Simulation and Experimental Analysis of Surface Adherence for Air Flow over Tilted Surface

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***Abstract*— Flow of fluid over a surface and its effect has been an interesting topic for research for scientist for years. Adherence effect is the tendency of the fluid to get attached to the adjacent surfaces while the fluid flowing is passing along the wall boundary. This phenomenon of is used in this work to understand the variation in adherence with respect to change in tilt of the surface. This article presents the simulation and experimental analysis of the flow of air over tilted surfaces of different angles. The project was conducted to understand various factors influencing the surface adherence. The CATIA software was used to draw 3D model for the simulation and the simulation analysis was conducted in ANSYS FLUENT. The practical analysis was done with help of wooden setup and equipments at atmospheric pressure. The result of both simulation and practical are presented for comparison and representation of pressure, velocity and outlet discharge distribution along the distance of flow has studied. The motive of the article was to get higher outlet discharge using the principle of surface adherence effect.**

***Key Words*: surface adherence, negative pressure, air flow.**

1. INTRODUCTION

The Surface adherence is defined as a phenomenon in which fluid jet has the tendency to attach to a curved wall surface. In free surroundings, a jet of fluid enters and mixes with its surroundings as it flows away from a nozzle. When a surface is brought close to the jet, this restricts the entry of jet in that region. A pressure difference across the jet occurs and the jet is deflected closer to the surface eventually attaching to it. Even if the surface is curved far away from the initial direction, the jet tends to remain attached. This result is often accustomed amendment the jet direction. In doing thus, the speed at which the jet is commonly considerably augmented compared therewith of a similar free jet.

CAD models for various surfaces were drawn using CATIA software. By using model from the CATIA software simulation of flow of air on different angles of surfaces was performed using ANSYS software.

The practical analysis was done in wooden container with proper equipped instruments. Air flow from the blower was made to pass over different surfaces inclined at various standard angles with vents to get the extra air at the outlet. The angles were increased of flat surface, where the flow was passed over upper surface. Due to Surface adherence, fluid flow gets attached along the angled surface resulting in negative pressure near the space. This made air get sucked through the vents from atmosphere. The fluid flow gets added to main stream flow thereby giving more discharge at outlet. Different angles were tested and same procedure was followed for each angle. Anemometer was used for measuring fluid velocity at different places like blower suction, vents and outlet discharge.

2. LITERATURE REVIEW

Study on the Hysteresis of Coanda effect on flat plate by changing the plate deflection angle and exclusion of Reynolds number was identified. By conducting experiments, different values of forces on plate were obtained. [1]. Study of Surface adherence on Different curved surfaces with variation radius of Curvature was carried out, thereby exploring potential of using the effect on building capable and cheap aerodynamic system. It gave relation between viscous shear on curved surface, drag and thrust with Surface adherence. [2] In the study of directional control of jet using Surface adherence, with increase in velocity of secondary jet and curvature radius leads to greater deflection. Further study was done using CFD which highlighted positive and negative aspects.[3] Fluid flow was done on 3-D Curved wall where fluid jet with different impinging angles was passed onto surface of circular cylinder. This analysis was done using PIV measurements.[4]Flow characteristics of Air Amplifier with Coanda Nozzle was studied. A higher discharge of 20% was obtained with respect to other model. Pressure and velocity distribution graphs were drawn under various operating conditions. [5] Variation of lift was resulted by varying Coanda Profile angle shown by UAV model. Coanda craft was made as a means of delaying flow separation and vortex generator for improving overall perform.[6] Analysis of air flow about convex wall at different angles velocity, and length were done. Performance of flying vehicle is improved by using numerical formula of Surface adherence. [7]

