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Design and Analysis of Ducted Wind Turbine for House Hold Purpose

Priyanka.Chore [1], Dr. L.G.Navale [2],

[1]*Priyanka C. Chore,*
[1]*priyankachore29@gmail.com,*
[1] *PG Student, Dept. of Mechanical Engg. DYPIET, Pimpri, Pune, Maharashtra, India*

[2] *Dr. L.G.Navale*
[2] *Professor, Dept. of Mechanical Engg. DYPIE, Pimpri, Pune, Maharashtra, India*
[2]*lgnavale2006@yahoo.co.in,*

Abstract - *An Energy harnessing from non-conventional energy sources has become necessary due to drawbacks of conventional sources. All these sources are renewable or inexhaustible and do not cause environmental pollution. Tremendous work done on wind energy conversion and windmill. Convention windmill has some disadvantages like large size of blades, maintenance complications and harmfulness to ecosystem. Ducted Wind Turbine means increased velocity, is the system that uses the principles of flow of fluids through convergent section, so as to increase incoming air velocity at throat section. In Ducted Wind Turbine system, air captured from height with initial natural velocity and passes it through closed reduced area section to the ground. Air flow through convergent section of venturi, so we get higher air velocity at ground level. At throat section of venturi where the turbine is placed to get desired output. The main advantages of Ducted Wind Turbine over traditional windmill will be as, conversion of energy system will be placed at ground level, so to reduce damage and maintenance. Comparatively lower blade size required for same energy output due to high air velocity at blade plane, less effect on ecosystem due to enclosed energy conversion system. Mainly the manufacturing and installation cost will be reduced largely.*

Key Words: Ducted turbine, Pressure coefficients, Wind power, CFD, Renewable energy

1. INTRODUCTION

Initially utilization of wind control returns similarly as 3000 years back. Transformation of twist vitality to electrical power denoted a defining moment for the breeze control industry in late 1800s. The reference gives a decent portrayal of its verifiable improvement. While present scenario, wind turbines began to quickly spread over the globe over the most recent three decades, the cost has not reached the levels to compete with fossil fuel. While the breeze turbine industry has made real advances in expanding the power limit by expanding the rotor distances across and the pinnacle statures, yet the low limit factors, unnecessary downtime, and O&M costs have been real difficulties in making wind reasonable and dependable. . These issues have moderated wind control achieving its maximum capacity. Currently this wind turbines are frequently subjected to extreme downtime because of long time (frequently 2e3 weeks) required to keep up and repair sharp edges, yaw, pitch control, or generator disappointments at the highest point of tall towers. The cost of downtime added to the cost of support and repair influence a utility scale to wind control plant exorbitant to work. What's more, individuals and end clients are more mindful of the negative effect of the huge turbines to untamed life, farm creatures, and human. The last has brought about fast increment in objections that keep on plaguing the business. These days, individuals have communicated solid restriction to the conventional windmills because of damage to human wellbeing from high-decibel low-recurrence sound waves, propeller commotion, optical glimmering, and visual aggravations of substantial breeze control plants. New advances have been created by trend-setters over the globe. Among new thoughts are vertical hub turbines, airborne units with turbines at 300e500 m over the ground, and single and various exhibit ducted turbines. . Ducted Wind Turbine delivery system captures, concentrates, accelerates, and harvests wind power in a funnel or shroud. This system uses the principle of fluid flow, so velocity at throat section will increase to get the maximum electric power output.

The normal wind power utilizing sources has limitation, if the velocity of air continuously rises, there is a chance of breaking the blade. In order to overcome this problem, the design of ducted wind turbine for household application has been carried out. The CAD modelling of Venturi by CATIA software and Computational Fluid Flow analysis using ansys software has been done. Further, simulation of Venturi is carried out to find velocity of air before and after throat section. Optimum dimension of venturi has been found through analysis to get maximum electric output. Also experimental testing has been carried out by using anemometer and multimeter to find out electrical output at different velocities.

