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THE FLOW BEHAVIOUR STUDY OF SPLITTING DEVICE FOR HORIZONTAL PIPELINE

Mohamed Azren, Norasikin Mat Isa and Azmahani Sadikin
Faculty of Mechanical and Manufacturing Engineering, University of Tun Hussein Onn Malaysia
E-Mail: sikin@uthm.edu.my

ABSTRACT

The study of the flow behaviour of splitting device for horizontal pipeline was conducted by using the numerical simulation. The splitting device is functionally to force the roping flow to become homogenous. The study scrutinised the air flow in the pipeline, and also the air flow with particle which is anthracite injected into air in the pipeline. A piping system with 5 different type of splitting device is simulated to find the best splitting device that can make the roping flow become homogenous and improved the roping problem. The simulation was conducted by using the Ansys Fluent. From this study, it can be concluded that the splitting device, does help successfully in reducing the roping problem in the horizontal pipeline.

Keywords: horizontal pipeline, splitting device, bending pipe.

INTRODUCTION

Pneumatic conveying is a system that uses air as a source of force to transfer the medium from one place to the others place, where it is suitable for powdered and granular material in factory, site and plant situation [1]. These conveying systems are ecosystem friendly because using a natural source which is air. And in fact, since these systems are completely enclosed, the material lost and dust emissions are reduced [2]. However, the limitation of this system is need a high source of power to transport a large material.

Nowadays, pneumatic conveying is widely used in the industries. The typical medium that used the pneumatic conveying technology is ash, pulverised coal, cement, calcium carbonate, plastic pellets, chemical powders, and food products [3].

In power energy industry, pneumatic conveying normally is used in the coal power plant where the granular material is transport from one place into the other place. The granular material such as pulverised coal is transported from the mill into the several burner by using the air from pneumatic conveyor as a power source. The size of the pipe is normally are 660mm diameter, made of steel and lined with ceramic tiles [4].

In the transportation process, the large pipeline flow splitting device such as trifurcators and riffle type bifurcators is needed to distribute the pulverized coal evenly between each of the burner [5]. This splitting device is responsible to make sure that the flow is evenly divided in each of the pipe. The splitting devices is an object that act as a stabilizer to the medium that is transport where the roping flow of the medium become evenly distributed when it is passing through the splitting devices.

When the coal is transported from the mash place into the burner, the flow need to evenly distributed in all other sides. Normally, the conveying system not all is in straight line, where design of bending pipe is need to give more flexibility to the pipe by allowing routing and distributing [6]. When the gas and the particle are flow through the bending pipe, the particle stratify into the small portion of the cross sectional area of the pipe. Once happen, the roping flow become disperses and turn to mix over the cross sectional of the pipe because of the flow is turbulent [7]. The roping flow are happen due to several reason such as affected by complex parameter, like centrifugal force, formation and dispense of rope, secondary flow and erosion at bend outer wall [8].

METHODOLOGY

The simulation software, computational fluid dynamics (CFD) Ansys workbench are used to simulate the flow of the air and also the injection of particle. Solid work software also used to model the rig. The chosen design of splitting device then was running by using the simulation software and then the data is validate with the experiment data from the studies by Izzat Malek [9]. In this studies, there are one tube and five type of splitting device that are used to simulate the data.

Grid independence study was also performed to determine the adequate number of meshing used in the study. In this study, the number of mesh 350000 is selected.

The analysis of the turbulent model used were also performed. From the investigation it can be concluded that the RKE model is produce less percentage of error compare to other type of model.

Figure-1 shows the meshed geometry. The meshed geometry contained more than 60 000 nodes and 350 000 cells of tetrahedral grids for all designs.

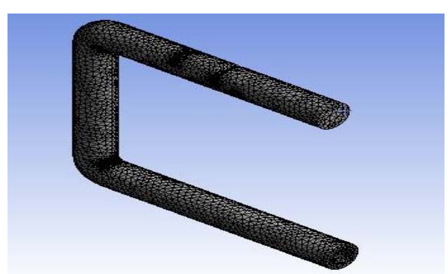

Figure-1. The piping grid.

