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Pressure Drop Analysis of Water and Fly Ash Mixture Flow through Straight Pipeline

[1]Subhash Malik, [2]Lakshya Aggarwal, [3]Ankit Dua
[1,2,3] Department of Mechanical Engineering, M. M. University, Sadopur (Ambala), Haryana
[1]subhashmalik604@gmail.com, [2]lakskiet@gmail.com, [3]dua_ankit09@yahoo.co.in

ABSTRACT
Slurry transportation through pipeline provides better effect on material transportation system. Transportation of bottom and fly ash in thermal power plants through pipeline is best example of slurry transportation system. Transportation through slurry pipeline is a safe, pollution free and reliable method. In the present work, Rheological properties of bottom and fly ash are studied to know the flow behaviour of coal slurry. The Rheological properties of slurry depend on a number of factors such as particle size distribution, pH value and settling characteristics. Rheometer is used to know the shear rate and shear stress variation for the different concentrations of slurry. In this paper, computational simulation is performed on the slurry flow through pipeline for the analysis of pressure drop in pipeline. Modelling of pipeline developed in Gambit and Fluent is used for the numerical evaluation and the performance is analysed on various concentrations and flow velocities.

Keywords: - Computational Fluid Dynamics, Finite Volume Method, Slurry Transportation System.

I. INTRODUCTION

Fly ash is the finest of coal ash particles. It is called fly ash because it is transported from the combustion chamber by exhaust gases [1]. Fly ash is the fine powder formed from the mineral matter in coal, consisting of the non combustible matter in coal. Bottom and fly ash are quite different physically, mineralogical, and chemically [2]. The mixture of solids and liquids is known as slurry. The physical characteristics of slurry are dependent on many factors such as particle size distribution, solid concentration in the liquid phase, turbulence level, temperature, conduit size, and viscosity of the carrier [3]. Slurry is a mixture of a solid particles and fluid held in suspension [15]. Water is the most commonly used fluid. The speed of slurry flow is sufficiently high to maintain the particles in suspension [4]. Slurry transportation through pipeline provides better effect on material transportation system. This system has various advantages such as very less pollution and less noise. So, there is requirement of detailed study of pipeline slurry transportation system to improve its performance [5]. Slurry pipelines are used to transport solid materials using water for short or long distances. These pipelines are used in many industrial applications involving transportation of coal and disposal of slurry in thermal power plant [6]. In the present work, Rheological properties of bottom and fly ash are studied to know the flow behaviour of coal slurry [7]. The Rheological properties of slurry depend on a number of factors such as particle size distribution, pH value and settling characteristics. Rheometer is used to know the shear rate and shear stress variation for the different concentrations of slurry [8]. Computational simulation is performed on the slurry flow through pipeline for the analysis of pressure drop in pipeline [10]. Computational Fluid Dynamic [CFD] is the analysis of system involving fluid flow by means of computer based simulation [11]. Computational fluid dynamics is one of the branches of fluid mechanics that uses numerical methods and algorithms to solve and analyse problems that involve fluid flows [12]. It has become an indispensable tool in the design, development, evaluation and refinement of new industrial equipment and processes.

II. COMPUTATIONAL SIMULATION OF PIPELINE

Computational Fluid Dynamic (CFD) is the analysis of system involving fluid flow by means of computer based simulation. Computational fluid dynamics is one of the branches of fluid mechanics that uses numerical methods and algorithms to solve and analyse problems that involve fluid flows [13]. The use of computational fluid dynamic reduces the development cost of new products and cuts the time to market of these products [14]

III. METHODOLOGY

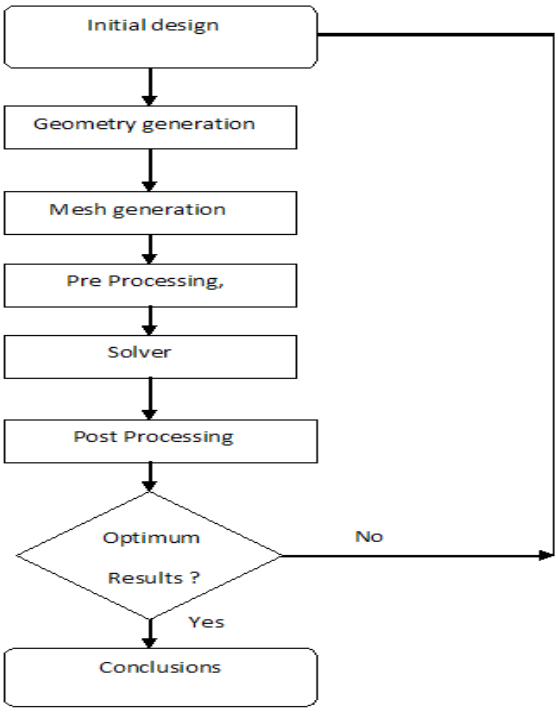

Figure 1: Methodology adopted

IV. SIMULATION RESULTS

Figure 2 shows that the pressure drop in 100 meter straight pipe is increased from inlet to outlet.

