Dense Medium Cyclone Technology to Improve Quality of Coal

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Abstract **- Chimney emissions of coal-fired plants have a negative impact on the environment, as well as causing disruption to the ecosystem and human health because of the spread of SO2 (sulpur dioxide), ash, Nox (nitrogen oxide) and CO2 (carbon dioxide). Using technology, dense medium cyclone, ash from coal lignite and sulpur reduced from 18.82% to 11.70% and 0.91% to 0.88%**

Keywords **- Decrease ash and sulphur coal**

1. INTRODUCTION

Coal has been the backbone of the electric utility industry since its advent in the late 1800s. Through the first few decades of the 20th century, coal was used almost exclusively to power utility generators across the U.S. and the world. Although many alternative energy sources have been made commercially viable in the past century, including hydro, natural gas, oil, and nuclear energy, coal-fired power plants continue to account for approximately 52% of the electricity generated in the U.S. in recent years.

Coal-fired plant pollution is due to the release into the atmosphere of the hot flue gasses produced from the combustion of coal. Dust from power plants has been linked to cancers, while SO2 and NOx have both been identified as acid rain precursors. NOx has also been associated with the production of photochemical smog. Various pollutant control systems have been developed over the past several decades and are continually evolving. However, even with these systems in place, coal-fired plants still produce significant levels of emissions, and certainly carry this stigma with them.

Approximately 60% of Indonesian coal is lignite coal, ie coal with ash content and high water and carbon content and low calorific value.

Lignite coal reserves in Sumatra is as much as 21.3 billion tons. This low-quality coal has an average water content greater than 35% and calorific value between 3400-5000 kcal / kg.

TABLE I
COAL RESERVES IN SUMATRA AND KALIMANTAN
(In Million Tonnes)

Coal type	Sumatera	Kalimantan	Total	%
Antrasit	132	-	132	0,4
Bituminus	651	4561	5212	14,4
Subbituminus	2584	6940	9524	26,3
Lignit	21309	4	21313	58,9
Total :	24676	11505	36181	100

Source : [5]

The main parameters determining types of coal for electricity generation is higher calorific value than that of ash content and low sulpurnya.

As with burning oil, coal pollutes, especially air pollution. *Chimney emissions* of coal fired power plant that could disrupt ecosystems and human health, among others, SO2 (sulpur dioxide), ash, NOx and CO2 (carbon dioxide). SO2 and NOx gases are the cause of acid rain, eye irritation and cancer, while CO2 is a contributor to greenhouse gases that cause global warming. Besides coal fired power plant flue ash very much also can be a source of pollution.

The use of coal as an alternative energy source is an option which has a fairly high priority because of the amount of coal reserves which can still be relied upon for long periods of relatively longer (> 200 years), especially low-quality coal reserves (type lignite) that the amount of 70% of total reserves overall. Lignite has a flash point between 400.°C to 500°C. Today's coal conversion technology still has shortcomings in terms of combustion efficiency (only 70% - 80%), the formation of side products such as fly ash disturbing enough (fly ash) and toxic gases (NO_x and SO_x).

For low-quality coal to reduce pollution need to be implemented value-added technologies such as coal washing technology (dense medium cyclone).

Coal washing, can be defined as a transfer of substance / mineral materials from coal minable to obtain or produce clean coal, and its primary purpose is to improve the quality and calorific value (Btu / lb) of coal to reduce sulfur content and ash content (ash), half or two thirds of which occurred in the coal sulfur can be removed with a solution and separation through a mechanical process. All substances or materials contained in coal can be cleaned physically.

Expected to produce better quality coal after washing process beforehand, and would also produce good quality fuel and reduce pollution impacts occur.

On the whole purpose of physical coal cleaning is to produce a salable coal products consistently, specifically will improve production quality and the relatively comparable to the cost and results that have been issued by the mining company.

Coal washing, will eliminate minerals from coal in order to obtain clean coal with high quality and calorific value increases. Minerals contained in coal is physically cleaned by washing or mechanically such as by technology Baum Jig Plant.

