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CFD analysis of diffuser augmented wind turbine

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ABSTRACT

Flanged Diffuser is a collecting-accelerating device that shrouds a turbine. Forgiven rotary engine diameter, the power augmentation may be achieved by a brimmed diffuser, popularly known as wind lens. The current numerical investigation deals with the result of the low region created by wind lens to analyze the sturdy vortices shaped by brim connected to the shrouded diffuser at the exit. Additionally, during this analysis, a comparative numerical prediction of mass flow rates the turbine has been allotted with numerous sorts of wind lens that successively helps to optimize the torque augmentation. It's been well-tried that there's an important increase within the vortex strength & wake formation once the brimfull effect is added to a diffuser.

Keywords— *DAWT, Windlens, Brim, Diffuser*

1. INTRODUCTION

For the application of an efficient energy resource in future, the limitation of fossil fuels is obvious and also the security of different energy sources is extremely necessary subject. Moreover, due to environmental problems, i.e., heating, etc., application of renewable and clean energy are powerfully expected. Amongst all others, wind energy technology has developed quickly and are about to play a necessary role during anew energy field. However, making comparison with the overall demand for energy, the dimensions of wind power usage continues to be tiny. As for some reasons, various causes area unit occurred. For instance, the restricted local space for wind power plants, the complicated terrains compared to it in European or North American countries & the turbulent nature of the native wind noted. Therefore, the invention of a brand new wind generation system that produces additional power output even in these areas wherever lower wind speeds and sophisticated wind patterns are created. Power generation by exploitation wind is proportional to the cube of wind speed. That's why for increasing the output we must always have to increase the speed of the approaching wind to a wind turbine. If we tend to utilize the fluid dynamic nature around a structure or topography we tend to increase the wind speed particularly if we tend to concentrate the wind energy domestically additionally the facility output of a wind turbine be accumulated. This study is concerning the improvement of a wind generation system with additional output, aims at determining a way to collect the wind energy effectively and which kind of turbine will generate energy with efficiency from the wind. There are some hopes for utilizing the wind generation by more economical means. During this gift study, the idea of accelerating the wind was named the "windless" technology. The wind turbine with a brimmed or flanged diffuser shroud -so-called "windless turbine"- is developed mutually of high-performance wind turbines. The wind-lens rotary engine generates electric power even in low-speed wind since the brimmed-diffuser shroud will increase the speed of wind at the rotor. Wind lens windmill could be a compact formed high-efficient urban tiny windmill that may be put in any place. It's been greatly increasing the output by mounting the special ducts on blades than conventional wind generation generator. to beat varied problems within the typical wind generation by reducing the noise, will currently tiny wind generation generator which may be easily put in up to now areas. A special duct is attaching around the rotor, and it generates a robust vortex within the rear of the wind turbine. Due to the vortex, lowers pressure region is produced at the rear of the windmill, it accelerated the speed of the wind that flows into the duct (see figure 1).As power generated by the turbine is proportional to the cube of the wind speed, it's potential to extend output some3-fold once compared to the absence of the duct. What is more, the rotation area of the blade (sound source) is that and also the current Fluidic structure itself is compact and has achieved wonderful silence because it suppresses the blade tip vortex that becomes the noise source. Additionally, since the collector-style lens is encircled by a blade, it additionally obtained a visible sense of security.

