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Optimizing Igniter's Current Measurement to Prevent Start Failure in Combined Cycle Power Plant

Muhammad Syaifuddin Zuhdi[1*] and Primanda Arief Yuntyansyah[2]

[1] Operation System, PT. PJB, Indonesia
[2]Electrical Engineering, PT. PJB, Indonesia
zuhdibeji@gmail.com

ABSTRACT

The start process was challenged combined cycle power plant because it was operated as a peaker power plant that increased its start-stop frequency. Start failure can happen anytime. One of so many factor that caused start failure is igniter abnormal. In this paper majority about start failure was discussed and igniter's current measurement attended for effective solution of it. This solution effectively mitigated the start failure that caused by igniter abnormal and help the power plant avoid loose production from the case. The result of this study shown that igniter's current measurement effectively decreased the igniter's abnormal case from 21.94% to 6.89%. This solution easy to be used by anyone and anytime. It also easily can be applied to other combined cycle power plant.
Keywords: combined cycle power plant, current measurement, igniter, peak load demand, start failure

1. Introduction

Indonesian electricity grid system still largely depends on thermal power plant like steam power plant and combined cycle power plant. They played 64,32% and 16,94% to supply the grid system [1]. Steam power plant and combined cycle power plant (CCPP) have different function, steam power plant usually used as a base load and combined cycle power plant as a peaker power plant. The peaker power plant is a power plant that was operated when the grid system at peak load and increased start-stop frequency of it [2]. One of combined cycle power plant (CCPP) in east java with capacity of 1.500 MW was proceed start stop until 616 times in 2021. The start frequency trend from 2013 has shown in figure 1.

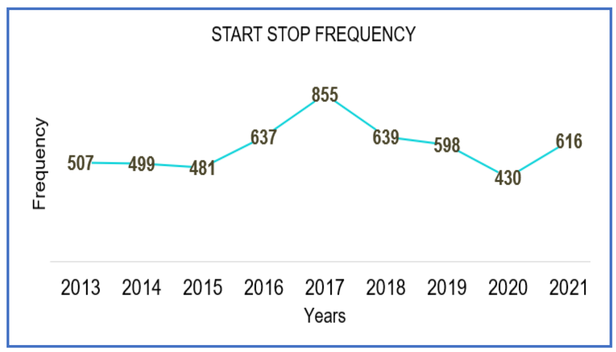

Figure 1: The Frequency of CCPP's start

The start process was challenged the CCPP that operate as a peaker power plant. Not only in Indonesia, but in other countries that used CCPP as a peaker power plant. In most developed countries with strong capacity and demand, proportion of peak load power plant are high. For example, in Japan (74,5%), United States (58,2%), France (26,6%) and China (21,3%) respectively in 2006 [3]. One of the most problem when operated CCPP is start failure. In this study was founded 155 times start failures case from 2006 to 2017 shown in table 1. There are so many factor that caused start failure. From the studied before [4], 75 failure modes was identified can affect the start failure of gas turbine and the highest failure modes depend on fuel valve operation and igniter. Table 2 presented, top 10 failure mode of gas turbine start failure. It calculated with Risk Priority Number (RPN) method.

Start failure must be decreased because it can be impact to the starting reliability [5].

Table 1: The Cause of Start Failure from 2006-2017

Cause Start Failure	Total Case
Electrical fault	17
Flame out trip (Igniter abnormal)	34
Tube leakage in HRSG	11
Exhaust temperature high	11
Fuel valve abnormal	22
Trouble from outside	42
Bleed valve abnormal	4
Starting device abnormal	6
Others	8
Total	155

Table 2: Top 10 Failure Mode of Gas Turbine Start Failure

Failure Mode	Severity	Occurrence	Detection	RPN
Fuel valve can't open	4	4.6	4.4	81.0
Igniter abnormal	3.7	4.6	4.6	77.6
Combustion not happen	4	4.3	4.1	71.0
Combustion can't detected by sistem or sensor	2.9	4.4	4.6	57.8
Fuel valve shut off suddenly	3.3	4.6	3.7	55.8
Torque converter pressure low	4.3	2.6	4.3	47.2
Sequence from control oil not ready	3.3	3.6	3.6	41.9
Torque converter not work properly	3.4	2.7	4.1	38.6
Fuel valve open status can't detected by system	3.1	3.3	3.7	38.4
Deviaton in bladepath control	3.3	2.7	3.4	30.3

Source: (M. Suef, 2019)

From table 1, start failure mostly caused by trouble from outside. It was happened because of fuel supply's pressure low from the supplier or disruption from the grid system that makes generator cannot synchronize immediately. The second was caused by flame out trip. Flame out trip indicated that there are no combustion in your gas turbine because igniter cannot emited sparks and initiated flame. The third caused by fuel valve abnormal. There was a lot of factor that caused fuel valve can't work properly such as part of fuel valve was broke, control oil was dirty, fuel valve open status can't detected by system, fuel valve shut off suddenly and etc. From three items that caused of start failure above, we will focus to mitigate start failure from igniter abnormal. The decision to mitigate it in depth is not unreasonable because in this study, igniter abnormal happen in 34 times along the time. This case contributed 21,94% of all start failure in CCPP.

