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# Design, Modeling and FEA Analysis of Turgo Impulse Turbine Blade

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**Abstract -**This research work is mostly deflecting on Turgo turbine design and its basic analysis. As there are many turbines are already in work. But there are much less data and usage of Turgo turbine. We did establish some conclusion using Design and simulation data using CAD software. Our research work solely described the development of Turgo turbine blades using the Solidworks software. Finite element Analysis- FEA (Ansys V20) has been used for analysis of stress and deformation produced inside the Turgo impulse turbine. FEA is effective when it is used to determine the stress and strain distribution. It also has been seen during procedure that the maximum stress occurs at the root of blade suction side. Different velocity 24.46 $m/s^2$, 32 $m/s^2$, 40 $m/s^2$were taken as an input parameter to find the respective force occurs on the Bucket of Turgo turbine. With that force we get von-mises stress and deformation occurs on the respective bucket surface area. With that deformation taken into consideration we did seen that our SolidWorks design was safe.

***Key Words*:**Turgo turbine, CFD Analysis, FEA, Turbine Blade.

## 1.INTRODUCTION

A turbine is a device which can utilize the kinetic energy of fluids- like water, steam, air and changes that energy into the rotational motion. And this type of devices is used in power plant, engines assembly, and many other propulsion systems etc. As demand of electricity increases, which in turn requires step up in technology to scale up the recent power plants. New and new ways of increasing efficiency and ability to perform are getting introduced. Many researchershave done their part. Chandrasekaran M. et al [1] used NX-CAD, MATLAB and ANSYS for performance testing of rotodynamic pump. Use of simulation in CAD software is globally accepted. Whereas Edwin Gallego et al [2] studied the analysis on the performance of a Turgo turbine – Pico Hydro turbine using 15 runs using ANOVA and RSM method in which Diameter, Nozzle numbers, Velocity were considered as a parameter. Budiarso et al [3] done some amazing and surprised in their experiment and that was Turbine was made using coconut shell which is available in almost any area. And this design is working perfectly fine by their experiment results. Uvaraj V et al (2020) [4] use MATLAB to measure all parameters of Pelton wheel turbine blade at full efficiency. Material consideration to analysis all study done by using same software. Von mises stress, displacement, safety factor was obtained to check the feasibility of design and finally they found out that their design was safe. Hani Muhsen et al and F. Guerrerro et al and also Poole s. et al [5] [10] [12] used 3D printer to print out part. which is a good way to check the design physically. M.M Soe at al [6] found out about effect of jet angle on Turgo turbine. They used three different angle 10º, 20º,30º to carried out their study. 20º was found to be the perfect angle for Turgo turbine jet. Budiarso et al [7] performed experiment for Pico hydro plan installation in remote area at low cost as low as $48. D.S. Benzon et al [8] Studied the Turgo operational range, principle and benefits over another turbine types. And Reviewed Turgo Pico-Micro & Small-Medium scale turbine applications & manufacturers. He concluded that the CFD analysis is one of the best alternatives to carry out the performance study of Turgo turbine. K. Gaiser et al (2016) [9] experimented on Pico hydro Turgo turbine to investigate design parameter using RSM. Also, they find out that jet angle also depends on number of blades used in turbine. N. Nava Indrasena Reddy et al [11] designed the Pelton turbine using CATIA V5 CAD software. They concluded their result with respect to taking different material for the blade. Saurabh Khurana et al (2013) [16] done the modelling and FEM analysis on Turgo turbine. They did model in Solidworks and analysis in ANSYS. First, they find the force acting upon the bucket portion. after finding the force they derived the stress generated on it. after performing full analysis on ANSYS they found that deformation was negligible and concluded that their design was safe. we have found that Turgo turbine has some qualitative characteristics that can be used in remote locating areas who does not have electricity. That is why we have decided to work with Turgo turbine. there are many design consideration and performance parameters for Turgo turbine such as Velocity, Discharge, Head, Speed, Nozzle Diameter, outlet velocity, Angle consideration, etc. And there is much software for Modelling of Turbine. We have decided to use SolidWorks because it is user friendly and one of the best software that are used by Industry. For analysis we have perform Finite Element Analysis. And for that we are going to use ANSYS as it is one of the best for analysis.

## 2. Methodology

### 2.1 3D modelling of Component

We Design the Components like Turgo Turbine Blade, Hub/Plate, Nut and Bolt in SolidWorks CAD software as seen in Figure 1& 2. Steel was selected as a material for Blade.