3. SIMULATION

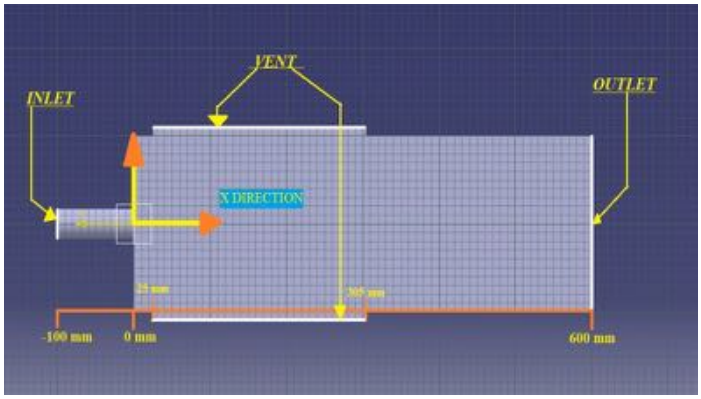

Fig. 3.1 Drafted model

3.1 45^0 ANGLED SURFACE

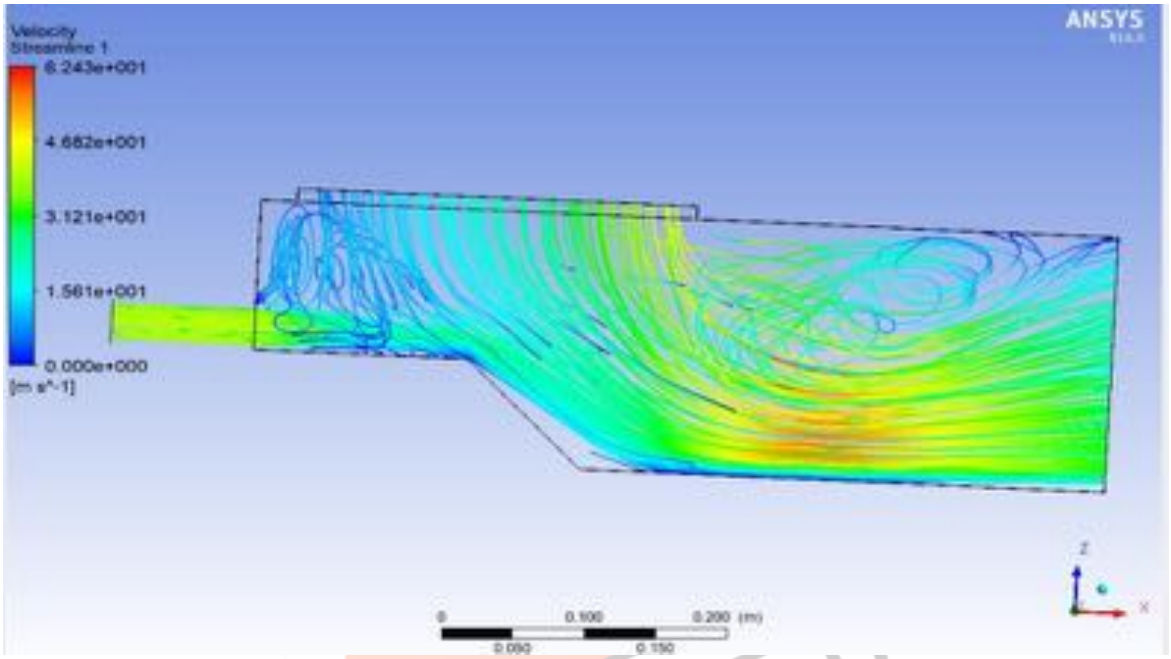

Fig. 3.2 Velocity streamline for the 45^O angled surface

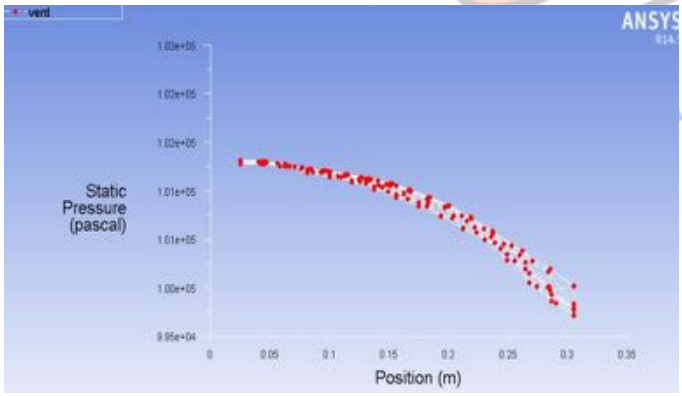

Fig. 3.3 Static Pressure vs. Distance along vent section

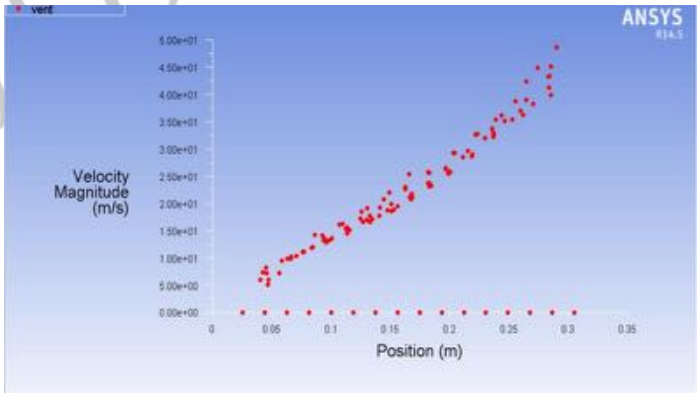

Fig 3.4 Velocity Magnitude vs. Distance for vent

In 45^0 tilted surface, some amount of turbulence is created at the inlet section. From Fig. 3.3 it is seen static pressure decreases with increment in x-direction. 1.8% pressure drop is absorbed at the vent. From Fig. 3.4 variation of velocity magnitude increases with increase in distance along x-axis is observed. The increase in velocity is 8.59%.