2. Literature Review

2.1. Igniter

The condition to make combustion according to the triangle of fire theory are there is fuel, oxygen and heat [6]. Combustion process of gas turbine was happen in combustor chamber. Compressor will pull air from atmosfer through intake air filter, fuel was supplied by fuel system and heat was sparked by igniter. It is overall combustion process.

Igniter as a device to initiate combustion. With sparks any electricity, igniter spread heat energy in combustor chamber. In our CCPP using Yokogawa Root Igniter with specification [7] in Table 3.

Based on the start sequence of gas turbine, igniter must ON at 550 RPM of turbine speed as in Figure 2. IGNITION block will light if igniter can work properly and if there are good combustion in our combustor chamber, FLAME ON block will light too. Some case when igniter cannot give a good sparks, there were no flame in combustor chamber, so it makes IGNITION and FLAME ON block not light and declared start failure for CCPP.

2.2. Start Sequence of the Gas Turbine

The start process of gas turbine for the company followed the start-stop sequence in Figure 2. Before start process begin, all of READY TO START block requirement must be fulfilled. At this position, speed of gas turbine is 3 RPM. When READY TO START block is light, indicated that gas turbine ready to operate with automatically. Every block indicated the step of process and operate some equipment as the

Table 3: Specification of Igniter

Ambient Temperature	70^{0}C
Voltage In	110 VAC
Current In	5 Ampere
Frequency	50 Hz
Voltage Out	3000 VDC
Energy	16 Joule
Sparks	6 Spark/second

