Coal Transportation Technology with Pipeline System: a Step Towards National Energy Independence

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Abstract—The increasing use of coal as a source of energy instead of petroleum, it will also increase the ability to produce coal, as well as the national energy policy (KEN) in 2009 in which the use of coal in the energy mix in Indonesia in 2025 rose as much as 33%. Plus more of the coal transport that causes the social impact like a jam. Therefore one of the prospects of coal transportation system to be developed is a pipeline system, which is a system of coal transportation by utilizing pipelines for transportation, while the material is transported in the form of liquid or slurry that assisted with the pump. Coal slurry pipeline activities include grinding, mixing ratio of 1: 1 or concentration of crushed coal by 60 % and slurry transport via pipeline. In the end, the coal is separated from the water and ready to be used to fuel power plants. In Indonesia, the pipeline transportation system for transporting coal has never been done, therefore it is necessary for the study and analysis of the possibility of using coal transportation pipeline system.

Keywords—coal; pipe; slurry; transportation.

I. INTRODUCTION

With the increasing use of coal, especially the use of coal as a source of energy instead of petroleum, it will also increase the ability to produce coal, as well as the national energy policy (KEN) in 2009 in which the use of coal in the energy mix in Indonesia in 2025 was increased by 33%, which is where the technology is able to transport as one way to achieve national energy policy for the years 2010-2025.

While the industry with the development of Indonesia, hence the need for the use of coal as an energy plant is very vital at all, so the need for coal will rise. Subsequent impact is required a coal conveyance system with large capacity and relatively low cost, especially for the transport distance away with difficult terrain. Coupled with the social impacts that occur in the coal transportation, such as the presence of congestion and the demo period is happening, both in the way of traffic and transport on rail transportation.

Hence the need for a new technology that is applied in Indonesia, one of the prospects for coal transportation system to be developed is a pipeline system, ie a system of coal transportation by utilizing the pipeline as a means of transportation, while the material is transported in the form of liquid or slurry. In Indonesia, the pipeline transportation system for transporting coal has never been done, therefore it is necessary for the study and analysis of the possibility of using coal transportation pipeline system.

II. LITERATURE REVIEW

A. Transportation of coal

Transportation of coal consists of several stages, ie transport of mine (open or underground) to wash, transport from leaching into loading bin and transportation to consumers. Which will be discussed in this regard is the transportation to the consumer. As for the kinds of transportation, ie rail system, the system truck by using the public highway, and pipeline systems.

Of the three kinds of transportation, which will be developed is good because the pipeline system rail system and truck system has been widely used, has given rise to many problems, both by the general public, as well as for the company itself agencies.

Pipeline transport is the transportation system by using pipes as a means of transportation while the material is a liquid or slurry transports. To be clearer, the historical development of the pipeline are presented below.

Pipeline transportation history took place in the past. The year 5000 BC, China typically uses bamboo to provide water and in 900 BC typically uses natural gas pipeline to the evaporation of salty water. Romans typically uses a pipeline for water supply and disposal limbah. Various sizes and design, plumbing system is not perfect until the 1800s. In 1825, the first commercial pipeline built to deliver natural gas, followed by crude oil pipeline first time in 1862.

In 1863, James L. Huitching build a 2 ½ mile pipeline with a 2-inch diameter pipe from cast-iron and the steam-driven rotary pump. At development, pipes and pumps are inefficient. Pipeline which was first successfully built oreh Samuel Van Syckel. With the cost of $30,000, he built a 5 mile pipeline construction. 32,000 feet of pipe length is divided into 15 sections and have been spliced together. There are three steam pumps with flow oil production of 80 barrels (42 gallons / barrel) per hour. Since the pipeline has become the main mode of transportation for the transportation of oil and gas. Pipeline began transporting a variety of solid material in the 1940s. Because the pipeline industry has historically had a low public profile once the progress has been slow. Growth and development oil almost parallel to the domestic industry.