3.2 60^0 ANGLED SURFACE

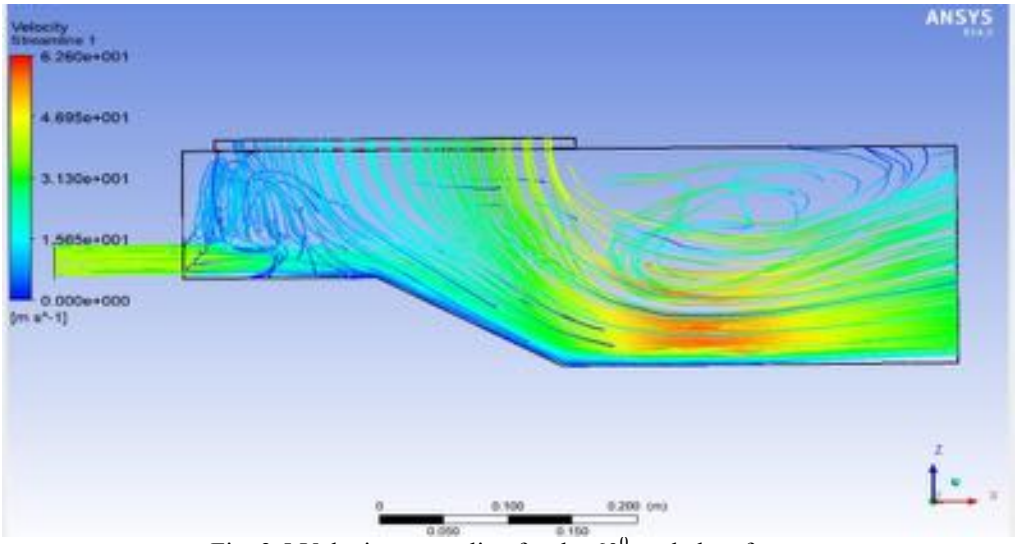

Fig. 3.5 Velocity streamline for the 60^0 angled surface

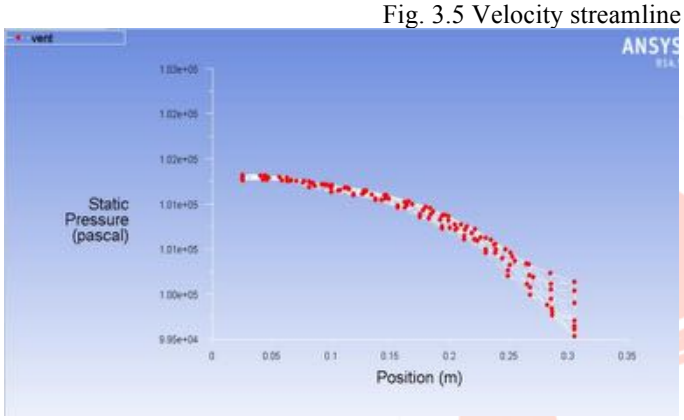

Fig. 3.6 Static Pressure vs. Distance along vent section

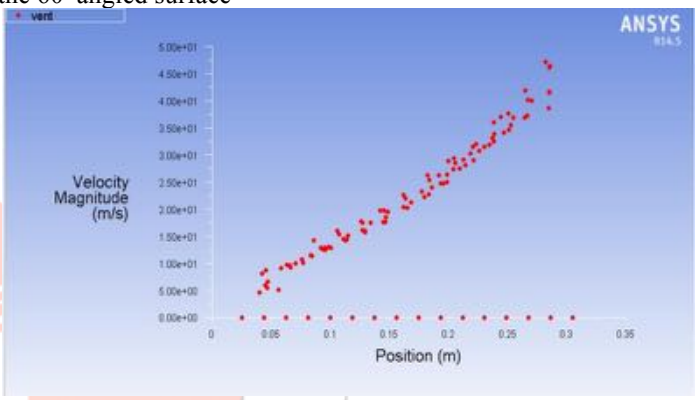

Fig. 3.7 Velocity Magnitude vs. Distance along vent section

For 60^0 angled surface, turbulence is created at inlet section and near the outlet section. The velocity of fluid flow is more in this case. Static pressure decreases gradually at 1.9% with increment along x-axis is shown in Fig 3.6. Velocity magnitude increases with increment along x-axis at 9.39%, shown in Fig 3.7.