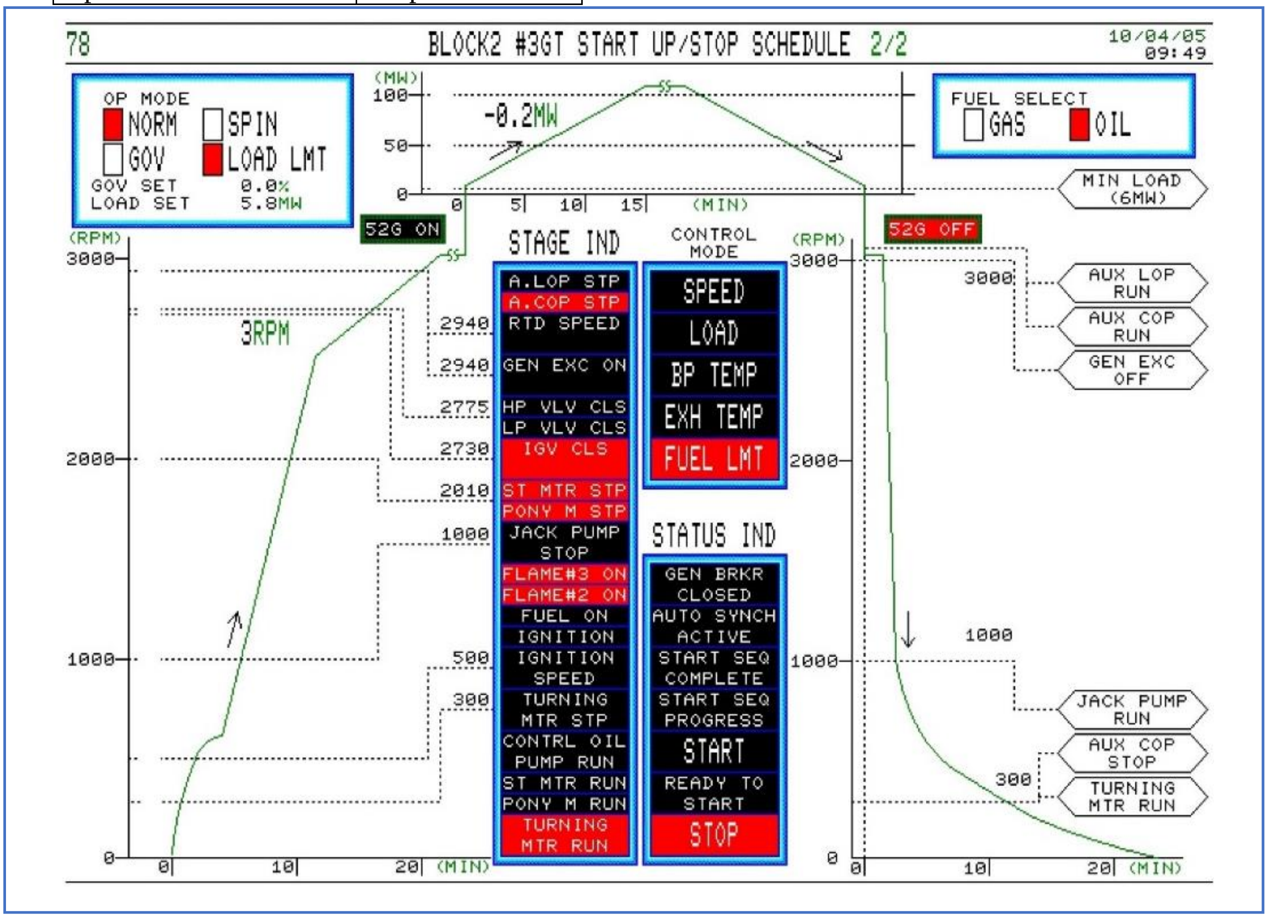

Figure 2: Start –Stop Sequence of Gas Turbine.

requirement of the step until speed up to 3000 RPM. The block will not appear light when the equipments does not start and speed of turbine will stuck in there. If this condition happen, as soon as possible must doing some maintenance activity to make the equipment can run normally. But unfortunately, maintenance activity need time and shutdown the turbine. So, very important to make sure all of your equipment in good condition before operating CCPP.

CCPP was declared by customer as a peak load demand power so this plant must can be operated when the power grid need high demand. This condition make our plant more often doing start and stop according to not scheduled customer requests. If the plant was requested to start by customer have failed to start during the specified time, then the plant will be declared by costumer as start failure plant and the customer will request another plant that more ready to start. It will take effect to company’s income and customer satisfaction.

3. Data Analysis

The igniter abnormal was identified by break down chart (Figure. 3) to know root cause of it. From manual book of CCPP and senior expert experience, there are three main of problem that caused igniter abnormal, igniter does not fire, igniter sometimes misfire and igniter was fires but combustor can't be ignited. From three main of problem, there are 11 failures mode that contribute to make the problem. So we make research to look for the solution or method to fix the problem. Our research involve experts from operation and maintenance crew and from studying literature and the result in Table 4. From Table 4, 6 from 11 failure mode have indication abnormality in current measurement, so we concluded that half of failure mode can mitigate with measure the current. With measure it, abnormalilty of igniter can be known early by checking the conditions of the igniter by measure the current from the igniter when ignited. The advantages of checking the igniter condition by current measure can do anytime without waiting shutdown.

Table 4: Failure Mode, Indication and Solution of Igniter Abnormal

Failure mode	**Indication**	**Solution**
Power circuit is faulty	**Current is zero**	Check and repair power circuit
Malfunction of exciter igniter	**Current is lower than 4 A and no spark in igniter plug**	Repair
Output lead open circuited	No spark in igniter plug. May caused safety resistor and capacitor broke, so voltage will higher	Repair output lead connection
Electrode broke	**current is lower than 4 A**	Replace with new electrode
Igniter plug is at end of life	**Low current and few spark**	Replace with new igniter plug
Poor contact through loosened connections	**Voltage and current is not stable (fluctuation)**	Inspect each connection
Igniter plug is at end of life	**Low current and few spark**	Replace with new igniter plug
Top of igniter plug is not in appropriate firing position	Fire not happen in combustor	Reposition igniter plug properly
Nozzle plugged	Fuel can not spread normally	Take and clean nozzle
Burner is not maintained in order	Fire not happen in combustor	Check and repair burner
Malfunction of fuel system	Fire not happen in combustor	Check and remedy fuel system

In 2018 this company initiated to measure using clamps ampere meter. But the disadvantage was sometimes not done because the availability of this tool is limited and maintenance crew who have this tool have a lot of workload.

The next step, we installed the ampere meter to facilitate observation. With the ampere meter the operator can easily measure the igniter current. But this also has weaknesses. measurement accuracy is not good because the ampere meter available on the market is quite large in scale. So the accuracy is lacking. For this reason, the idea of installing a digital ampere meter appeared. This digital ampere meter will be installed on the igniter breaker panel like in Figure 5. It will help to increase accuracy than other measurement method before and more easy to read the result.