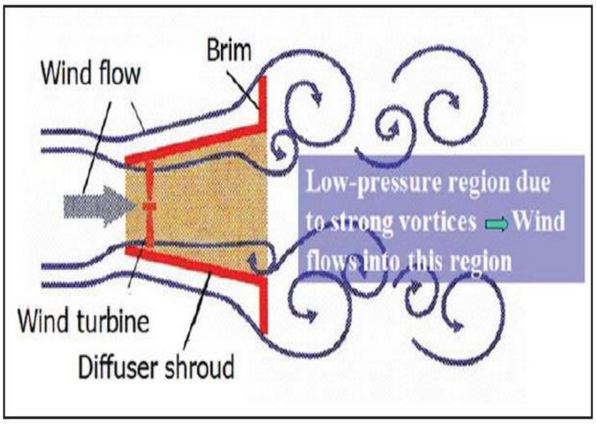


Fig. 1: Principle of increase in the mass flow rate of air

2. DIFFUSER AUGMENTED SYSTEM

2.1 Airfoil Blade

Profile: NACA 63(2)215 airfoil
Material- Wood

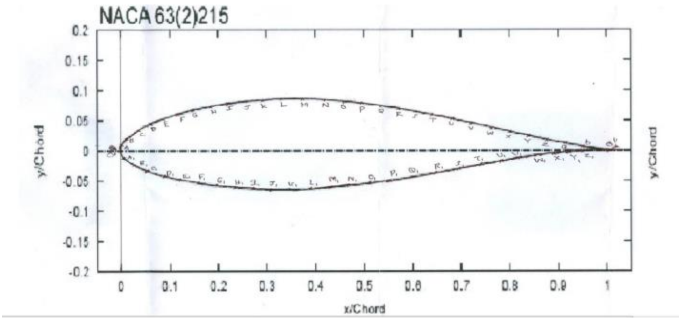


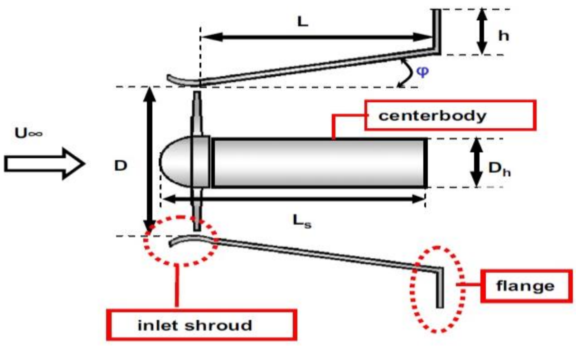
Fig. 2: NACA 63(2)215 Airfoil blade **Fig. 3: NACA 63(2)215 Airfoil blade-Actual**

2.2 Hub

Blade diameter-130 mm.
The angle of attack- 6^0
Hub diameter – 50 mm

Fig. 4: Hub

2.3 Wind Lens (shroud)



D=1300 mm
L = 0.15 D = 228 mm
Ls = 0.35 L = 85 mm
Dh = 0.04 D = 50 mm
h = 0.1D = 128 mm
Ø= 12^0
Material used: G.I sheet

Fig. 5: Schematic diagram of the shroud with relative dimensions

3. CAD MODELS OF DIFFUSERS

The basic 3D model was drawn on CREO software.

