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The comparison between influence of reducer and inner pipe diameter to the pressure and velocity of gold slurry using 3D solid work simulation

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Abstract. Gold mining Pipe with slurry was modified to observe its effect in pressure-discharge pipe. The fluid was transport using centrifugal pump, while the model simulated using solid work 2018 edition. Three models used in this case were: 28-inch pipe without reducer-pipe; 30-inch pipe without reducer pipe, and 28-inch pipe with reducer-pipe. Each model will produce the discharge pressure, slurry velocity, and the friction. The result shows that the 30-inch pipe without reducer will increase the pressure on the discharge pipe. However, the pressure is not as homogenous as 28 inch-pipe without reducers. 10 % of slurry produced less pressure because the friction occurred in the wall caused by the diameter difference. Meanwhile, the models in 28-inch pipe with reducer-pipe clearly show significant improvement of discharge-pipe pressure. However, the pressure is variety from the centre to the edge of the pipe, with the highest pressure located in the centre of pipe.

1. Introduction

Piping is the system used to transport fluid or gasses mechanically from one location to another using pipe. The system itself is designed according to many factors such as: the fluid and its properties (temperature, density, viscosity, etc.), the location to transport, surrounding system, etc.

Currently, piping plays important role in the wide variety application. We can see the pipe almost in every situation and location. The clean water we use every day, the sewage system we used to transport our public disposal, power plant that produce electricity in our house, chemical factory, HVAC etc. Most of these system used piping as their arterial to transport the material.

According to Abhisek Sharma [1], piping contains many components but some major components are pipe, fitting, flanges, valves, gasket & bolting. Reducer is pipe's element used to reduce the diameter of the pipe to increase the pressure of the fluid.

Some energy may loss from the fluid in piping system. Thus, decrease the pressure of the fluid. Longer piping system will increase the energy loss. This is the reason why the pressure gauge always located on the discharge of the piping system to make sure the pressure – sometimes even the temperature – are as high as expected. The energy loss may contribute to friction caused by pipe's material roughness, the piping parts such as flange, fitting, etc. The energy loss because of bad weldments, joints in piping, different inner diameter.

In the mining system or petroleum, the fluid transported called "slurry". The slurry contains of high-price material such as gold, silver, gemstone, etc. The pressure located in to the discharge pipe could play important role before the slurry going to the distributor box cyclone.



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It has been reported [2] that minor loss can be solved by increasing the density of the fluid. However, for some special material such as mining-slurry that contains most of mining material (gold, silver, etc.), density is intolerable – unchangeable procedure parameters.

It is also reported [3] [4] that a model of turbulent drag reduction by polymer additives in both hydraulically smooth and rough pipes could lead to increased pressure. D.Eskin describes the other method by equation [5] [6].

A ice slurry was modelled perfectly and compared to the previous research [7] [8] for refrigeration application, however ice slurry has a big different density than to the mine slurry. Mining slurry has many ores as contaminant, followed by other minerals that cannot not be denied easily. Therefore, the modelled cannot apply to the simulation.

Among the literatures, there are some information about reducers in solving the pressure problems especially when the mining slurry is the fluid used. Therefore, this research's purpose is to provide the information about the reducers simulation in piping system before enter distributor cyclone. Changing inner piping diameter also provided as comparison.

2. Method and Simulation

The specific pump type used in this paper are:

Pump Sentrifugal GIW KSB Company
 Pump Type : LSA 20x24 – 48 C/4ME
 Vane Diameter : 48.00”
 Free Passage : 6.1 x 12.8 “
 Frame Size : 9K
 Seal Type : K, F, M

Cyclone Separator FL Smith
 Optimal Supply Flow Rate : 22,000 gpm
 Optimal Working at Pressure : 10 psi

Drawing Engineering Betchel Group
 Company Drawing Number:
 0205B9 – P – 002706 5 B
 0205B9 – P – 002706 – B
 Slurry

