EFFECT OF SPLITTER VANES ON BLOWER PERFORMANCE

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ABSTRACT

A Centrifugal air blower is a mechanical device which uses centrifugal force to propel air forward. Inside a centrifugal air blower is a wheel with small blades on the circumference and a casing to direct the flow of air into the center of the wheel and towards the edge. Splitter vanes are additional, smaller airfoils that are placed circumferentially between the main blades of the rotor to improve overall performance in terms of velocity and pressure distribution. The diffusion of flow process is highly complex in blower operation which affects the performance of the blower. The performance of the blower can be enhanced by introducing splitter vanes at judiciously selected locations with optimized parameters. This project aims at studying the effect of splitter vanes on the performance of the blower and redesigning the existing blower with splitter vanes. The modified blower is then analyzed using CFD and the results are compared with the existing blower.

Keywords: Centrifugal blower, Impeller, Splitter vanes, CFD

1. INTRODUCTION

1.1. Centrifugal Blowers

A centrifugal blower is a mechanical device for moving air or other gases. These blowers increase the speed of air stream with the rotating impellers. They use the kinetic energy of the impellers or the rotating blade to increase the pressure of the air/gas stream which in turn moves them against the resistance caused by ducts, dampers and other components. Centrifugal blowers accelerate air radially, changing the direction (typically by 90^{o}) of the airflow. They are sturdy, quiet, reliable, and capable of operating over a wide range of conditions. It has a blower wheel composed of a number of blower blades, or ribs, mounted around a hub. The gas enters from the side of the blower wheel, turns 90 degrees and accelerates due to centrifugal force as it flows over the blower blades and exits the blower housing.

1.2. Backward-Inclined and Backward-Curved Air Blowers

A backward-inclined blower, operating at roughly twice the speed of a forward-curved air blower, has flat blades that slant away from the direction of travel. This type of blower is highly efficient (low horsepower requirement) and has a rugged construction suitable for high static pressure applications. This type of air blower is best used in locations where the air is either clean or mildly contaminated. Similar to this style is a backward-curved air blower. The blades of a backward-curved blower are a single thickness throughout and curve away from the direction of travel. These blades are sturdier than backward-inclined blades and can be used in corrosive and erosive environments.

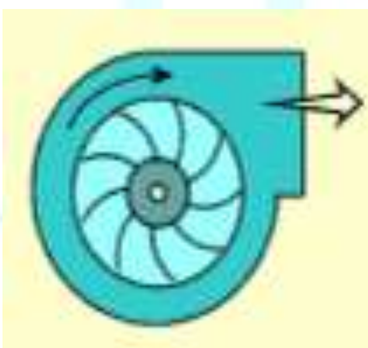
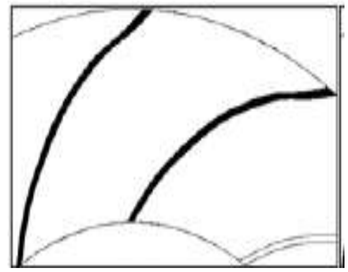


Fig.1. Backward curved centrifugal blower

1.3. SPLITTER VANES

In the process of Air Blower design, Splitter vanes could be adopted in the rotor to improve the blower performance. Generally, the performance of a centrifugal blower could be enhanced by introducing Splitter vanes at judiciously selected locations. An extensive numerical whole field analysis on the effect of Splitter vanes placed in discrete regions of suspected separation points is possible using CFD.



(a) Without splitter vanes

(b) With splitter vanes

Fig.2. Splitter Vanes

1.4. COMPUTATIONAL FLUID DYNAMICS

Computational fluid dynamics, usually abbreviated as CFD, is a branch of fluid mechanics that uses numerical methods and algorithms to solve and analyze problems that involve fluid flows. Computers are used to perform the calculations required to simulate the interaction of liquids and gases with surfaces defined by boundary conditions.

