Improved Design Skirt Board and Analysis to Reduce Build Up Dust: Case Study at Rembang Power Plant

Andi Desi Sunarno
Manitenance Department
PT Pembangkitan Jawa Bali
Surabaya, Indonesia
andidesi.sunarno@gmail.com
andidsunarno@students.undip.ac.id

Gunawan Dwi Haryadi
Department of Mechanical Engineering
Diponegoro Univeristy
Semarang, Indonesia
gunawandwiharyadi@lecturer.undip.ac.id

Khoiri Rozi
Department of Mechanical Engineering
Diponegoro Univeristy
Semarang, Indonesia
khoirirozi@lecturer.undip.ac.id

Ferdiand Rosi Saprudin
Manitenance Department
PT Pembangkitan Jawa Bali Services
Sidoarjo, Indonesia
ferdiandrs@gmail.com

***Abstract*—The problem related to coal transportation is the dust generated that flies in the environment which has the potential to endanger the health of employees and also the surrounding equipment. Transfer chute becomes a focusing area whereas coal collides on the chute wall and next conveyor which causes dust to form. Performing a simulation, using tool CFD Analysis, of coal flow analysis and air velocity flow on the skirt board so that an analysis of the formation of coal dust can be calculated, both of existing design and modified design. Improvement design by change the geometry in the length and height of the skirt board, then simulated CFD using parameter's simulation according to the existing design. The results of the simulation analysis show that the material flow velocity in the existing design is 9.75 m/s, the dust formed is calculated at 39.81 tons/hour. While the simulation on the new design obtained a material flow velocity of 5.88 m/s, dust formed 11.24 tons/hour. Dust reduction of the existing skirt board design compared to the new design by 72%.**

Keywords—dust generated, skirt board, CFD simulation, dust reduction

I. INTRODUCTION

Transfer chute as explained by Swinderman, R. Tod, et al [1], is part of the coal transportation system that functions to connect one conveyor to another. Coal collisions on the transfer chute walls and the conveyor subsequently become one of the causes of dust formation. Part of the transfer chute mounted on the conveyor structure is the skirt board. Installed after loading chute which aims to form the profile of the coal pile and stabilize the coal pile to be able to match the belt speed. Another function is, to reduce spills and coal dust out of the conveyor system.

The process of transferring coal from barges to stockpiles and coal bunkers at Rembang Power Plant through belt conveyor equipment, often forms dust, especially in the transfer point area. The air moving along with the falling material from the transfer chute and the sliding of the material on the conveyor is slowed and controlled in this skirt board space. The flying particles gather together and fall back onto the conveyor. The size of the skirt board that is not suitable causes material to spill from the conveyor, dust flies out of the conveyor, so the size of the skirt board is something that must be considered to control dust at the transfer point.

Based on Fig.1, the path system transport of coal, there are 7 Junction Towers (JT) and 1 Coal Crusher, which can be potentially the formation of coal dust. Location transfer chute on JT 1 – JT 6 are in an open area compared with the transfer chute in the area of crusher and JT 7. The condition of the structure JT 7, which merges with the structure of the boiler and the fully covered wall, makes the condition of the room so stuffy when there is coal dust, and this condition is hazardous for the health and safety at work.

The current skirtboard geometry, skirt board height and width are in accordance with the Conveyor Equipment Manufacturers Association (CEMA) reference. The explanation of the geometric design only considers the dimensions of the conveyor belt, but the author has not found a relationship between the standard dimensions of the skirt board and the characteristics of coal.

In the previous study, based on journal references related to dust control, research conducted by A. Katterfeld, et al [2] concluded that analyzing material flow and airflow in the transfer chute was carried out by simulation and empirical methods to calculate the resulting dust emissions. Bo Zhang's research [3] stated that most of the dust control research focused on the hopper area, mechanical ventilation, and water spraying, while research related to skirt board optimization was still small.

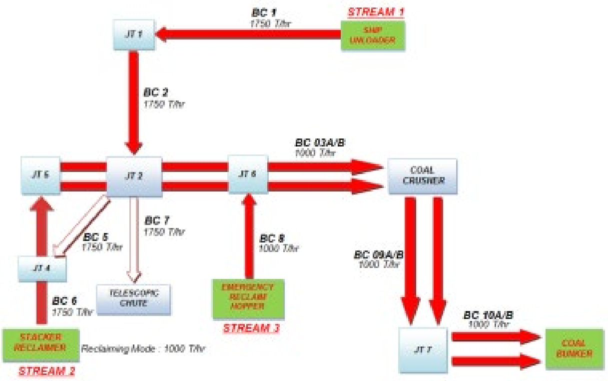

FIGURE 1. Lines System Transport of Coal at Rembang Power Plant

The current conditions of supply of coal Rembang Power Plant are dominated type of coal Low-Rank Coal (LRC). Obtained that the type of coal Low-Rank Coal (LRC) produces dust more than the type of coal Medium Rank Coal (MRC). Condition type coal LRC that has the potential to generate dust is a lot on the design of the skirt board at this time. By the condition, make the author do analyze coal dust build up in transfer chute with existing skirt board design and improve the skirt board design to obtain a reduction in coal dust generated.