1.2 OBEJECTIVE

By designing these projects we can utilize the wind energy in different form such as it should work in typhoon and in all weather conditions. The main objective of designing these projects is to occupy wind energy coming from all the direction and leaving it through venturi were its speed raises which will give maximum output and after passing through venturi due to its divergent section its pressure gets equal to atmosphere pressure. Performance, evaluation of the Ducted Wind Turbine system.

1.3 METHODOLOGY

This study / project would be consisting of following the chronological step of working:

A. Literature study: Currently most of the researcher focused on the conventional power source than the non-conventional power source. So we are focusing on the project of the non-conventional power source. During the literature study of non-conventional power source providing sustainable, affordable electrical energy by doing theoretical and CFD analysis.

B. Project Details: As we are planning to design the project, can fix to the city area for household use so that we can increase the use of non-conventional power source in major applications.

C. Project literature study: As we start a study on our project we find that we can't increase the duct size of the system because of height constraints in urban areas. So we have decided to fix the size of the duct and will work on the venturi part of the Ducted Wind Turbine. We are studying different 5 model of the venturi with different dimension and find out the optimum result from them.

D. Design stage: In the design part firstly we are planning to design the duct of Ducted Wind Turbine, after finding out the length of duct, by fixing duct length we design 5 different venturi and do their analysis (CFD).

E. Material procurement: Mainly whole structure will be manufactured in sheet metal so most of the material will be purchased

F. Manufacturing stage: In the manufacturing stage we are assembled all parts of the workshop, by using drilling, welding, grinding and other basic operations.

G. Testing: testing of project on the terrace of the society with the model and one forced moving fan for constant air velocity. Also, major the potential difference across the turbine.

2. CFD ANALYSIS FOR DUCTED WIND TURBINE

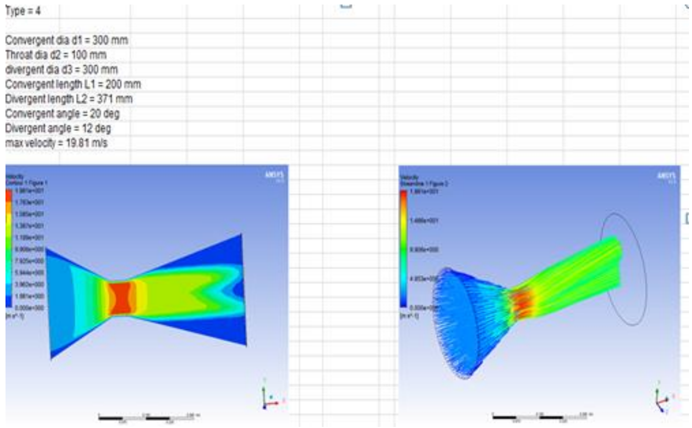

Fig -1: CFD of Venturi

Table -1:Table for Venturi selection

Section	Convergent dia	Throat dia	Divergent dia	Convergent length	Divergent length	Max velocity
1	118	50	100	100	100	13.69
2	118	30	112	100	150	13.84
3	216	80	234	200	371	16.98
4	**300**	**100**	**300**	**200**	**371**	**19.81**

From the above conclusion table we have selected the Type4 Venturi, the velocity we get is the highest amongst all the type which we have concluded. Here we get maximum velocity i.e. 19.81 m/s.

2. 1 DESIGN CALCULATION

Taking for stream air velocity as 2 m/s.