Two main categories of pipelines, water lines and the good lines. Water lines provide water for culinary, commercial, industrial, recreational, agricultural and others. Good lines are widely used to transport crude oil, oil products.
and natural gas. With the addition of energy demand, limited supply of oil, refinery products are well have a transportation problem. This can be solved with the pipeline.

Another type of goods lines are solids pipelines. With a relatively short pipeline distance, then this type of look does not develop well in the future. Some types of these pipeline systems, namely:

- Slurry pipeline; system that transports fluid, a mixture of water with the material, for example, coal.
- Pneumatic pipeline
- Capsule pipeline

In Table I below, can be seen along with the types of pipeline transport distance ever used.

### TABLE I. TYPES OF PIPELINE

<table>
<thead>
<tr>
<th>Pipeline</th>
<th>Transport Distance (Mil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>265.409</td>
</tr>
<tr>
<td>Crude Oil</td>
<td>103.127</td>
</tr>
<tr>
<td>Petroleum Products</td>
<td>67.764</td>
</tr>
<tr>
<td>Slurry</td>
<td>273</td>
</tr>
<tr>
<td>Chemicals</td>
<td>4.050</td>
</tr>
<tr>
<td>Total</td>
<td>440.623</td>
</tr>
</tbody>
</table>


#### B. Coal transport by pipeline system

Transport coal or coal slurry pipeline system is a pipeline transportation of coal through a pipe in the form of slurry (a mixture of coal with water) and assisted with the pump. Coal slurry pipeline activities include grinding, mixing ratio of 1:1 or for the time being that is widely used is the ratio of the concentration of crushed coal by 60% and slurry transport via pipeline. In the end, the coal is separated from the water and ready to be used to fuel power plants.

Slurry pipeline can be divided into three main components, namely:

- Slurry preparation plant, covering grinding into desired size. Terserbut fine particles mixed with sufficient water in accordance with the comparison.
- Pipeline, requiring pumps.
- Dewatering.

The specific explanations of the three components above are as follows:

1) **Slurry Preparation Plant:** Coal slurry pipeline preceded by carriage after the mining is done and then go to phase slurry preparation plant. Transport from the mine to the washing is done in series with a series of conveyances, the chain conveyor, belt conveyor, trolley electroic, tripper. Transportation from open pit to wash done by stages, namely coal from surface mining to dump transported by dump trucks. Of used dump wheel loaders and bulldozers to put the coal into a hopper, which is then transported to the place leaching by conveyor belt.

Leached coal haulage transported to the bunker that housed shaft using conveyor belt. Coal loading bins before being transported to the next stage prior to grinding is done, the coarse coal with a size of more than 5 mm and fine coal between 5 to 0.5 mm.

After the washing step, the next step is mixing. This means that the ratio in balance and form a homogeneous mixture. Results than mixing it called slurry which is then deposited into the bunker and ready to be pumped into the pipeline.

Usually water use in coal slurry approaching 250 gallons of water per ton of coal. The water used is certainly safe for the environment. If possible can use underground water but can cause environmental problems when lowering local groundwater. For example, coal slurry-Arkansas pipeline in Wyoming, no more use of 15,000 acre-feet of water/year. Water is pumped from wells geological formation called the Madison formation.

2) **Pipeline:** Made homogeneous slurry and flow through right with constant speed or normal operation is called. This flow rate should be optimal because if the flow is faster or slower then the operating efficiency will decrease. Press slurry pump through the pipeline. Pump for large diameter pipes pumped with great force, which serves to add pressure pipe flow. Pumping stations placed along the pipeline route (generally at every 30-100 miles) depending on their respective areas. Plumbing maintenance is important for safety and environmental sustainability.

Continuous downhill slope is a good area because it can facilitate the drainage of slurry. Buried pipeline can be shaped almost parallel with the ground. If the surface is a flat plane then the pipeline flow can be tilted pipes or pumped. When the pipeline reaches a maximum depth below the ground surface in the slurry is pumped to the highest elevation level is useful to drain slurry, for example, an area with distant sinusoidal topography and undulating. The use of the pipeline can solve the excessive pressure pipe. With modern methods can be determined maximum pressure range, ie 900-2100 psi (63.28 to 147.65 kg/cm2) and the highest pressure may be useful in the future.