3.3. 75^0 ANGLED SURFACE

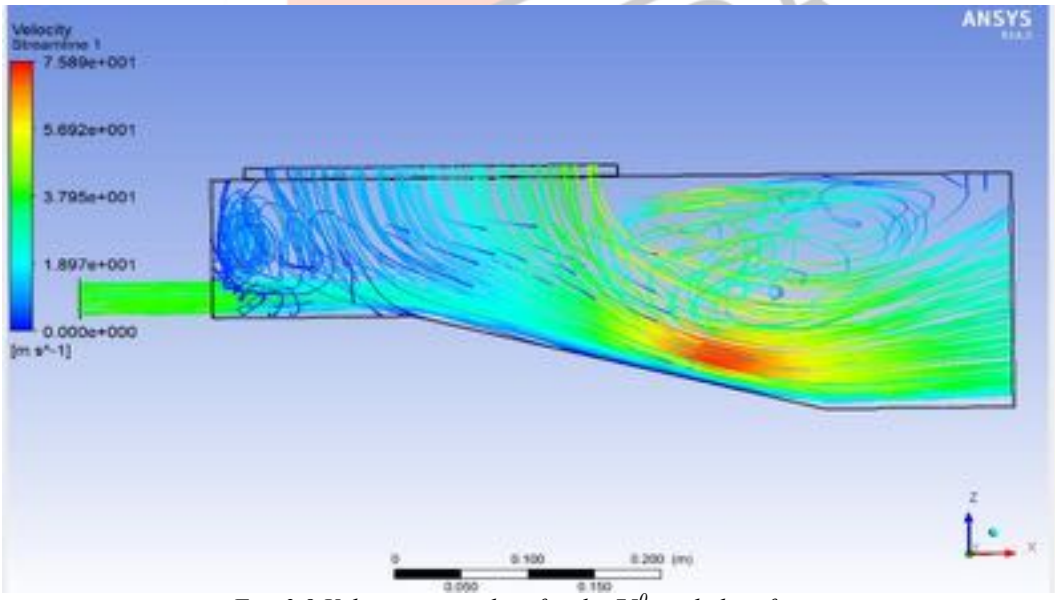

Fig. 3.8 Velocity streamline for the 75^0 angled surface

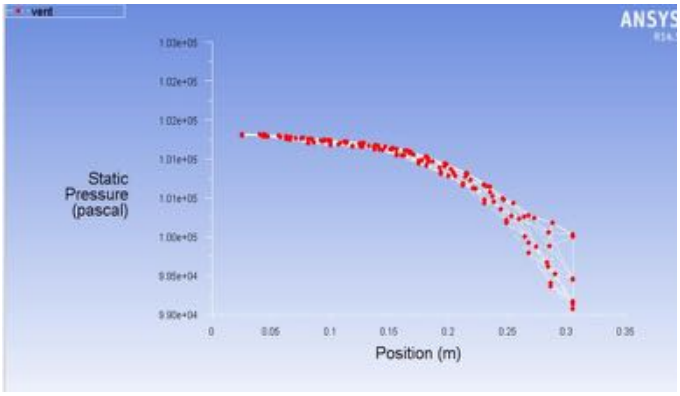

Fig. 3.9 Static Pressure vs. Distance along vent section

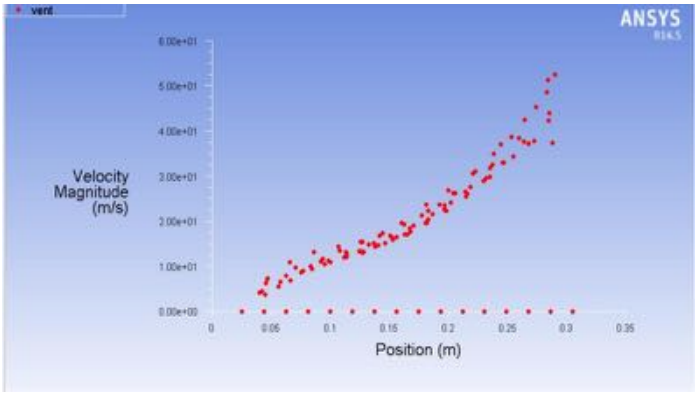

Fig. 3.10 Velocity Magnitude vs. Distance along vent section

In 75^0 angled surface, more turbulence is observed than 45^0 and 60^0. Static pressure decreases gradually with increment along x-axis. The pressure drop about the surface is 2.5%, as shown in Fig 3.9. Velocity magnitude increases at 18% slowly, with increment along x-axis is shown in Fig 3.10.

