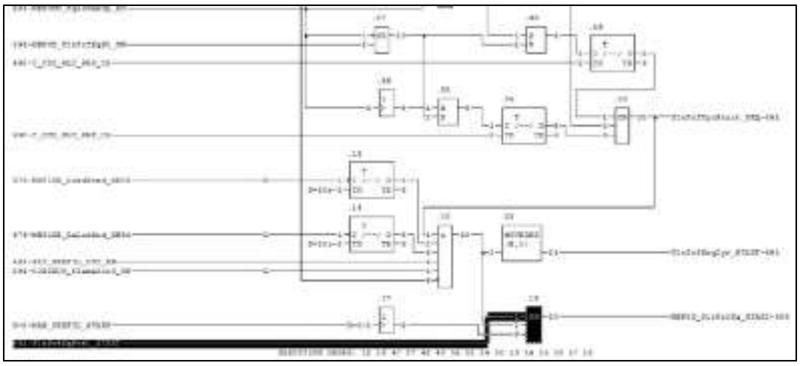

Figure 2. Prefill System Logic

Fig. 2. describes prefill system, where prefill will be enabled or start (PltPrfSqPrel_START) with 2 modes i.e. periodically time (PltPrfSeqCyc_START) or decrease in load. In every 4 hours, gas turbine will experience periodic prefill at any load that it cause interruption to Protective Load Shedding (PLS). Interruption to PLS by high pulsation is caused by over mass flow rate from MBP43 or pilot valve.

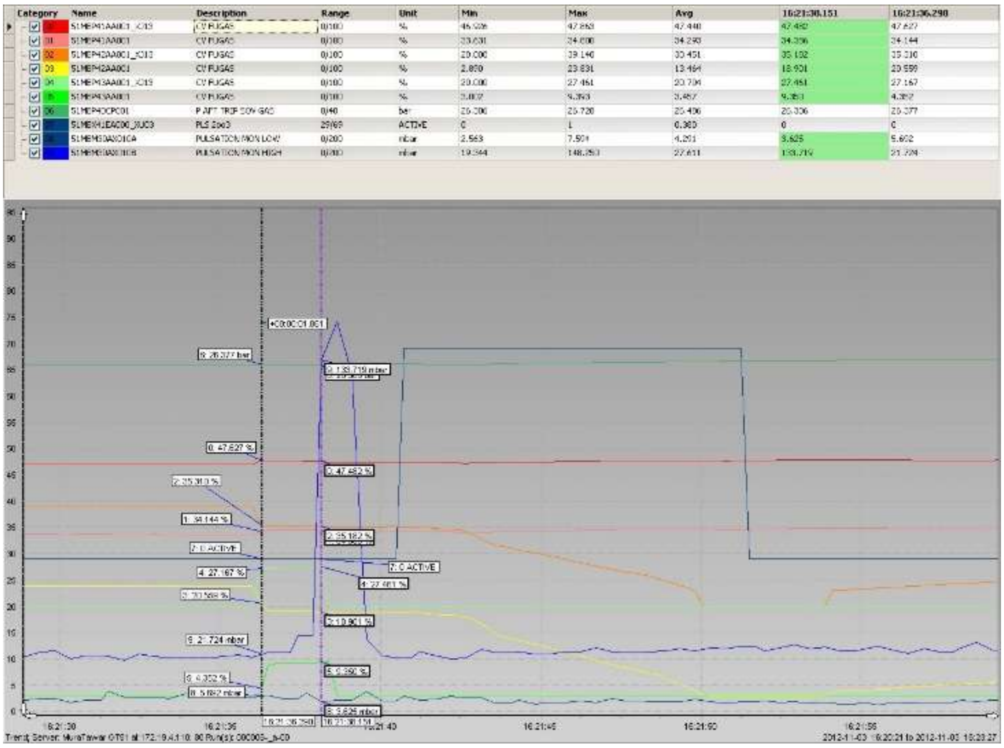

Figure 3. Prefill Cause High Pulsation

Fig. 3. shows the high pulsation which resulted PLS 148 mbar. High pulsation occur because MBP43 (number 4) is activated and mass flow rate or gas fuel flow rate of 0.250 kg/s up to 0.285 kg/s during 10 seconds. This logic setting can be observed from Fig. 4.