3) **Dewatering:** Dewatering is the final stage in the pipeline transportation of coal. Dewatering equipment placed near a coal processing unit. Three contained in the dewatering process, ie thickening, filtration, and drying.

Thickening is the removal of most of the liquid from the slurry or suspension, which resulted in entrainment of solid part with the principle of sedimentation. Once this process has continued to the filtration of water containing a small amount. Then, done drying, the release of water from the coal by using heat (thermal drying).

#### C. The formula calculating the critical speed, \( V_c \)

Important consideration in determining the particle size is the flow velocity. The resulting flow, pipe diameter, is the main thing that must be considered. Speed is an important aspect in the slurry flow. Critical speed is the minimum speed necessary to maintain the slurry flow without any clumping. Critical speed is defined as follows:
\[ V_c = 3.48 \frac{g}{d^{0.5}} \left( \sqrt{g} + g \frac{C}{d} \right)^{0.5} \]  

Where:  
\( V_c \) = critical velocity (ft/sec)  
\( g \) = gravitational constant (ft/sec\(^2\))  
\( d \) = diameter of pipe (ft)  
\( G_s \) = specific gravity  
\( C \) = concentration  
\( C_d \) = coefficient of drag (resistance)

III. DISCUSSION

A. Coal Slurry Pipeline

If seen from its use, coal slurry pipeline in the region in accordance with difficult terrain (mountainous areas) and the relative distance to distant consumers. Compared with other transport systems (rail system or truck), there are several advantages pipeline system. Coal slurry pipeline will run well if it does not clot in the slurry pipeline if appropriate because it will clog the flow. This can happen because the average flow is not optimal. Then the continuity of the flow needs to be maintained at a constant flow rate (critical speed).

Railroad system capacity is limited, especially on-line railroads are a bit wonky and if the rail line is toothed. Similarly with truck transportation system, in addition to high operating costs as well as traffic management through public roads and loading problems can make queue.

In the previous chapter, there is a calculation of the critical speed of the formula1. Here is the calculation of the critical speed in the area with the pipeline transportation system:

Coal slurry pipeline had been used in Ohio and Black Mesa east Arizona. In Ohio, coal slurry pipeline was built in 1957 with a length of 108 miles and a 10-in diameter pipe. Coal slurry pipeline that transports coal from Coal Company Hamma to Cleveland Electric Company power plant in Eastlake, Ohio.

At Black Mesa coal slurry pipeline built by the Southern Pacific Railroad in 1970. With a length of 273 miles and use a pipe diameter of 18 ins.

Transportation coal slurry pipeline from the open pit in northern Arizona to Nevada power plant that has four pumping stations with Horse Power 1750 and 7600 pounds of pressure per square inch.

The count are as follows:

Given:  
\( g = 9.8 \text{ m/dt}^2 = 32.67 \text{ ft/sec}^2 \)  
\( d = 10 \text{ in. dan 18 in.} \)  
\( G_s = 1.4 \)  
\( C = 60 \% = 0.6 \)  
\( C_d = 1.5 \)

Asked: \( V_c \) at 10 in. and 18 in = ?

So: For \( d = 10 \text{ in.} = 0.8467 \text{ ft} \)

\[ V_c = 3.48 \left( 0.6^2 \right)^{0.5} \left[ \frac{32.67 \text{ ft/sec}^2 \cdot 0.8467 \text{ ft} \cdot (1.4 - 1)}{\sqrt{1.5}} \right]^{0.5} \]

\[ = 2.94 \left[ \frac{11.7 \text{ ft/sec}^2}{1.22} \right]^{0.5} \]

\[ \approx 8.95 \text{ ft/sec} \]
\[ = 6.1 \text{ mil/hour} \]
\[ = 9,816974 \text{ km/hour} \]
\[ = 2,7269 \text{ m/s} \]