3.4 90^O ANGLED SURFACE

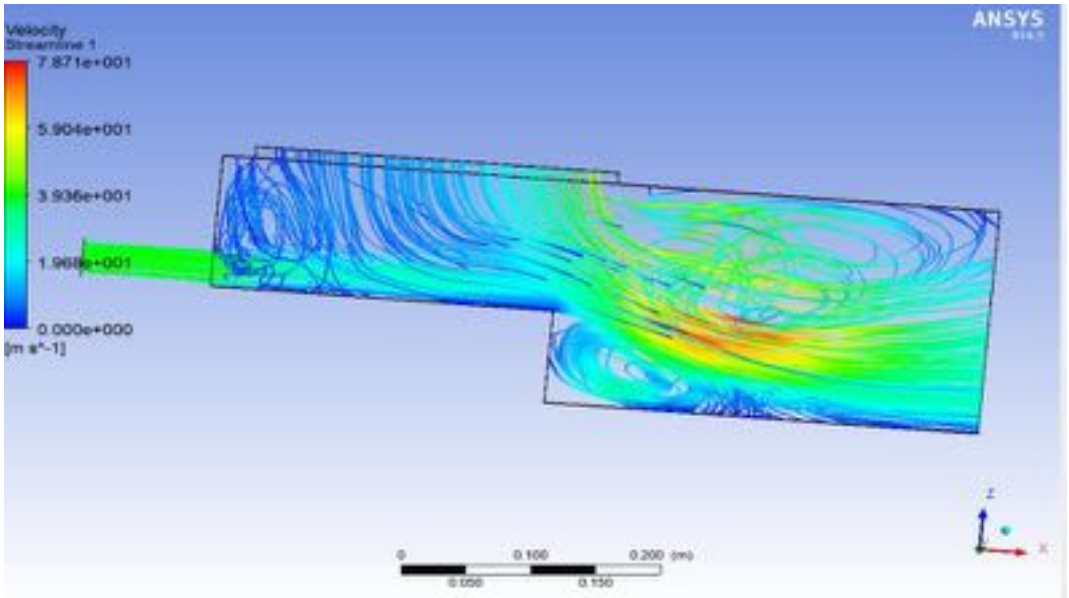

Fig. 3.11 Velocity streamline for the 90^0 angled surface

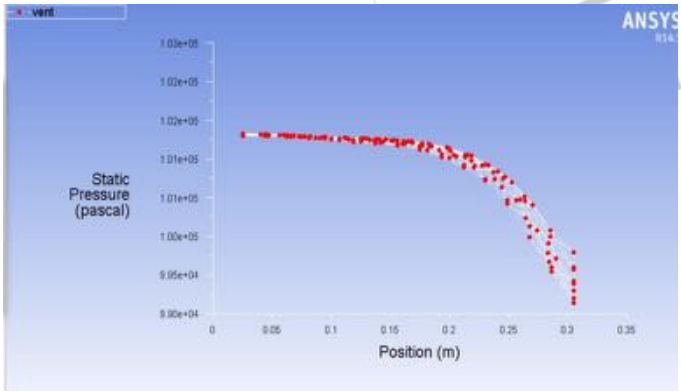

Fig. 3.12 Static Pressure vs. Distance along vent section

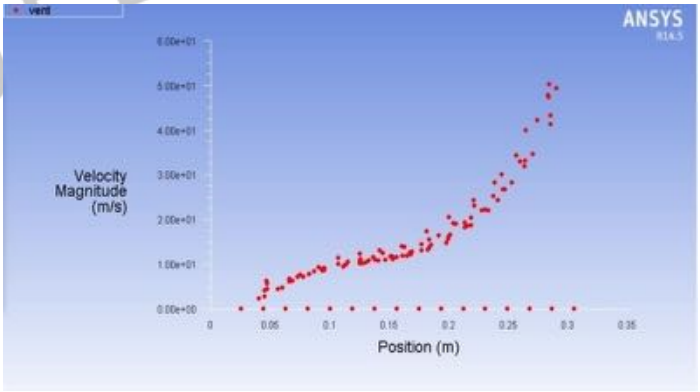

Fig. 3.13 Velocity Magnitude vs. Distance along vent section

In 90^0 angled flat surface is made available for the adherence to the flowing fluid and more negative pressure is observed. Static pressure decreases with increment along x-axis at 2.4%, as shown in Fig3.12. Change of velocity at the vent area has been plotted in Fig 3.13. The velocity increases at 20.77% approx. along the x direction.

4. EXPERIMENTAL SETUP

Sr. No	Parts Name	Specification
1	Blower	Air Volume = 2.3 m^3/min Power Input=500 W
2	Anemometer	Velocity limit= [0.4 - 30 m/sec]
