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[Perianto *et al.*, 8(1): January, 2019]
IC™ Value: 3.00

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

INTEGRATION OF GAS PIPING SYSTEM TO INCREASE RELIABILITY AND COST REDUCTION

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DOI: 10.5281/zenodo.1436288

ABSTRACT

Muara Tawar power station has three gas suppliers i.e. PGN, Pertamina EP (PEP) and Nusantara Regas (NR). For gas supply from PGN and PEP, supplied pressure is still below the minimum requirement of GT, hence the additional gas booster (compressor) is used to increase pressure. PT PJB uses compression services by 3rd parties related to the work. The compression service used to backing up pressurized gas supply to Block 1-4, while block 5 has its own compressor unit. There are 5 gas supply streams leading to GT, 1 & 2 phase compressors (managed by 3rd parties), V-block, CNG and NR gas compressors. Gas turbines operation pattern in Muara Tawar power plant are fluctuate because of demand fluctuations in Java and Bali. Start-up plant priority per blocks are sequentially start from block 1 (3 units), block 3-4 (6 units), block 2 (2 units) and the last block 5. With different operating priorities, and unintegrated pressurized gas distribution conditions of stream, can result in shortage of pressurized gas supply in one block. In order to maintain the reliability of the unit and optimizing the absorption of fuel gas related to the problem, Muara Tawar power plant make an improvement in "Integration of Gas Pipe to Maintain Unit Reliability and BPP Reduction". From this research, it can be conclude that integration of piping system have capability to increase the reliability of the gas supply to the turbine gas unit.

KEYWORDS: Gas Turbine, Piping system, Reliability.

1. INTRODUCTION

The reliability of a power plant to provide electricity is the most important task to ensure energy availability [1]. PT Pembangkitan Jawa Bali (PJB) Muara Tawar or Muara Tawar, a subsidiary of state-owned electricity firm PLN is a power plant that generate 1943 MW. Muara Tawar consist of 12 units of gas turbine (GT) which can use both natural gas and HSD fuel. The utilization of gas turbines in power generation has increased over the time [2]. PLN prioritizes the operation by using natural gas to reduce production costs. Table 1.1 show unit and capacity for each block in Muara Tawar power plant.

Table 1. Block Capacity in Muara Tawar Power Plant

Block	Unit	DMN	Gas Requirements
1	3 Gas Turbine 3 HRSG 1 Steam Turbine	411 MW (3 x 137) - 204 MW (ST)	114 - -
2	2 Gas Turbine	274 MW (2 x 137)	76
3	3 Gas Turbine	420 MW (3 x 140)	1`14

ISSN: 2277-9655
Impact Factor: 5.164
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4	3 Gas Turbine	420 MW (3 x 140)	114
5	1 Gas Turbine 1 HRSG 1 Steam Turbine	143 MW - 71 MW	38 - -

Muara Tawar power station has three gas suppliers i.e. PGN, Pertamina EP (PEP) and Nusantara Regas (NR). The pressure of gas from PGN and PEP is lower pressure of the minimum requirement of GT. Hence, it required additional gas booster (compressor) to increase the pressure. PT PJB uses compression services by 3rd parties related to the work. The compression service used to backing up pressurized gas supply to Block 1-4, while block 5 has its own compressor unit. There are 5 gas supply streams leading to GT, 1 & 2 phase compressors (managed by 3rd parties), V-block, CNG and NR gas compressors.

PGN supplies the gas to all blocks, including to the CNG plant. PGN is the largest gas supplier to Muara Tawar power station. Gas from PEP is used to supply 2 units of compressors in phase 1, with a capacity of ± 20 MMSCFD. Although the capacity is small, PEP gas price is the cheapest compared to other gas suppliers. The gas from NR supply to Blocks 3-4 and 5, where its pressure exceed the minimum requirement of GT, Therefore, it does not require the booster again. Maximum NR gas capacity is 75 MMSCFD.

