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International Journal Of Modern Engineering Research (IJMER)

Static Analysis of a Pyro Turbine by using CFD

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ABSTRACT: *This paper aims to develop a standard design procedure for pyro turbine that can be manufactured locally in developing countries with very low head, steady power (200W to 1 kW with no discharge regulation), low cost and isolated network operation. The present research work has been carried out to modify the original blade material i.e. AK Stainless Steel 340 with different blade material ASME Stainless Steel SA516 Gr. 70 to withstand turbulence at the site which significantly affected the turbine operation. For this, a solid 3D model of turbine is generated through Catia V5. Static analysis by using CFD for original blade material is done Further static analysis by using CFD is done to the modified blade material for turbulence which shows that turbulence was successfully withstanded and had withstanded the high Pressure and Von-Mises Stress as well as minimum .deformation The results obtained by comparing original and modified blade materials are within the limits. The design is safe.*

Keywords: *Ansys (Static), Catia, Pyro Hydro Turbine, Turbulence, Von-misses Stress*

I. INTRODUCTION

Climatic changes all over the world are believed to be due to the excessive use of conventional (fossil) energy sources [1]. It is felt essential to draw attention towards the application of renewable energy sources which seem to be the most suitable future fuel. Importance of small hydroelectric power plants have increased manifold to meet the fast increasing electrical energy demand as well as to develop rural electrification for smaller and remote villages that cannot afford a larger hydropower project. This case study of design process is a critical process to understand the effectiveness of design methods which were implemented by human designers to overcome design fixations [2]. Even though the power generated is less than 5kW, but the benefit gain from this energy is the ability to raise the standard living of residents in remote areas [3]. Similar studies and tests on a series of Hydro – Turbine design models are conducted in rural parts where the national grid is inaccessible and reiterated that impulse forces at specific time instances i.e. peak hours cannot be replaced or replicate upon each other [4]. Due to improper blade profile in the existing blade design, the required power enhancement is not achieved [5]. In developing countries like India, Nepal, Vietnam etc. energy savings, high power consumption as well as power generation are of very much concern. So they are opting for Offline Grid system, Stand-alone Systems etc. At present scenarios, their daunting problem of concern is the turbulence. With this background, an attempt has been made to reduce turbulence by modifying original blade material.

II. PYRO HYDRO TURBINE

The factors given in the below table 1 determine the type of hydro power scheme to be used:

Table 1: Power Output Classification of Hydro Power Scheme

Classification	Power Output, P
Pyro	10W to 200W
Pico	0.2KW to 5 KW
Micro	5-100KW
Mini	100KW- 1MW
Small	1-10 MW
Medium	0-100 MW
Large	>100KW

Figure 1: Profile of Pyro Hydro Turbine

III. MATERIALS AND METHODS

The material used to fabricate a turbine blade should have fine grain structure with particle size, excellent formability, good weldability, uniform surface, maximum thickness (205mm), high Brinell hardness (x100 – 4.15), high tensile strength (485MPa-620MPa), corrosion resistance, sturdy construction and temperature resistance. This ensures that the turbines will function at their best efficiency for the expected life span on the pyro turbine. With the above background, ASME Stainless steel SA516 Gr.70 (Gr.70 stands for increasing tensile strength levels of 55, 60, 65, 70) used for present research so that the turbulence will be minimized. Mechanical properties are shown in below Table 2:

Table 2: Mechanical Properties of Original (AK Stainless Steel 340) and Modified blade material (ASME Stainless Steel SA516 Gr. 70)

Sl. No	Mechanical Properties	Original blade material(AK Stainless Steel 340)	Modified blade material (ASME Stainless Steel SA516 Gr.70)
1	Thickness (mm)	134	205
2	Brinell Hardness(BHN)	3x100	4.15 x 100
3	Tensile Strength(MPa)	325	485 – 620
4	Yield Strength(MPa)	241	260

IV. STATIC ANALYSIS

4.1 Static Analysis for Catia model of pyro turbine for original and modified blade material at 1200 Rpm
Original blade material Total pressure = 5.07e5 Pascal = 0.507 Mpa
Pressure on each blade = 0.507/12 = 0.0422MPa = 4.2 e -002
Modified blade material Total pressure = 1.28e6 Pascal = 1.28MPa
Pressure on each blade = 1.28/12 = 0.106 Mpa