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The number of element and node corresponding to every model can be seen in the Table-1.

Table-1. Node and element for every model.

No	Model	Node	Element
1	Tube	63664	341046
2	Hollow	64801	346898
3	Zig zag	67860	352066
4	Inverse zig zag	67987	353026
5	Flip zig zag	68697	357143
6	Inverse flip zig zag	67985	353081

RESULT AND DISCUSSIONS

In order to investigate all possible factors that may affect the result, the analysis is divided by two. Which is the analysis of the air and the analysis of the injection of particle which is anthracite. Three different air velocity, 5 m/s, 10 m/s and 15 m/s have been selected for evaluation. Eighteen test cases; with various design, were conducted for each velocity on the piping system. The variation velocity helps to visualise the effect of several design on flow behaciour. For injection of anthracite, the initial velocity is 10 m/s and the size of particle injected are in three group which is 10 micron, 50 micron and 100 micron injected together. The variation of particle sizes helps to visualise the effect of several design on the percentage of escaped particles. The splitting devices tested in this study were hollow splitting device, zigzag splitting device, inverse zigzag splitting device, flip zigzag splitting device and the last is inverse flip zigzag splitting device. Comparison also made for the tube (the piping system) the result were analysed at position 1 and position 2 as shown in Figure-2.

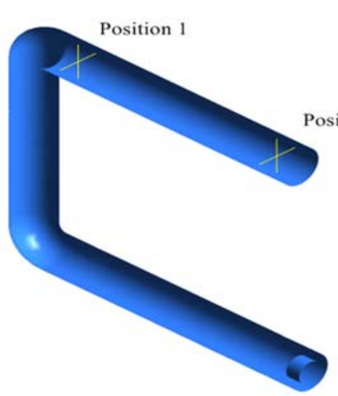

Figure-2. The position of analysis.

The tube is tested first to ensure that the roping flow is really happen due to the bending pipe. The view of cross section of position 1 air flow distribution as shown in Figure-3. The flow is intend more focused on the top of the splitting device, due to the air at the bottom of splitting device is collide with the bending pipe.

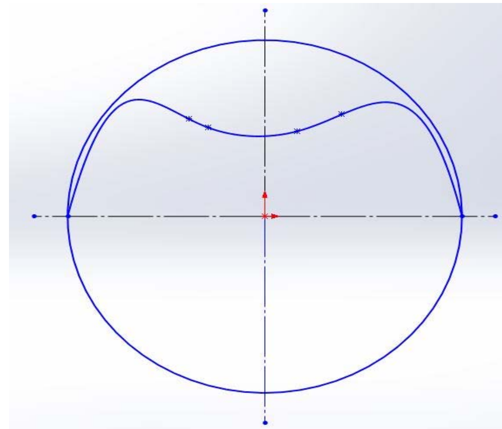

Figure-3. Cross section of position 1 air distribution.

Every device is illustrate a different air flow, since the flow of air is affected by the hurdle that located in the splitting device. From the Figure-4-7, it shown the velocity profile of air in the position 2 of vertical and horizontal side.

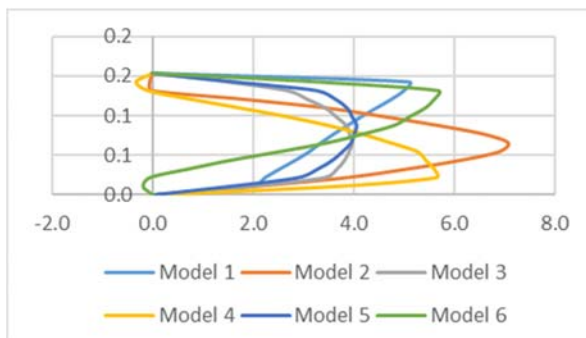

Figure-4. Velocity profile model 1, 2, 3, 4, 5 and 6 in verticle side of the piping system.