Fluctuated fuel gas supply can be affected to reliability of combined cycle power plant [3]. Gas turbines operation pattern in Muara Tawar power plant are fluctuate because of demand fluctuations in Java and Bali. Start-up plant priority per blocks are sequentially start from block 1 (3 units), block 3-4 (6 units), block 2 (2 units) and the last block 5. The different class of operating priorities for each block and disintegrated pressurized gas distribution conditions can result in unbalanced of gas supply pressure for entire blocks. In order to maintain the reliability of the all units and optimizing the utilization of fuel gas, Muara Tawar power plant make an improvement in "Integration of Gas Pipe to Maintain Unit Reliability and BPP Reduction"

2. REVIEW

Piping

Piping is pipe distribution with a certain size that is connected from one area to others. By using piping, the gas fluid can be transport from one process to others. The components of a piping consist of: Pipe (tube), pipe fitting , traps/steam traps, strainer, flange, valve, and expansion joint.

Basic Flow Equations of Gas in Pipe.

There are many equations for calculating the flow of gas isothermal in the horizontal pipeline. The most common equation used is the rational gas flow formula [4]:

$$p_1^2 - p_2^2 = Bf\left(\frac{ZTGQ^2}{D^5}\right)L$$

Where:

B :Dimensional constant (5608)
D :Internal diameter (mm)
F :Friction factor
L :Length (km)
G :Gas gravity
P1 :Initial line pressure (kg/cm2)
P2 :Final line pressure (kg/cm2)
Q :Flow rate (m3/hr)
T :Absolute gas pressure (kelvin)
Z :Compressibility factor or average condition

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To calculate in difference pressure elevation and gas flow in the pipeline, the rational gas flow formula are modified into formula called correction method of elevation by Ferguson as follow [5].

$$p_1^2 - e^s p_2^2 = Bf\left(\frac{ZTGQ^2}{D^5}\right)L_e$$

Where:

e : log n (2.71828)
es : Eleveation correction factor
Le : Effective length (es -1) L/s (Km)

Pipe Design Formula

In order to calculate the pressure design for a gas piping or nominal thickness of the pipe for a given working pressure, it can be determined using the equation as follow.

Where :

P : Permissible design pressure (Kg/cm2)
S : Yield Strength (Kg/cm2)
D : Nominal Outside Pipe diameter (mm)
T : Nominal pipe wall thickness (mm)
F : Design factor
E : Longitudinal pipe joint factor
T : Temperature factor

3. METHOD

Pipeline and Gas Supply in Muara Tawar.

a. Gas From PT PGN (Persero)

Gas from PT PGN is delivered through Transmission Java Sumatra 2 (SSWJ II) to Muara Bekasi gas station owned by PGN. The handover point between PLN and PGN is located at Muara Bekasi. From Muara Bekasi Station gas is flown through 26 inch pipes owned by PLN along 7 km to Muara Tawar. Gas derived from PGN has a good composition, the methane value is greater than or equal to 90%. PGN gas distribution scheme through SSWJ II pipeline to Muara Bekasi Station can be seen in Figure 1.

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Figure 1. Gas Transfer from PGN to Muara Bekasi

b. Gas from Pertamina EP

Gas from Pertamina EP is non associated gas derived from Pondok Makmur Well, Pondok Tengah, Tambun and Tegal Pacing. Gas is transported through Pertagas's 12-inch gas distribution pipeline to Muara Tawar. Non associated gas belonging to Pertamina EP tends to be wetter than PGN gas, and its methane composition about 74% only.

c. LNG From Nusantara Regas

Gas from PT. Nusantara Regas is LNG that is converted to gas in FSRU (Floating Station Regasification Unit) before it is distributed to Muara Tawar through Muarakarang - Muara Tawar transmission line owned by PT. Pertagas. Regasification from LNG to gas has good quality and low impurities.

d. The Muara Tawar Pipe Line Gas Schematic

Gas from the three suppliers are transported to the existing gas installation facility in Muara Tawar power plant with a different point. Figure 2 shows the piping schematic diagram of gas distribution at Muara Tawar power plant.

