

Design and Analysis of Bladeless Windmill

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Abstract—Vortex Bladeless S.L a Spanish Tech came up with a radically new approach of using wind energy as a windmill without bladeless as conventional windmill are very costly to use. It works on the principle of Vortex Induced Vibration Phenomenon which is considered as an undesirable effect that plagues engineering as it may seriously effect structural integrity or the reliability of performance but along our research we will see if the vibration is substantial, it can be used to extract useful energy from surrounding. Since the introduction of Vortex Bladeless many improvements have been made and its still strives for the betterment. In our research we are going to conduct CFD Analysis using ANSYS Fluent of the base line model from[1] and couple it with Static Structural and the interaction between fluid and solid will be studied using Fluid solid interaction and Modal will be used to find the frequency of structure and validate it with experimental data[1]. Our area of focus is shape optimization of these Windmill in order to its increase frequency and displacement and can have better stress distribution since its prone to high fatigue stresses due to resonance that will be required in its operation.

Keywords—Vortex Bladeless, Vortex Induced Vibration, CFD Analysis, ANSYS Fluent, Fluid Solid Interaction.

I. INTRODUCTION

Due to the ever increasing demand for renewable energies Vortex Bladeless S.L a Spanish Tech start-up came up with a radically new approach of using wind energy as a multi-patented windmill without bladeless. It works on the principle of Vortex Induced Vibration (VIV) Phenomenon i.e. when a wind passes over a blunt object it creates vortices behind which creates alternate low and high pressure region which makes object to vibrate randomly. When the frequency of vortices generated matches frequency of object it creates lock in effect.

As conventional windmill are very costly to use. The cost of production, transportation and maintenance is considerably high. Setting up a conventional windmill takes up a lot of area which is a major problem. They are prone to harm birds during their operation and during their operation they develop low frequency sound which are not good for human health. Since its introduction to the world many improvements have been made and it's still strikes for the betterment and soon after it can also replace conventional windmills.

Our research emphasis on the improvement on the efficiency of these Vortex Windmill. Our area of focus is shape optimization of these Windmill in order to its increase frequency and displacement and can have better stress distribution since its prone to high fatigue stresses due to resonance that will be required in its operation.

II. OBJECTIVE

- To improve the efficiency of the turbine by optimizing its shape and size for local use.
- To control stress distribution that may occur due to fatigue.
- To achieve optimum amplitude of vibration for maximum power generation.
- To achieve unidirectional motion.

III. LITERATURE REVIEW

J. C. Cajas, D. J. Yanej, [1]They develop the tool for simulation of fluid structure interaction problems like FSI analysis of vortex-bladeless device. To do the analysis they made the alaya code at the Barcelona Supercomputing Center. For analysis the

scale model is made and do the FSI analysis on model. The result got from the analysis check with the experimental result and they make the report on it.

Gaurao Gohate et.al, 2016 [2] Studied VIV theory and Lock in phenomenon. Research paper study identified the VIV theory, parameter that affect the VIV, Dimensionless parameters etc. and the method & calculation of natural frequency of cylindrical body.

Abhilash Khairkr et.al, 2016 [3] Utilization of wind energy with the help of new designed windmill. Research paper tells about vortex shedding phenomenon and vortex shedding frequency. Also the calculation of vortex shedding frequency and role of Reynolds number, strouhal number. The results of this study concluded that the bladeless windmill is more efficient than conventional windmill for the given space of blade windmill.

Akshay Agrawal and Adity Sheth, 2017 [4] New approach for capturing wind energy and use to produce electricity. When wind strikes on the structure different flow pattern of wind are produced and known about design criteria of bladeless windmill. Studied the working methodology of windmill and also advantages, disadvantages & application of bladeless windmill.

Prof. Dilip Deshmukh et.al, [5] Studied the principle of vortex shedding. Change in the pressure when a fluid flows toward the bluff body. Also the calculation of mast and various methods of electricity generation like piezoelectric, linear generation, rack & pinion mechanism etc. and studied the some future scope in renewable energy field. They concluded that the vibration energy which is scientists try to avoid it will be used to produce the usefully electrical energy by using bladeless windmill.

IV. PROBLEM DEFINITION

From the problems identified from literature review the problems with bladeless windmill is that it won't be having gearing system or any kind of amplification device to increase output in order to reduce mechanical losses and simplicity of design. Idea is to make the most compact electricity generating device. Then our only option is to modify the structure to improve the efficiency of working.

V. PROPOSED METHODOLOGY

5.1 Problem Identification

Problem with bladeless windmill is that it won't be having gearing system or any kind of amplifying device to increase output in order to reduce mechanical losses and simplicity of design. Idea is to make most compact electricity generating device. Then our only option is to modify its structure to improve the efficiency of working.

5.2 Proposing various solution and selecting appropriate solution

Various solution found up-till now is that by modifying shape and size it may improve efficiency, try changing material to improve frequency and deflection and our optimal option will be modifying shape.

5.3 Design Data

In this basic model is generated using experimental data of geometry mentioned in J. C. Cajas [1]. Data generated in this paper were using experimental methods. So we will take this data as a base for stimulation.

5.4 Generating 3D CAD Model

In this we generate 3D CAD model as per data given in research paper J. C. Cajas [1] using SOLIDWORKS. Then convert it into neutral setup file like STEP, Parasolid_txt, etc. that is supported in ANSYS Workbench.



Fig. 1. Solid model of Bladeless Windmill

5.5 Mesh Generation and Mesh Control

In this we discretize model into “n” number of small elements, controlling their size and shape. Shape suggested for these kind of stimulation is “tetrahedral”.

