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Computational Study of Domestic Kitchen Chimney for Draft Angle

Mohammad Imam B. Shaikh
M. Tech (CAD/CAM)
Symbiosis Institute of Technology,
Pune , India

Prof. Nitin K. Khedkar
Mechanical Department
Symbiosis Institute of Technology
Pune, India

***Abstract*— Domestic chimney helps to remove heat and moisture and improve room ventilation. For the good ventilation and removal of moisture draft angle of hood type domestic chimney plays very important role. The present study aims at finding proper draft angle for chimney using computational fluid dynamics (CFD) software STAR CCM+ Duct size of chimney varies according to home and kitchen infrastructure. Study considers geometric size variation and checking its performance mainly focusing on draft angle of the chimney. The height of chimney is kept constant that is 1143mm and base hood area is also constant that is 736mm×482mm. Draft angle is varied from 30° to 40°. Cad model is created in CATIA V5 R19 and simulated in STAR CCM+. The best model out of the four models is manufactured and tested. Validation of this project is done by comparing software results with the experimented data.**

Keywords*— Computational fluid dynamics; Chimney; Draft angle; mass flow characteristic

I. INTRODUCTION

Kitchen is very important part of home and cooking is essential, while cooking there are lots of heat and moisture will be generated these fumes needs to be exhausted from our kitchen. For the cleanliness and health purpose using chimney hood at kitchen. . It is estimated that more than three billion people currently rely on biomass as their primary cooking fuel [2]. Since the gas cooking equipment involves combustion and for cooking equipment is used requires sufficient supply of oxygen for the combustion process. Hence, a large ventilation rate is required to meet the combustion and ventilation requirements resulting in high energy consumption. A performance of the exhaust hood is important to remove contaminant and keep good air quality.

In the market there are many type of smoke chimney available they are having inbuilt fans and all mechatronics equipments but these are required electric supply to run. Cost of these chimney are high, when electricity is not there these are not in working condition and room will be full with smoke sometimes it is not affordable too ,so here is concept making the natural conventional hood type chimney without any power supply and aim is to remove maximum amount of smoke from the kitchen,.

Krzaczek M., et al (2015) researcher found that the ventilation stacks are becoming increasingly common in the design of naturally ventilated buildings. [6] To understand the effect of the ventilation system, this study only focused on velocity field, temperature field, relative humidity field, and concentration distribution varying with following whether cooking or not [8]. On the other hand, it is also found that the temperature and velocity distribution of air and airflow rate in chimney are highly dependent on heat flux and chimney gap [5].

As vary in the length of duct result will vary. [2]. Chae M. and Chung B (2015) researcher investigates the heat transfer enhancement of a chimney system, both experimentally and numerically, by varying the height and diameter of the chimney, and the Prandtl number of the working fluid [3]. Sakonidou V., et al (2007) researchers had develop a mathematical model to find out the tilt that increase natural air flow within chimney using daily solar irradiance data on a horizontal plane [15]. Increasing excess air decreased combustion efficiency, increasing the frictional loss coefficient of a chimney by decreasing the diameter was shown to reduce CO production through a reduction of excess air [12].

Duct size of chimney varies according to home and kitchen infrastructure.

In this paper geometric size varying and checking its performance mainly focus on draft angle of chimney. The height of chimney kept constant that is 1143mm and base hood area also constant that is 736mm×482mm. Draft angle is varied from 30° to 40°. Cad model is created in CATIA V5 R19 and simulated in STAR CCM+ best model then manufactured and tested. Validation has done by simply comparing software result with experiment result..

II. NUMERICAL DETAILS

A. Solver details:

Kitchen hood chimney model has been created with the help of CATIA V5 R19 software, four model been created. The height of chimney kept constant that is 1143mm and base hood area also constant that is 736mm×482mm.model (a) is having flat hood, model (b), model (c), model (d) having draft angle 35°, 40°, 45° respectively.

Table 1 Dimension of chimney

Case	Height	Inlet area (mm^2)	Outlet area (mm^2)	Draft angle
Flat	1143	354.:52	64.516	Flat
35°	1143	354.752	54.984	35°
40°	1143	354.752	87.680	40°
45°	1143	354.752	118.502	45°

Meshing has been done with help of star CCM+ number of element use are 500,000 mesh type unstructured polyhedral mesh

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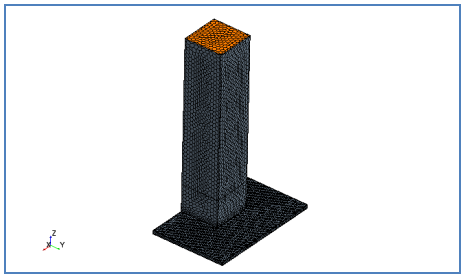