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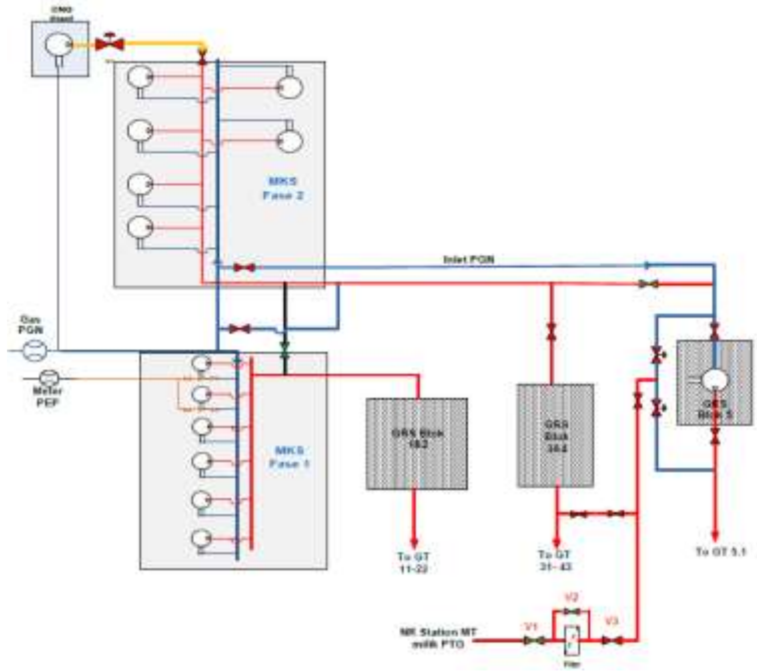

Figure 2. Piping Distribution Schematic Diagram of Muara Tawar Power Plant

In gas turbine block 1-2 and block 5 the minimum gas pressure required is 21 barg, whereas in block 3-4 the minimum gas pressure required is 18 barg. The gas supply from PGN is pressurized ± 20 bar and the gas supply from Pertamina EP is pressurized ± 15 bar. Therefore, Gas from PGN and Pertamina EP flow into Muara Tawar unit through gas booster compressor. Gas booster compressor raise and maintain the stability of gas pressure until requirement of gas turbine reached. For NR gas has a high enough pressure so that NR gas feed into the gas turbine without compression. Gas supplied from PGN and PEP in block 1-2 compressed by MKS phase 1. PEP gas is dedicated to C1 and C2 MKS phase 1, while PGN gas can be compressed by all compressors in MKS phase 1. Gas coming out of the compressor enter into Gas Recieving Station (GRS) Block 1-2. In GRS the gas is filtered through a scrubber and filter, then flowed into a turbine gas.

Gas supplied from PGN in block 3-4 compressed by MKS phase 2 and transferred into Gas Recieving Station (GRS) block 3-4. In addition to PGN, block 3-4 supply also comes from NR gas tapping from discharge side of GRS block 3-4.

Gas supplied from PGN in block 5 compressed using gas booster compressor owned by PLN dedicated to block 5. Muara Tawar power plant also owns CNG Plant, where on CNG Plant PGN gas is compressed and stored in pressurized storage up to 250 barg. PGN gas stored in the skid tube is used during peak hour where high gas demand and gas availability during peak hour are limited, this can reduce the use of HSD and reduce the use of more expensive NR gas.

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Problem Solving

Some alternative solutions to deal with emerging problems are shown in Table 1.

Table 2. Alternative Problem Solution No Alternative Solution Feasibility Implementation

No	Solution	Feasibility
1	Adding gas compressors unit	Difficult to do, related to the not optimal utilization of all compressors that exist today
2	Integration of gas pipeline between streams	Easier to do with lower investment costs and can be directly implemented.