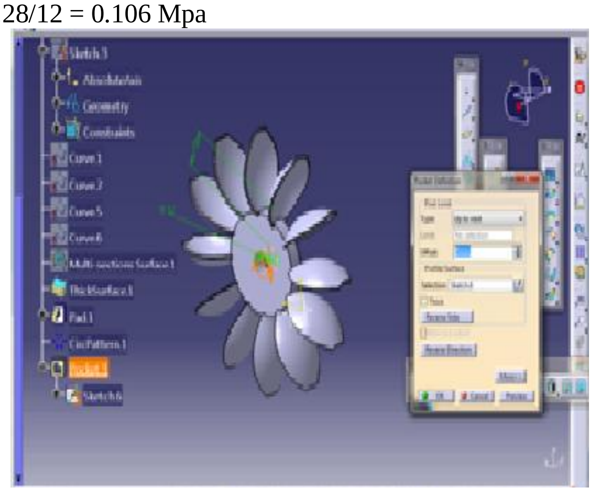

Figure 2: Catia model of Actual turbine of AK Stainless Steel 340

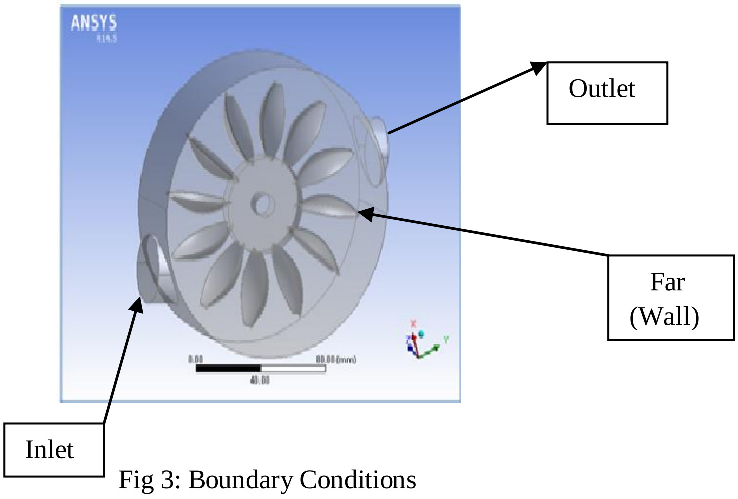

Fig 3: Boundary Conditions

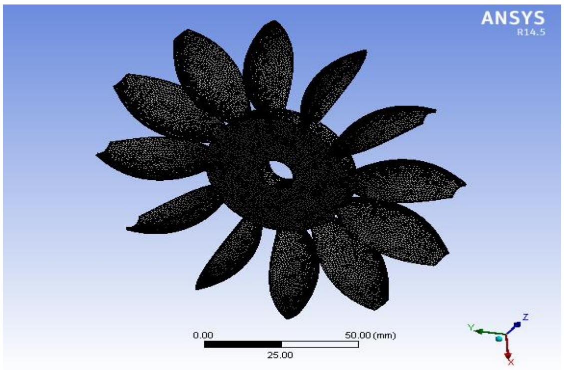

Fig 4: Original Solid meshed File

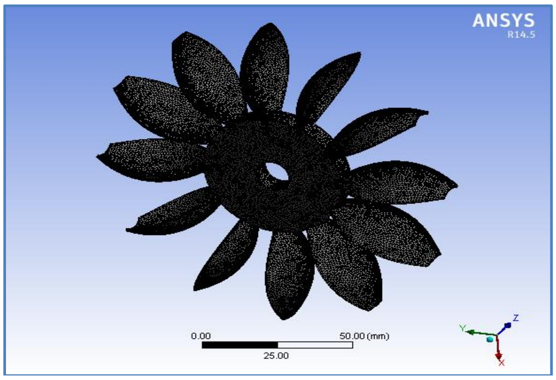

Fig 5: Modified Meshed File

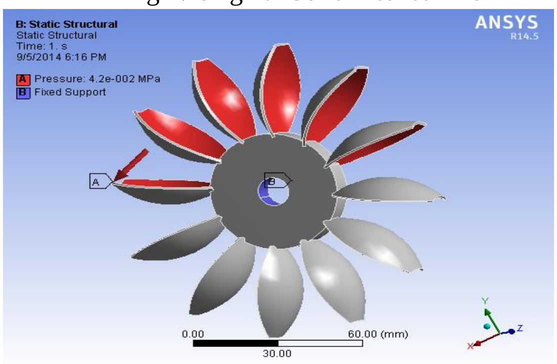

Fig 6: Original Fluid pressure applied on all Blades

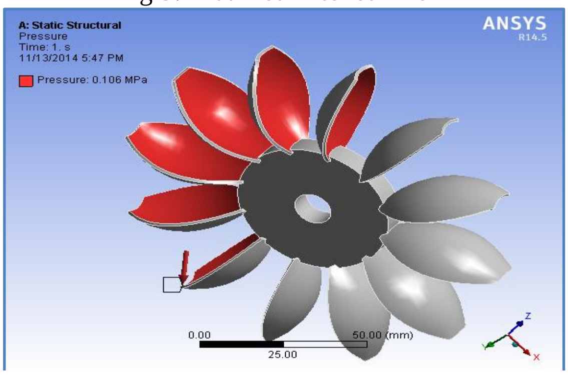

Fig 7: Modified Static pressure applied on all Blades

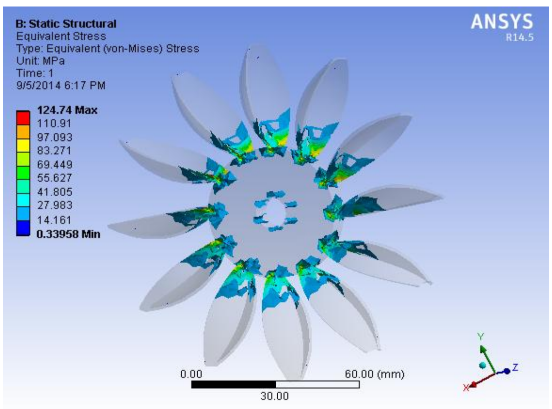