For \( d = 18 \text{ in.} = 1.524 \text{ ft} \)

\[ V_c = 3.48 \left( 0.6^2 \right)^{0.5} \left[ \frac{32.67 \text{ ft/sec}^2 \cdot 1.524 \text{ ft} \cdot (1.4 - 1)}{\sqrt{1.5}} \right]^{0.5} \]

\[ = 2.94 \left[ \frac{19.9 \text{ ft/sec}^2}{1.22} \right]^{0.5} \]

\[ = 11.88 \text{ ft/sec} \]
\[ = 8.1 \text{ mil/hour} \]
\[ = 13,035654 \text{ km/hour} \]
\[ = 3,621015 \text{ m/s} \]

For the drag coefficient \( (C_d) \) can be seen in fig. 2 below:

![Fig. 2. Relationship Between Coefficient of Drag and Particle Diameter](image)

Seen from the graph above can be explained that the diameter of the particles affects the coefficient of drag. The smaller the diameter of the particles will tend to agglomerate. From the graph above is a good diameter from 0.01 to 0.05 in. with a coefficient of drag \( (C_d) = 1.5 \).

As for the specific gravity obtained from the following table II.

<table>
<thead>
<tr>
<th>MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPECIFIC GRAVITY</td>
</tr>
<tr>
<td>PARTICLE SIZE</td>
</tr>
<tr>
<td>Perspex</td>
</tr>
<tr>
<td>Coal</td>
</tr>
<tr>
<td>Sand</td>
</tr>
<tr>
<td>Gravel</td>
</tr>
<tr>
<td>Manganese Dioxide</td>
</tr>
</tbody>
</table>

B. Prospects for coal transportation by pipeline systems in Indonesia

So from the above calculation showed that the transport of coal by pipeline system is a technology that very prospect, especially in Indonesia to meet the need for a national energy according to the blueprint contained in 2009 about a national energy management set out in the national energy policy (KEN). In the discussion of the need for the government to allocate coal by 33% in 2025 at achievement of approximately 15% before the energy of the coal used at this time.

Fig. 4. Target National Energy Mix 2025

Based on the 2025 national targets on energy mix that has been set by the government in national policy (KEN) about national energy management, it can create a self-sufficiency in energy to supply the energy required.

Moreover, in terms of State-owned mining company revenue decline in the mining business. This is due to transportation is not in accordance with the market demand rises, as it did in PT. Bukit Asam Tbk is a state-owned coal mining company whose experienced a decline in income, but the volume and demand rising, because of inadequate transportation. Coupled with the existence of the government will ban the use of coal transportation using trucks that do a lot in the demonstration by the students, because it can affect social problems such as traffic jams and so on. Various pros and cons of going inside, because that's one way to solve problems and answer questions from the community and national governments in addressing the most vital issues in the energy sector is to diberlakukannya and implementation of a technology that can address national issues, such as the transport technology coal using a pipeline system.

Therefore, it is said the prospect of transport innovations to be applied in Indonesia by looking at the above factors, so as to realize an energy independent Indonesia 2025.

IV. CONCLUSION

A. Conclusion

The conclusion that can be drawn are as follows:

- Pipeline system is the transportation system by using pipes as a means of transport, while the material in the form of liquid or slurry.
- Coal slurry pipelines can be economical and efficient when it comes to transport coal to the difficult terrain and relatively long-distance
- With the increase in coal production will have difficulty in transporting problems with coal unit-train and dump truck. Thus enables the development transportation with pipeline systems.
- The main components in the coal slurry pipeline is the slurry preparation plant, pipeline and dewatering.
- By looking at the conditions and factors exist then the prospects for this technology in Indonesia so as to overcome the national social problems, such as the presence of congestion.
- This technology is capable of providing the energy mix of contributions to the achievement of the 2025 national energy policy (KEN) in 2009.

B. Recommendation

The recommendation that can be delivered in this paper are as follows:

- In the event of agglomeration slurry in the pipe, can be overcome by setting the strength or power pumps that will be used. In this case the controller needs experts in the transport process in the pipeline system is used.
- We recommend that further research needs to be done for this application, both in terms of technical, economic and environmental.

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REFERENCES