3	Wooden Box	Box Dimension [600×200×180]mm
4	Nozzle	Circular Hole Diameter [Ø35 mm]
5	Flat Surfaces	Surface with angles of 45^0, 60^0, 75^0 and 90^0. Fixed surface length = 150mm Movable surface length = 117 mm

Fig, 4.1 Experimental Set-Up with angled flat surface

Wooden Box having curved surface of fixed surface length = 150 mm and movable surface length = 117 mm with blower to provide airflow.

5. RESULT AND DISCUSSION

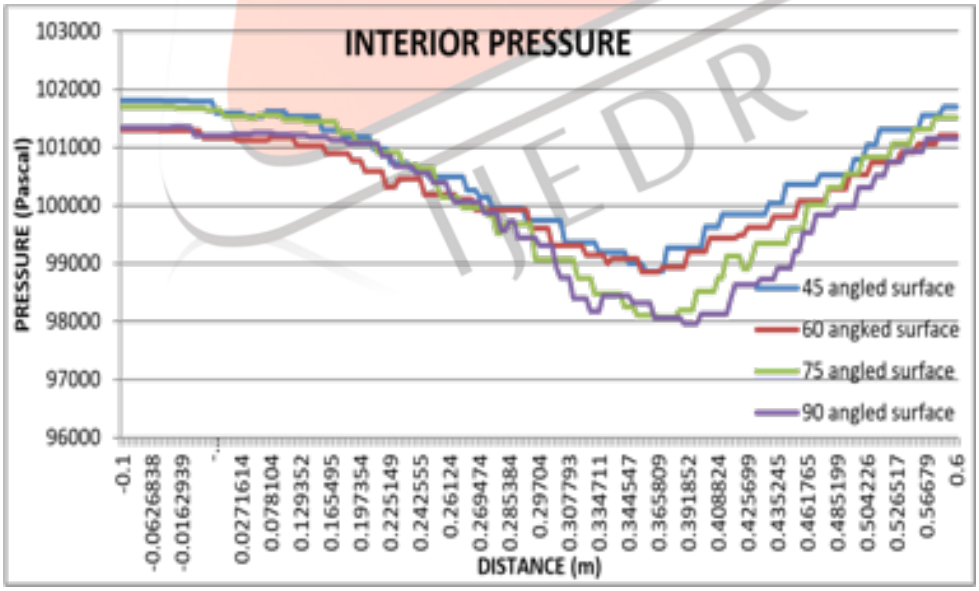

Fig 5.1 Variation of pressure for all angled surfaces at interior section

Fig 5.1 represents the plot of interior pressure for all surface angles. The surface is providing negative pressure for all the angles. This drop in the pressure is creates suction in the system, resulting in greater outlet discharge. Greater outlet discharge is representation of enhanced surface adherence.