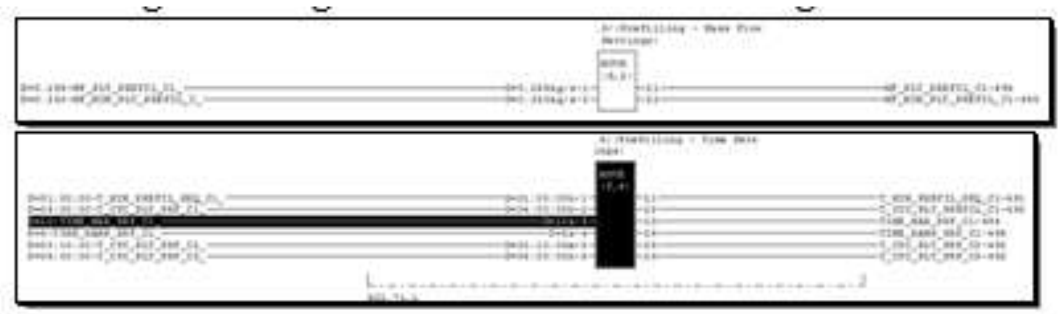

Figure 4. Logic Setting Mass Flow and Time Max Prefill

Periodic prefill is set up for every 4 hours which often result in high pulsation. Total mass flow rate can be obtained by two ways i.e. the mass flow rate on the scale is too large or the setting time is too long for each prefill process.

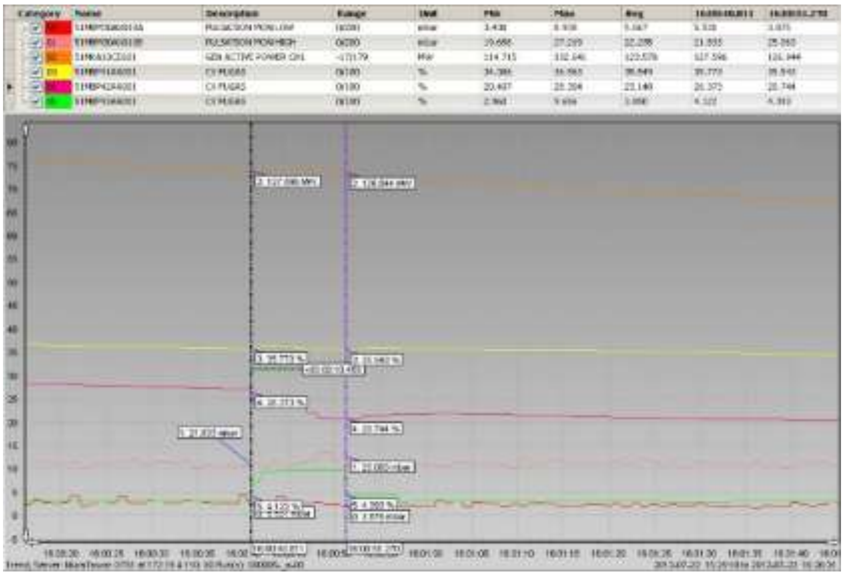

Figure 5. Prefill Without High Pulsation

If the prefill normally occur, in example when gas turbine operates at 126 MW (Fig. 5.), prefill will not cause high pulsation. Since there is no change in high pulsation value, prefill process will stop in 10 seconds.

3.2. Fix the Prefill Function on the Operational Concept from the Advant logic side

Based on the investigation of the logic prefill compared to the DEPP data trending it is necessary to make some parameters modification that will affect the prefill process as well as Prefill operation pattern. Improvement of the prefill logic is done by several stages. The first stage is to modify the maximum time for each prefill (TIME_MAX_PRF_C1). The maximum time for prefill is gradually lowered and applied directly when gas turbine operates by monitoring DEPP trending data continuously.

Table 1. Change in Setting Time Resulting in High Pulsation

No	Setting Time	High Puls. mbar	diff.TAT
1	10	121	V
2	9	98	V
3	8	68	V
4	7	47	V
5	6	25	

Based on Table 1. It can be seen that decrease in setting time will reduce the pulsation that occurs in the burner. However, the maximum limit of changes shown by the absence of diff TAT. Diff TAT indicate that the prefill has perfectly filled the FDS. The maximum prefill time decrease gradually and reaches the optimum value of 7 seconds. However, change in time setting is not the best choice because gas turbine is still experiencing PLS due to prefill for a while. The next step is decreasing pilot valve mass flow rate value in logic prefill shown by Fig. 6. Mass flow rate value is decrease gradually while pulsation pattern and changes in TAT is continuously observed.