Table 1. Slurry Specification

<i>Parameters</i>	Data		
	<i>Value</i>	<i>Units</i>	<i>Notes</i>
<i>Concentration by Weight</i>	68.00%		<- Input
<i>Concentration by Volume</i>	43.15%		
<i>S.G Fluid</i>	1		<- Input
<i>S.G Solid</i>	2.8		<- Input
<i>S.G Mixture</i>	1.776649746		
<i>Dynamic Viscosity Liquid (l)</i>	0.001	Pa.s	<- Input
<i>Dynamic Viscosity Mixture (m)</i>	0.001304831	Pa.s	
<i>Kinematic Viscosity Liquid (m)</i>	1.23E-04	m ² /s	

Here are 3 Models Used in this paper:

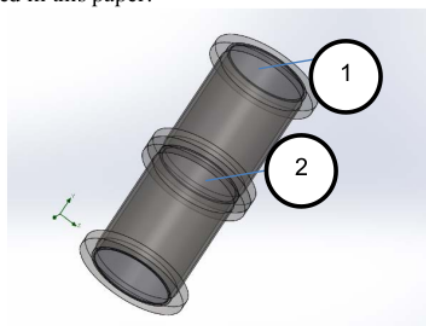


Figure 1.Model 1 – Discharge piping system 28 inch

Part no.1 is 28-inch spool pipe from box distributing part in cyclone. While number 2 is 28-inch pipe connected to the main system.

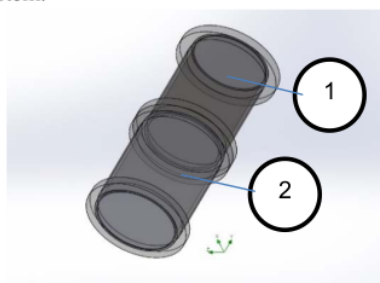


Figure 2.Model 2 – Discharge piping with diameter 30inch

Part no.1 is 28-inch spool pipe from box distributing part in cyclone. While number 2 is 30inch pipe connected to the main system

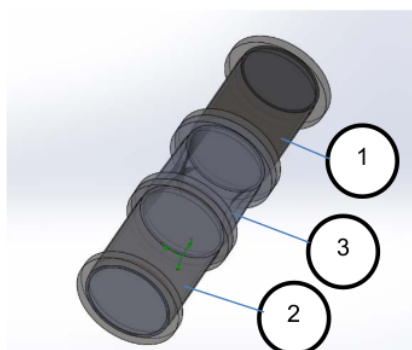


Figure 3.Model 3 – Discharge piping system modified using Reducer

Part no.1 is 28-inch spool pipe from box distributing part in cyclone. While number 2 is 30inch pipe connected to the main system. Number 3 is reducer-pipe.

3. Result and Discussion

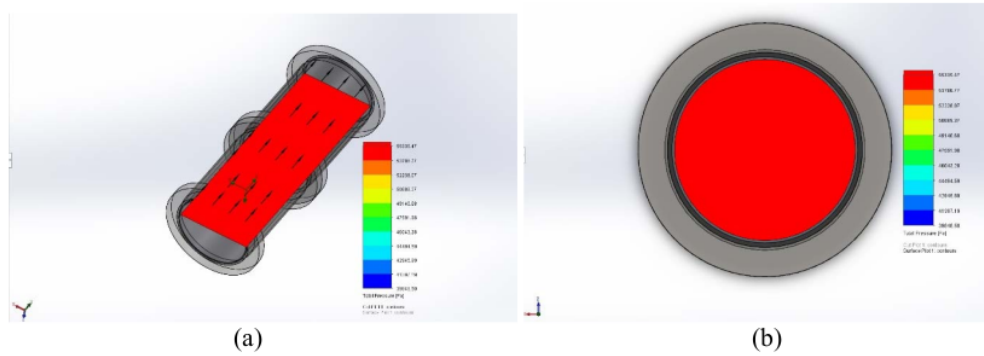


Figure 4.Model 1 – (a) Pressure distribution (b) Pressure contour

The figure a) show a homogeneous pressure along the pipe and the spool pipe while the figure b) show the detail from its contour. The pressure range variety from the blue colour which indicate the smallest pressure (39kPa), to the highest pressure which indicated by red colour (55kPa). The detail contour image shows that the pressure occurred in the edge of pipe is less than the majority which may be contributed to minor losses in the edge of the linear streamlines [2].