In this research, the parameters of the airflow velocity and the material that causes dust to form were reduced, not studied.

II. METHOD

A. Flowchart

The steps in this research can be explained by the flow chart in Fig. 2 as follows.

B. Collecting & Determining Parameter Design

The data on conveyor belt equipment provided by the company [4] used in this study are listed in Table 1. The coal used in this study is low-calorie coal with a calorific value of 4200 kCal/kg. The coal properties that will be used in the modeling are written in Table 2. It is necessary for the actual data to benchmark the modeling and simulation system will be reviewed. Those data will be used in modelling.

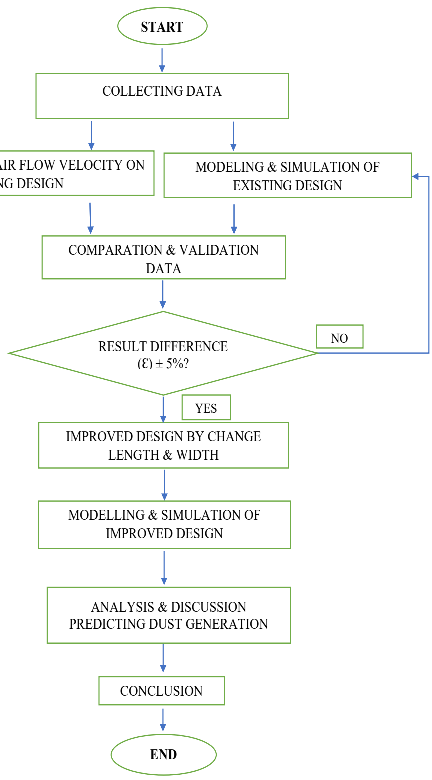

FIGURE 2. Flow Chart Research Method

TABLE 1. Specification of Belt Conveyor (BC)

Item	BC 9	BC 10
Belt Width (mm)	1200	1200
Flow rate (ton/h)	1000	1000
Belt Speed (m/s)	2.7	2.7
Inclination (°)	12.815	10.464

TABLE 2. Coal Characteristic

Coal Characteristic	Existing	Simulation
Material Bulk Density (Ton/m3)	0.8 ~ 0.95	0.862
Coal Size (mm)	> 70 (1.49%) 50 < x < 70 (7.40%) 32 < x < 50 (19.84%) 2.28 < x < 32 (58.06%) < 2.28 (13.22%)	10 - 30
Moisture Content (%)	15 (max)	-
Temperature (°C)	30	30

C. Measurement Air Flow

The air velocity entering the inlet chute BC 9 and exiting through the skirt board BC 10 was measured using 2 portable anemometers. Air velocity measurements were carried out on the inlet side of the transfer chute and the outlet side of the skirt board. The measurement points can be seen in Fig. 3 and the measurement results are shown in Table 3, then the measurement results are used as the initial reference value for air velocity on the inlet and outlet sides. The average value of the measurement results, namely on the outlet side, 2.34 m/s and 2.43 m/s will be used as a comparison value with the simulated airflow velocity.

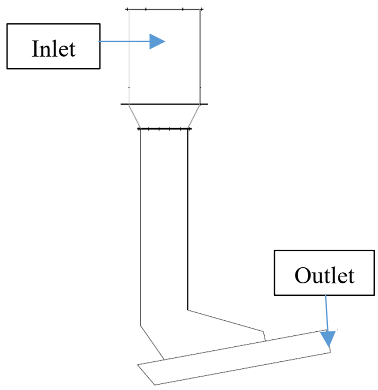

FIGURE 3. Location of the Point Measurements of Wind Speed

TABLE 3. Measurement Air Velocity

Inlet Side (m/s)		Outlet Side (m/s)	
Tool 1	**Tool 2**	**Tool 1**	**Tool 2**
1.0	1.02	2.2	2.33
1.1	1.13	2.3	2.47
0.8	0.95	2.5	2.66
0.9	0.85	2.4	2.45
1.0	1.22	2.3	2.24
Avg: 0.96	Avg: 1.03	Avg: 2.34	Avg: 2.43

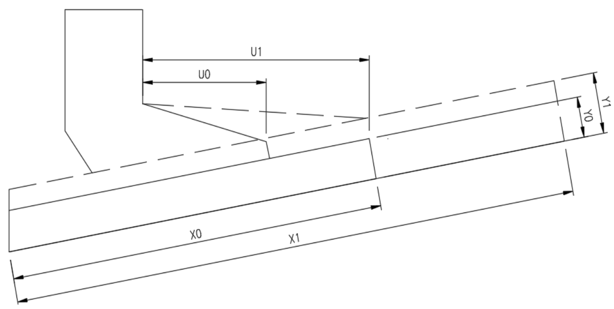

FIGURE 4. Geometry Skirt Board Existing (0) and Improved Design (1)

D. Improved Design

Changes in the skirt board geometry were made by lengthening the skirt board from size X_0 to X_1, raising the skirt board from Y_0 to Y_1, and widening the inner side of the chute from U_0 to U_1 (Fig. 4).

