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Interconnection Design Strategy in Pipeline 406 for Kamojang Unit 5 Power Plant, Indonesia

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ABSTRACT

Kamojang Geothermal Field is one of the geothermal fields in Indonesia. Since its operation in 1983, the power generation in Kamojang has continued to increase until 2015 reaching 235 MW with the operation of Unit 5 Power Plant. For Unit 5 Power Plant, steam is supplied by four wells, KMJ-80,84,79 and KMJ-86. To maintain the sustainability of the power plant, drilling of two make-up wells was carried out. From these two wells, a connection will be made to the existing pipeline, PL-406. To connect the two make-up wells with existing pipeline, it is necessary to adjust the flow rate that will pass through the pipe because the two wells will be connected which has the flow rate of around 150 tons / hour, meanwhile the main pipeline of PL-406 is 32 " in size which is also used for four existing wells. This paper will explain the interconnection design strategy in PL-406 Unit 5 Kamojang without changing the size of the main pipeline, making it more effective and efficient in terms of cost and optimum plant operation.

1. INTRODUCTION

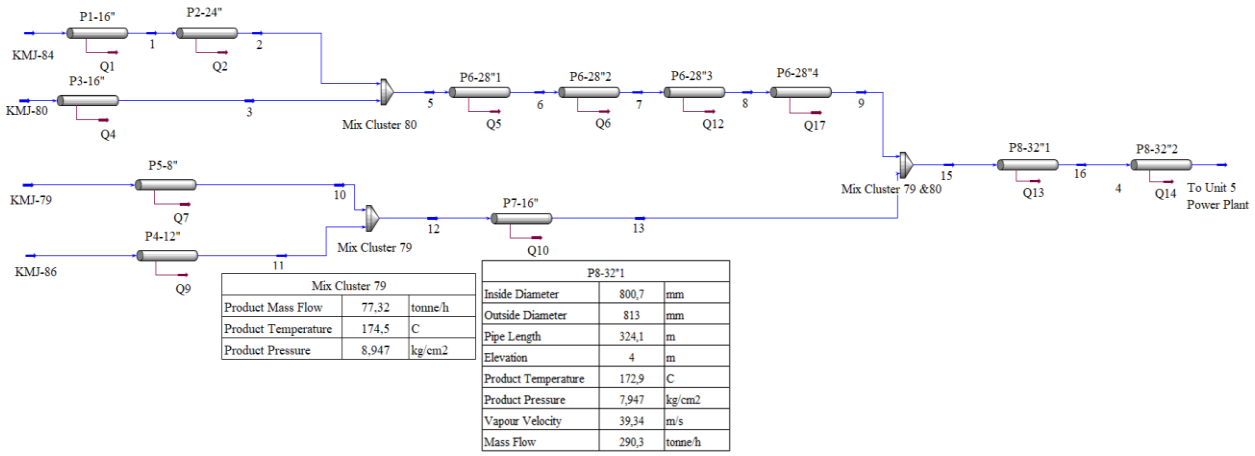
The Kamojang Unit 5 Power Plant first started its operation in 2015, which has produced 35MW electricity. This unit is supplied by four wells: KMJ-79,80,84 and 86, which are divided into two clusters namely cluster 80 and cluster 79. Cluster 80 consists of wells KMJ-80 and KMJ-84, and cluster 79 consists of wells KMJ-79 and KMJ 86.

One of the efforts to maintain the amount of supplied steam to the Unit 5 power plant in Pertamina Geothermal Energy (PGE) already drilled two makeup wells in the area of cluster 79. The two wells were KMJ-90 and KMJ-91. The production tests result from these two wells are about 150 tons / hour on wellhead pressure of 20 kscg.

In order to achieve optimum utilization of these two new wells, a strategy must be made in the piping design. So that the process of sending steam to the power plant not necessary to change the size of existing pipes, because the existing pipe cannot accommodate the steam capacity from the six wells. Then simulations were made to arrange the design of pipes where they remain flexible in operation and will be effective to reach the 35 MW.

2. DESIGN OF EXISTING PIPES

Figure 1 illustrates the existing pipe design prior to the addition of KMJ-90 and KMJ-91 wells. Using the existing operational data from these four wells, the critical point to consider is the mix line between KMJ-79 and KMJ-86 wells with 16" size of diameter and the main pipeline of 32 " size of diameter.