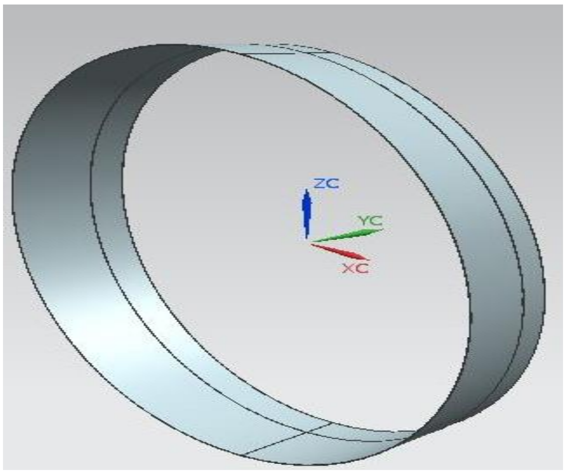


Fig. 6: Straight diffuser without a brim

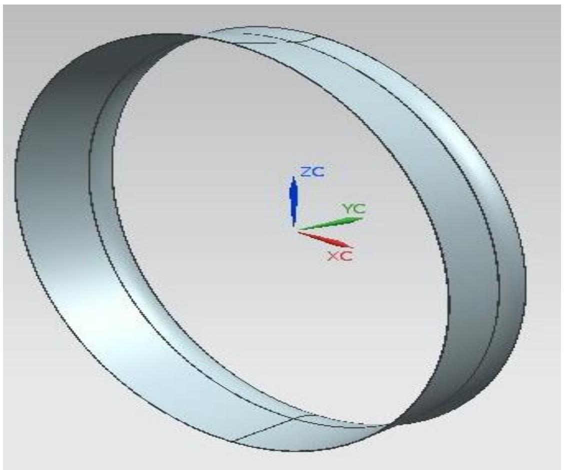


Fig. 7: Curved diffuser without a brim

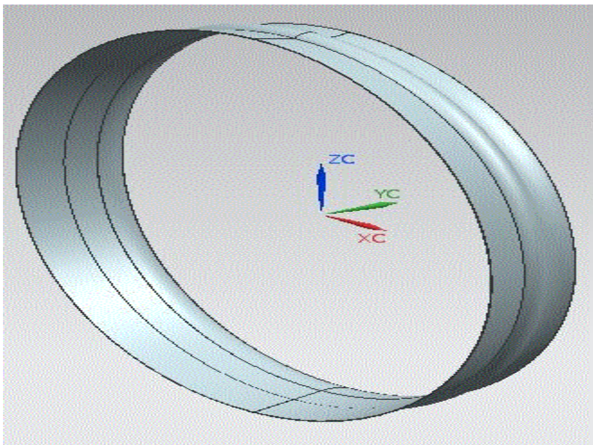


Fig. 8: stepped diffuser without a brim

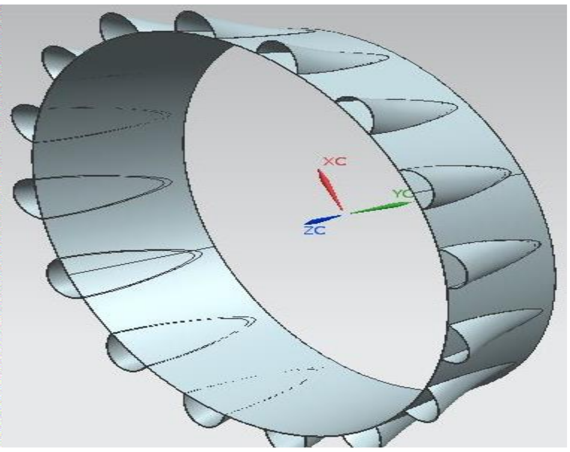


Fig. 9: Bumped diffuser without brim

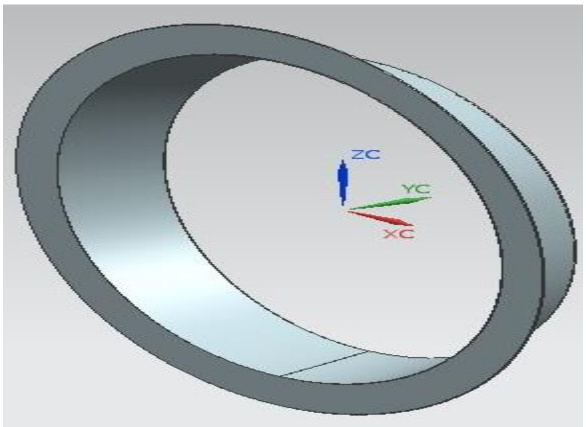


Fig. 10: Straight diffuser with a brim

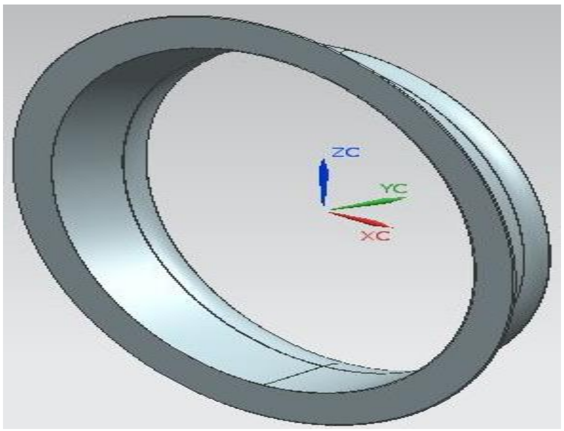


Fig. 11: Curved diffuser with a brim

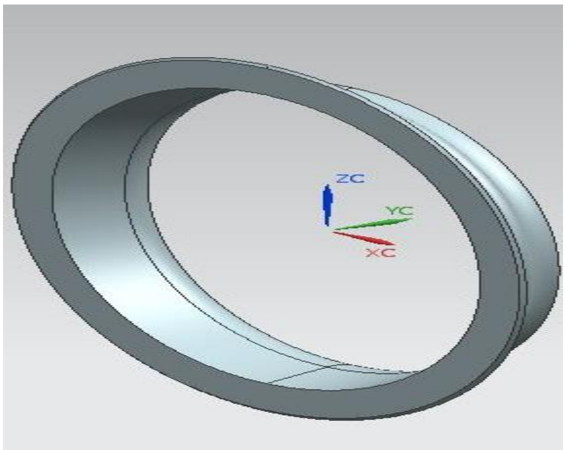


Fig. 12: stepped diffuser with a brim

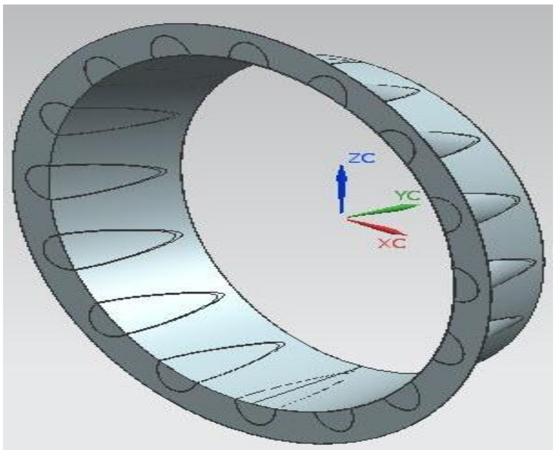


Fig. 13: Bumped diffuser with a brim

