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The Influence of Spiral Blade Distributor on Pressure Drop in a Swirling Fluidized Bed

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Abstract. This work reports studies on the aerodynamics of air flow in the plenum chamber of a swirling fluidized bed. The study focused on the effect of annular spiral blade distributor configuration whereby the effect of various pitch length (60 mm, 80 mm and 100 mm) via various horizontal inclination angle (0°, 12° and 15°). The CFD method is used to compute and obtain the performance results as well as pressure drop data. Moreover, high pressure drop is undesirable since high pumping power is needed to sustain the pressure needed to run the swirling fluidized bed processes. It should be as low as possible to reduce the power being wasted during the processes. The numerical result at the parameter of horizontal blade inclination of 15° via pitch length of spiral blade distributor of 100 mm shows that effect on large overlapping length of blade (trapezoidal) area consume less pressure drop.

1. Introduction

Fluidized beds are widely used in many industrial especially in chemical process industries. The mechanism of a fluidized beds can be seen when gas passes through the particle and experiencing sufficient drag force from the air or fluid [1]. Compare to the conventional fluidization, the current design of swirling fluidized bed had an array inclination distributor which forms annular opening as shown in Fig. 1 [2]. The current study of spiral distributor was carried out in order to seen the same effectiveness of air flow of the conventional fluidized bed. The main objective of this study is to determine the pressure drop in a swirling fluidized bed through to the various pitch length of annular spiral blade distributor.

The idea of spiral blade distributor was come up from the screw conveyors design. The screw conveyors was most reliable and cost-effective methods for conveying some amount materials. Moreover, the screw conveyors can be operated at any angle position, from vertical to horizontal condition. Furthermore, the design was base on the objective, the suitable design and development will bring a long times undisrupted service and productivity [3].



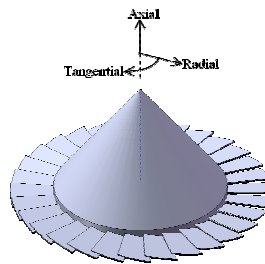


Figure 1. Distributor blade with a conical centre body.

2. Methodology

2.1 Numerical Methodology

Investigation of the air flow distribution in a SFB was conducted using commercial CFD software – FLUENT 6.3. The computation domain and grid generation was developed via GAMBIT 2.4.6. The two parameters were changed to obtain the correlation between the spiral blade length and blade horizontal inclination angle as shown in Table 1. The horizontal inclination has been selected based on previous studies by [4].

Table 1. Spiral blade distributor configuration in a swirling fluidized bed.

Case	Cylinder Base Diameter (mm)	Pitch Length (mm)	Horizontal Inclination Angle (°)
1	8	60	0
2		80	
3		100	
4		60	12
5		80	
6		100	
7		60	15
8		80	
9		100	

2.2 Boundary Condition

The air inlet was modeled as velocity inlet boundary condition of 2.25 m/s. The velocity and other parameters were based on the actual SFB system in the Faculty of Mechanical and Manufacturing Engineering, UTHM, which is currently used for drying of biomass. Same setting with previous researcher [4] of numerical simulation in CFD software in swirling fluidized bed has been applied on current study. The air outlet was modeled as a pressure outlet of 1.01325 bar (atmospheric pressure). Meshing of the SFB system was generated in such a way that it may capture airflow taking place through narrow opening of the distributor blades. Grid sensitivity was done prior to actual investigation to ensure the independence of grid size on the flow and to reduce possible numerical errors. The suitable grid size is chosen in such a way that they total number of elements are less (to reduce computational costs) without compromising simulation results. Hence, the Tri:Pave Meshing Scheme was applied to the surface and it allowed GAMBIT 2.4.6 to create a face mesh consisting of irregular triangular mesh elements. The Tet/Hybrid parameter type that specifies tetrahedral, hexahedral, pyramidal and wedge element were defined to the meshing algorithm. The mesh elements in the computation domain as well as the spiral blade distributor is presented in Fig. 2.