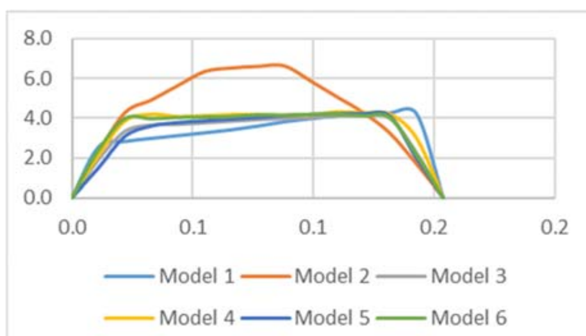

Figure-5. Velocity profile model 1, 2, 3, 4, 5 and 6 in horizontal side of the piping system.

The shape of velocity profile for initial velocity of 10 m/s is quite different between each other model. Model 1 which is tube pipe show the velocity of air is

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really high at the top of the pipe for verticle side. It is due to the this model did not have any hurdle inserted. For horizontal velocity profile, the velocity of air flow become high at the right side. The flow for the model 2 which is hollow splitting device become really high at the middle of model for both verticle and horizontal side, due to the hurdle in this model is consist of a set of small hole. Model 3 which zigzag splitting device show a good result also in both vrticle and horiontal side. The air velocity flow is distributed well in the model.

For verticle velocity profile, model 4 which is inverse zigzag splitting device is over-corrected the flow of air where the flow of air that high in velocity at the top side of the pipe in position 1 turn to become higherat the bottom of the pipe when it is passing through the splitting device. While for horizontal side, the velocity profile is quite good as the velocity flow is scretter evenly in the model. As the model 3, model 5 which is flip zigzag splitting device also give a good result in both verticle and horizontal side where the velocity flow of air spread equally inside the model. The last one is model 6 which is inverse flip zigzag splitting device shows no significant result. The velocity of air in verticle side is quite same as in position 1 even though there are already inserted with splitting device. However, the velocity profie for horizontal side is reasonably good. The velocity profile for the initial velocity of 5 m/s and 15 m/s is quite similar with the initial velocity of 10 m/s. for the analysis, it is obviously state that the best splitting device for air distribution is model 3 and 5 which is zigzag splitting device and flip zigzag splitting device.

Subsequently, the velocity contour and velocity vector of the chosen model is verify to make the analysis more precise as shown in Figure-6 and 7. From the velocity contour, the best splitting device is model 5 which is flip zigzag splitting device followed by the model 3 which is zigzag splitting device. It is due to the flow of velocity distribution in model 3 is more uniform. In adddition, there are a lot of high velocity of air at the middle of model 3 if compared to the model 5.

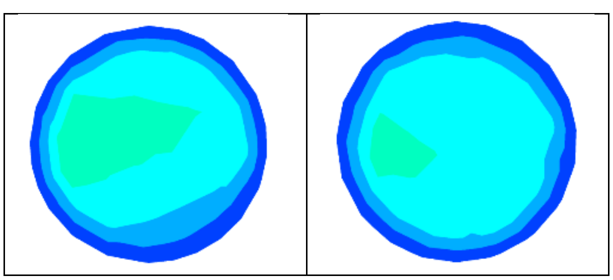

Figure-6. Velocity contour for model 3 and 5.

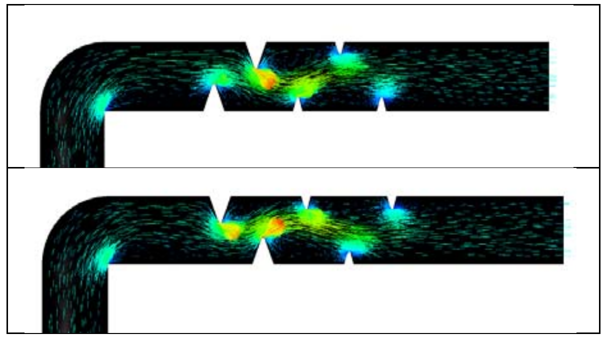

Figure-7. Velocity vector for model 3 and 5.

