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DESIGN ANALYSIS OF AN ARCHIMEDEAN SCREW TURBINE USED FOR MICROHYDRO POWER GENERATION

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ABSTRACT

This study details on ANSYS Workbench gives analysis on aspects of discharge variation on Archimedean Screw Turbine which would help in producing results regarding effects of stresses on the turbine. By using ANSYS Workbench we can find out stresses distribution and deformation of flights in Screw Turbine easily. Generation of 3-D geometry and meshing of those profiles to evaluate performance of screw turbine based on number of flights could also be done in ANSYS Workbench. Simulation of working of Screw Turbine by using "Transient Structural Mode" in ANSYS Workbench is conducted for study of stress distribution and deformations. The numerical analysis is conducted using ANSYS software commercially available. Transient Structural Mode in ANSYS Workbench can be used because it can import files from other modeling software, through this we can observe stress distribution, thermal contours and deformation. Also the Archimedean turbine is also analyzed from design point of view with respect to the different number of flights by using ANSYS Workbench, simulating the behavior of stresses through the rotating blades and investigating effects on performance of turbine .Conducting the study derives the conclusion that for particular numbers of flights there are different values of forces, stresses and corresponding deformations. These values can help in determining the best Turbine model , which allows us to optimize power and production cost of turbine.

This study is vital as there is much potential of these Turbines in India. Analyzing the performance parameters would allow us to improve their efficiency and cost thus using hydro power more efficiently.

KEYWORDS: Archimedean Screw Turbine, Flights, ANSYS Workbench etc.

I. INTRODUCTION

Due to diminishing availability of fossil fuels as well as associated direct environmental concerns, the desire for new sustainable and environment friendly sources of energy has grown substantially. Micro hydropower is an eco-friendly and non-polluting renewable source of energy. It is the renewable energy method for production of electricity known to mankind mechanically.

In current scenario, India is blessed with half a million locations where water mills are serving for centuries. Hydro power plants are installed there, equivalent of 15000MW can be generated & 20 million Indians may get employed. There are (approx.) potential sites over the entire Himalayan region that generate power as much as of 25000 generate at least 5KW. Till date only 25% (approx) of the total hydro power potential has been harassed to generate power. Water mills are enough to run TV, refrigerator, cooler, fan & light bulbs etc.

Micro hydro power plant is a type of hydro electric power plant that typically produces power up to 100 KW using

natural flow of water. Micro-hydro power plants generally uses Archimedes turbine. This turbine can be installed in many regions of various states in India with minimum requirement of 1m head hydro Archimedean screw turbine works with efficiency of 85 %(approx.).

Archimedes screws were OLD idea, but recently, they have always been used to pump up water. By letting water drop through an Archimedes Screw it is possible to generate electrical power. This turbine contains 2 or more helix shaped blades mounted on a central shaft. This shaft assembly is put into a trough and is set an angle between 20 and 35 degrees relative to horizontal surface typically. And so stress analysis on these turbines on the basis of variation in number of flights becomes important, as it can help us in determining the best turbine model which allows us to optimize production cost. Also analyzing the performance parameters would allow us to improve their efficiency and cost thus using hydro power more efficiently.

II. LITERATURE REVIEW

India is blessed with abundant hydro electric potential, estimated 19749.65 MW, rank 5th in the world, in terms of utilizable hydro potential. But when compared to other sources of micro hydro power, Screw turbine is negligible in consideration. Micro hydro power system or more specifically, screw turbine power plant can be implemented and would prove as a sustainable source of electricity in states, especially in hilly areas where the potential like canals, small rivers, ponds etc. are available. Micro hydro power system or more specifically, screw turbine power plant can be implemented and would prove as a sustainable source of electricity in states, especially in hilly areas. [1] To gain an understanding of the dynamics of an AST system, a small AST (hereafter “S1”) was installed on a small watercourse in southern Ontario (Canada), and data from the site was recorded from 2011-11-18 to 2012-06-27. AST S1 was installed at a concrete weir on Big Creek, Dehli, Ontario with approximately 0.9 m of available head (Fig 4). The upper head level could be modified by placing or removing stop logs in the weir, and the downstream head was affected by downstream conditions (for example, Fig. 5 flooding, and Fig. 6, design head). S1 was designed with a design flow rate (*Q design*) of 70 L/s, and a design head (*H design*) of 0.915 m. The AST was connected to a synchronous induction generator with a constant-speed gearbox with a gear ratio of 25.71:1; the AST was designed to run at 70 RPM. The target power output of the AST was 400 W. [2]