Mix Cluster 79		
Product Mass Flow	77,32	tonne/h
Product Temperature	174,5	C
Product Pressure	8,947	kg/cm2

P8-32"1		
Inside Diameter	800,7	mm
Outside Diameter	813	mm
Pipe Length	324,1	m
Elevation	4	m
Product Temperature	172,9	C
Product Pressure	7,947	kg/cm2
Vapour Velocity	39,34	m/s
Mass Flow	290,3	tonne/h

Figure 1: The existing pipe design.

To utilize two new wells, it is necessary to recalculate remaining flow rate that can be accommodated by the pipelines especially in critical line, which are pipeline from cluster 79 (16” size) and the main pipeline 406 (32” size). The result of this calculation is the remaining flow rate for pipeline from cluster 79 is 4,13 t/h and for the main pipeline 406 is 70,37 t/h by using steam velocity of 40 m/s. See on Table 1.

Table 1: Remaining flow in existing pipes.

Parameter	Mix Cluster 79 (16")	Mix Cluster 79 & 80 (32")
Input Data		
Line Pressure, P_1 (kscg)	7,60	7,94
Line Pressure, P_1 (barg)	7,45	7,78
Temperature (°C)	171,94	173,59
ρ, vap @P line (kg/m^3)	4,31	4,47
Steam Velocity (m/s)	40,00	40,00
NPS (inch)	16,00	32,00
Schedule	XS	XS
Outside Diameter (mm)	406,40	813,00
Pipe Inner Diameter (mm)	381,00	787,60
A (m^2)	0,11	0,49
Calculation Data		
Steam Flow Rate (kg/s)	19,64	87,11
Steam Flow Rate (t/h)	70,69	313,60
Existing Data		
Steam Flow Rate (t/h)*	66,56	243,23
Remaining Max. Flow		
Steam Flow Rate (t/h)	4,13	70,37

* Based on operation data in Jan 2017

3. PIPING DESIGN STRATEGY

Based on the results of production tests that have been carried out on two wells of KMJ-90 and KMJ-91, at wellhead pressure 20 ksc, the mass flowrate from both wells is around 150 tons/ hour. From the calculations on the existing pipeline based on Table 1, the pipe from cluster 79 cannot accommodate mass flowrate from this two new wells, so these two wells will need separate pipeline. For this reason, the pipeline diameter of each well needs to be calculated and will be connected to the main pipeline 406.

To calculate the size of pipes that will be used for two new well, we use the following equation:

$$\dot{m} = \rho.v.\mathrm{A}\,, \tag{1}$$

$$D = \sqrt{\frac{4\dot{m}}{\rho.v.\pi}} \tag{2}$$

where *m, ρ, v, A, D,* are mass flow rate, vapour density, velocity, area, pipe diameter.

After calculation, for Well KMJ-90, with a mass flowrate of 68.99 t/h and pressure upstream at 7.6 barg, we use pipe with diameter 16" size. Whereas for well KMJ-91, with a mass flowrate of 87 t/h, and pressure upstream of 7.6 barg, we use pipe with diameter 18" size. It is necessary to calculate the diameter of the two combined pipelines. The calculation results for these combined pipelines diameter is 24" size, see on Table. 2.

Table 2: Pipe diameter calculation.

PARAMETER	KMJ-90	KMJ-91	Mix 90 & 91
Input Data			
Wellhead Pressure (barg)	19,15	21,15	
Steam Flow Rate (ton/h)	68,99	87,00	155,99
Steam Flow Rate (kg/s)	19,16	24,17	43,33
Line Pressure, P_1 (kscg)	7,70	7,70	7,70
Line Pressure, P_1(barg)	7,55	7,55	7,55
ρ, vap @P line (kg/m^3)	4,36	4,36	4,36
Steam Velocity (m/s)	40,00	40,00	40,00
Calculation Data			
Pipe Inner Diameter (mm)	374,19	420,20	562,66
Pipe Selection			
NPS (inch)	16,00	18,00	24,00
Outside Diameter (mm)	406,40	457,00	610,00
Schedule	XS	XS	40,00
Pipe Inner Diameter (mm)	381,00	431,60	575,04