For particulate analysis, the particle size which is 10 micron, 50 micron and 100 micron is injected together. In Figure-8, the particle distribution is quite different in each of the model. For model 1 which is tube pipe, the particle distribution is collected more at the top of the tube. The maximum particle resident time is 1.174 second with the particle escape is 100%. The particle distribution of the model 2 which is hollow splitting device is quite surprise, where it is look like the particle is trapped in the splitting device. It is due to the hurdle inserted is too small, blocking the particle way too much. The maximum particle resident time is 2.141 second and particle escape is only 96.05%. Meanwhile, the particle distribution in the model 3 which is zigzag splitting device is quite good. The particle successfully distributed where the space of the splitting device at outlet is being occupied by the anthracite particle. The maximum particle resident time is 1.074 while the particle escape is 100%

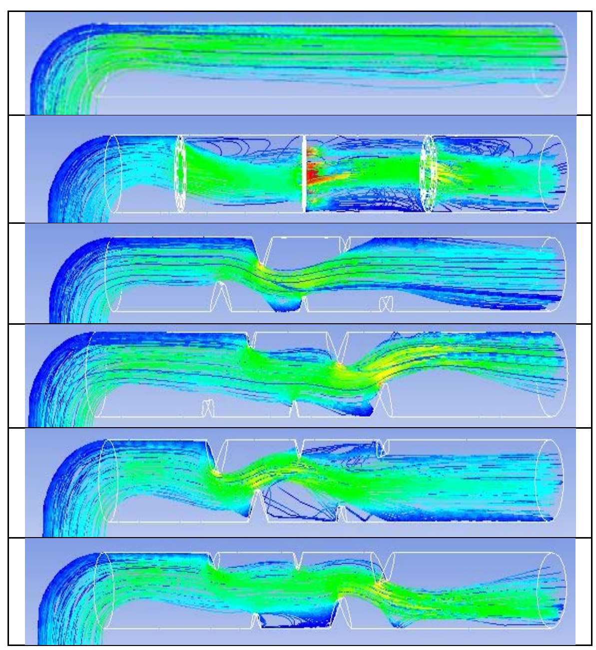

Figure-8. Particle track for all of the device include tube pipe.

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Table-2. Particle resident time.

	Particle resident time (s)		
Partical size (Micron)	**10**	**50**	**100**
Tube type	1.174	0.9634	0.9395
Hollow	2.141	1.247	1.343
Zigzag	0.9551	1.064	1.074
Inverse zigzag	0.999	0.9668	1.007
Flip zigzag	1.003	0.963	1.163
Inverse flip zigzag	1.014	0.9354	1.446

The particle distribution for model 4 which is inverse zigzag splitting device shows poor result, where the particle is sticking together at the top of the splitting device. It is due to the last hurdle is too tall, make the particle thrown away to far to the top. The maximum particle resident time is 1.007 second and particle escape is 100%. The result from model 5 which is flip zigzag splitting device is as good as model 3, but unfortunately, the particle escape in this splitting device is only 98.57%. The particle resident time is 1.163. And last but not least is model 6 which is inverse flip zigzag splitting device. The outcome is quite bad as the model 4 but in this model, the particle is trown down to the bottom of the splitting device due to the last hurdle is too tall. The maximum particle resident time is 1.446 while the particle escape is 98.57%.

Table-3. Particle escape.

	Escape (%)		
Particle size(Micron)	**10**	**50**	**100**
Tube type	100	100	100
Hollow	96.05	100	100
Zigzag	100	100	100
Inverse zigzag	100	100	100
Flip zigzag	98.57	100	100
Inverse flip zigzag	98.57	100	100

CONCLUSIONS

Simplified numerical and experimental studies can be used to assist in the design of improved splitting device and provide some insight into conveying system. Initial CFD simulation has given some insight on the effect of changing the design on the distribution of air and particles. Zigzag splitting device illustrates the flow of air and the particle injected become distributed well and homogenous.

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