From the existing problem the alternative solutions, an inter-stream gas pipeline integration solution was chosen.

Implementation

a. Implementation Phase 1: Additional Bypass Line between Blocks 1-2 with 3-4 Blocks

The purpose of this modification is to optimize the existing compression services, which supply to blocks 1-2 and blocks 3-4. Some considerations to make this modification include:

- The loading/operation of different compressors between phases resulting from different GT operating patterns.
- Different compression service contracts between phases 1 and 2.
- On higher loading/operating phases, it is more difficult to manage maintenance schedules. Where it affects the reliability of the compressor.

Related to the different compression service contract, the tapping point selection refers to the flow meter position as per term and conditions of the payment transaction. The tapping point is selected between GT 2.3 and GT 3.1. From the operational point of view, the determination of tapping point between GT2.3 and GT3.1 is chosen because of gas inlet GT pressure parameter. For block 1-2, the inlet GT gas pressure is maintained at 24 barg, where pressure at GRS 1-2/phase 1 compressor discharge is 25 barg. For blocks 3-4, maximum pressure inlet GT is 24 barg. Refer to these conditions, selecting tapping points between GT2.3 and GT3.1 are considered ideal, since the lowest pressure in block 1-2 is still appropriate for the conditions in blocks 3-4.

Related to the condition of gas composition, based on existing data output phase 1, a mixing gas between PGN and PEP has a methane value of 86 - 88%. For phase 2 (pure gas PGN) has a methane value of 89%. With the condition of each stream, the mixing condition provide the composition of methane content inside the standard range of 86 - 89%. This condition match with GT requirements and provide good availability.

b.Testing result of Bypass Line between Block 1-2 and Block 3-4

Based on historical data recorded, before the modified line, fault caused by limitation of the compressor in block 1-2 or 3-4 is often, which is influenced by compressor's capacity and the reliability of the compressor itself. When the compressor operates continuously without any back up, it will be difficult to set up maintenance schedules, result in compressor reliability declining.

After modification, the compressor loading pattern is more flexible, where phase 1 can back up block 3-4 and vice versa. The modification are obtained some advantages as follow.

1. When maximum loading occurs in one block and in another block there is spare, it can be backed up. Thus reducing the risk of unit disturb caused by limited supply of pressurized gas.
2. With the integration between phase 1 and 2, it is easier to schedule the maintenance of the compressor to maintain reliability.

c. Implementation Stage 2: Tapping Line NR on GRS 1-2, Tapping Outlet Compressor Block 5 to Block 3-4 and Block 1-2 With Pep Line Tapping In Block Compressor Inlet 5.

The objectives of this modification are included as follow:

- Optimize streams outside of Compression Services so as to reduce dependency on 3rd parties. From the existing operating data, where operating patterns are interconnected with the contractual conditions of the gas, the loading pattern of UP Muara Tawar is currently decreasing compared to previous years. Therefore, it is necessary to optimize the utilization of 3rd party outflow stream to back up the requirement in UP Muara Tawar.

- Optimize gas utilization from suppliers. Priority of gas absorption at present is PEP, PGN and NR. It is based on price and capacity. PEP gas has the lowest price despite its lowest capacity. Therefore PEP gas absorption is prioritized. Initial conditions, PEP gas absorption can only be done by 2 units of compressors in phase 1. With the modification of PEP tapping line in the compressor inlet Block 5 allows for back up of PEP gas absorption. Tapping modification of NR in block 1-2 is done on GRS 1-2. Pressure of NR gas approaches gas pressure outlet of phase 1 compressor, ranging from 26-28 barg, with adjustable flow. This allows for mixing, where PGN gas still can be absorbed as needed. The block 5 gas compressor which is currently in standby condition, due to the low block 5 operation plan, is used to backup the needs in other blocks. Tapping line outlet of compressor block 5 to GRS 1-2 and GRS 3-4 is done to accommodate flexible gas distribution according to loading condition at Muara Tawar power plant. Operationally, the pressure of the block 5 compressor outlet is still in accordance with the conditions in each GRS (1-2 and 3-4).

d. Testing result of NR Line Modification on Block 1-2, Modified Compressor Line Outlet Block 5 to GRS 1-2 and GRS 3-4 and Tapping Line PEP on Compressor Inlet Block 5.