Owned coal quality, which is usually also the parameters of the sale price of coal, among others:

- Content of ash (ash);
- The water content (moisture);
- The materials evaporate (volatile matter);
- Specific Energy;
- Composition of the ash (ash Composition);
- Melted ash content (ash fusibility);
- Concentration precipitated ash (ash precipitability);
- Grindability (HGI).

Minerals and water content can be controlled directly on the coal washing process. Therefore, most of the coal supply contracts are determined by a maximum price of ash, usually in dry air conditions, and the total water content.

Before there was machinery for the mine construction, the separation of coal from the rocks by hand. Furthermore, the use of machinery and workmanship with high process has replaced the coal seam separation from other materials manually (by hand) and has been pushing for the development of more economical coal washing and raising the quality of coal, the better.

Method of coal washing is first operated with jigs method which can also be applied to minerals other than coal. Particle separation in jigs (non-coal material) is material that has a lower density of the gravitational pressure will make the particles are carried away through a whirlpool. While the results (material coal) is consistent with the value of density will float. (See Figure 1)

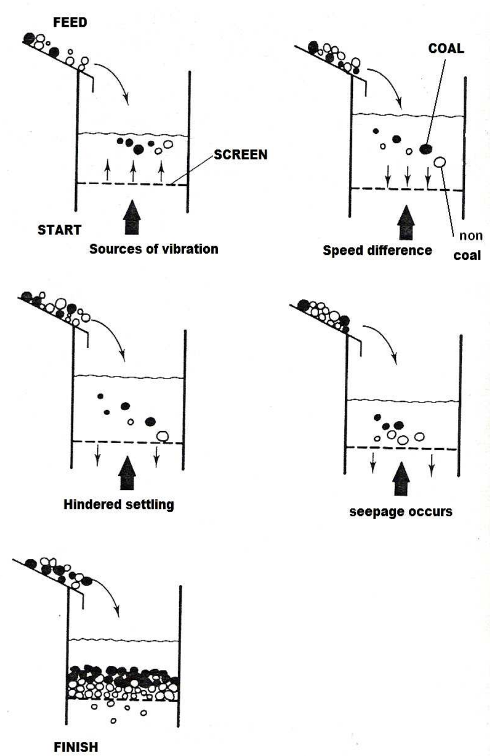


Figure 1. Principles of coal washing – jigs

Very different, the separation of coal by using a medium-separator (dense medium), no clear separation between coal products with non-coal particles in a jig. This causes not possible in an efficient separation for particles that have a high proportion of coal deposits near density separator medium and small coal particle sizes.

II. DENSE MEDIUM CYCLONE (DMC)

Raw coal that is mined contains a number of impurities and is typically processed to improve its overall quality. The mineral processing of this run-of-mine (ROM) coal involves a complicated and sophisticated operation including comminution, classification and separation. These separation processes normally make use of particle classification on the basis of density .

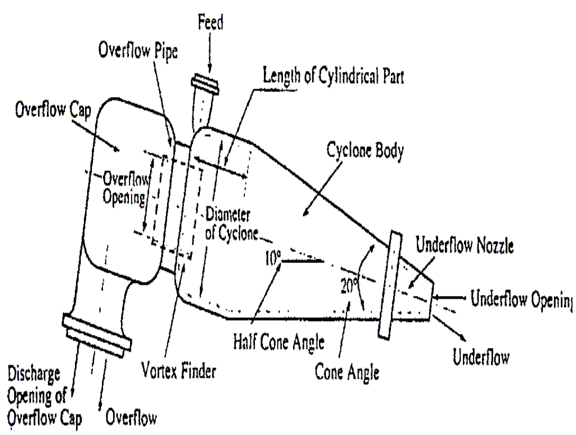
Coal, typically being lighter, is separated from the heavier gangue by utilising the difference in specific gravity. These processes can make use of mediums that are made to have specific relative densities to ensure the separation of coal from gangue.

Coal beneficiation primarily makes use of gravity separation in coal washing . It is explained that dense medium separation (DMS), specifically the dense medium cyclone (DMC), is the main processing unit used for cleaning coal, beneficiating nearly 55% of coal that is washed worldwide The United States makes use of the DMS process for 65% of its washed coal. It can be determined from the data collected that 98% of the 53 coal-preparation plants in South Africa are making use of the DMC as their beneficiating unit.