Tensile Yield Strength(MPa) – 207

Compressive Yield Strength(MPa) – 207

Ultimate tensile strength(MPa) - 586

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## 2.2Finite Element Analysis

The results of an FEA-based simulation are typically depicted using a color scale that shows, the pressure distribution over the object or deformation or displacement. ANSYS 2020 R1 software was used for FEA. You can check the parameters taken in ANSYS in Table 1. Also, checkout figure no 3 for Meshing.

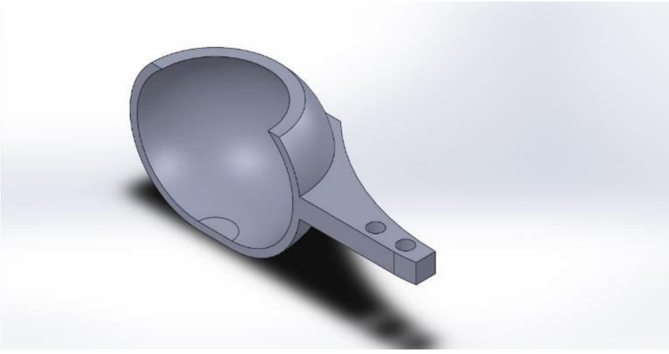

**Fig -1**: Turgo Turbine Blade

**Fig -2**: Turgo Turbine assembly

The first step was to import the geometry into ANSYS and assigning the material to it. Selected material for Blade is stainless steel because of its corrosive resistance and strength and low weight.

Steps Followed to obtain Results:

1) Modelling of the geometry on Dassault systems SolidWorks software.
2) Meshing of the geometry on ANSYS.
3) Solving of the equations.
4) Post processing to obtain the results.

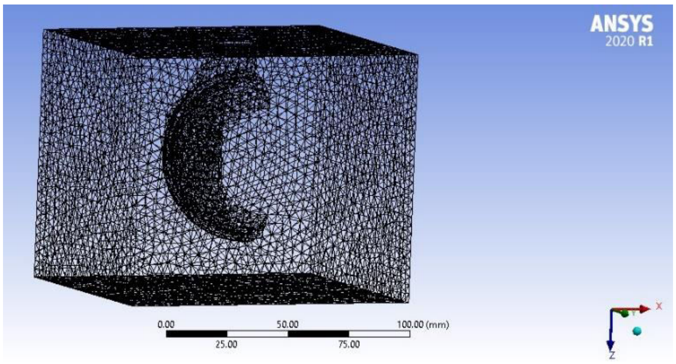


**Fig -3**: Turgo Turbine blade Meshing

**Table -1:** ANSYS Input Data

| Domain | Boundaries | |
|---|---|---|
| Default Domain | **Boundary - Inlet** | |
| | Type | INLET |
| | Location | Inlet |
| | *Settings* | |
| | Flow Regime | Subsonic |
| | Mass and Momentum | Normal Speed |
| | Normal Speed | 2.4460e+1 [m s^-1] |
| | Turbulence | Medium Intensity and Eddy Viscosity Ratio |
| | **Boundary - Outlet** | |
| | Type | OUTLET |
| | Location | Outlet |
| | *Settings* | |
| | Flow Regime | Subsonic |
| | Mass and Momentum | Static Pressure |
| | Relative Pressure | 0.0000e+0 [Pa] |
| | **Boundary - Bucket** | |
| | Type | WALL |
| | Location | Bucket |

## 3. Result and Discussion

The essential idea utilized in the FEM is that a body or design might be separated into more number components called Finite components. This collection of these components associated at a limited number of joints called nodes. The properties of the

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components are formed and consolidated to acquire the answer for the whole body or construction.