5.6 Setting up CFD Domain

Now we setup CFD Domain in ANSYS Using “ANSYS Fluent”. In this we create a fluid domain around our geometry and suppress our geometry for convenience then discretize the geometry into smaller segments in Pre-Processing stage. Then in Fluent Solver we setup up its physical problem like fluid material, fluid flow, etc. and solve the problem. Then in Post-Processing we analyze the results with different methods like Contour Plots, Vector Plot, Streamlines, and Data Curve Etc. for Appropriate Graphical Representations and Report.

5.7 Coupling It with Static Structural

In this we import the solution obtained from ANSYS Fluent into the setup of Static Structural. The fluid domain is suppressed and un-suppress our physical geometry. We fix one end of our geometry and import load from ANSYS Fluent using FSI (Fluid-Structure Interaction) On Geometry Surface and Solve the Problem. We get results in the form of Stress and Deformation.

5.8 Coupling It with Modal Setup

In this we share Material, Geometry, Setup info using coupling of Static Structural and Modal. We import solution of static structural into modal setup. Next we find the Natural Frequency of the object generated due to fluid pressure using FSI and find the displacement.

5.9 Validating Analytical Data

In this we compare our results with results present in research paper [1]. If results obtained are satisfactory we will assume our stimulation is correct. Then we can finally move forward with our Optimization using same setup as above.

5.10 Optimizing Shape and Size of Structure

Once validation is done we will move further to Modify the Shape, Size and Material of the Geometry as per Our Environmental Needs and Further Optimize It to Strive for Improved Efficiency of Our Project i.e. Improved Oscillation and Displacement.

VI. RESULT AND DISCUSSION

The proposed methodology investigates the comparison of performance between existing model and modified model.

The following results are expected at end of this project:

- Improved efficiency of the turbine by optimizing its shape and size for local use.
- Controlled stress distribution that may occur due to fatigue.
- Optimum amplitude of vibration for maximum power generation.
- Unidirectional motion

VII. CONCLUSION

From the various Literature studies done we studied that the various constraints offered by conventional windmill was overcome by a S.L. Spanish Tech Start-up Known as Vortex Bladeless. Soon it also came up with its own constraints such as its efficiency is comparatively low as compared to traditional windmill. It's still in development phase and requires huge stakes from investors. It produces large power fluctuations and has low energy conversion. It is subjected to high mechanical stresses and no control of active and reactive power.

Our study focuses on improvisation on the concepts of bladeless turbine. In this the efficiency of the turbine will improve. By optimizing its shape and size for local use it can be made commercially available to locals. By controlling its stress distribution that may occur due to fatigue its only drawback shall be minimized. By achieving optimum amplitude of vibration for maximum power generation it will help reduce the energy demand. By achieving unidirectional motion it can help improve its stability.

Up till now we have studied various research papers and found various drawbacks as mentioned above and generated the model as per dimensions presented in J. C. Cajas [1]. We have generated the fluid domain using enclosure in ANSYS design modeler. Then we generated mesh for the model.

REFERENCES

- [1] J. C. Cajas , D. J. Yanej, "SHAPE Project Vortex Bladeless:Parallel multi-code coupling for fluid structure interaction in wind energy".
- [2] Gaurao Gohate, Abhilash Khairkar, Sameer Jadhav, "Study of Vortex Induced Vibrations for Harvesting Energy", IJRST – International Journal for Innovative Research in Science & Technology, Volume 2, Issue 11, 2016 , pp.374-378.
- [3] Abhilash Khairkar, Prof. Saurabh Bobde, Prof. Saurabh Bobde, Gaurao Gohate, "Power Generation by Bladeless Windmill", IJSRD - International Journal for Scientific Research & Development, Vol. 4, Issue 01, 2016 , pp.457-459.
- [4] Akshay Agrawal, Adity Sheth, "Bladless Windmills Based On The Principle of Vibration", International Journal Of Scientific Research, Vol. 3, Issue – 5, 2017, pp. 13-16.
- [5] Prof. Dilip Deshmukh, Niteen Kumar, Khursheed Alam, Sudhanshu Kumar, "Vortex Bladeless Turbine", ierjournal.org
- [6] Mr. Akshay Aaiwale, Mr. Pranav Babras, Mr. Ajay Metkar, Mr. Husain Bharmal, "Vortex Bladeless: A New Paradigm Wind Mill", IJPRET – International Journal Of Pure And Applied Research In Engineering And Technology, Vol. 5, pp. 1-10.
- [7] Chandrakant D. Mhalungekar, Swapnil P. Wadkar, "CFD And Experimental Analysis Of Vortex Shedding Behind D-Shaped Cylinder", IJIRAE - International Journal of Innovative Research in Advanced Engineering, Vol. 1, Issue – 5, 2014, pp. 80-86.
- [8] Antonio Barrero-Gil, Santiago Pindado, Sergio Avila, "Extracting energy from Vortex-Induced Vibrations: A parametric study; Universidad Politecnica de Madrid, Plaza Cardenal Cisneros 3, E-28040 Madrid, Spain.
- [9] M. Sami Akoz, M. Salih Kirkgoz, "Numerical And Experimental Analyses Of The Flow Around A Horizontal Wall-Mounted Circular Cylinder", Transactions of the Canadian Society for Mechanical Engineering, Vol. 33, 2009, pp. 189-215.
- [10] Vishal Digambar Bodkhe, "Design And Development of Vortex Blade Less Turbine", IJTSRD - International Journal of Trend In Scientific Research and Development, Vol. 2, Issue – 3, 2018, pp. 2460-2462.