ISSN (e): 2250 – 3005 || Vol, 04 || Issue, 7|| July – 2014 ||
International Journal of Computational Engineering Research (IJCER)

A Numerical Study and Performance of a Sirocco Fan Using Contra-Rotating Rotors

V.Ragavendra Vamsi Krishna[1] M.Lava Kumar[2]
[1] (Department of Mechanical Engineering, G.P.R College of Engineering, Andhra Pradesh, India)
[2] Assistant Professor (Department Of Mechanical Engineering, G.P.R College of Engineering, Andhra Pradesh, India)

ABSTRACT:
A sirocco fan is a centrifugal fan with a forward curved blade. It is used for low pressure but has a large discharge use. The outlet port of this fan may have a rectangular shape. Indeed, a forward-curved vane can give large momentum to the fluid, but it cannot make for better efficiency. A sirocco fan using contra-rotating rotors in which an inner rotor is settled inside the sirocco fan rotor and each rotor rotates in an opposite direction was proposed for the purpose of getting the higher pressure and making the structure of a sirocco fan more compact. In this thesis, analysis is carried out with two models of sirocco and sirocco fan with contra rotating rotors by varying number of blades (50, 45&40) are analysed. CFD analysis is done on all the models of sirocco fan and sirocco fan with contra rotating rotors running at speeds of 800rpm and 2000rpm. Steady state Structural analysis carried out with two models to verify the strength of the Blades.

KEY WORDS: *Sirocco fan, forward curved vane, Contra-Rotating rotors, Strength*

I. INTRODUCTION

Sirocco low-pressure fans consist of a rugged, welded spiral housing in which a dynamically balanced ventilation impeller, with (usually) forward-curved shovels. Low-pressure fans stand out through near-constant pressure over a wide volume spectrum, low-noise operation as well as stable controlling at low counter pressure. Three types of drive are on offer: direct drive (the impeller is directly situated on the shaft end of the drive motor); belt drive (the drive is carried out by a belt drive) or coupling drive (the drive is carried out by the coupling). In addition, there are two types of construction: one-sided suction (SI) and double-sided suction (DI). Main application areas for low-pressure fans are industrial ventilation systems and extractor systems, as well as suck-blowers in the boiler construction. A sirocco fan using contra-rotating rotors in which an inner rotor is settled inside the sirocco fan rotor and each rotor rotates in an opposite direction was proposed for the purpose of getting the higher pressure and making the structure of a sirocco fan more compact. If the high discharge pressure is obtained with the adoption of the contra-rotating rotors, it could be used for various purposes. Pressure coefficient of a sirocco fan with contra-rotating rotors is high as the conventional sirocco fan and the maximum efficiency point of contra-rotating rotors shifts to larger flow rate than a conventional sirocco fan. On the other hand, it was clarified from the flow measurement results that circumferential velocity component at the outlet of the outer rotor of contra-rotating rotors becomes larger than a conventional one.

II. LITERATURE SURVEY

Extensive work has been reported in the literature on sirocco fan with contra rotating rotors. Fukutomi et.al [1] have studied performance and internal flow of sirocco fan using contra rotating rotors with varying number of blades and concluded that the pressure coefficient of a sirocco fan with contra rotating rotors is 2.5 times as high as the conventional sirocco fan. Yohan Jung et.al [2] have considered a numerical study on the flow behavior of an automotive sirocco fan and concluded that the improvement of efficiency could be achieved by reducing the width of impellor. Stefan Funk et.al[3] conducted design and improvements of sirocco fan by means of Cfd and concluded that the computational fluid dynamics in conjunction with particle image velocimetry is a useful way to reliable improve sirocco type fans.

III. MODELING AND MESHING, ANALYSIS OF SIROCCO FAN

The sirocco fan with contra rotating rotors is generated by GAMBIT software. The inner and outer rotor circles are created by selecting face command create circle. And the duct is created by joining the key

points. The blade profile is created by selecting the edge command curve. And by joining the curves face of the blade is generated. By selecting face command copy or move and mention the number of blades it creates by rotation of 360°. And same procedure is carried out by creating contra rotating rotors with varying number of blades (50, 45&40). And the meshing is done in work bench for accurate meshing. And import the mesh file in FLUENT, then define model and mention the boundary conditions. In ANSYS the structural analysis is carried out by model is discretised using solid element (solid 20 node95). And by applying the pressure loads and find out the maximum stresses induced in the blade.