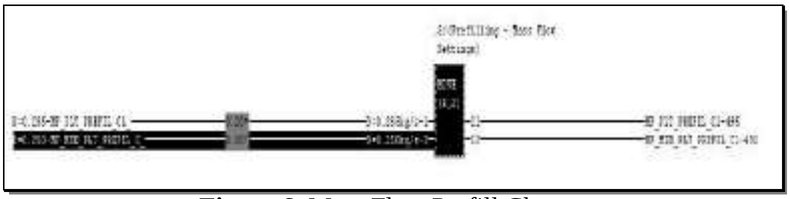

Figure 6. Mass Flow Prefill Change

Changing of pilot valve mass flow rate parameters compared to the pulsation values can be observed in Table 2.

Table 2. Change in Mass Flow Pilot Valve

No	Min Flow kg/s	Max Flow kg/s	High Puls. mbar	diff.TAT
1	0.25	0.285	120	**V**
2	0.25	0.27	121	**V**
3	0.25	0.26	112	**V**
4	0.25	0.25	84	**V**
5	0.23	0.24	64	**V**
6	0.21	0.2	41	**V**
7	0.2	0.2	23	**V**
8	0.2	0.18	23	

Any decrease of mass flow rate will result in a decrease of high pulsation value. However, the maximum limit of changes indicated by absence of diff TAT. Change in mass flow rate value obtained minimum high pulsation at the point of 0.2 kg/s for both minimum and maximum mass flow rate.

IV. Results And Discussions

Prefill system on turbine gas will help avoiding flame off when there is a change in the area of switch over or switch back point. However, the active prefill will cause high pulsation so PLS or Protective Load Shedding will be active. PLS will cause turbine gas load to drop until normal condition is reached and PLS is reset.

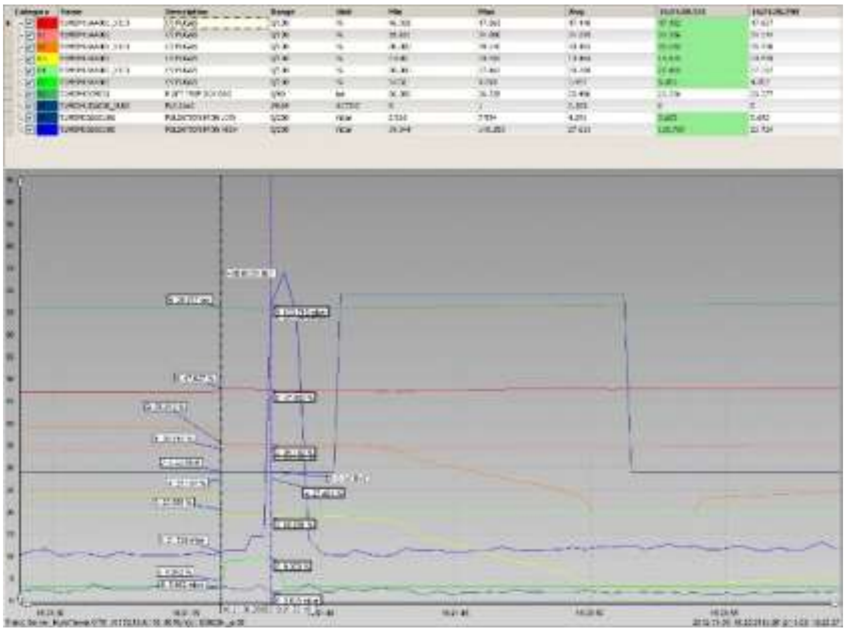

Figure 7. PLS Event in Prefill

In Fig. 7. There is an active PLS signal from signal number 7 that is 51MBX41EA000_XU03 PLS 2oo3 or PLS 2 out of 3 active signal. PLS is active because of signal high pulsation number 9, 51MBM30AX010B reach 148 mbar. High pulsation reaching 148 mbar would cause PLS. PLS always happens when prefill process takes place. There are several times occurrence of PLS during the prefill that has been summarized in Table 3.