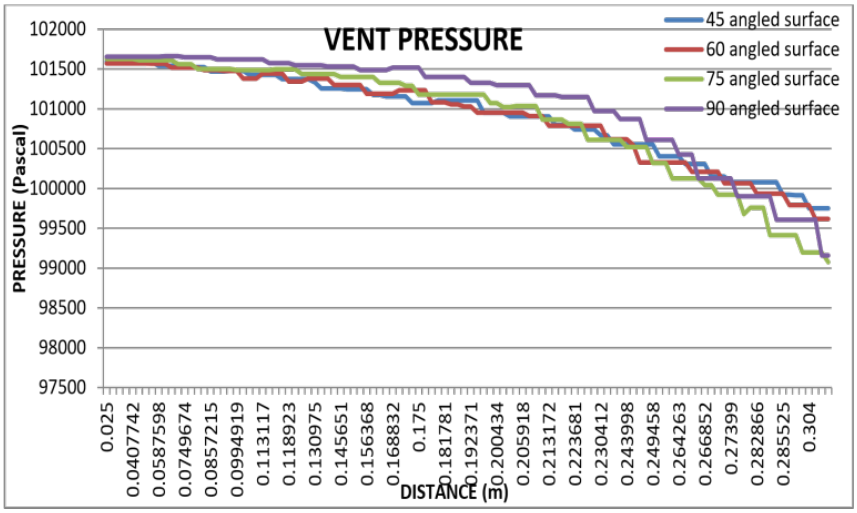

Fig 5.2 Variation of pressure for all angled surfaces pressure at the vent section

The drop in the pressure about the surface is also creating negative pressure at the vent area. Fig 5.1 and Fig 5.2 shows significant pressure drop about the surface.

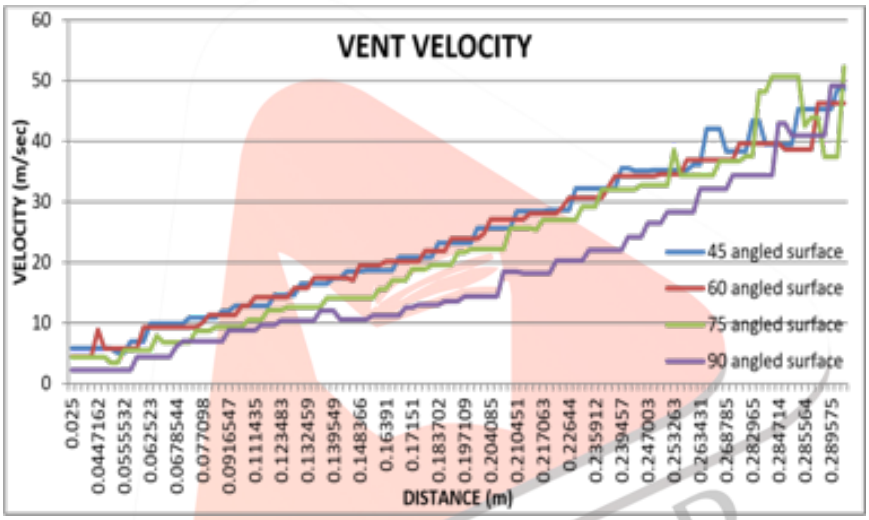

Fig 5.3 Variation of pressure for all angled surfaces velocity of air at vent section

The vent area suffers drop in the pressure due to suction of air and the velocity of air at the vent increase as it adheres on the surface. This increase in the velocity is observed in both simulation and the practical results.

The interior pressure and the pressure at the vent, for all the tilted surface drop about the surface provides suction pressure for the atmospheric air, the plot for both pressure drops is shown in Fig 5.4 and Fig 5.5.