2. LITERATURE REVIEW

- **C.N. Jayapragasan et.al [1]** investigated three different volute geometries using CFD. And then two new volute geometries are modeled and analyzed based on the air flow through the blower. The numerical investigation revealed that blowers with modified volute geometries have better outlet velocities. It was found that air gets obstructed between the tongue geometry and the impeller. To overcome these problems volute parameters like radial distance between impeller and volute and tongue geometry are modified. It was also found that radial gap of 10mm between impeller and volute giving better result.

- **Liu Jitang et.al [2]** proposed that splitter vanes could be adopted in the middle of the rotor to improve air blower performance using CFD. Standard k - ε turbulence model and unstructured grids are applied in computation. The results showed that the air flow was increased by 5% and the outlet pressure increases more than 10%.

- **Madhwesh.N et.al [3]** analyzed the effect of splitter vanes using CFD and the conclusion was that Splitter vanes provided at the circumferential mid-span between two impeller vanes provided relatively large static pressure recovery of the fan than splitter vanes at leading edge and trailing edge of the impeller.

- **N. Yagnesh Sharma and K. Vasudeva Karanth [4]** explained that the converging suction slots located on the impeller blade about 25% from the trailing edge, significantly improves the static pressure recovery across the fan. Also it is found that slots provided at a radial distance of about 12% from the leading and trailing edges marginally improve the static pressure recovery across the fan.

3. FINDINGS

From the literature survey, the following conclusions can be made about the effect of Splitter Vanes on the performance of the blower:

- Introduction of Splitter vanes on the impeller blades can enhance the performance of the blower.
- Splitter vanes can improve the velocity and pressure distribution of the blower when compared with the blower without splitter vanes.
- While installing the splitter vanes, its structure should be carefully considered.
- The length of the splitter vanes affects the air flow and hence the length should be optimized.
- Splitter vanes located at impeller leading edge improves the static pressure recovery of the fan.
- Splitter vanes provided near to the trailing edge of the impeller adversely affect the static pressure recovery of the fan.
- Splitter vanes adopted in the middle of the impeller increased the air flow of the air blower by more than 5% and the outlet pressure is increased by more than 10%.
- The important parameters involved in the design of splitter vanes are Length and Thickness of the Splitter vanes, Number of Splitter Vanes and Position of the Splitter Vanes on the impeller.

4. PROBLEM DEFINITION

In a Centrifugal blower the flow field is highly complex with the flow reversal taking place on the suction side of the impeller. This adversely affects the performance of the blower. To enhance the performance, Splitter Vanes can be introduced. From the literature survey it is clear that, introduction of splitter vanes at judiciously selected locations on the impeller improves the velocity, static pressure recovery and the performance of the blower. But the optimized position and parametric values of the splitter vanes is not reported as per the literature survey which has to be determined in this work.

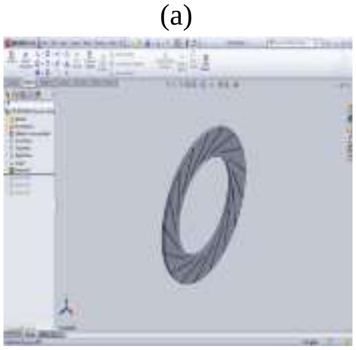
5. OBJECTIVES

This project aims at the following objectives:

- To Study the Effect of Splitter Vanes on Blower
- To redesign the impeller with splitter vanes
- To analyze the blower performance using CFD

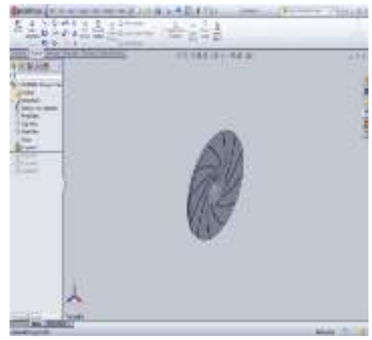
6. MODELING

(a)



(b)