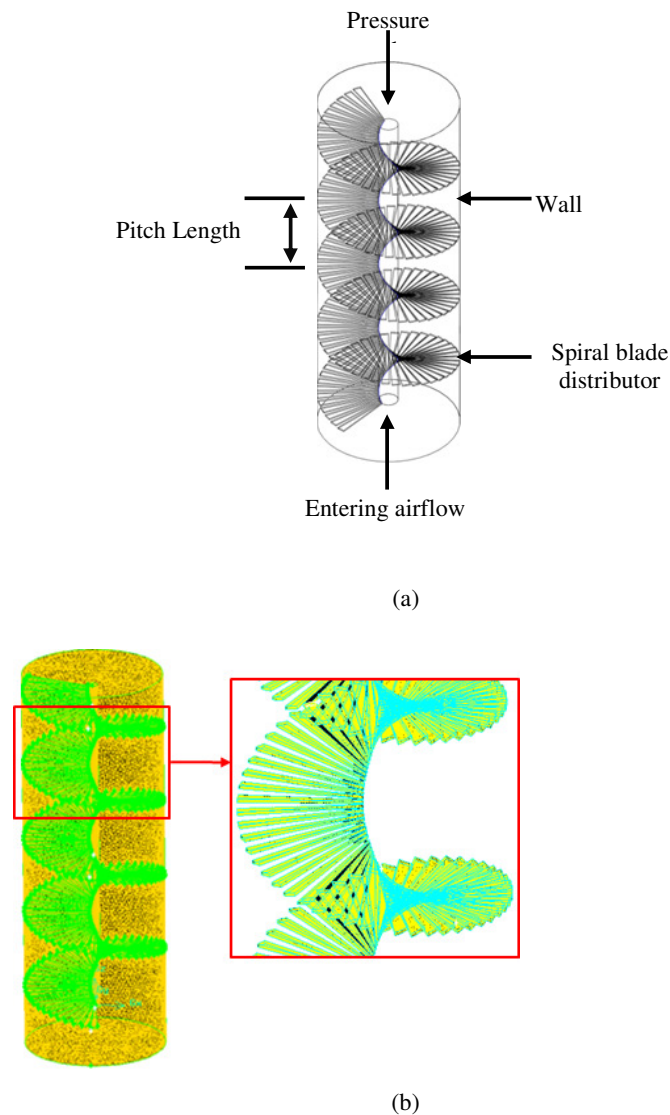


Figure 2. (a) Domain ; (b) meshes on the spiral blade distributor.

2.3 Solver Solution Techniques

The Reynolds Averaged Navier Stokes (RANS) turbulence Equation Models that being considered for usage in this study is RNG $k-\varepsilon$ RANS turbulence of RNG $k-\varepsilon$ model with enhanced wall treatment is used as this type of equation gives the closed results when being compared to the experimental value. The RNG $k-\varepsilon$ is similar in form to the standard $k-\varepsilon$ model, but has additional term in its ε equation that improves the accuracy significantly for rapidly strained flows and provides an analytical formula for turbulence Prandtl numbers and also the effect of swirl on turbulence is included in the RNG model [6] and [4].

3. Results and Discussion

3.1 Low Pressure Drop

The pressure drop was obtained by computing the pressure differences amongst the studied planes which located at 28 mm and 32 mm above the inlet. Effect on axial entry type plenum chamber with various number of blades (depends on pitch length and the 10 mm spacing for each designated configurations) and the trapezoidal area opening of blades would determine the pressure drop on each parameter like as shown in Table 2. The data that was obtained have shows that the pressure drop is significantly differ to its pitch length with horizontal inclination angle of blade distributor. The blade angle of 0° at pitch length of 60 mm has the highest pressure amongst the other parameters for every section of the system. It has the total of

1674.16 Pa of pressure drop overall for the system. Whilst, when the blade angle at 15° and the pitch length in 100 mm, the lowest pressure drop has been acquired on the system compared to other study parameters. The pressure drop and the condition was coincided with the previous statement [1].

Table 2. Static pressure data on blade 0° , 12° and 15° horizontal inclination.

Horizontal Inclination Angle	Pitch Length (mm)	Average Pressure at 28 mm Above Inlet (Pa)	Average Pressure at 32 mm above Inlet (Pa)	Pressure Drop (Pa)
0°	60	10743.39	9069.24	1674.16
	80	7723.97	6609.15	1114.81
	100	6267.26	5481.63	785.62
12°	60	15756.22	14784.19	972.02
	80	11953.37	11218.26	725.11
	100	6812.04	6256.71	555.33
15°	60	13010.14	12213.95	796.18
	80	8813.20	8189.91	623.28
	100	5661.70	5182.62	479.08

4. Conclusions

From the research, we can conclude that the pitch length of spiral blades distributor in a swirling fluidized bed (SFB) affects the pressure drop values. The findings from numerical study have shows that when the air flow go past at high horizontal inclination angle along with large pitch length of spiral blade the value of pressure drop tends to fall down. Moreover, the large area of trapezoidal have also effected on the pressure drop decline. At the horizontal inclination angle of 0° with 60 mm pitch length has the highest pressure drop (1674.16 Pa) compared to the lower pressure drop (479.08 Pa) at 15° with 100 mm pitch length parameter. The result was occurred due to the effect of trapezoidal area (spaces between blades) and the pitch length itself that allows air flow to travel more.

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