IV. NOMENCLATURE

D1 Rotor inlet diameter

D2 Rotor outlet diameter

Z Blade numbers

N1, N2 Speeds of the blade rotation

E Young's Modulus

μ Poisson's ratio

4.1 Details of sirocco fan

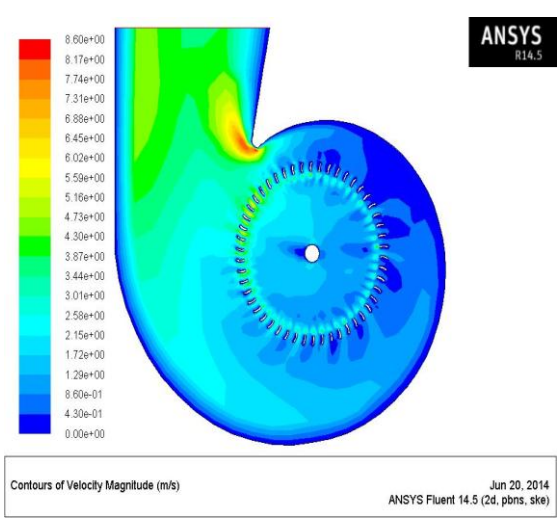
D1 =190mm, D2=210mm, Z=50, 45&40, N1=800rpm, N2=2000rpm,

4.2 Material properties of steel

E=205000mpa, μ=0.29

V. RESULTS AND DISCUSSIONS

The sirocco fan using contra rotating rotors was proposed for the purpose of getting higher pressure and making the structure is compact. The Cfd analysis is carried out with different number of blades of 50, 45&40 consisting of two models using a turbulence Realizable k-ε model. It is observed that the fig 1 the velocity is increases at the out let of the sirocco fan. The maximum velocity is obtained as 8.62m/sec because of the air is entered at the velocity of 7.985m/sec. From fig 2 it is observed that the maximum pressure of the sirocco fan is 34.5pa. By increasing the speed of the sirocco fan the outlet velocity and pressure is also increases. By observing the fig3 the inlet velocity if blades are 19.785m/sec. the maximum velocity of sirocco fan is obtained as 21.3m/sec. and it is observed that the fig 4 the static pressure is increases with increasing the speed of the blades, and it is obtained as 208pa.



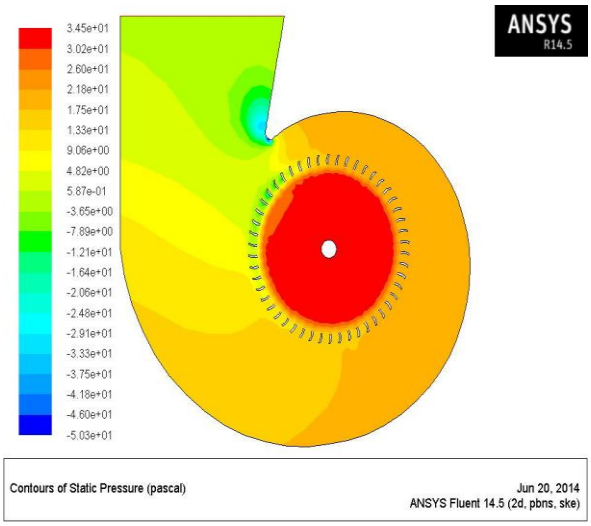
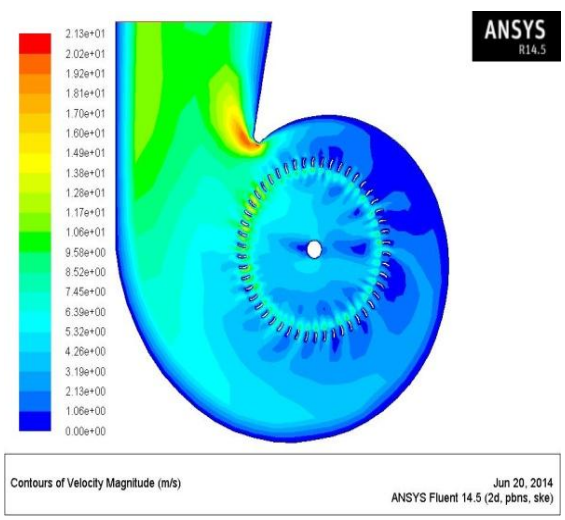