1. Diameter of venturi at 30cm (d1)

$$A_1 = \frac{\pi}{4} \times {d_1}^2$$

$$A_1 = \frac{\pi}{4} \times .3^2$$

$$A_1 = .07065 m^2$$

2. The throat section where the increase in velocity is expected (d2)=10cm

$$A_2 = \frac{\pi}{4} \times {d_2}^2$$

$$A_2 = \frac{\pi}{4} \times .1^2$$

$$A_2 = .00785 m^2$$

3. Continuity equation

Discharge at A1= Discharge at A2

$$A_1 V_1 = A_2 V_2$$

$$V_{21} = 18 m/s$$

4. At initial stage we have taken velocity 2m/s i.e V1=2m/s

So velocity ratio

$$\frac{V2}{V1} = \frac{18}{2} = 9:1$$

Since this is theoretical step up ratio, Actual ratio would be less considering losses

5. Design of venturi (Converging section)

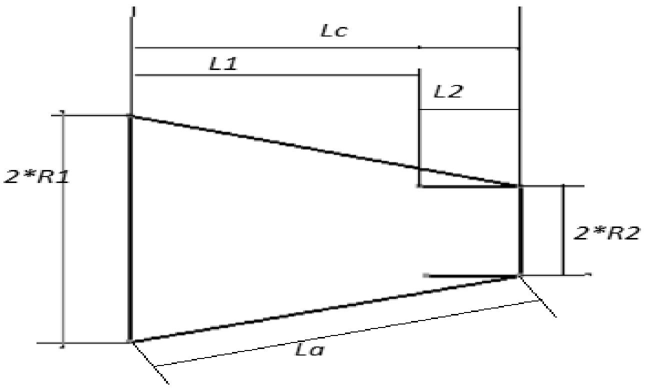

Fig -2: Converging Section

Typical values for convergent section is standard given by

$$\frac{Rarc}{R2} = 1.5$$

Convergent chosen angle, $\alpha_c = 20°$.

$L_2 = R_{C\,arc} \times \sin\alpha$

$L_2 = 0.0256$ m.

NOW

$$L1 = \frac{[Ro - Rt + R_c arc(\cos\alpha_c - 1)]}{\tan\alpha_c}$$

$L1 = 2.22m$

6. Design of diverging section

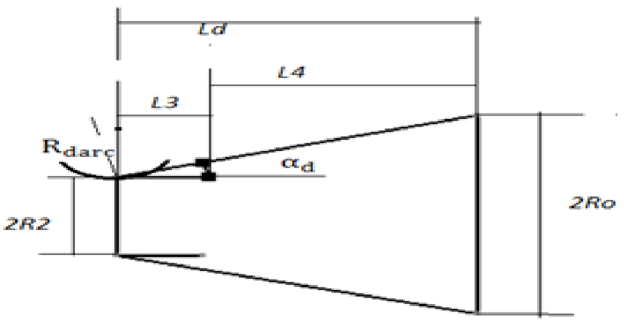

Fig -3: Diverging Section

$$\alpha d = \frac{Rdarc}{R2} = 0.4$$

We choose $\alpha_d = 12°$.

