CFD analysis of foam Generator using ANSYS CFX

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*Abstract:*The foam generator is very important device use in coal mines for dust control. The geometric variables of foam generator has significant effect on volume of foam generator. The current research investigates the effect of length to throat ratio and water inlet diameter of foam generator using techniques of Computational Fluid Dynamics. The CAD model of foam generator is developed using Creo design software and analyzed using ANSYS CFX. The velocity plot, mass flow rate and velocity plot are obtained for different dimensions of foam generator. The mass flow rate (at domain exit) of air decreases with increase in water inlet diameterand maximum mass flow rate is observed for 6mm water inlet which subsequently decreases with increase in water inlet diameter.

Key Words: *Foam generator, CFD, Dust control*

1. INTRODUCTION

The mining process involves various stages like crushing, grinding etc. The mechanical force by machines causes crushing and abrasion of surfaces which loads to generation of fine coal dust particles suspended in air. Along with these operations, the dumper movement and other heavy motor vehicles nearby mining or industrial area produces dust. The mining by heavy equipment mining machinery (HEMM) on the surfaces causes more dust as compared to underground mining. The miners are highly vulnerable to these dust particles. The inhalation of these dust particles along with SO_2 and NO_2 causes respiratory diseases.

2. LITERATURE REVIEW

Chaulya et al. (2002) [1] has worked on Fugitive Dust Modelling to determine emission rate of coal dust. The results of FDM is validated with area and line source model. The FDM has shown its suitability in Indian mining conditions.

Chaulya (2004) [2] has worked on Lakhanpur area to moniterPM10, SO2, NOx for duration of 10 months. The findings have shown that PM10 levels are 31.94% higher than prescribed standard by NAAQS.

Erol et al. (2013) [3]has conducted studies to determine factors response for cause of pneumoconiosis among miners. The study has shown that high quartz content in coal dust resulted in the respiratory illness. The quartz concentration of air was measured using MRE113A dust sampler.

Ghosh and Majee (2007) [4] have conducted studies on Jharia coalfield to determine concentration of air borne dust. The work zone air was found to have dust particles of size 20µm mean diameter and contained high amount of TSP, RPM and benzene soluble matter.

Kumari et al. (2011) [5] has used FTIR spectrometer to determine quartz content in ARD (airborne respirable dust) in Jharia coalfield. The GLA-500 PVC membrane filters are used to collect dust particles in mines. The quartz found in the dust particles was less than 1%.

3. OBJECTIVE

The current research investigates the design of foam generator using techniques of computational fluid dynamics. The CFD analysis is conducted on foam generator by varying throat to nozzle distance (ltn) and water inlet diameter. Three cases of throat to nozzle distance is taken for analysis i.e. 6mm, 10mm and 14mm. Similarly, for water inlet also three different cases are taken i.e. 6mm, 8mm and 14mm.

4. METHODOLOGY

The CAD model is developed using Creo design software. This package is sketch based and parametric software which enables editing at any instant which makes it suitable for complex modelling. The CAD model of cooling tower is developed. The model is developed using extrude, sketch and revolve tools. The chamber length is taken as 360mm and contraction angle is taken as 20^0 . The L_{tn}i.e. throat nozzle distance is varied and is taken as 6mm, 10mm and 14mm.

Figure 1: Sketch using line tool

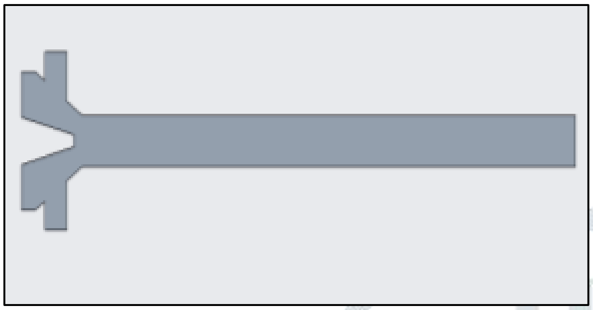

Figure 2: Extruded feature of foam generator

The CAD model generated in creo academic design software. This CAD design file is converted in more compatible design format for ANSYS software. The file format for design is .iges The CAD model of foam generator is developed using extrude, fillet tools. The model is checked for hard edges, surface patches and other errors which is rectified in ANSYS geometry modeller.

Figure 3: Imported CAD model in ANSYS

The CAD model is meshed using hexahedral elements. The element sizing is set to fine mesh, adaptive, inflation normal. The “hexahedral elements comprise of 8 nodes with 3DOF each node”.