Fig 8: Original Equivalent Von-Mises stress

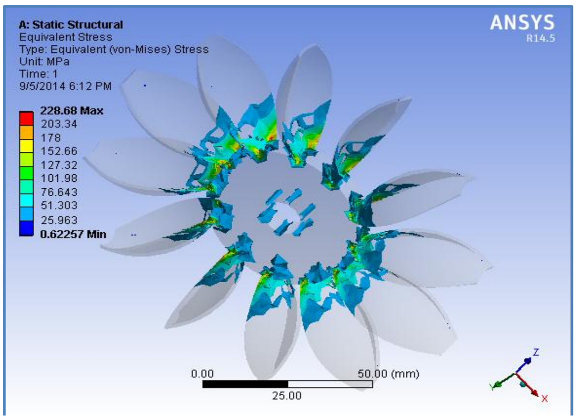

Fig 9: Modified Equivalent Von-Mises stress

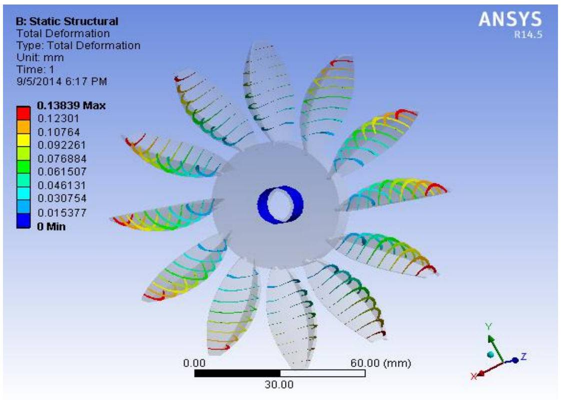

Fig 10: Original Total deformation

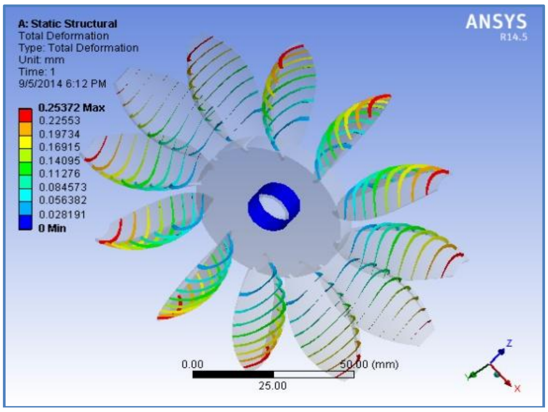

Fig 11: Modified Total deformation

V. RESULTS AND DISCUSSIONS

Table 2: Static Analysis Results

Material	**Applied Pressure for each blade(MPa)**	**Equivalent Von-Mises stress (MPa)**	**Total Deformation (mm)**
AK Stainless Steel 340	0.0422	124.74	0.13839
ASME Stainless Steel SA516 Gr.70	0.1066	228.68	0.25372