4. CFD ANALYSIS

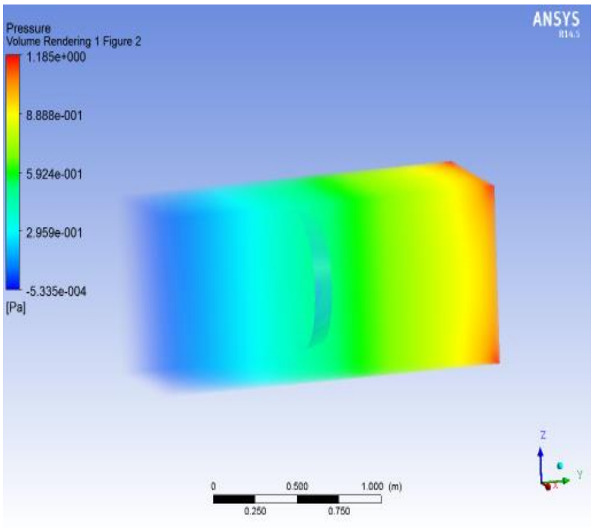


Fig. 14: pressure contour of straight diffuser without a brim

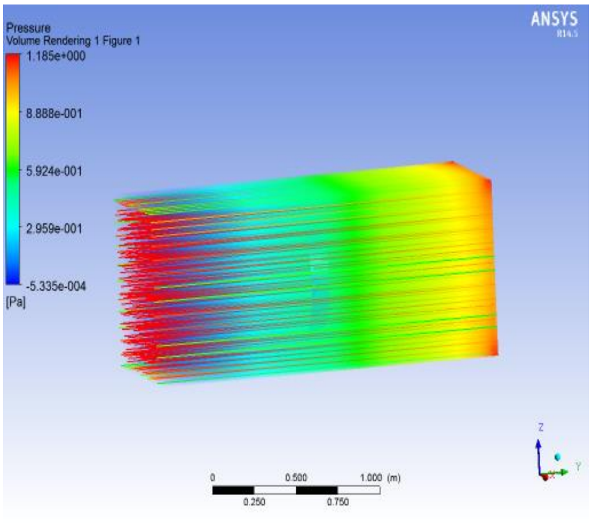


Fig. 15: velocity contour of straight diffuser without a brim

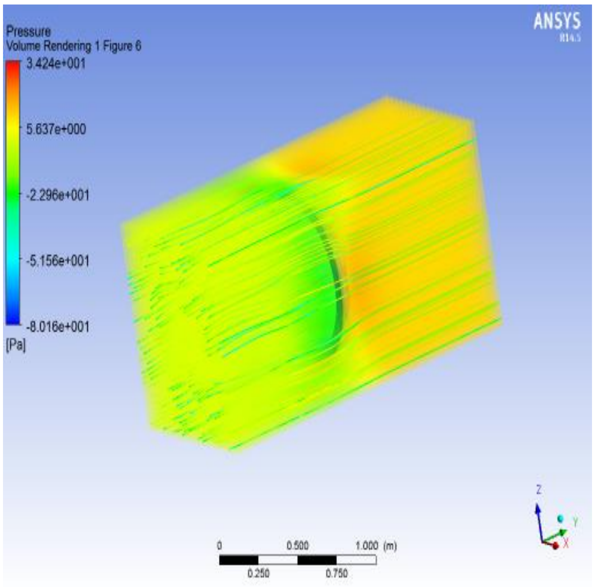


Fig. 16: pressure contour of the straight diffuser with a brim

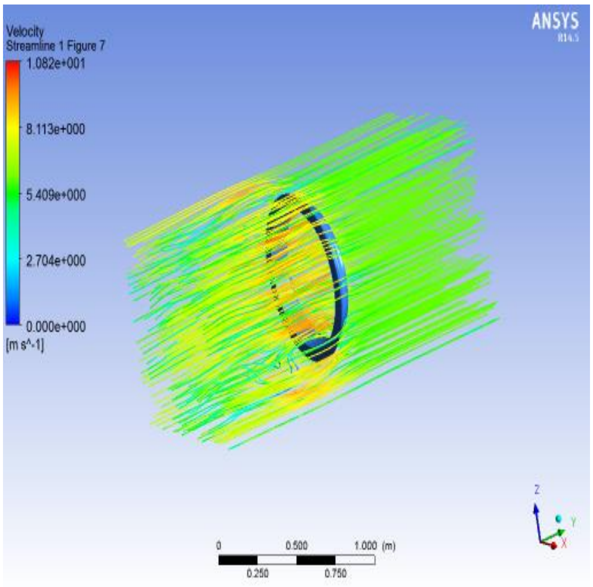


Fig. 17: Velocity contour of the straight diffuser with a brim

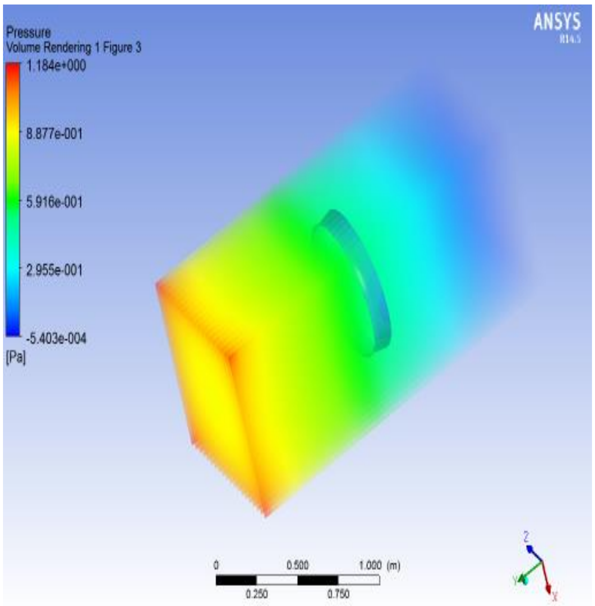


Fig. 18: Pressure contour of curved diffuser without a brim

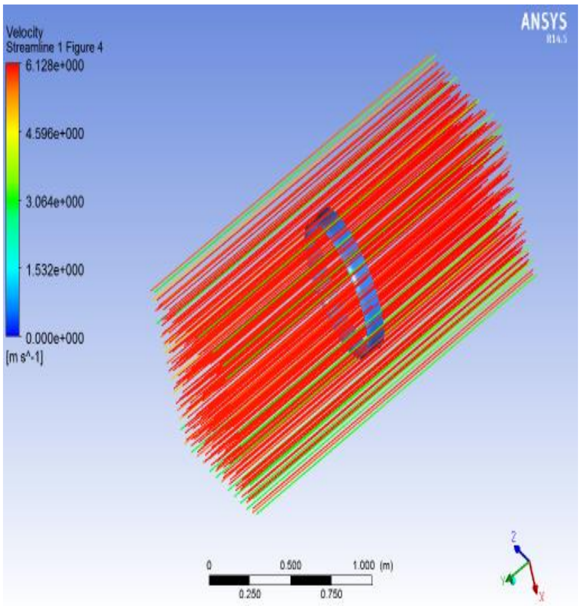


Fig. 19: Velocity contour of curved diffuser without a brim