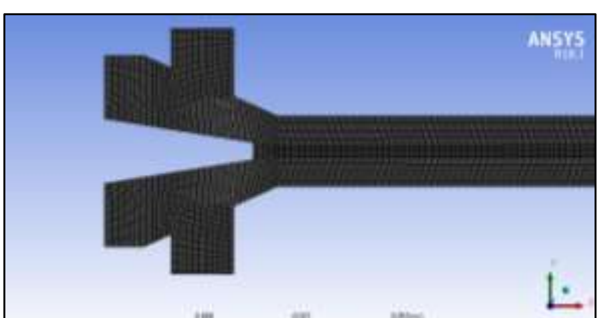

Figure 4: Meshed CAD model in ANSYS

The CAD model is applied with appropriate loads and boundary conditions which includes force and displacement support. “The loads and boundary conditions are applied as per literature. The water inlet is 89.75 m/s.The velocity inlet was taken as the boundary condition for the flow of water when the volumetric flow rate of water at the nozzle was fixed. The air inlet was set as the pressure inlet whilst the ejector outlet was considered the pressure outlet” .

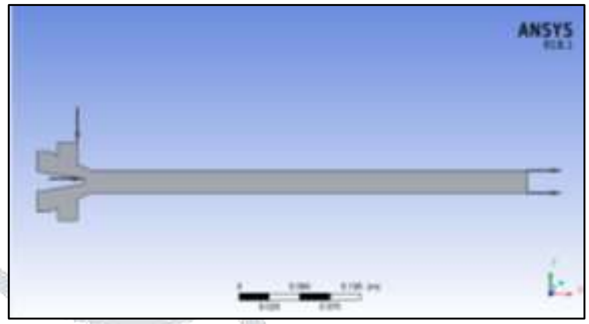

Figure 5: Meshed CAD model in ANSYS

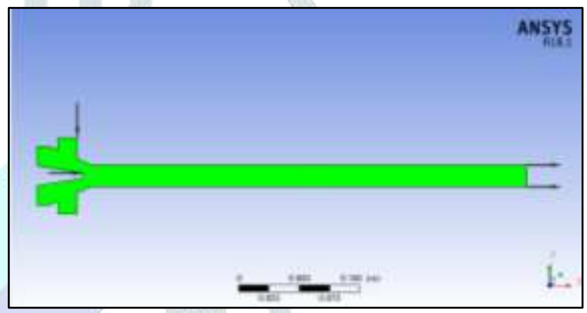

Figure 6: Domain definition

In the current analysis, single domain with different fluids is defined. The first fluid is air (f1) and 2nd fluid is water (f2). The turbulence model used for analysis is k-epsilon and reference pressure is set to 1atm. The domain description is shown in figure 6 above.

Figure 7: Water inlet boundary condition

The water inlet boundary condition is defined with 89.75m/s as shown in figure 7 above.

5. RESULTS AND DISCUSSION

The velocity plot for both fluids i.e. air and water is generated and is shown in figure 8 and figure 9 below. The velocity magnitude is higher at the corner region with magnitude of 250 m/s as shown by red color and reduces when domain area increases as shown by yellow and green colored regions.

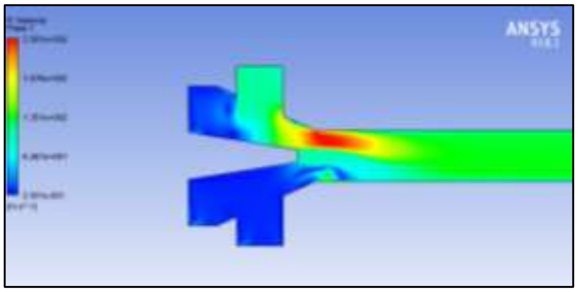

Figure 8: Velocity plot for air

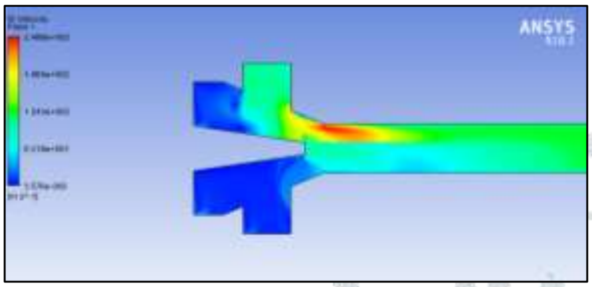

Figure 9: Velocity plot for water

The velocity plot for water is generated and is shown in figure 9 above. Although the velocity inlet for water is defined at 89.75m/s but due to effect of air flow the water velocity decreases to nearly 62m/s and is almost constant as shown in light blue color.

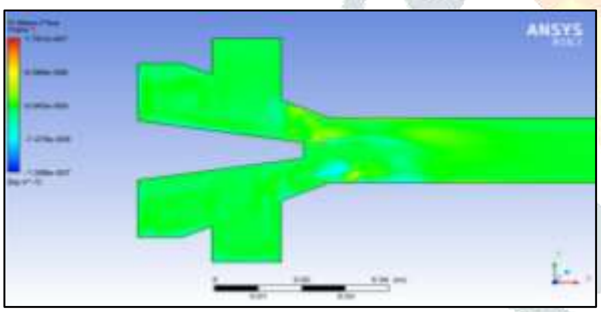

Figure 10: Air mass flow

The mass flow rate for air is shown in figure 10 above. The mass flow rate is constant throughout the domain as shown by green color. The mass flow rate at the corner is minimum as shown by light blue contours.