$L_3 =$ Rd arc $\times \sin\alpha d$

L3 = 0.00415 m

$$L_4 = \frac{[R_0 - R_t + R_d arc(\cos\alpha_d - 1)]}{\tan\alpha_d}$$

L4 = 0.562 m

7. Calculation for power available at throat inlet section

$$P_1 = \frac{1}{2} \times \rho \times A_1 \times V_1^{\,3}$$

$P_1 = .35$ watts

8. Power available at inlet of throat section

$$P_2 = \frac{1}{2} \times \rho_2 \times A_2 \times V_2^3$$

$P_2 = 28.04$watts

9. Considering the actual losses and coefficient of performance of turbine as(15%)

$P_2 = 0.15 \times 28.04$

$P_2 = 4.206$watts

2. 2 CAD MODEL AND CFD ANALYSIS

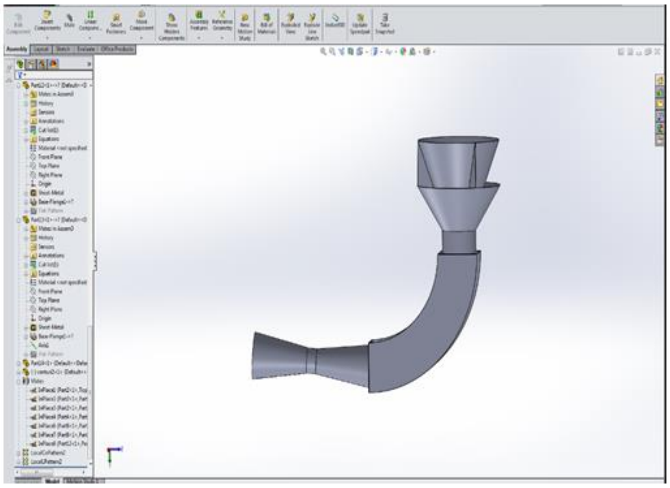

Fig -4: 3D Model of Ducted Wind Turbine in CATIA

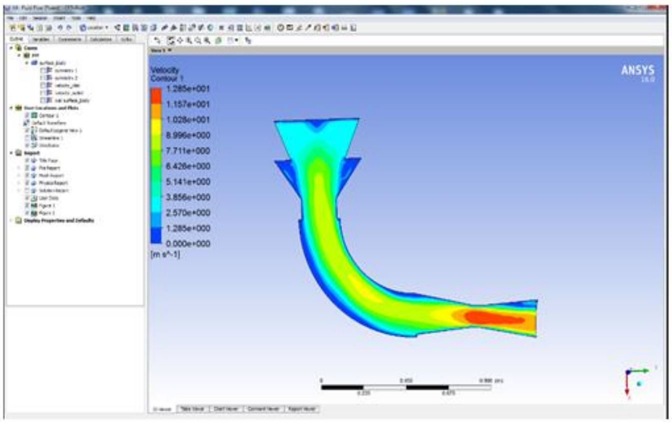

Fig -5: Velocity Counter

(Max Velocity acquire at throat section when whole body is considered)

Results of 2D CFD Considering whole body

The procedure of 2D CFD Analysis is done in the above section to find the Velocity; here the Velocity which acquires in the throat section is 12.85m/s, when the whole body is considered.

2. 3 MANUFACTURING

- For manufacturing of Ducted Wind Turbine we have use Mild steel of 1mm(if we increase the thickness the laser cutting will also increase, which will lead to increase in cost)
- The Mild steel is Laser cut and then proceed to the rolling operation
- After completing the rolling operation the arc welding and tig welding is used for joining process
- The reason behind Tig welding is thickness of sheet is less so there are chances of creating holes while welding
- The tip of Tig welding is very skinny so it create much less flux which avoid damage to sheet
- The motor mounting as a generator is done laser cut, bending
- The selection of fan or rotor is done according to throat diameter,
- The instruments which has been used for testing is anemometer and multimeter; anemometer s use to calculate wind speed i.e. wind velocity and multimeter is used to calculate current and voltage.

Fig -6: Soldering of motor wire connection

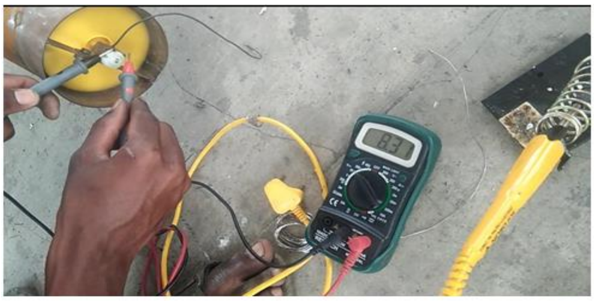

Fig -7: Testing of results

Fig -8: Full assembly of Ducted Wind Turbine

Table -2: Theoretical Power output available at Throat section

Velocity at inlet (m/s)	Theoretical power available at funnel inlet (w)	Velocity at Throat section (m/s)	Theoretical power available at throat (w)
1	0.0045	1.4	0.0136
2.5	0.0125	2.9	0.1215
3.3	0.0164	4.1	0.3190
4.2	0.0209	5.1	0.6612
5.4	0.0271	6.1	1.1326
7.8	0.0388	8.6	3.1705
9.2	0.0458	10.2	5.289