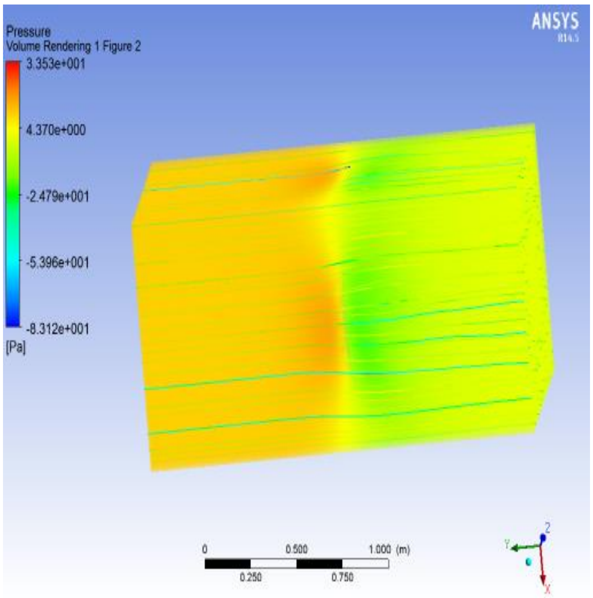


Fig. 20: Pressure contour of the curved diffuser with a brim

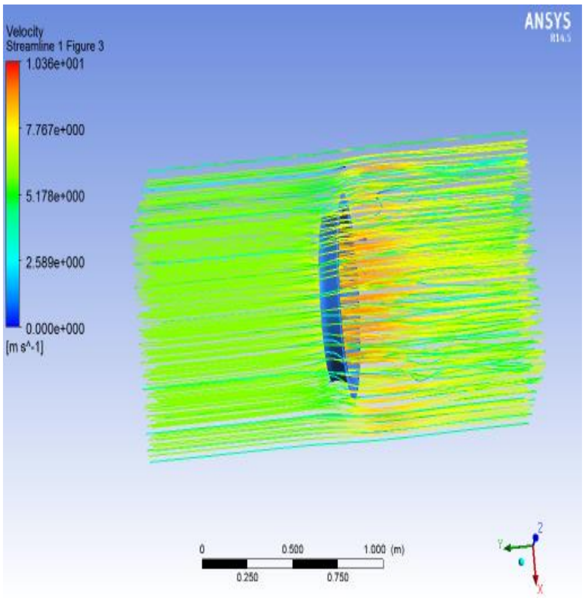


Fig. 21: Velocity contour of the curved diffuser with a brim

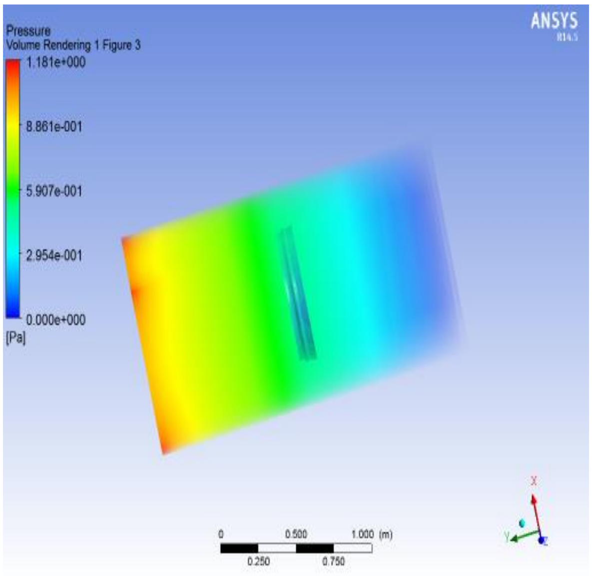


Fig. 22: Pressure contour of Stepped diffuser without a brim

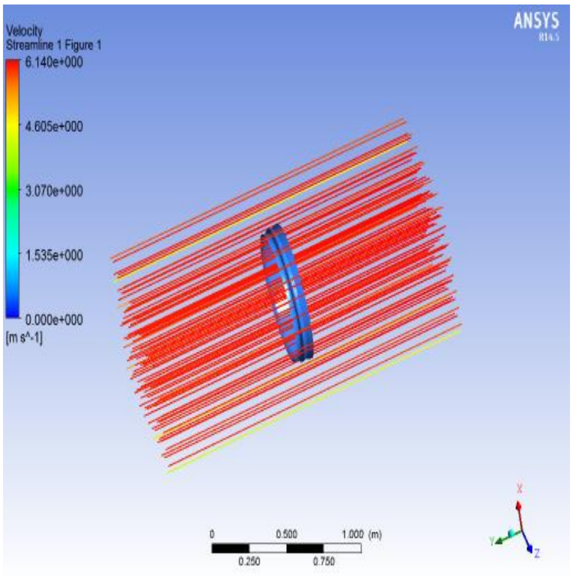


Fig. 23: Velocity contour of Stepped diffuser without a brim

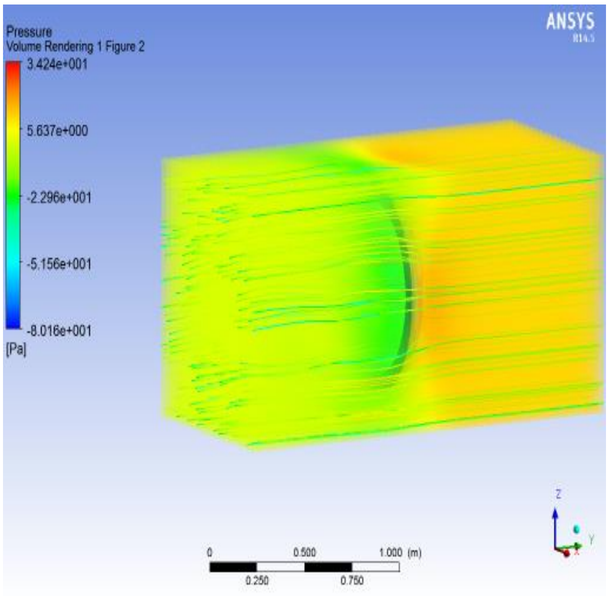


Fig. 24: Pressure contour of Stepped diffuser with brim

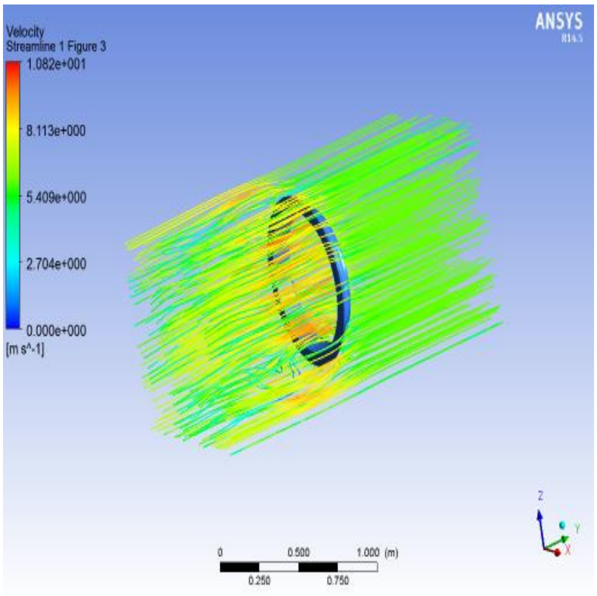


Fig. 25: Velocity contour of Stepped diffuser with a brim