Fig 1 Velocity magnitude at speed of 800rpm Fig 2 Static Pressure at speed of 800rpm



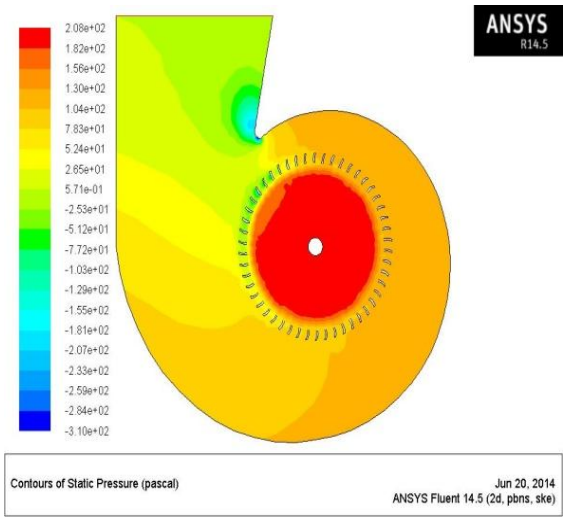
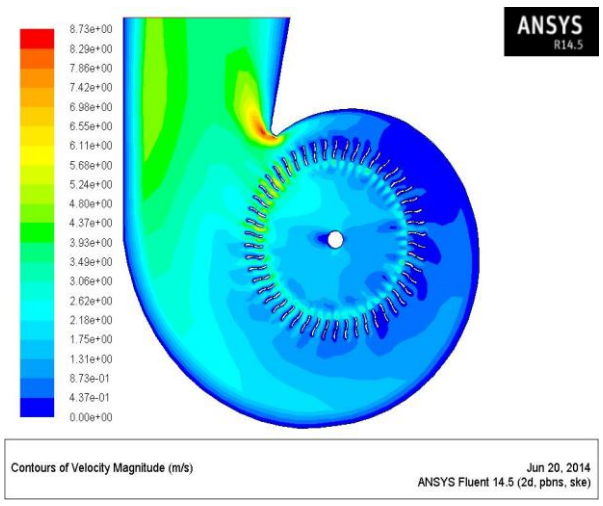


Fig 3 Velocity magnitude at speed of 2000rpm Fig 4 Static Pressure at speed of 2000rpm

The sirocco fan with contra rotating rotors is used for developing the higher pressures with more compact structure. By observing the figs 5&6 the velocity of the sirocco fan is increasing with addition of contra rotating rotors, and it is obtained as the 8.73m/sec, and the pressure of the sirocco fan is also increases with contra rotating model and it is obtained as the 34.7pa. By increasing the speed of the blades the velocity and pressure also increases. By adaption of contra rotating rotors with the inlet velocity of blades is 19.785m/sec. it can be observed that figs 7&8, the maximum velocity of fan model containing 50 blaes is 21.5m/sec and the pressure is obtained as 215pa. It is found that the pressures of the sirrocco fan is increased with adaption of contra rotating rotors. The steady state structural analysis is carried out with two models of sirocco fan and sirocco fan with contra rotating rotors with containing 50 number of bades. By observing the figs 9&10 the stresses are developed in sirocco fan model is less than the sirocco fan with contra rotating rotors. And these stresses are varied at the section of veocity inlet to the velocity exit. And it is found that the induced stresses of the both models are with in allowable limits.By observing the figs 11&12 the velocity and the static pressure of the contra rotating rotors is higher than the sirocco fan with varying number of blades. And it can be observed that the models contsisting of 50 blades are having maximum pressures and the decreasing number of blades the pressures also decreases. By observing the fig 13 the mass flow rate is maximum for the sirocco fan with contra rotating rotors consisting of 50 number of blades. By observing the figs 14, 15&16 whenever the inlet velocity of blade speed is increases then the veocity,pressure and the mass flow rates are increases. It can be found that the sirocco fan with contra rotating rotors are developed under the high discharge pressures without changing the structure of the sirocco fan.