Here first we did find the Force acting upon Bucket using ANSYS at Velocity 24.46 $m/s^2$ ($Figure$ 3). From that we did find Force acting along the Bucket Surface.As per research maximum stress will be placed upon a place where blade and hub are connected (Figure 4).Force calculated as above is exerted on bucket and it is found that the maximum stress generated at a place of connection between blade and Hub. Von-mises stress (MPa) is found to a 1.2753 MPa.Total Deformation is found to be maximum 0.00292

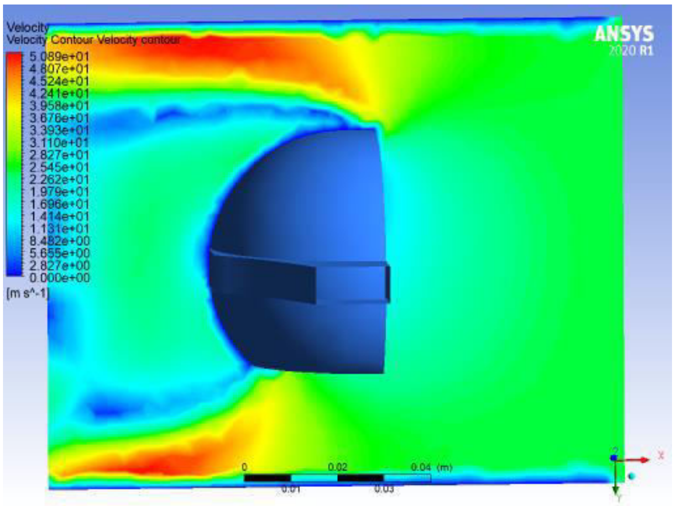


**Fig -4**: Velocity Contour

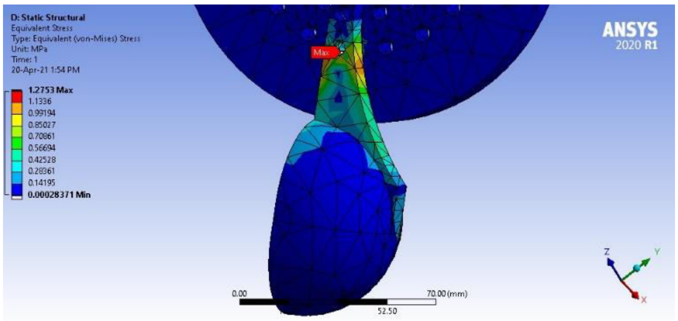


**Fig -5**: Meshing and Structural analysis of blade

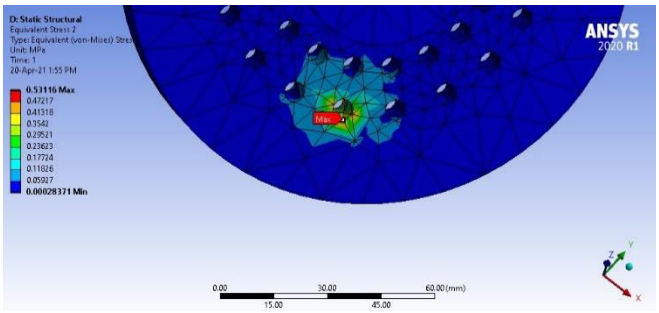


**Fig -6**: Maximum stress will be found at junction

This same procedure was carried out by using 2 different velocities 32 $m/s^2$ and 40 $m/s^2$.

### 3.1 Result Summary

**Table 2:** Summary table

| No | Velocity ($m/s^2$) | Force at Given Velocity(N) | Von-mises Stress(MPa) | Deformation (mm) |
|---|---|---|---|---|
| 1 | 24.46 | 4.54768 | 1.2753 | 0.00292 |
| 2 | 32 | 7.86452 | 2.2054 | 0.005052 |
| 3 | 40 | 12.1395 | 3.4042 | 0.007799 |

## 4. Conclusion

Design of the Turgo impulse turbine is made by using SolidWorks and Total analysis is carried out by ANSYS. From there we get the following Result.

1) After the stress analysis and deformation on the Turgo turbine blade, we get maximum VON MISES stresses are 1.2753MPa, while the deformation produced when the jet strikes the blade at Velocity 24.46 $m/s^2$ is 0.001076 mm. At a force of 4.54768 N, the design made on SolidWorks software is safe.

2) After the stress analysis and deformation on the Turgo turbine blade, we get maximum VON MISES stresses are 2.2054MPa, while the deformation produced when the jet strikes the blade at Velocity 32 $m/s^2$ is 0.005052mm. At a force of 7.86452 N, the design made on SolidWorks software is safe.

3) After the stress analysis and deformation on the Turgo turbine blade, we get maximum VON MISES stresses are 3.4042 MPa, while the deformation produced when the jet strikes the blade at Velocity 40 $m/s^2$ is 0.007799mm. At a force of 12.1395 N, the design made on SolidWorks software is safe.

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