With the NR line to GRS 1-2, it helps accommodate the availability of pressurized gas supply to block 1-2 and tapping outlet of compressor block 5 to block 1-2 and block 3-4. With the backup, and the current low loading conditions of Muara Tawar, PT PJB can reduce the value of the compression services contract. With the reduced value of the contract is expected to be more optimal utilization, due to the previous condition of losses caused by the realization of the use of compression services.

For the modification of the PEP tapping line in the block 5 compressor inlet, it accommodates the decrease in the value of the compression service contract with the 3rd party, PEP gas can still be prioritized.

4. RESULTS AND DISCUSSION

Non-Financial Benefits.

From the implementation of stages 1 and 2 that have been implemented some results are obtained:

- Increase unit reliability, by minimizing the possibility of "lack of pressurized gas supply" in certain blocks.
- Decrease the value of compression services contract.
- Facilitate the implementation/scheduling of maintenance compressor booster
- Improving Customer Satisfaction. With the increased reliability and flexibility of the distribution will have an impact on increasing customer satisfaction.

Financial Benefits

By modifying the gas pipeline and increasing the flexibility of the gas drainage from various suppliers and channeling between blocks, the negotiation of the contract value in compression services with third parties since December 2017 is decrease, from IDR 9,560,232,000/month, to IDR 3,325,000,000/month. Compression services per MMSCF also decreased from IDR 1,689,940 to IDR 1,170,400, -. The decrease of contract value and compression services per MMSCF is a savings for Muara Tawar unit.

Table 4.1 show data history of gas distribution realization of compression services before modification (old contract) with realization since modification (new contract). There has been a monthly average savings of IDR 4,972,959,980 per month since the modification and execution of the new contract.

Table 3. Cost Reduction due to Modification

Month	Before Modification			
	Compression Volume	Contract Value	Difference between Compression Volume and Contract Value	Cost
January	4,199.90	5,400	1,200	2,028,099,638
February	3,431.94	5,400	1,968	3,325,907,332
March	3,223.97	5,400	2,176	3,677,356,155
April	1,329.67	5,400	4,070	6,878,602,695
May	609.32	5,400	4,791	8,095,945,749
June	598.51	5,400	4,801	8,114,217,748
July	1,794.83	5,400	3,605	6,092,517,504
August	2,268.48	5,400	3,132	5,292,080,217
September	2,623.30	5,400	2,777	4,692,443,901
October	2,459.74	5,400	2,940	4,968,859,089
November	1,734.64	5,400	3,665	6,194,228,094
	After Modification			
December	2,439.00	2,840	401	469,727,764
January	2,472.00	2,840	368	430,707,200
February	2,524.00	2,840	316	369,846,400

5. CONCLUSION

Integration is needed to optimize gas usage and flexibility of the gas turbine operation. Integration capable to increase the reliability of turbine gas unit and it have some benefits in financial and non-financial view of points. By using this modification line, it can reduce cost or average savings of IDR 4,972,959,980 per month.

6. ACKNOWLEDGEMENTS

The authors gratefully thank to PT. PJB UP Muara Tawar Indonesia for providing the facilities in conducting this research.

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Perianto, J., Firmansyah, I., Suprianto, E., Matradji, Cordova, H., Gunawan, K. S., & Biyanto, T. R. (2019). INTEGRATION OF GAS PIPING SYSTEM TO INCREASE RELIABILITY AND COST REDUCTION. *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY*,*8*(1), 10-17.