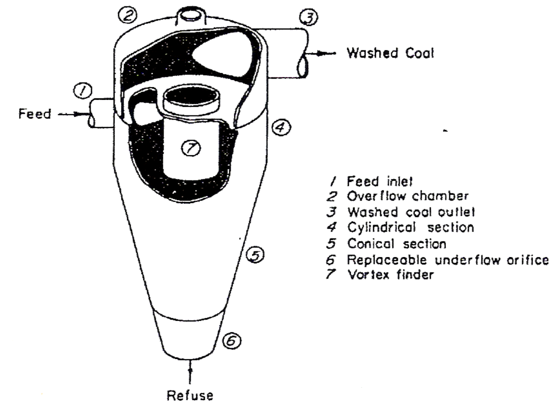
A cyclone which consists of a cone stuck with the cylinder at its end (See Figure 2.a.) and the supply hole in the cylinder. Material supply flow is divided into two vortex flow, ie, faster flow (overflow) and low flow (underflow). Fast flow collected in a pipe located in the middle of a search tool called the cyclone vortex (vortex finder) which flows through the wide end of the vortex. Slow the flow of exhaled through the door (underflow opening) at the narrow end of conical section. Blowpipes point is known as the mouth (orifice) or a low flow pipe (nozzle).

Raw coal (raw coal) with a suitable size range, pumped or supplied from the head tank (feed) into the cyclone inlet as a suspension in the flow of solid-containing magnetite. Clean coal is transported into the vortex and released in the flow faster. Materials rejected (non-coal) flows through the body towards the vortex of stoppers and out through the low flow.

Orifice diameter has a size smaller than the diameter of vortex finder, intended to suppress some of the coal out through the vortex finder where most of the coal to flow normally.



(a)



(b)

Figure 2. Coal washing appliance – cyclone[1]

A lump of coal in the round (with the assumption that these objects exist), with mass *m* and volume *v* If the mass of the lump of coal is less than the mass of liquid with the same volume, then the object will not be submerged in the liquid (Fig. 3.)

Lump of coal in power is mg, where *g* is the increase in speed / acceleration caused by gravity which is also represented by *gdv*, where d is the density (density) of coal. This is because $m = dv$, v the volume of fluid was removed and has mass will be equal to the volume of coal chunks of *v*.

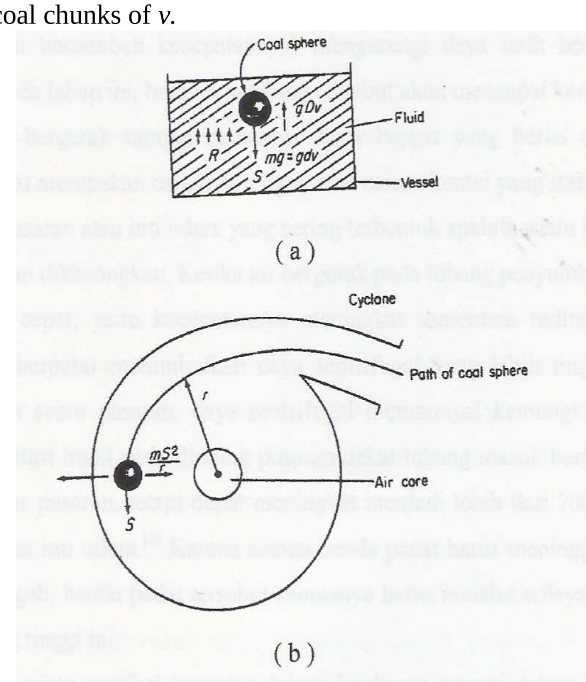


Figure 3. Resources that affect the deposition of the coal vein.

If the coal has been sunk, but the fluid is generating upward thrust, which is called buoyancy. Therefore, the sphere will not be drowned if *gdv* = *gDv*, and thus velocity will be zero. Because of the difference between *gdv* and *gDv* widened, round object will settle at a rate of speed that was increasingly growing. So that the speed *s* is proportional to this difference, namely:

$$s \propto gdv - gDv \qquad (1)$$

In actual circumstances, coal fragments were not round, not even a smooth and lump coal would meet with resistance from the effects of buoyancy.