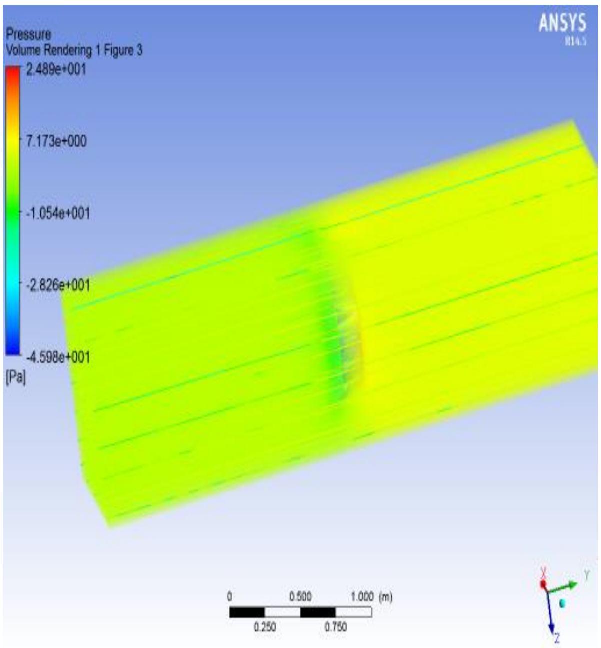


Fig. 26: Pressure contour of bumped diffuser without a brim

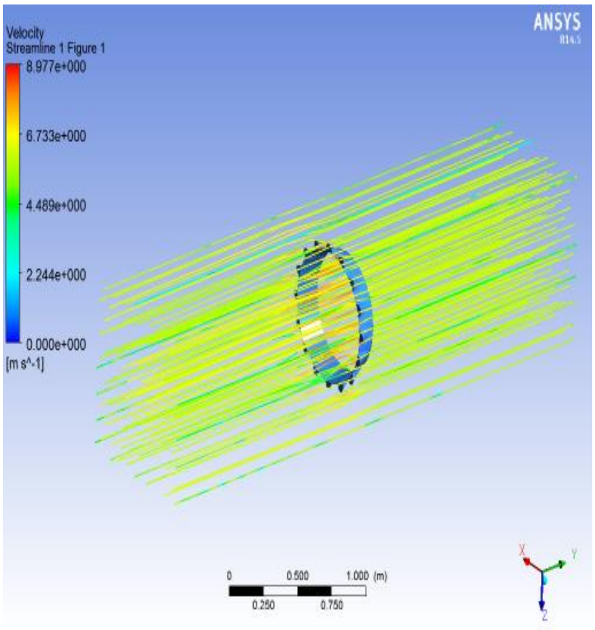


Fig. 27: Velocity contour of bumped diffuser without a brim

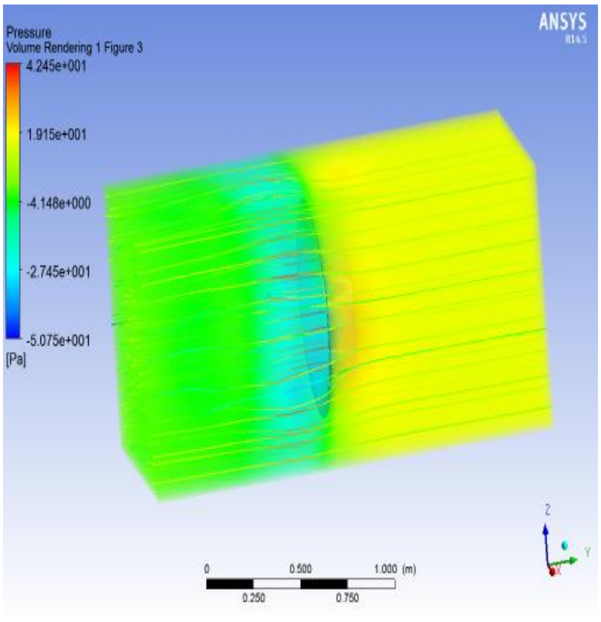


Fig. 28: Pressure contour of the bumped diffuser with a brim

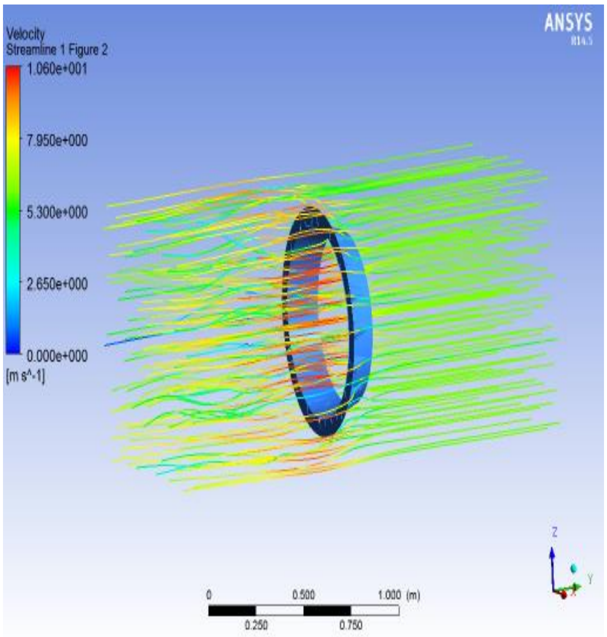


Fig. 29: Velocity contour of the bumped diffuser with a brim

4. RESULT TABLE

Table 1: Result

Turbine		Bare wind turbine	Straight without brim	Straight with brim	Curved without brim	Curved with brim	Stepped without brim	Stepped with brim	Bumped without brim	Bumped with brim