Figure 1 Meshing

The CDF work in this study carried out by using STAR CCM+ solver based on finite volume method. Working fluid was air which was module into ideal gas. The entire model built into CATIA V5 R19 full scale model then import into STAR CCM+ model meshing done boundary condition are apply on basis actual data collection. Here inlet and outlet pressure is atmospheric, inlet temperature 45°C, outlet temperature is atmospheric 26°C. fig.2 In this case, the narrow gap resulted in irregular flow patterns with jet like features Here, in fig.5 the flow is more streamlined and more uniform flow pattern could be observed

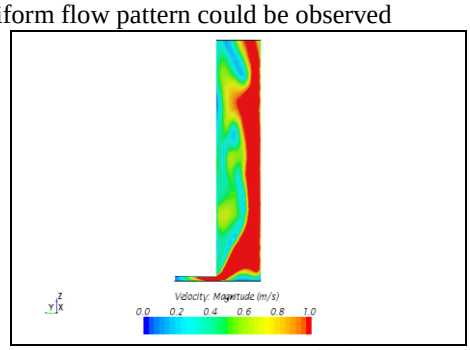

Figure 2 Velocity magnitude for flat case

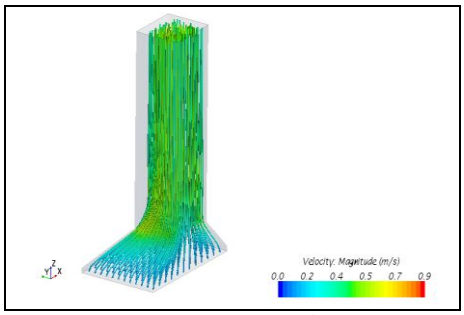

Figure 3 Velocity magnitude for 35° case

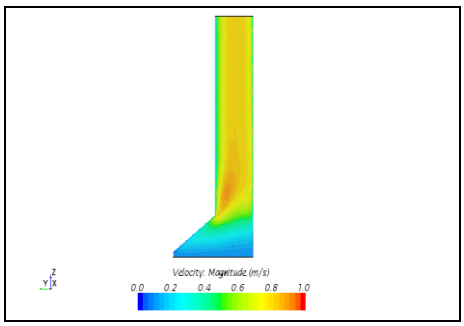

Figure 4 Velocity magnitude for 40° case

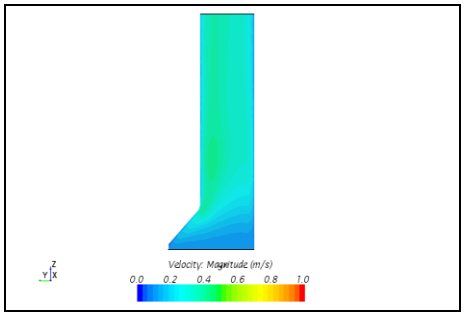

Figure 5 Velocity magnitude for 45° case

Steam Properties
Density: 1.17989 kg/m3
Thermal Conductivity: 0.02603 W/m-K
Dynamic Viscosity: 1.85505e-5 Pa-s
Specific Heat: 1003.62 kJ/kg-K

III. RESULTS AND DISCUSSION

Analyze various Chimney wall designs using experimental and computational fluid dynamics (CFD) simulations for identifying the best performance

The performance of the chimney shall be identified based on the high mass flow [ability to remove high quantity of fluid] for the identical conditions.

The mass flow rate the chimney outlet was calculated based on the velocity. With the help of anemometer, the velocity at the chimney outlet was calculated at various locations. And, the averaged velocity was considered for mass flow rate estimation.

Table 2 Results

Configurations	Mass flow rate, kg/min	
	CFD	Experimental
Flat Walls	2.2836	-
35 Deg	1.9425	-
40 Deg	2.8005	-
45 Deg	4.6346	4.2136

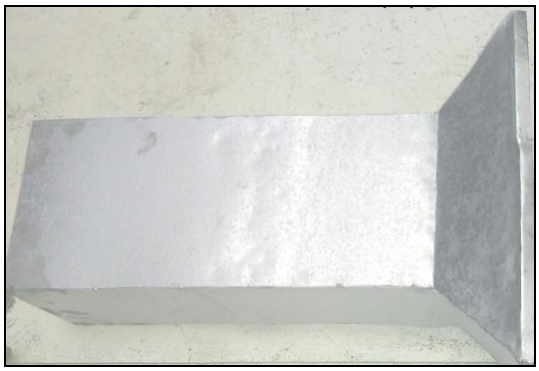

Figure 6 Actual model

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IV. CONLUSION

The effect of different draft angle for domestic chimney hood type chimney is presented. It can be concluded that by varying the angle significant impact in performance of the chimney is observed. The chimney with 45° draft angle gives the best results. In the present study total height and base area kept constant while the effects of variation in draft angle are observed.

For future point of view this project can be extended for commercial chimney and further the effect of change in length and area on the performance can be studied

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