In an effort to further moves down, the coal has faced resistance *R* which should also be deducted from downward traction to deliver the fastest

$$s \propto gdv - gDv - R. \qquad (2)$$

Rounded coal will continue to accelerate until the increase in *R* (which occurs when the spheres are bertembah speed) reduces the attractiveness of the net down to zero. At this stage, the sphere of coal will reach speeds in which the object is moving up to reach the bottom of the vessel containing the liquid (assuming the liquid is a homogeneous liquid or viscous liquids are stable).

A whirlpool or air core which is often formed when a pool or tub washer emptied hand. When water moves into the opening in the stopper, the water is spinning faster, the speed increases while the radius decreases. Rotating speed of the water causes a higher centrifugal force at the center of the vortex. In a vortex, centrifugal forces have probably twenty times earth's gravitational force on the vortex wall near the pit entrance at the top of the cylinder-shaped vortex, but could increase to more than 700 times Earth's gravity near the central air core. Because all solid objects must leave the vortex near the central axis, solid objects are all must pass through areas with high centrifugal forces.

If a particle rotates in a circle like a whirlpool, then the acceleration centrifugal are:

$$g = \frac{S^2}{r} \qquad (3)$$

Where: S = particle velocity around the circle, r = radius of the circle.

Equation (3) This explains why when choosing the direction of particle vortex center, the velocity becomes larger, because *r* is continuously growing small and *S* increase.

The principle of floating and sinking, ie the relative values of *d* and *D* are not affected, but because of the centrifugal acceleration is much larger than Earth's gravity, the speed at which everything happens, whether floating or submerged, much faster.

Thus, the vortex is comparatively a small piece of equipment, has a high flow capacity because the power of a much bigger push, making everything take place much faster than if done in a pond with a solid flow.

So, from Figure (5b.), if *s* is negative, is floating lumps of coal. And the power which regulates the speed of the sphere settles *s* coal in a vortex becomes:

$$s \propto \frac{S^2}{r}vd - \frac{S^2}{r}vD - R \qquad (4)$$

Organic liquids such as water and the solution is rarely used in separating solid medium and therefore the properties of viscous liquid of fine particles of solids which are of great importance in using the process commercially.

Relative density (density) of solid medium is the most important thing that can be used. Particle size of solids that will determine the stability of viscous fluid is to be used as a means of separation.

Thus, $\propto$ *gc (d-D)-R* if the speed settles, where g acceleration due to gravity, *v* is the volume of medium particles, *d* is the relative density of the particle medium, *D* is the relative density of liquids containing solid medium, ie water = 1 and *R* is the resistance factor, the association showed that the rate of sediment can be reduced and thus stability can be improved by having:

(a). small particles, namely low-v;
(b). solid medium with relatively low density, ie d; or
(c). high resistance to the motion of fluid particles, i.e. R is high.

This situation is realized in practice because: facilities digerinda solids to a size which is usually very smooth, thick liquid that contains megnetit usually stabilized by maintaining the ratio of clay mud; all this mud while reducing *v*, also adds to the density of infrastructure, thereby increasing *R*. However, if the resistance is too heavy as a result of piling mud, the facilities will be against the movement of coal and broken rock and ketidakefisiennan will arise in the separation. This should be corrected with a 'clean' means that by removing excess clay from the coal washing machine.

Most of the coal washing process industry standard in the world using a thick porridge made from fine solid magnetite. Fine magnetite suspended in water is used to clean coal by creating an average specific gravity (heavy medium) between that of coal and its associated impurities so that a separation is effected. The magnetite must be reclaimed and cleaned to prevent the build-up of impurities in the cleaning circuit. Advances in the cleaning of finer coal sizes require.

Dense Medium Cyclones (DMCs) are key processing units in many coal preparation plants for density separation of energy or coking coal from rock . A slurry of crushed coal containing unwanted rock is mixed with a dense medium and continuously fed into a DMC unit, which is basically a cylindrical steel (or ceramic-lined) chamber with a central feed, tapered at one of the two discharge ends.