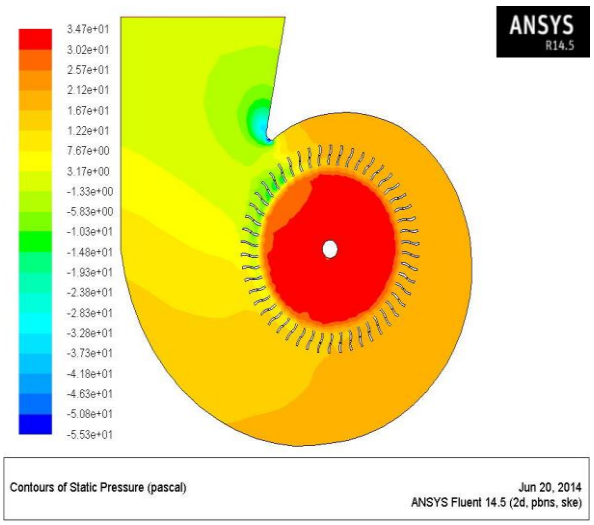


Fig 5 Velocity magnitude at speed of 800rpm **Fig 6 Static Pressure at speed of 800rpm**

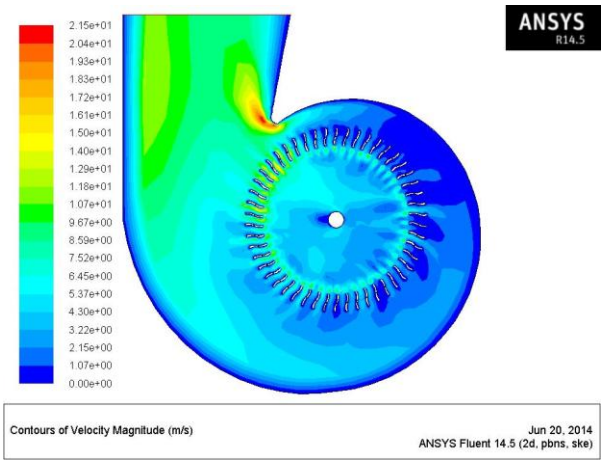


Fig 7 Velocity magnitude at speed of 2000rpm

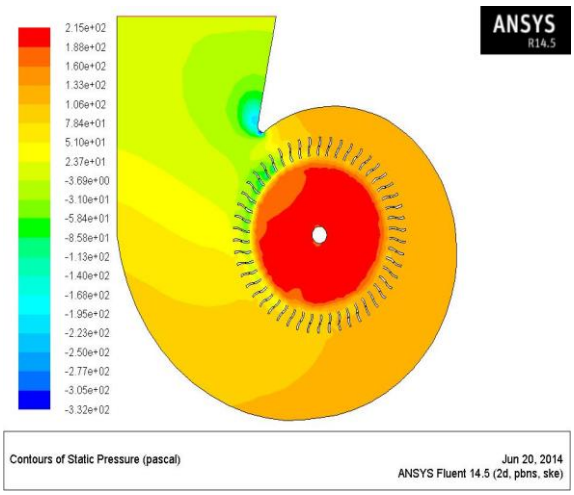


Fig 8 Static Pressure at speed of 2000rpm

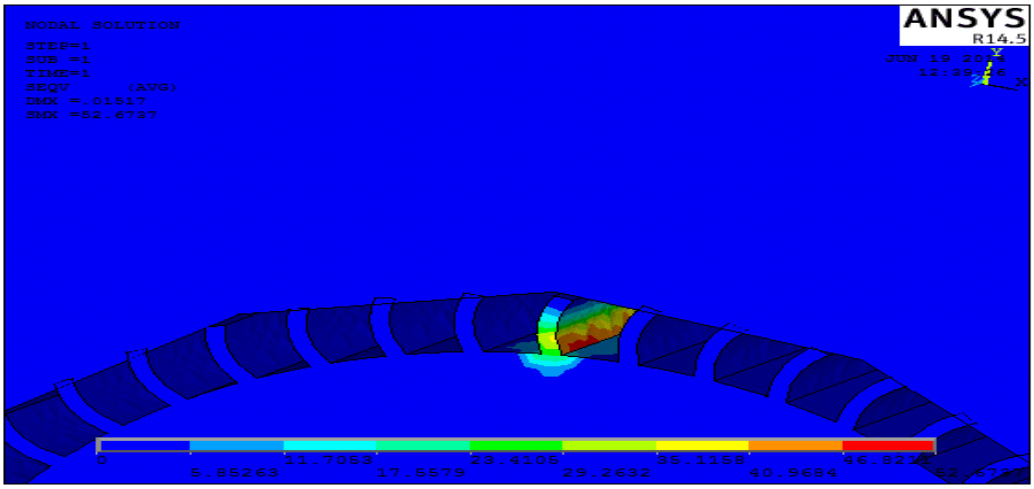


Fig 9 Von Misses Stress for sirocco fan

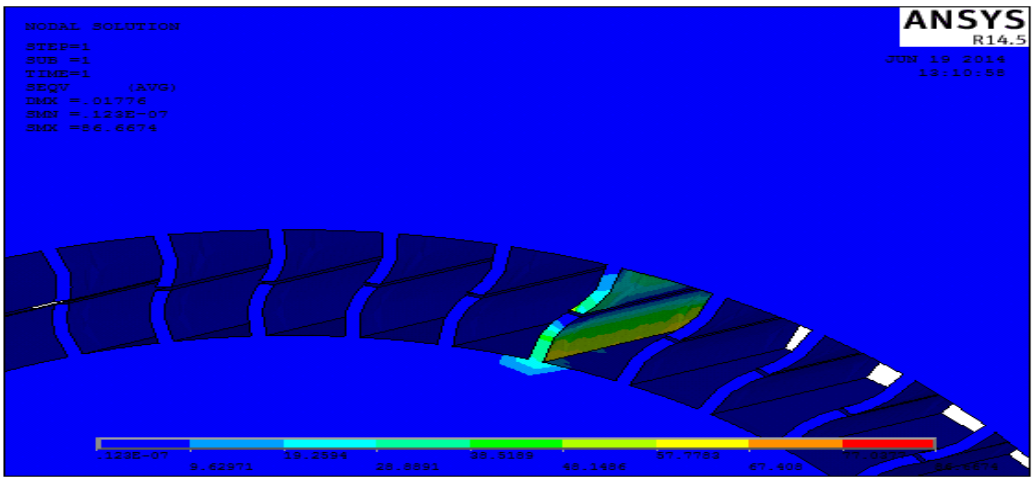


Fig 10 Von Misses Stress for sirocco fan with contra rotating rotors

Table 1 Sirocco fan at a speed of 800 rpm

Number of blades	50	45	40
Velocity magnitude (m/s)	8.60	7.76	6.84
Static Pressure (Pa)	3.45e+01	2.92e+01	2.51e+02
Turbulent Kinetic Energy (m^2/s^2)	9.91	9.65	8.96
Mass flow rate (Kg/s)	0.1248	0.0092	0.0081

Table 2 Sirocco fan at a speed of 2000 rpm

Number of blades	50	45	40
Velocity magnitude (m/s)	2.13e+01	1.79e+01	1.68e+01
Static Pressure (Pa)	2.08e+02	1.79e+02	1.51e+02
Turbulent Kinetic Energy (m^2/s^2)	6.09e+01	5.92e+01	5.78e+01
Mass flow rate (Kg/s)	0.0379	0.0312	0.0267

Table 3 Sirocco fan with contra rotating rotor at a speed of 800 rpm

Number of blades	50	45	40
Velocity magnitude (m/s)	8.73	8.18	7.19
Static Pressure (Pa)	3.47e+01	3.01e+01	2.56e+01
Turbulent Kinetic Energy (m^2/s^2)	8.45	8.35	8.28
Mass flow rate (Kg/s)	0.0156	0.0139	0.0094