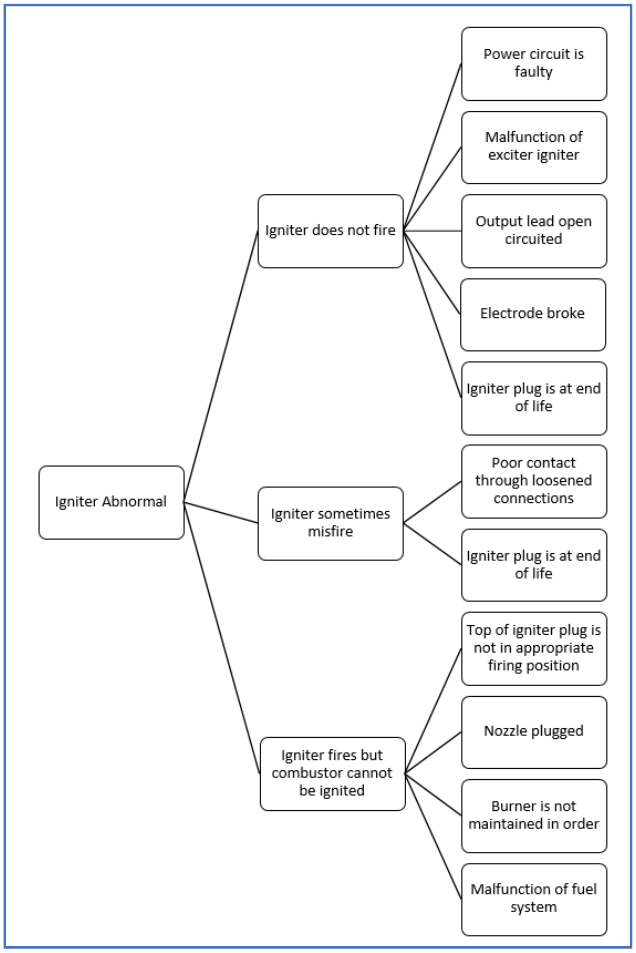

Figure 3: Breakdown Chart of Igniter Abnormal

4. Results and Discussions

The effectiveness of ampere igniter measurement is very good. From Table 5, we founded that start failure caused by igniter abnormal happen 4 times from 2018 – 2020. So we can calculated if the ampere meter measurement method applied in CCPP, it can reduce up to 6.89%. From this calculation, indicated that installation of a digital ampere will more effectively in order to reduce the start failure.

From current measuring activity there were some benefit we will get. First, the combine cycle power plant can safe the opportunity losses from start failure. As we know, if start failure happen in the plant, means the power plant spent some revenue for it. For one hour force outage (FO), the compensation up to 48 million rupiahs with detail cost for force outage and derating status, fuel and auxiliary power consumption. It will be more expensive if doing more start trial because every start process need some fuel and auxiliary power.

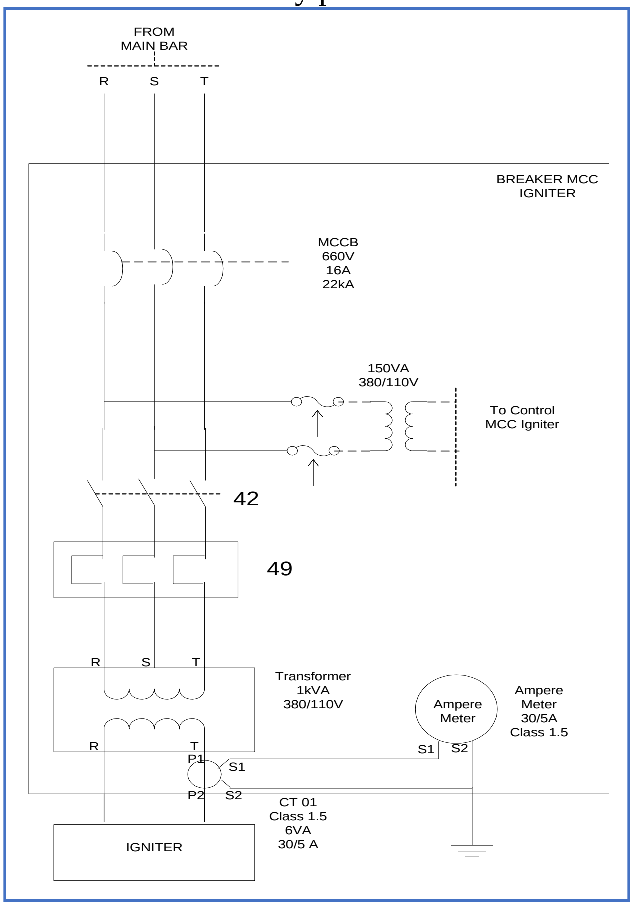

Figure 5: Wiring Diagram to Install Digital Ampere Meter in Panel Breaker of Igniter