Fig.3. (a) Volute (b) Stator



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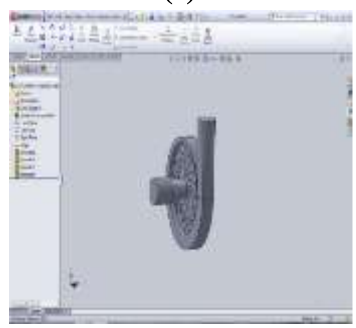
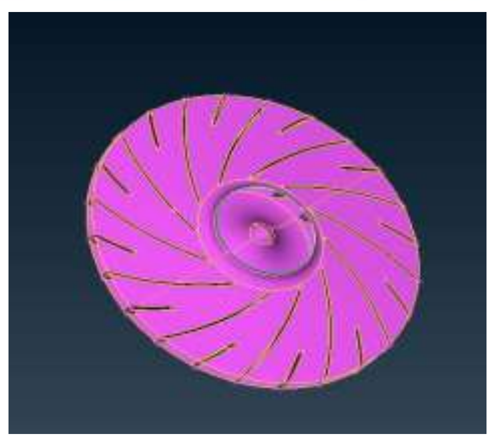


(b)

Fig.4. (a) Impeller (b) Assembly

7. MODIFIED DESIGN

The base model is modified by introducing splitter vanes in the middle of the impeller and 2 splitter vanes per blade.



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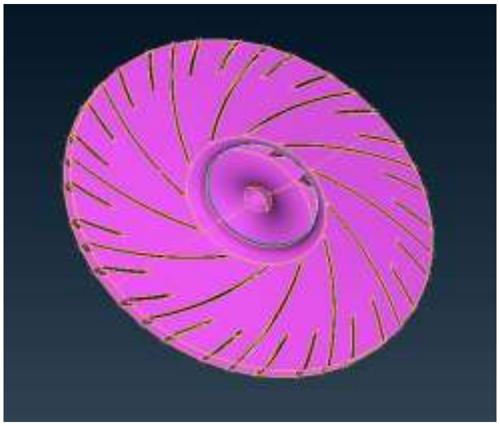


(b)

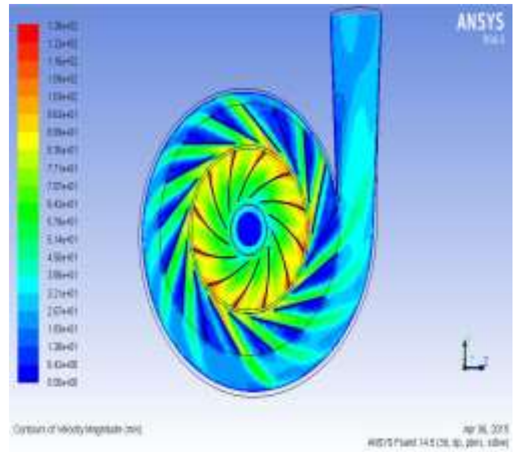
Fig.5. (a) Splitter at middle of the blade
(b) Two Splitters per blade

8. CFD ANALYSIS

For CFD analysis the following where the boundary conditions assumed:

1	Medium	Natural Gas	Density = 37.24 kg/m^3
2	Turbulent model	K-ω SST model	
3	Moving reference frame	Impeller	Velocity = 5400rpm
4	Inlet Conditions	Static pressure	Pressure = 290000Pa
5	Outlet conditions	Mass flow rate	To be found
6	Flow	Steady state flow	
7	Solver	FLUENT CFD	

8.1. Base Model



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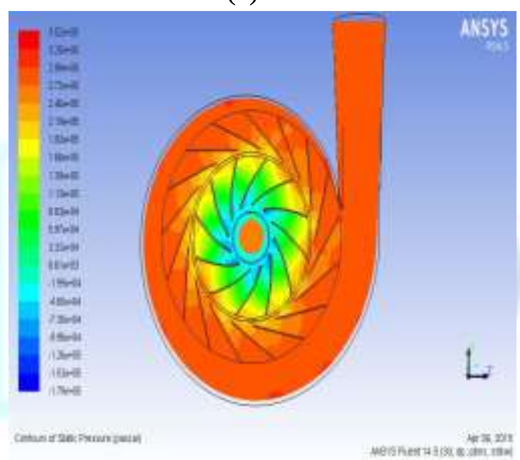
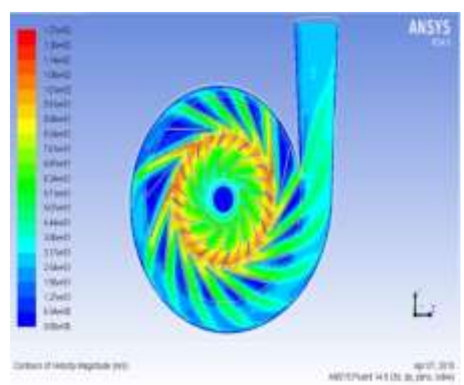