Table 4 Sirocco fan with contra rotating rotor at a speed of 2000 rpm

Number of blades	50	45	40
Velocity magnitude (m/s)	2.15e+01	1.91e+01	1.79e+01
Static Pressure (Pa)	2.15e+02	1.82e+02	1.63e+02
Turbulent Kinetic Energy (m^2/s^2)	5.44e+01	5.14e+01	5.06e+01
Mass flow rate (Kg/s)	0.0669	0.0496	0.0295

Table 5 Maximum von misses Stresses and Strains with fan models

	Sirocco fan	Sirocco fan with Contra rotating rotors
Stress (N/mm^2)	52.6727	86.6674
Strain	0.00258	0.00426

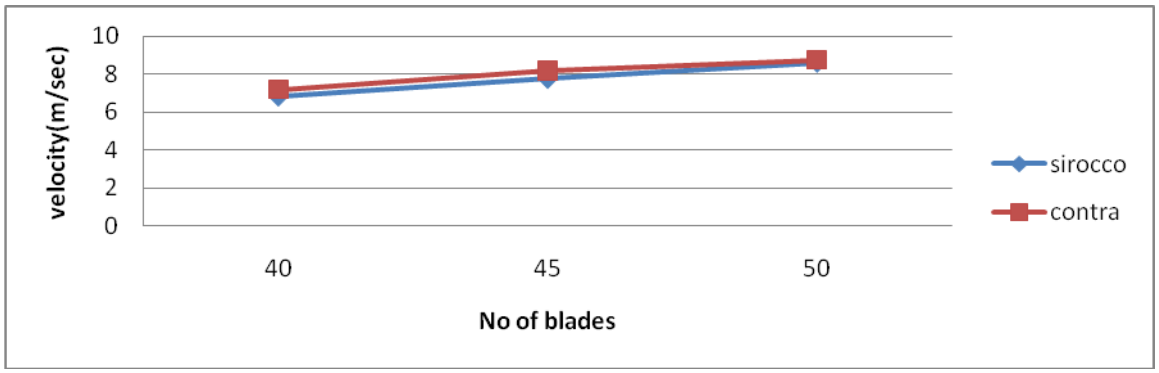