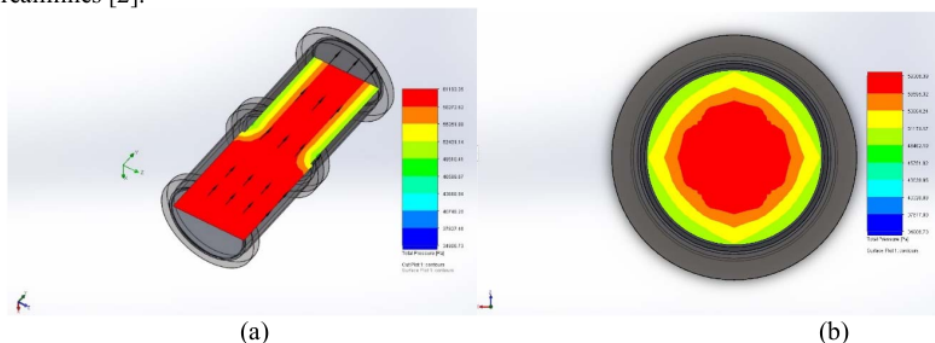


Figure 5.Model 1 – (a) Pressure distribution (b) Pressure contour

Difference result shows in the model 2. The result shows slight difference range in pressure than the model 1. The blue colour indicated the smallest pressure in 34kPa, while the red colour shows the highest pressure 59kPa. However, unlike model 1, the contour occurred in the model 2 is heterogeneous. The highest pressure located mostly in the centre of the pipe, and then gradually decreased to the edge of the pipe.

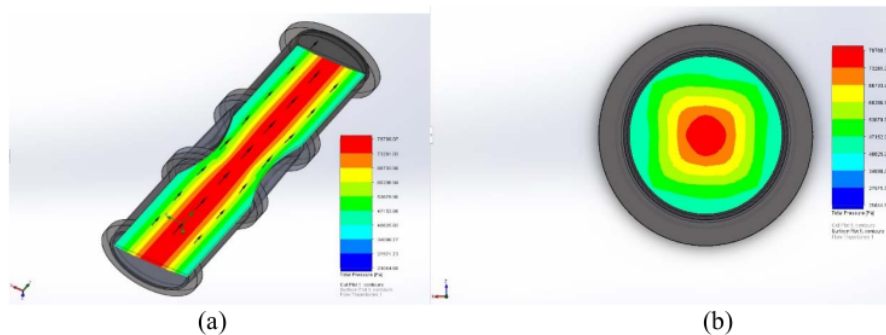
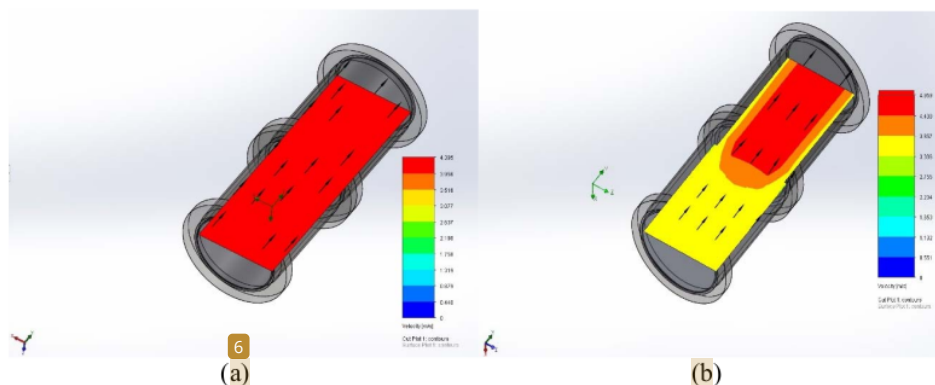


Figure 6. Model 1 – (a) Pressure distribution (b) Pressure contour

The figure a) show totally different result from the others. The range increased greatly from 29kPa – indicated by blue colour – to 79kPa – indicated by red colour. The contour occurred is heterogeneous and started even in the beginning of the spool pipe. The pressure is slowly decreased from the centre of the pipe to the edge.