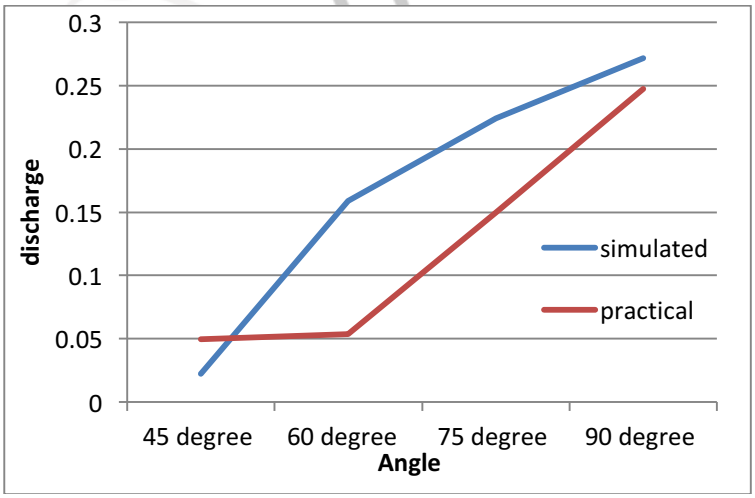

Fig 5.7 Outlet discharge for all angled surfaces

As we increase the angle of the surface, the discharge at the outlet increases. This is due to adhesion of fluid on the surface, resulting in negative pressure.

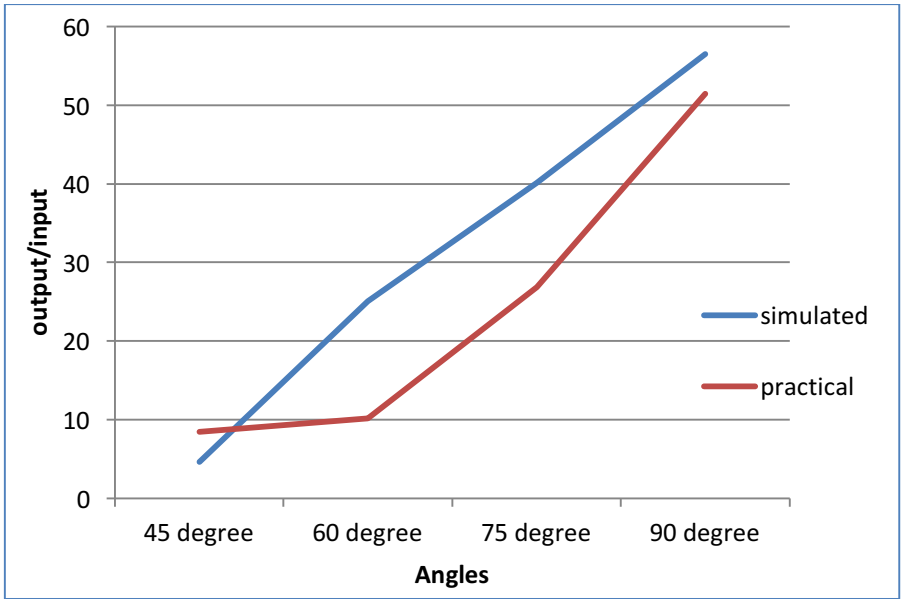

Fig 5.8 Output/Input for all angled surfaces

From Fig.5.8, it is observed that suction created due to adhesion of fluid, increases with increase in angle.

6. CONCLUSION

This study expresses the behavior of the air flow with respect to the surfaces which were analyzed. For the study of flat surfaces with different angles were studied. Simulated and the practical analysis were performed to get the behavior of the air profile about all the surfaces. It is observed that with increase the angle, the adherence of the air to the surface increased resulting outlet discharge to be increased. Hence the Surface adherence providing greater negative pressure in the system as we increase the angle, thus creates suction at the vents and increasing discharge at outlet.

7. REFERENCES

[1] Aldona Skotnika – Siepsiak, ― Hysteresis of the Coanda effect‖, Journal of Fluids Engineering Research, (March 10, 2017)

[2] Md. Rezaur Rahman , Department of Mechanical Engineering, Khulna University of Engineering & Technology, Bangladesh , (2018)

[3] Florin Frunzulica, Daniel Crunteanu , ― Directional control of a jet using the Coanda Effect, American Institute of Physics, (2016)

[4] Julian Tan Kok Ping, ― Coanda effect test Bench (CoETB) – Design Enhancement of the Coanda craft‖, IEEE University of Malaysia , (Oct-11)

[5] Mirae Kim, Hun Dong Kim , ― Flow characteristics of 3D curved wall jets on Cylinder , Journal of fluid Engineering (June 2017)

[6] J.M.Lee ,M.Y.Cho , ― Effect of Coanda Nozzle Clearance On The Flow Characteristics Of Air Amplifer, Graduate School Of Mechanical Engineering ,Sungkyunkwan Korea (2016)

[7] Crivoi , I Doroftie , ―Some Experimental Result on Coanda effect With Application of Flying Vehicle. University of Romania 2016