The Archimedes screw design centered on optimizing the rate of pitch change throughout the length of the turbine, the pitch being longer at the entry and continually decreasing over the turbine. In order to generate the continual pitch change, three methods were used: a constant pitch, an arc tangent pitch, and power 1.5 pitch. In order to create these curves, parametric equations were created, points were defined in MatLab and imported as curves into SolidWorks . Hydrokinetic Design is also analysed. While the Archimedes screw design utilizes a pressure gradient in order to generate energy, a purely kinetic design has many applications as well. [4]

It is found that non uniform pitch in Archimedean screw turbine is much important than uniform pitch analysed by CFD rotating mesh analysis. The trend in required head, total power and efficiency are calculated over the range of volumetric flow rates and rotation rates. [5]

III. OBJECTIVES OF WORK

1. The objective of this research underlies analyzing the performance parameters of Archimedean screw turbine with respect to different number of flights on ANSYS Workbench. This becomes important as it allows a technological edge instead of going into the lengthy and cumbersome model-prototype analysis. Additionally it helps in deducing those performance parameters at micron level.

Our main objective is to analyse stresses and deformation created inside Archimedean screw turbine by varying discharge (variation in discharge will cause changes in force), variation in number of flights.

2. Advantages of Stress analysis on Archimedean screw turbine:

2.1.Easy analysis possible by changing different parameters.

2.2.The solution can be converged automatically if it is feasible.

2.3. A Micron Level study could be conducted.

2.4. A relief form hectic model analysis.

2.5. Easy demonstration that allows a better understanding.

2.6. Easy comparison by simply changing the number of flights.

2.7. Different kind of forces, moments and the fluid flow can be analyzed.

2.8. Optimal solution could be found by changing the boundary condition.

2.9. Saves Time and manual efforts.

IV. METHODOLOGY

There is a set methodology behind planning and implementing the stress analysis of Archimedean screw turbine on ANSYS software. This being geometry creation,

grid generation, choosing appropriate models, supplying appropriate boundary conditions, finding an appropriate solution to the governing equations and boundary conditions, and post-processing the results of the computation. Following Steps will be carried out for analysis:

1. Development of geometry**:** Geometry generation is usually carried out by computer aided design (CAD) or 3D modeling package. Attention has to be made to simplify the geometry so that a satisfactory grid is generated in the next step. In this study we will be using CATIA V5 R18 as the modeling software.

2. Meshing: Geometry will be transferred into ANSYS Workbench. In the next phase, a mesh is generated from the input geometry. There are several considerations that must be taken into account in what will make up the mesh. The accuracy of result produce through ANSYS and calculation as good as the mesh provided for analysis. There are few basic meshing techniques such as a structured or unstructured mesh and a mesh can be comprised of different element types. The most common elements types are hexahedra, tetrahedral, square pyramids and extruded triangles. Unstructured 3D grids tend to use hexahedra and tetrahedral elements, while structured grid rely more all quadrilateral and hexahedral elements. Attention had to be made with the elements sizes used in the mesh. Using smaller meshes can improve the accuracy of the solution, but will require more computational resources and time to generate the solution.The next step after meshing is naming the region.

3. Setup**:** Following mesh generation an appropriate model must be chosen for the problem at hand. Question such as must the solution be in 3D or can it be simplified to a 2D problem needs to be determined. A 3D model is chosen for this particular analysis.Once an appropriate model is chosen for the goals of simulation, the boundary conditions are supplied. Input parameters such as the number of iterations must be supplied.

4**.** Solution: For finding the solutions of this analysis the number of iteration are taken. While running these iterations either a converged or a diverged solution is obtained which indicates whether the solution is feasible or not.

5. Results: Following above steps we will be able to find out optimized parameters under analysis, during variations mentioned in objective.

V. Conclusion

After Stress analysis we can determine an optimized design with improved efficiency. Also the analysis in software is very much fast and convenient for designer. A relationship between Archimedean screw turbine efficiency and geometry of flights in a particular band of number of flights can developed on the basis of analysis. Thus to operate these turbines at maximum efficiency, this analysis proves highly beneficial.

Power generated by these Archimedean turbines is eco-friendly, fish friendly & there is no requirement of cutting trees as well as relocating people and other nature harassments. In these types plant there are no requirements of big dams, large Discharge, high Head & penstock etc.

Micro hydropower based on Archimedean turbine plant have less total cost of generation, operation, other costs & more overall efficiency at similar conditions as compared to other power generating units etc.

The efficiency of plant does not vary with load, but Power output & Speed of this plant vary with discharge at same Head condition. Hence this type of power plant is highly suitable power generating method in the present time.

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