For optimization, interconnected will be made through the two combined pipelines into existing pipeline of 16” size diameter and to the main pipeline 406 of 32” size diameter. The schematic of the latest pipeline design by using the 32" main pipeline can be seen on Figure. 2

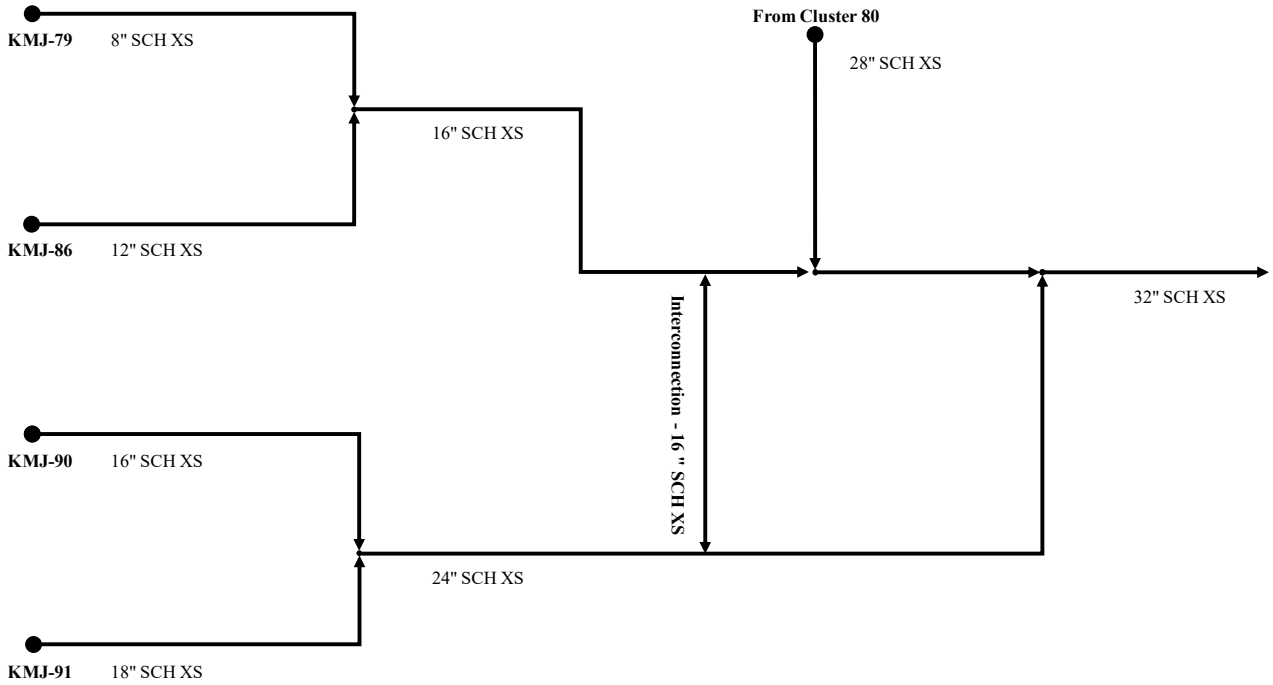


Figure 2**:** Schematic design on pipelines with additional wells of KMJ-90 and KMJ-91**.**

After interconnection, the total available steam capacity for unit 5 power plant is 393 t/h. This amount is surpassing the flow rate permitted for the size 32” pipe (see Table1). On the other hand, the steam capacity that will be transferred to generate electricity of 35MW is only 280 t/h, so it is necessary to adjust the number of wells that will be delivered to the power plant. One important thing that we have to consider is the maximum mass flowrate on pipeline 24" size not more than 173 t/h.

4. CONCLUSION

The interconnection between the existing pipelines and new pipelines at KMJ-90 and 91 wells, provides several advantages in operational activities including:

a. Steam supply for unit 5 power plant has some production reserves
b. The steam distribution is more flexible since it has exceeding capacity of 393 t/h while we need only 280 t/h
c. Downhole and maintenance activities that related to well shut off, can be more effectively, since it can be done without waiting the power plant shut down.

From the results of this interconnection design, the main pipeline can still be utilized optimally while still making it effective for Unit 5 power plant.

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