Table 2. Average number for samples

	Model I	Model 2	Model 3
<i>Average Pressure</i>	55237 Pa	57352.7 Pa	55289.4 Pa
<i>Discharge Pressure</i>	55296 Pa	59306.9 Pa	79322.5 Pa
<i>Average Velocity</i>	4.3114m/s	4.0078 m/s	4.3899 m/s
<i>Discharge Velocity</i>	4.331 m/s	4.9280 m/s	7.0994 m/s
<i>Friction Force</i>	24.716 N	19.9893 N	21.311N



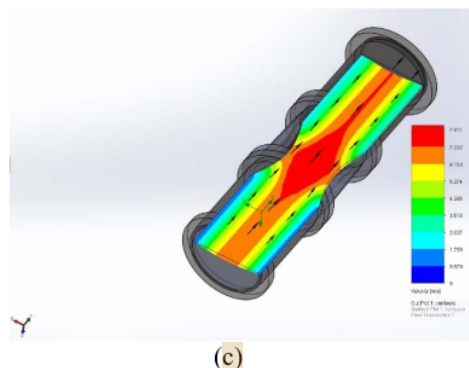


Figure 7. Velocity Distribution along: a) Model 1 (b) Model 2 (c) Model 3

The figure a, b and c show the results of the simulation for model 1, 2 and 3 in case of slurry velocity. The slurry's velocity of model 1 result in homogeneous flow shown by red colour in almost every part of the pipe. The velocity of slurry is 4,33128 m/s. However, the edge of pipe shows blue colour, which indicate 0m/s slurry velocity. This may because the surface of pipe will make a force to prevent the slurry smooth flowing. This force known as friction force, which influenced by many factors such as; the pipes surface roughness, the fluid velocity, etc. Thus, pipe surface will experience shear stress. The homogeneous of fluid make the impact stress between the pipe material and the fluid. Thus, the surface will experience the biggest friction like shown in the table.

Unlike model 1, model 2 simulation shows un-homogeneous contour of slurry velocity. There are 3 main type velocity beside 0m/s. Most of slurry velocity at the connecting pipe are 3.3 to 3.8 m/s indicated by yellow colour, and change mostly to 4,9 m/s when goes to slope-pipe indicated by red colour. However, the velocity gradually decreased from the centre of the pipe, to the edge of the pipe, 3.87m/s indicated by orange colour to 3.3 m/s indicated by yellow colour. The diameter difference between slope-pipe and connecting-pipe will prevent slurry going smoothly in joint section. Some of slurry – that flow in the edge of pipe – will collide the pipe-diameter-extend wall and try to flow back. The back-flow slurry will collide the other slurry, thus make the disturbance in the joint section. Therefore, the slurry movement will jam; more over the velocity will decreased. However, since the slurry in the edge pipe flow slower than the slurry in the centre, the edge-slurry will act as a shield for pipe surface to prevent the faster slurry colliding with the pipe's surface. This is why the surface friction is small according to the table.

The model 3 shows more complex slurry velocity. The figure shows six colours: blue colour (0 m/s), light blue colour (1,75m/s), green colour (3,5m/s), yellow colour (5,2m/s), orange colour (6,5m/s) and red colour (7,9m/s) from the pipe's edge to pipe's centre respectively. This phenomenon caused the 30-inch pipe and 30-inch reducer-pipe sandwiched the 28-inch connecting-pipe. In the beginning, the same phenomenon occurred in the model 2 happening in slope-pipe. However, the reducer-pipe diameter enlarging the movement of the slurry thus increased the pressure of the slurry. The friction occurred in this phenomenon is similar to the model 2. However, the velocity formed by this model is far greater, which make the friction becomes higher.

4. Conclusion

From the discussion above, we can conclude the experiment in these points:

1. Enlarging the diameter of the slope-pipe will increase the discharge-pipe pressure for the slurry
2. Enlarging the diameter of the slope-pipe will decrease the uniformity of the discharge pressure from the edge-pipe to the centre of the pipe.
3. Enlarging the slope-pipe diameter will decrease the friction, thus the shear stress occurred in pipe's surface.
4. The addition of reducer-pipe will increase the discharge pressure greatly, while the uniformity will increase in range.

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