Table 3. PLS Caused by Prefill

No	Date	Number of Event	First Load (MW)	Decrease in Load (MW)	High Pulsation (mbar)
1	10 February 2012	1	110.3	97	74
2	30 March 2012	1	110	96	75
3	9 May 2012	1	112	97	120
4	12 May 2012	1	112	95	121
5	14 May 2012	1	110	96	120
6	22 July 2012	1	112	95	112
7	4 August 2012	2	110	96	90
8	5 August 2012	1	113	97	76
9	8 August 2012	1	112	95	109
10	10 August 2012	1	112	94	110
11	11 August 2012	2	113	96	121
12	14 August 2012	2	114	97	135
13	16 August 2012	2	112	98	119
14	18 August 2012	2	110	96	126

The total event for 2012 is 52 times starting from February 10, 2012 and the last event is November 7, 2012. High pulsation resulting in PLS because Prefill occurs in an area of about 60% to 65% Relative Power or approximately 112 MW. The operating load in 112 MW is the demand from the network at certain times. However, if prefill operates at a relatively high load (above 120 MW), then the prefill process will not cause high pulsation because the proportion of premix is so large that the effect of the prefill are relatively small. Using this information, logic improvements are needed by modifying the enabled function PLT_PREFIL_CYC_EN, so when turbine gas operates at a under load the cyclic prefill will not be active. This function can be activated when gas turbine operates with a relatively high load.

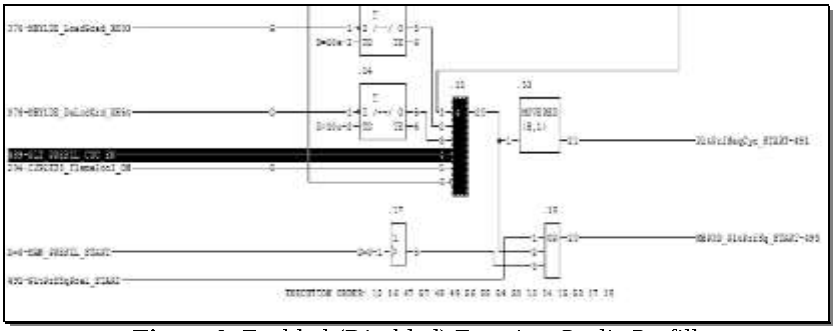

Figure 9. Enabled (Disabled) Function Cyclic Prefill

When under load, the prefill will be active when the gas turbine experiences a minimum load loss of 0.35 MW/s for 10 seconds. Fig. 10. show prefill process after modifying function has been done. Prefill occurs when Gas Turbine experiences a decrease in load from 143 MW to 113 MW within 2 seconds or a decrease of 15 MW per second. This prefill occurs optimally by being marked by a small power swing and no increase in pulsation value.

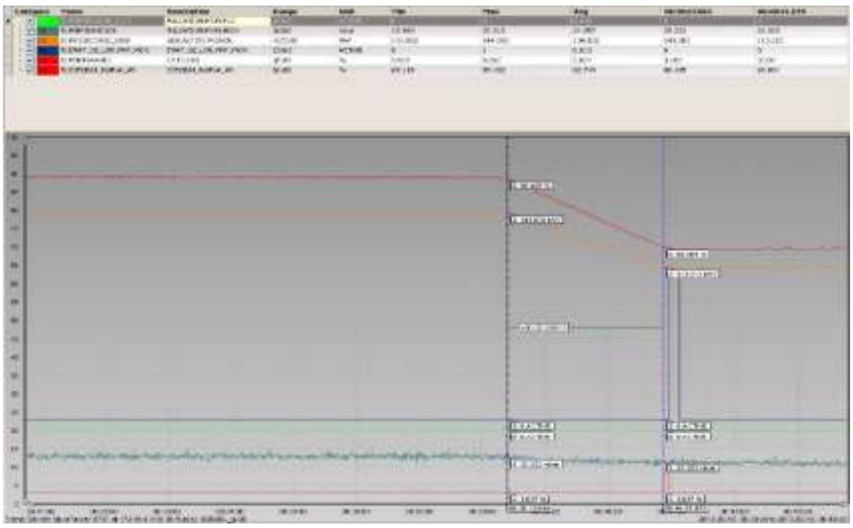

Figure 10. Decrease in Prefill Process

V. Conclusion

Fixing the prefill function from gas turbine can reduce and eliminate PLS due to High Pulsation. Prefill function improvement is done by disabled cyclic prefill function at under load. With the improvement of prefill function, there is no more derating because of prefill. Despite the improvement of the prefill system to the operational concept of gas turbine, monitoring of combustion parameters must continue

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