For other disadvantages of start failure, first is decrease the readiness of the gas turbine unit to be able to start normally. The second is impact to decrease EAF (Equivalent Availability Factor) and increase EFOR (Equivalent Forced Outage Rate). EAF measure the availability the

Table 5: The Cause of Start Failure from 2018-2020

Cause Start Failure	Total Case
Electrical fault	14
Flame out trip (Igniter abnormal)	4
Abnormality in HRSG	5
Exhaust temperature high	2
Fuel valve abnormal	12
Trouble from outside	17
Bleed valve abnormal	1
Starting device abnormal	1
Rotor cooling air leakage	1
Lube oil system abnormal	1
Total	58

Table 6: Work Order Request from Igniter's Current Measurement in 2018-2020 Period

Work Order Number	Description	Equipment Reference	Date	Priority
132586	Igniter Gas Turbine #2.1 abnormal. Current measurement equal 0 (zero) A.	GC21MBM-10AV001	2018-11-29	A
137963	Igniter Gas Turbine #2.1 abnormal. Current measurement equal 0 (zero) A.	GC21MBM-10AV001	2019-02-02	C
166439	Igniter Gas Turbine #2.2 upper side abnormal. Low current measurement and little sparks.	GC22MBB-10HB001	2019-12-05	C
174128	Igniter's current Gas Turbine #1.3 low. Measurement result equal 3.8 A	GC13MBM-10AV001	2020-02-16	E
130381	Request to check and replacement igniter Gas Turbine #1.1. Indication : current measurement fluctuative.	GC11MBM-10AV001	2018-10-26	B

plant like combined cycle plant. Each major generating block is treated as being either available or not available to contribute a preestablished percentage of the plant's output and EFOR was deduced from its mean time to repair and mean time between failure [5]. As we know this parameter used to measure a Key Performance Indicator of power plant unit. This parameter will inflict to the plant existence and company incomes too.
The third is decrease customer satisfaction. It also become assessment point for power plant industry from minister and holding company. There are four point customer satisfaction for power plant industry : Speed of response from power plant unit to the given order from power grid station to add or reduce power load, speed of rensponse to give information about power plant unit status and condition just in time, suitability of Start Up time for each generating unit and reliability of power plant unit to have responsive with power grid demand [8]. Start failure make company can't fulfill third and fourth point of customer satisfaction. So, start failure must be mitigate and the company can eliminate all of disadvantages.

Place digital ampere meter for measure current of igniter will help the company to mitigate one of the most case of start failure from igniter abnormal. It very easy to install and operate. This method can be done by anyone and any time when the unit has not been started yet. Know the current of igniter means we know the condition of igniter. So we can prevent the abnormality of igniter. The standard of current measurement of igniter 4 -5 Ampere. If the current below or over from the standard, it indicate that igniter was abnormal. It will cause start failure of the unit. So we can request to maintenance crew to check the igniter. Doing corrective activity before start is what the company expects because doing corrective when the plant online to the power grid have many disadvantage. Table 6 present some work order request after knowing the result of ampere measurement.

5. Conclusion

This article provided a preventive action to mitigate start failure in a gas turbine because start failure is a challenge to power plant particularly to the peaker power plant and start failure can caused a large losses of revenue to the CCPP and decrease readiness that will affect to their EAF and EFOR. One of the start failure case that happen in the CCPP was caused by igniter abnormal. From this study there were 11 failure mode about igniter abnormal. 6 from 11 failure mode can detect early with measure their current. So from 2018 we applied current measurement to the igniter to prevent igniter's failure. This solution effectively decreased the igniter's failure case from 34 case in 2006 – 2017 years (21,94%) to 4 case in 2018 – 2020 years (6,89%). It will more effective and accurate if we use digital ampere meter. This method easy to do and can be done by anyone and anytime. It also can be applied to other CCPP units. The next research should look for integration current measurement with logic sequence in programmable logic diagram. So, if the current abnormal, this information will give a message to control room that igniter was in abnormal condition and make CCPP in not ready condition.

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