III. Modeling and Simulation

This stage begins with modeling the skirt board BC 9 towards the BC 10 in the form of 3D and determining the air and coal transport limitations used in the simulation. The following research will analyze the effect of the chute's area on the air chute's velocity inside. As the velocity value increases, it signifies that more and more dust is carried. Computational Fluid Dynamic (CFD) analysis is a settlement of the case of fluid mechanics using numerical methods and algorithms computer-aided high speed to simulate the interaction of liquids or air against the surface or a design with the parameters that have been specified on the boundary conditions [7]. The air is assumed to be incompressible and at a constant density, while the particle (in this case is coal) are assumed to be spherical and have a uniform density (by previous data in Table 2).

In this case, the output displayed is velocity air and coal on the conveyor. There are two skirt board models to be analyzed, the existing and improved design, by changing the geometry of the chute skirt board in length and height. Modeling and simulation skirt board existing conditions and improvement design using CFD are shown in Fig. 5 and Fig. 6, and then the results of the particle velocity simulation of existing conditions and improvement design are shown in Fig. 7 and Fig. 8.

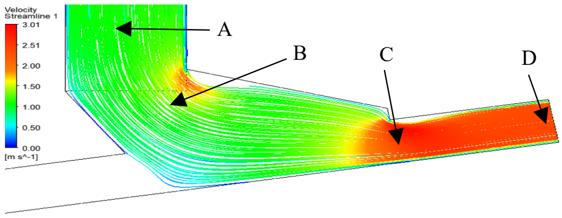

FIGURE 5. Simulation Air Velocity Skirt Board Existing

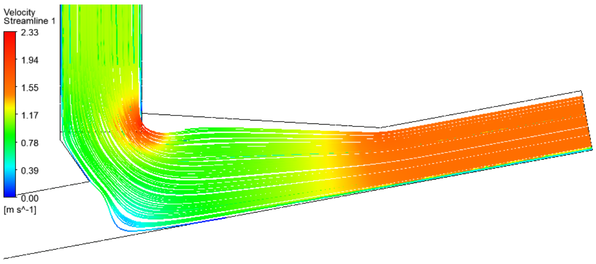

FIGURE 6. Simulation Air Velocity Skirt Board Improved Design

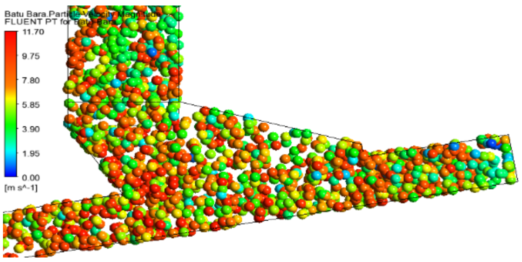

FIGURE 7. Simulation Particle Velocity Skirt Board Existing

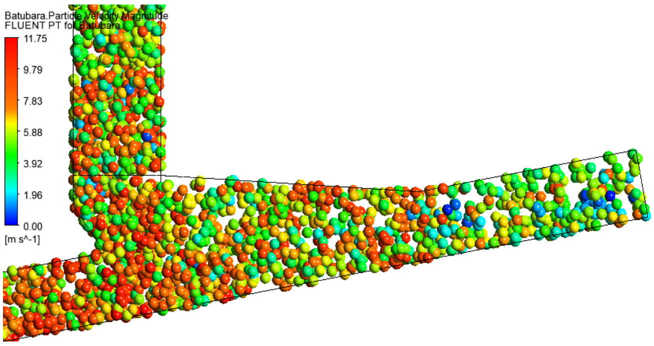

FIGURE 8. Simulation Particle Velocity Skirt Board Improved Design

IV. Result and Discussion

The simulation results obtained the value of the air flow velocity and material flow velocity at the outlet side of the skirt board. It shows that the air velocity contour on the existing skirt board has a higher velocity distribution when compared to the improved design.

Air flow velocity was analyzed in 4 data collection areas (Fig 5), points A, B, C, D. Point A is the entrance to the chute, while point D is the exit from the skirt board. Data were collected on the existing skirt board and improved design skirt board. The values obtained are displayed on Fig.9. Based on the law of conservation of mass in fluid dynamics, and assuming the airflow velocity at the inlet of the chute is constant, the change in the dimensions of the skirtboard becomes wider and longer, changes the area of the skirt board through, so that the airflow velocity will decrease.