Magnetite, a natural mineral foundation for the cleaning of coal, while the silicon-iron or a mixture of magnetite and silicon iron ore mines for the separation of large density. Magnetite is usually used to have 1:35 g/cm3 density, the density is below the stability will disappear quickly, thereon up to about 1.80 g/cm3, viscosity will be a problem. Magnetite has a cubic crystal structure, into the family of spinel with the formula Fe^{2+} $Fe_2^{3+}O_4$. Its chemical structure is based on the cubic lattice of oxygen in a tightly packed. Fe^{2+} and Fe^{3+} is greater than that of oxygen ions Fe^{2+} and Fe^{3+} is suitable for the hole (or locus) on the lattice oxygen. General specifications magnetite world is as follows:

- Relative density: 4.9 to 5.2 g/cm3;
- 95% by weight.≥- Magnetic material content:
- Chemical analysis in particular:

Fe	:	68,00 % min
P	:	0,09 % maks
S	:	0,05 % maks
SiO_2	:	2,50 % maks
Al_2O_3	:	0,60 % maks
Cu	:	0,03 % maks
Ti	:	0,23 % maks
Na + K	:	0,13 % maks
H_2O	:	10,00 % maks
Other	:	0,15 % maks

Excess flow of coal washing technology navel thick magnetite slurry compared with coal washing technology Baum jig plant, lies in its ability to wash coal of various sizes with good results, because this technology uses a thick porridge magnetite separation media that the density can be adjusted with the density of coal.

Figure 4. Magnetite

III. RESEARCH METHOD

In the coal washing process, there are three stages of the process that must be experienced by the coal. As for the third stage of the process are:

i) *The process of equating the size (sizing);*
coal mining will have the results from the size and shape varied, there is a chunk of large, medium, small size of sand or coal (coal fines). In this process coal is expected to be ready to be washed will have the 50mm - 100mm) so will be able to be supplied into≤same maximum size (the washing machine coal)

ii) *The process of leaching (washing);*
in this process will occur the separation between the material instead of coal (coal reject) with the materials of coal (clean coal).

iii) *Drying process (drying);*
coal out of the washing process will go into the dryer and ready for use.

Of the three stages of the coal washing process, washing process is the most important processes and determine the quality of clean coal produced.

The DMC's function is to separate the coarse reject material from the coarse coal (product). This is achieved by pumping the coarse material at a high velocity into the cyclone with a mix of water and magnetite, which creates a dense medium slurry. Once the coal and dense medium slurry are pumped into the cyclone together, the material is exposed to centrifugal forces within the cyclone, combined with the specific gravity of the dense medium slurry, the heavier material (reject) is discharged out the bottom (it sinks) of the DMC and the lighter material (coal product) is discharged out the top (it floats).

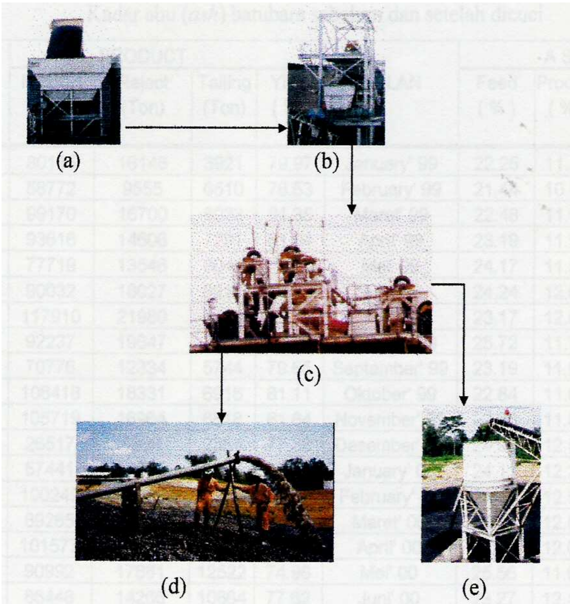


Figure 5. Coal washing process; (a), (b) the process of sizing, (c) the process of washing), (d) reject coal, (e) clean coal)

Figure 3. The author in front of the coal washing machine

IV. RESULTS AND DISCUSSION

Factors that may affect the quality of coal washing when transported from the mines to the user are:

- Means of transportation between the mines and coal wasting plant;
- Treatment of coal, such as splitting and separation of coal and non-coal;
- Landfill, the uniform washing and mixing at the plant;
- The washing process;

TABLE 1
Percentages of Ash Content, Water Sulpur Lignite and Lignite Coal Washing

MONTH	**COAL**							
	Coal Lignite (ton)	**Coal Lignite washing** (ton)	**Ash content**		**Concentration sulpur**		**Water content**	
			Lignite (%)	**Lignite washing** (%)	**Lignite** (%)	**Lignite washing** (%)	**Lignite** (%)	**Lignite washing** (%)
Sept'00	110530	90599	21,19	11,96	1,29	1,15	28,13	28,27
Okt'00	96345	70076	23,10	12,05	1,16	0,98	27,74	27,85
Nop'00	95115	68898	26,53	11,89	1,07	0,83	28,95	29,01
Des'01	34269	26517	24,98	11,87	1,17	0,87	28,1	28,13
Januari' 01	100184	80115	23,88	11,26	1,21	0,82	28,2	28,26
Peb'01	74837	58772	23,37	10,86	1,09	0,79	28,65	28,71
Maret' 01	121903	99170	23,47	11,88	1,04	0,80	28,45	28,53
April' 01	115513	93616	24,01	11,57	1,23	0,88	28,29	28,39
Mei' 01	99314	77719	24,37	11,84	1,20	0,81	28,2	28,27
Juni' 01	114276	90032	24,86	11,78	1,12	0,84	27,74	27,85
Averages	**96228,60**	**75551,40**	**23,98**	**11,70**	**1,16**	**0,88**	**28,25**	**28,33**

Source: Prepared according to Table Production Report of PT BHPMI [2]

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- Stockpiling, homogenization and mixing with the coal after washing from elsewhere in the terminal end of the coal;
- Transportation of coal after being washed from the factory to the user laundering.

As is known coal with higher calorific value and lower pollution can obtained by first washing process. In writing this kind of washed coal is Lignite and derived from the village of Asam Asam Kalimantan Timur. And in Table I, can be seen ash content, coal and water sulpur lignite and lignite coal washing. From table 1, can be seen that the lignite coal with an average weight of 75551.40 tons having distributed the average ash content of (75551.40 / 96228.6) x 23.98% = 18.82%. or weighing 14218.8 tons.

Lignite coal ash washing average amounted to 11.70% or 8839.51 weighing tons, so there is a reduction in ash content of coal: (18.82 to 11.70)% = 7.12%, or weight reduction: (14 218 , 8 to 8839.51) ton = 5379.29 tons. Lignite coal with an average weight of 75551.40 tons will have content. Distributed sulpur mean equal (75551.40 / 96228.6) x 1.16% = 0.91% or weighing 687.52 tons. Sulpur grade lignite coal washing an average of 0.88% or weighing 664.85 tons, so there is a reduction in levels of coal sulpur: (from 0.91 to 0.88)% = 0.03% or a reduction in weight: (687, 52-664.85) ton = 22.67 tons. Lignite coal with an average weight of 75551.40 tons will have a mean equal distribution of water content (75551.40 / 96228.6) x 28.25% = 22.18% and moisture content of lignite coal washing an average of 28.33 %

V. CONCLUSION

A **coal preparation plant** (CPP) is a facility that washes coal of soil and rock, preparing it for transport to market. The main parameters of coal as a fuel fired power plant is the amount of ash and sulpur.

Coal washing technologies using cyclone and magnetite media used to produce salable coal products consistently, specifically to improve the quality of production and the relatively comparable to the cost and results that have been issued by the mining company.

Dense Medium Cyclones (DMCs) are key processing units in many coal preparation plants for density separation of energy or coking coal from rock. A slurry of crushed coal containing unwanted rock is mixed with a dense medium and continuously fed into a DMC unit, which is basically a cylindrical steel (or ceramic-lined) chamber with a central feed, tapered at one of the two discharge ends.

The washability characteristics of a coal reserve are provided by obtaining liberation data on the raw coal. Liberation refers to the amount of physical breakage required to separate material of different material densities. Low density material is clean coal whereas high density material is reject (rock).

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