Pressure drop across diffuser (N/m^2)		1	1.181	104.49	1.181	116.65	1.181	114.1	70.87	93.2
Velocity (m/s)	I/P	6	6	6	6	6	6	6	6	6
	CENTER	6.1	6.14	9.99	6.14	10.36	6.14	10.82	8.977	10.6
	O/P	6.2	6.18	10	6.19	11.2	6.18	11.6	9.12	10.9
Power (Watt)	$\frac{1}{2}c_p\rho Av^3$	72.27	73.70	317.44	73.70	354.04	73.70	403.32	230.34	379.21

5. RESULT AND DISCUSSION

From the above table, it is concluded that when diffuser applied on a bare wind turbine, it will create a lower pressure space behind the turbine. Due to this space, more mass flow rate occurs. It will produce high power output as compared to bare wind turbine. If diffuser without brim & diffuser with a brim is compared, it shows that diffuser with a brim will give more vortex formation as compared to without brim.

Stepped diffuser with a brim will give 80.33 % extra power output as compared to the bare wind turbine. As well as it shows enhancement in the velocity of air. Bumped diffuser without brim enhances output power by 45.72 % as compared to the bare wind turbine. It shows higher power output as compared to all other remaining diffusers without a brim.

From the above discussion, it is concluded that stepped diffuser is highly efficient as compared to all other diffusers.

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