Fig 11 Maximum velocity of sirocco fan Vs no of blades

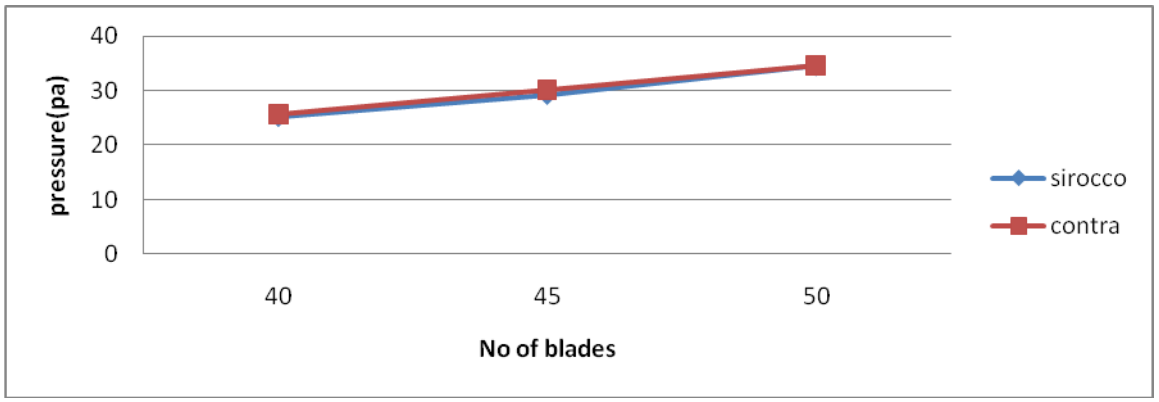


Fig 12 Maximum pressure of sirocco fan Vs no of blades

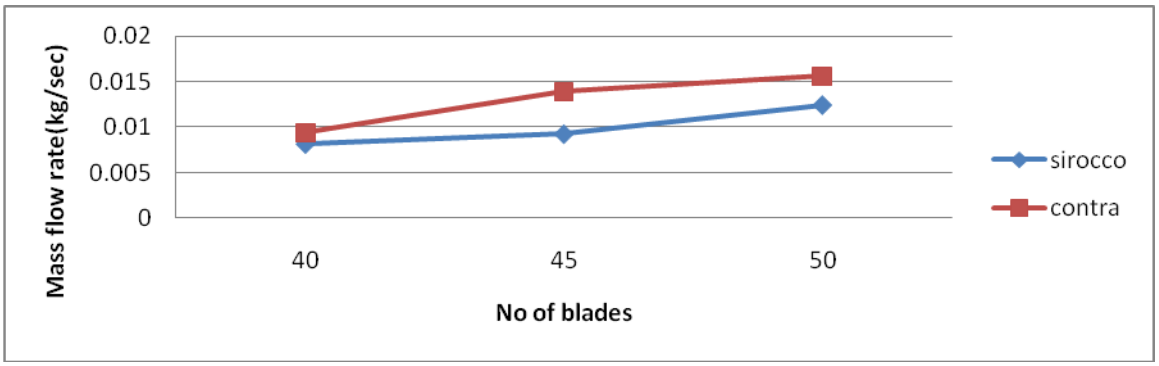


Fig 13 Mass flow rate of sirocco fan Vs no of blades

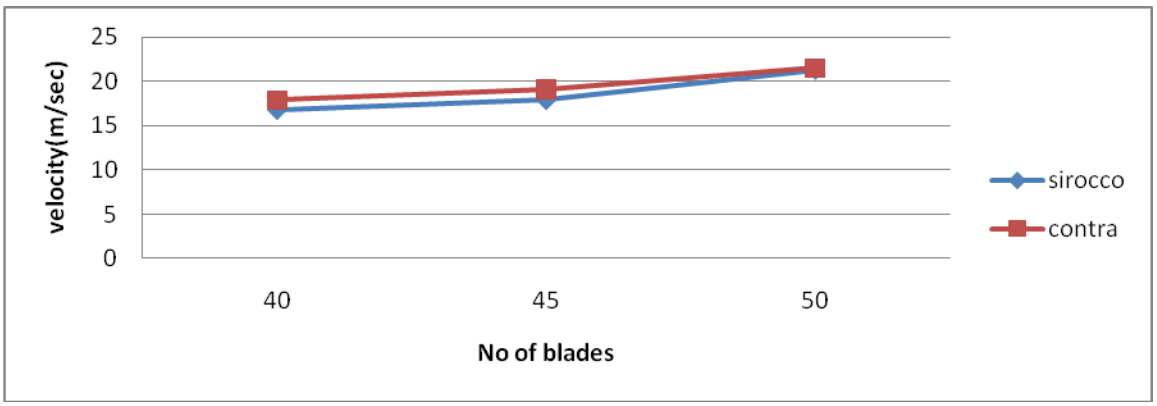


Fig 14 Maximum velocity of sirocco fan with contra rotating rotors Vs no of blades

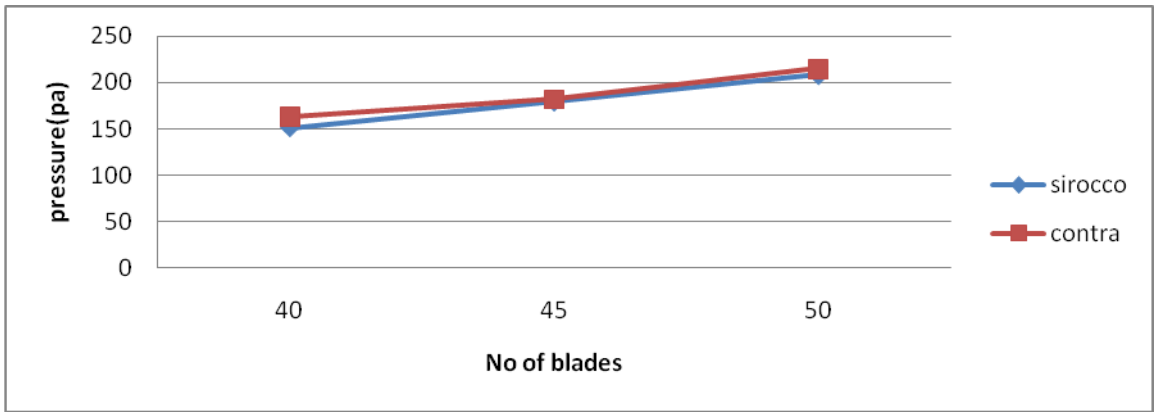


Fig 15 Maximum pressure of sirocco fan with contra rotating rotors Vs no of blades