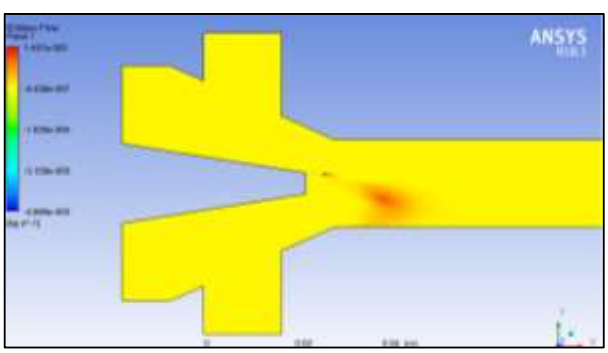

Figure 11: Water mass flow

The mass flow rate for water is shown in figure 11 above. The mass flow rate is constant throughout the domain as shown by yellow color and is maximum at the zone of air water interaction as shown by red colored region.

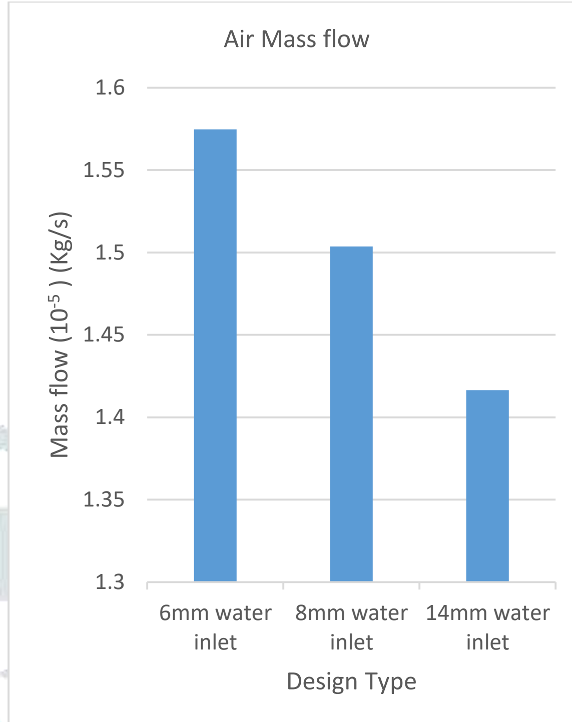

Figure 12: Air Mass flow

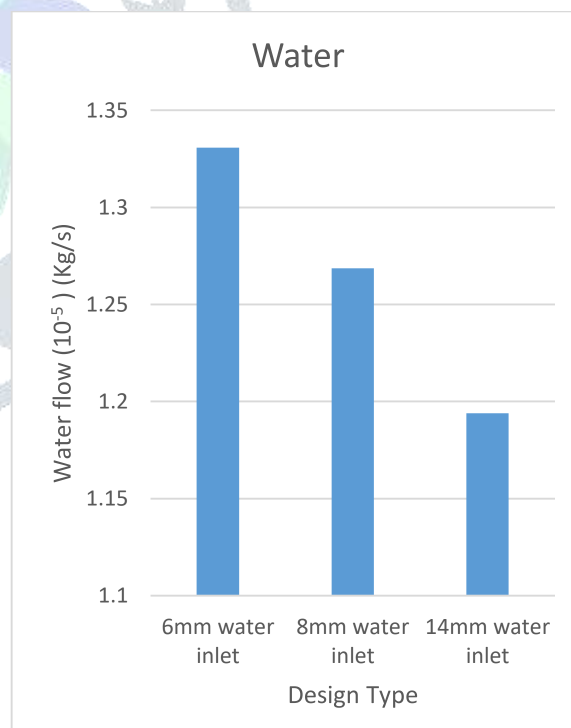

Figure 13: Water mass flow

As can be observed from figure 12 the mass flow rate (at domain exit) of air decreases with increase in water inlet diameter. The maximum mass flow rate is observed for 6mm water inlet which subsequently decreases with increase in water inlet diameter. The minimum mass flow rate is observed for 14mm water inlet. Similarly, it can be observed from figure 13 the mass flow rate (at domain exit) of water decreases with increase in water inlet diameter. The maximum mass flow rate is observed for 6mm water inlet which subsequently decreases with increase in water inlet diameter. The minimum mass flow rate is observed for 14mm water inlet. Therefore, the water inlet diameter has similar effect on mass flow rate of air and mass flow rate of water.

5. CONCLUSION

The performance of foam generator is studied using technique of Computational Fluid Dynamics. The use of computer simulations has significantly reduced computational time without any need of expensive and time-consuming experimental set ups. The mixture of both fluids i.e., air and water results in generation of foam and therefore the study of mass fraction of both fluids is essential. The mass flow rate (at domain exit) of air decreases with increase in water inlet diameter. The maximum mass flow rate is observed for 6mm water inlet which subsequently decreases with increase in water inlet diameter. The minimum mass flow rate is observed for 14mm water inlet.

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