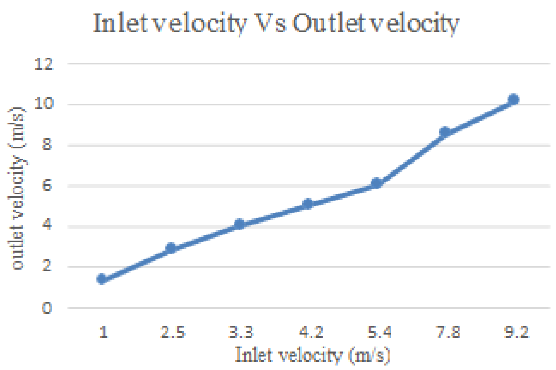

Chart -1: Graph of Inlet Velocity vs Outlet Velocity

The above graph shows the relation between the inlet velocity and output velocity. As the air flow through the convergent section then the velocity increases respectively

3. CONCLUSIONS

In this paper, venturi with optimum results is designed to increase the air velocity .It is observed that velocity is increased in throat section as compared to inlet section. As experimental testing is done by anemometer and multimeter with the help of this instrument inlet and outlet velocity has been gained i.e. at funnel and at throat section. In future project can be scaled in large model for windmill. This model can help to construct large capacity windmill with appropriate changes in design. This windmill is use in the venturi section of the Ducted Wind Turbine and by increasing air velocity through duct and venturi we can increase air velocity at throat and increase efficiency of the windmill. Validation is done by using CFD analysis, hence theoretical and experimental data has been compared for optimum solution, with this output increases.

REFERENCES

[1]] W.T. Chong, A. Fazlizan , S.C. Poh , K.C. Pan , W.P. Hew, F.B. Hsiao.,The design, simulation and testing of an urban vertical axis wind turbine with the Omni-direction-guide-vane, Applied Energy xxx (2013)

[2] Jung-Ho Cheng, Ssu-Yuan Hu.,Innovatory designs for ducted wind turbines, Industrial Technology Research Institute ,Renewable Energy 33 (2008)R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.

[3] M. J. Werle and W. M. Presz Jr. FloDesign Inc., Wilbraham, Massachusetts .,Ducted Wind/Water Turbines and Propellers Revisited, American Institute of Aeronautics and Astronautics , Vol. 24, No. 5, September–October 2008

[4] Andrew Grant, Cameron Johnstone, Nick Kelly.,Urban wind energy conversion: The potential of ducted turbines, Energy Systems Research Unit, Department of Mechanical Engineering, University of Strathclyde, Renewable Energy 33 (2008)

[5] Jui-Sheng Choua, Yu-Chen Oub, Kuan-Yu Lina,Structural failure simulation of onshore wind turbines impacted by strong winds www.elsevier.com/locate/enconman in 2018.

[6] Aierken Dilimulati , Ted Stathopoulos, Wind turbine designs for urban applications: A case study of shrouded diffuser casing for turbine Journal of Wind Engineering & Industrial Aerodynamics 175 (2018) 179–192

[7] R. Chandramouli., sheet metal operations-Cutting and relative processes, associate dean research, sastra university, Thanjavur-613401. NPTEL mechanical engineering forming.

[8] US Army repair shop technical officer. Metal properties, characteristics, uses and codes, sub course OD1643.

[9] Arundhati Kulkarni, Amit Patil, Mangesh Pawar, Sohan Jagtap, Pravin Yadav., Sheet metal bending machine, international journals of innovations in engineering, research and technology [IJERT] ISSN: 2394-3696 VOLUME 2, ISSUE 3, March.-2015

[10] A. McCabe, Ph.D., Design of supersonic Nozzle, London: Her