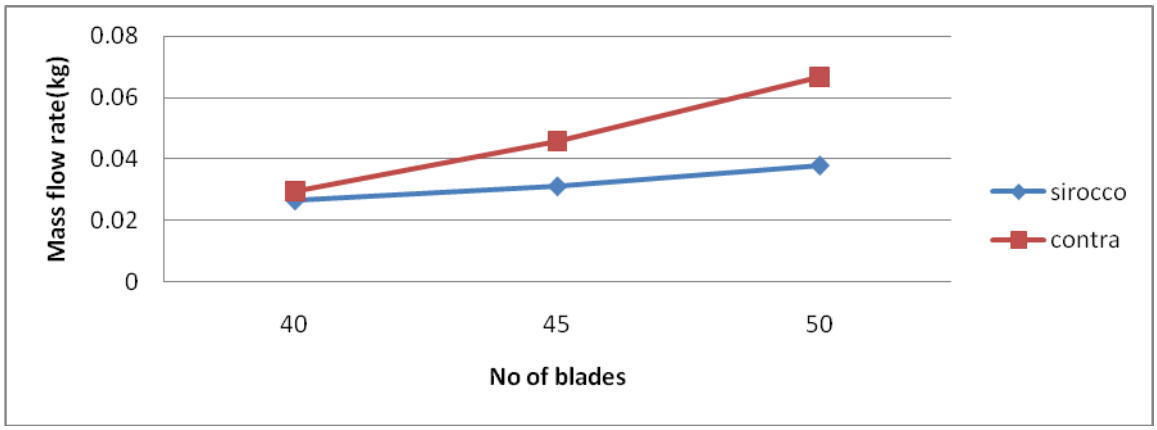


Fig 16 Mass flow rate of sirocco fan with contra rotating rotors Vs no of blades

VI. CONCLUSIONS

Performance of sirocco fan is carried out with two models consisting of sirocco fan and sirocco fan with contra rotating rotors. The analysis is carried out with varying number of blades of 50, 45and 40. By observing the graphs drawn for velocity, pressure and mass flow rates are more for sirocco fan with contra rotating model at a speed of 2000rpm. So it is concluded that the sirocco fan with contra rotating rotors is develop higher pressure and structure is more compact than sirocco fan.Structural analysis is studied on the models to verify the strength of the blades. By observing the analysis results, the induced stresses are within allowable limits, and the stresses are less than the sirocco fan compare to sirocco fan with contra rotating rotors.

REFERENCES

[1] J.Fukutomi,T.Shigenestu.T.Yosunoki "Performanance and Internal Flow Of Sirocco Fan Using Contra-Rotating Rotors" Journal of Thermal Science vol.17 no.1(2008).

[2] Yohan Jung and Jehyun Back "A Numarical Steady On The Unsteady Flow Behavior and The Performance of an Auto Motive Sirocco fan" Journal of mechanical & Science Technology22

[3] Tsutomu Adachi,1,3 Naohiro Sugita,1 and Yousuke Yamada, action "Study on the Performance of a Sirocco Fan (Optimum Design of Blade Shape)"

[4] Chan lee and hyun Gwon Kil "An Aero-Acoustic Performance Prediction method of Sirocco fan" by Adachi, T., 1995, Turbo machinery, (in Japanese), vol. 23, no. 6, pp. 339-347.

[5] [5] Kawaguchi, 1994, "Experimental Study on Noise Reduction of Multiblade Fan (2nd Report, Relation of Flow between Fan Blades and Pressure Fluctuations)" Trans. JSME, 1994 Ser. B, (in Japanese), vol. 60, no. 570, pp. 108-113.

[6] [6] Morinushi, K., 1991, "Noise Source of a Multiblade Fan,"Trans. JSME, 1991 Ser. B , (in Japanese), vol. 57, no. 543, pp. 3837-3844.