(b)

Fig.6. (a) Velocity (b) Static Pressure

8.2. Splitter vane at middle of the blade



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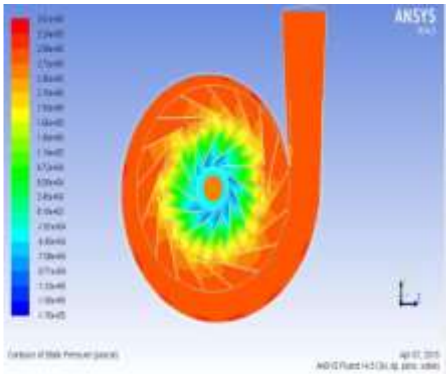
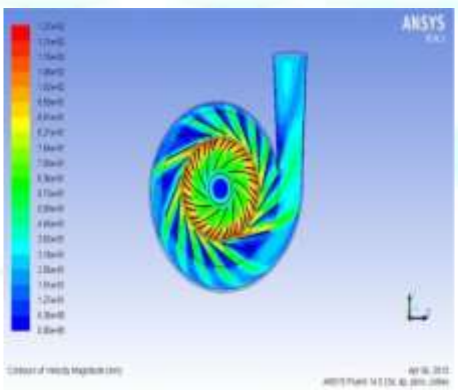


(b)

Fig.7. (a) Velocity Magnitude (b) Static Pressure

8.3. Two Splitter vanes per blade



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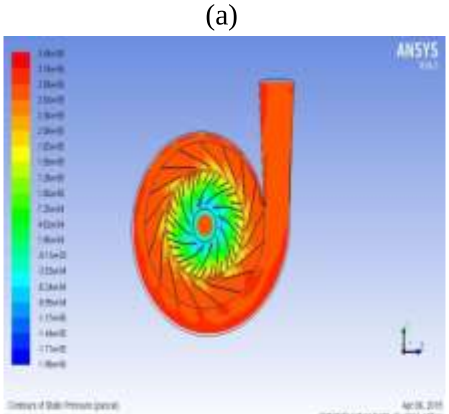

(b)

Fig.8. (a) Velocity Magnitude (b) Static Pressure

9. RESULTS

From the CFD analysis, the mass flow rate, outlet velocity and static pressure at inlet have been found.

Table 1: Parameter Values

Parameters	Base Model	Splitter Vanes at middle of the blade	Two Splitter Vanes per blade
Static pressure outlet (Pa)	290000	290000	290000
Static pressure inlet (Pa)	-11199.707	-13717.229	-13215.819
Velocity at Outlet (m//s)	25.3115	28.2261	27.1342
Mass flow rate (kg/s)	28.659	31.691099	31.13275

10. CONCLUSION

From the results it is clear that splitter vanes have effect on the performance of the blower. Introduction of splitter vanes increases The mass flow rate and outlet velocity of the blower to a certain extent.Following conclusions can be made from the results:

i) Splitter Vanes at middle of the blade increases the performance of the blower by 10.58% in terms of mass flow rate and 11.51% in terms of outlet velocity.

ii) 2 Splitter vanes per blade increase the performance of the blower by

8.63% in terms of mass flow rate and 7.2% in terms of outlet velocity.

iii) Comparing the results, blower with splitter vanes at middle of the impeller blade has better performance than blower with 2 splitter vanes per blade on the impeller.

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