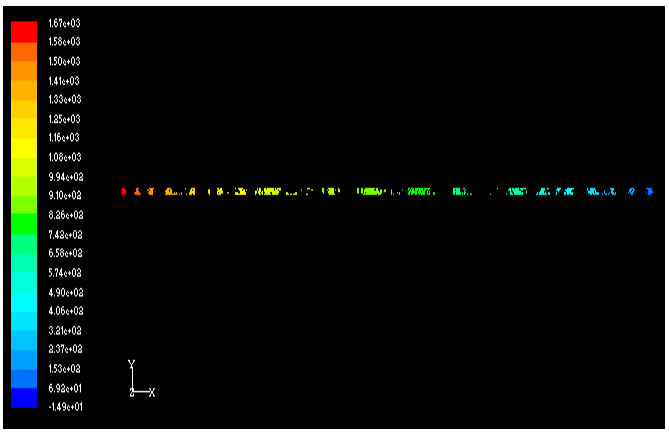

Figure 2: Pressure Display of Fly Ash at 50% Concentration in 100 meters Straight Pipe

When concentration of bottom ash is increased in slurry then pressure in pipe is also increased. Pressure will increase, when the velocity of slurry in straight pipe increases. It can be observed from Figure 3 that pressure loss difference at high velocities is considerably more than pressure loss difference at low velocities.

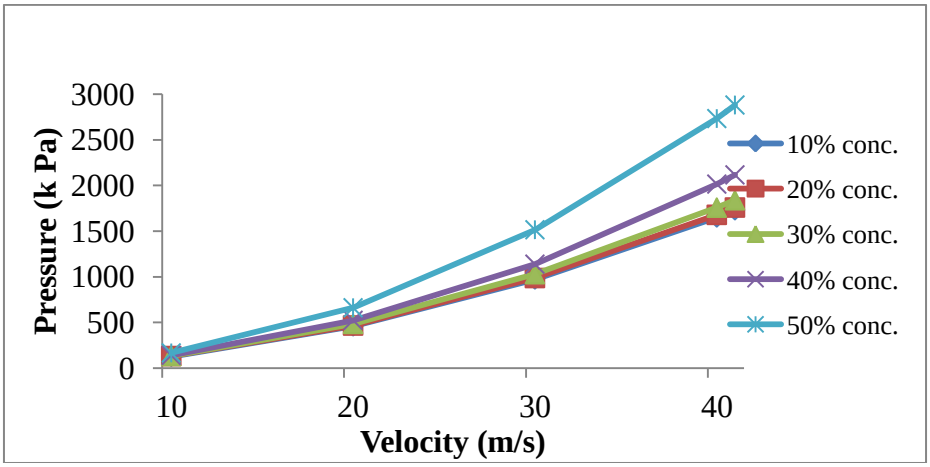

Figure 3: Pressure Drop per 100 meter Length with Different Flow Velocity and % Concentration (by weight) for Water and Fly Ash Mixture in Straight Pipe

Table 1: Pressure Drop per 100 meter Length with Different Flow Velocity and % Concentration

Velocity [m/s]	**Pr. Drop [k Pa] 10%**	**Pr. Drop [k Pa] 20%**	**Pr. Drop [k Pa] 30%**	**Pr. Drop [k Pa] 40%**	**Pr. Drop [k Pa] 50%**
10	126.94	132.79	133.34	139.87	167.31
20	460.04	466.85	484.72	524.09	661.98
30	972.50	986.82	1029.17	1138.65	1515.55
40	1651.19	1678.37	1757.71	201505	2732.48
41	1729.64	1758.56	1838.06	2116.06	2880.57

V. CONCLUSION

The simulation results show that the Pressure drop per 100 meter length across the straight pipe increases as increase in concentrations and flow velocities. Fluent results give the good agreement with analytical results for pressure drop in straight pipe for different concentrations of bottom ash slurry. It has been observed that the Slurry with 50% concentration can flow at velocity 41 m/s in straight pipe.

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