The air velocity value at the outlet side of the existing skirt board is 2.38 m/s. When compared with the results of the airflow velocity measurement, the values obtained are 2.34 m/s and 2.43 m/s, then the deviation of the airflow velocity values is 1.7% and 2.05%, respectively (Table 4). Assuming that the measurement error is ± 5%, namely the value of the air flow velocity in the existing skirt board and improved design. The first error value is the value of the first measurement (Tool 1) compared to the simulation results, the value is 1.7%. The second error value, the second measurement value (Tool 2) compared to the simulation results obtained a value of 2.05%.

The German VDI standard 3790 [9] describes a general method for the prediction of the dust generation caused by the continuous or discontinuous fall of the bulk material. The VDI 3790 uses the following empirical found equations (1) & (2) for the determination of the generated dust per metric ton of the discharged material.

$$q_{dust} = q_{norm} x 0.5 x \left(\frac{v^2}{4xg}\right)^{1.2} \quad (1)$$

with the q_{norm} standard emission factor given in accordance with Equation 2 as follows:

$$q_{norm} = 83.3 x Q^{-0.5} x a \quad (2)$$

where,
Q is the mass flow rate in t/h,
a is the dimensionless weighting factor for the dustiness of the bulk material (Table 5),
v is the material velocity at the main impact point,
g is the gravitational acceleration.

TABLE 4. Parameter Assumption Validation

Result	Value	Error 1	Error 2
Measurement 1 (m/s)	2.34	1.7 %	2.05%
Measurement 2 (m/s)	2.43		
Simulation (m/s)	2.38		

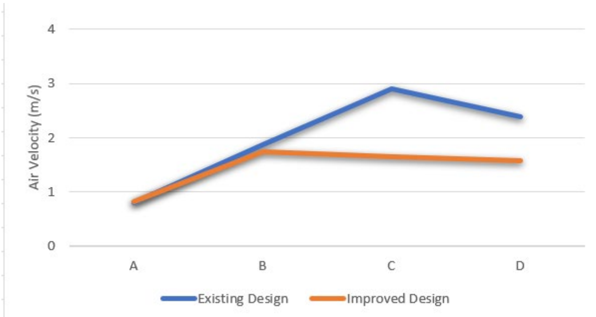

FIGURE 9. Air Velocity Existing and Improved Design

Coal particle velocity based on simulation results in the skirt board outlet area is 9.75 m/s so the coal dust formed is 39.81 T/h. Improved design conditions obtained the following results; the air velocity value at the outlet side of the skirt board is 1.57 m/s. The speed of coal particles based on the simulation results at the outlet area of the skirt board is 5.88 m/s so the coal dust formed is 11.24 T/h.

Finally, the results of the calculation of the dust formed on the existing skirt board design and improved design, it was obtained a decrease from 39.81 T/h to 11.24 T/h or reducing about 72% (Fig. 10).

TABLE 5. Weighting Factor for Dustiness

Material Property	a
High Dust Generation	$\sqrt{10^5}$
Medium Dust Generation	$\sqrt{10^4}$
Low Dust Generation	$\sqrt{10^3}$
Imperceptible Dust Generation	$\sqrt{10^2}$
Extra Moist / Low -Dust Material	$\sqrt{10^0}$

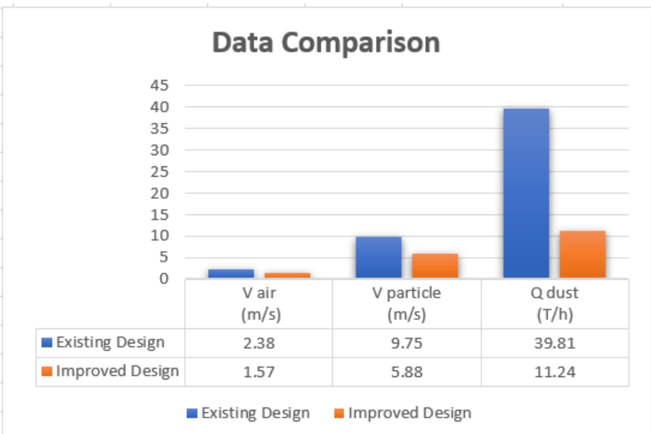

FIGURE 10. Existing and Improved Design Comparison Data Chart

V. Conclusion

In this study, the particle CFD method was used to analyze the velocity of air and coal during coal transportation. The assumption of input parameters on CFD is conditioned to be close to the actual value and the simulation results regarding the existing conditions can be accounted for. Improvement design by changing the geometry of the skirt board size and then performing simulations is proven to be able to reduce the formation of dust when flowing coal.

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