4.1 Comparison of Speed with respect to Pressure, Von-Mises Stress and Deformation

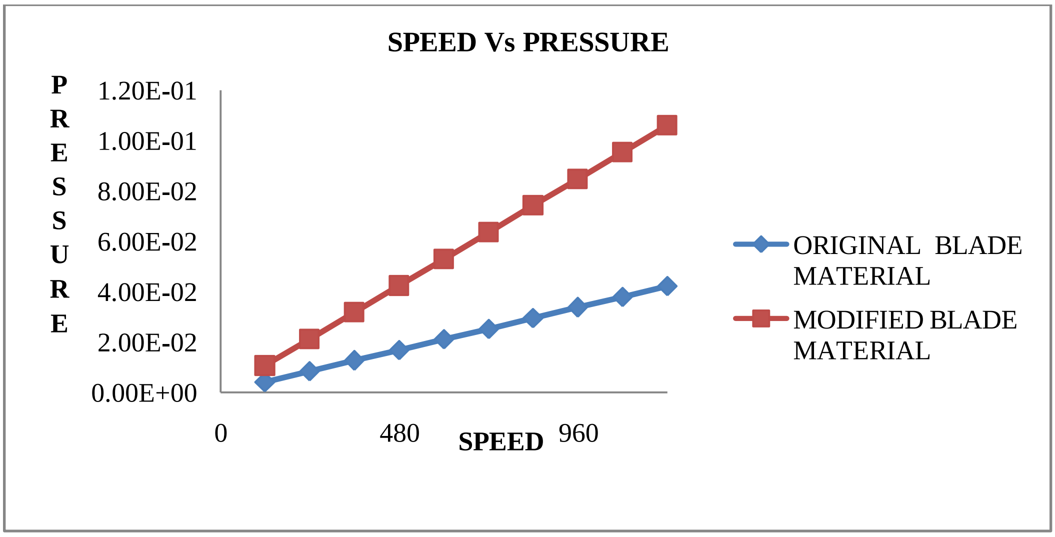

Fig 12: Speed Vs Pressure

Figure 12 represents behaviour of the exerted fluid pressure being applied on all blades for original and modified blade material at speeds 120,480, 960 and 1200 rpm. It can be observed that the exerted fluid pressure for the above said speeds are at 0.00422MPa-0.01688 MPa -0.03376 MPa -0.0422 Mpa and 0.01066 MPa -0.0424 MPa -0.0848 MPa -0.1066 Mpa. The exerted pressure on both blade materials substantially increases with the increase in speed and minimum at 120 rpm of 0.0422 Mpa and maximum at 1200rpm of 0.1066MPa.The effect of turbulence found to be increasing gradually with the increasing speeds. This behaviour can be correlated to turbulence effect with an expected positive result that it withstands higher turbulence and pressure of 0.1066MPa.

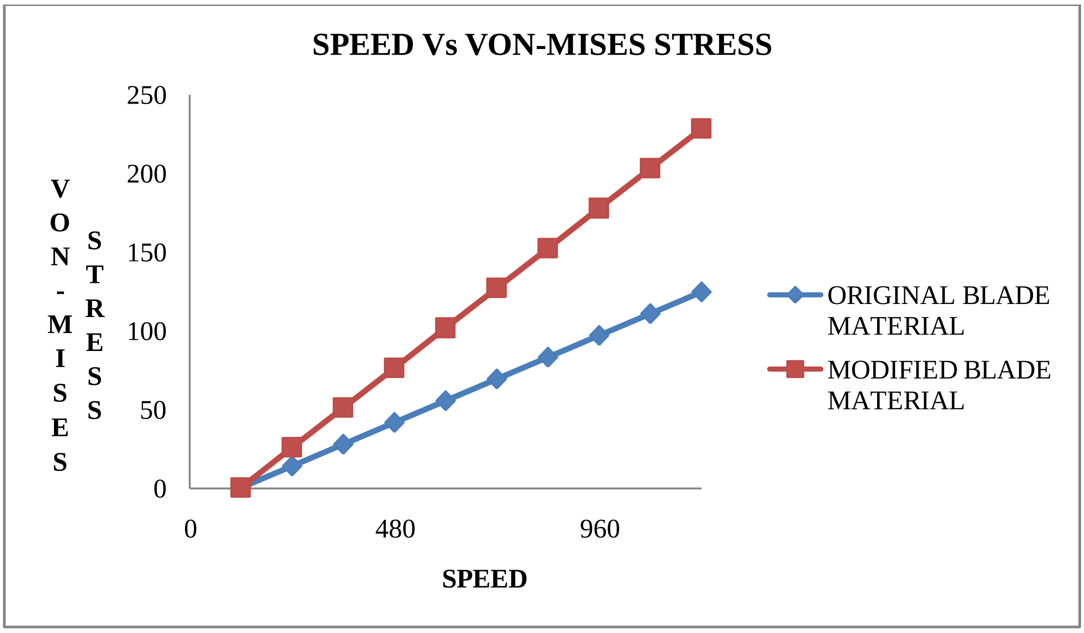

Fig 13: Speed Vs Von-Mises Stress

From fig. 13, it can be observed that the Von-Mises Stress for the above said speeds are at 0.33958MPa-41.805MPa -97.093MPa -124.74Mpa and 0.62257MPa -76.643MPa -178MPa -228.68MPa. The Von-Mises Stress on both blade materials drastically increases with the increase in turbulence as well as speed and minimum at 120 rpm of 0.33958MPa and reached maximum at 1200rpm of 228.68MPa. A drastic increment in Von-Mises Stress has been observed for modified blade material and the maximum value obtained is 228.68Mpa with an aspiring result that it withstands higher turbulence and maximum Von-Mises Stress. This can be highlighted as a good ductile and weldability behaviour.

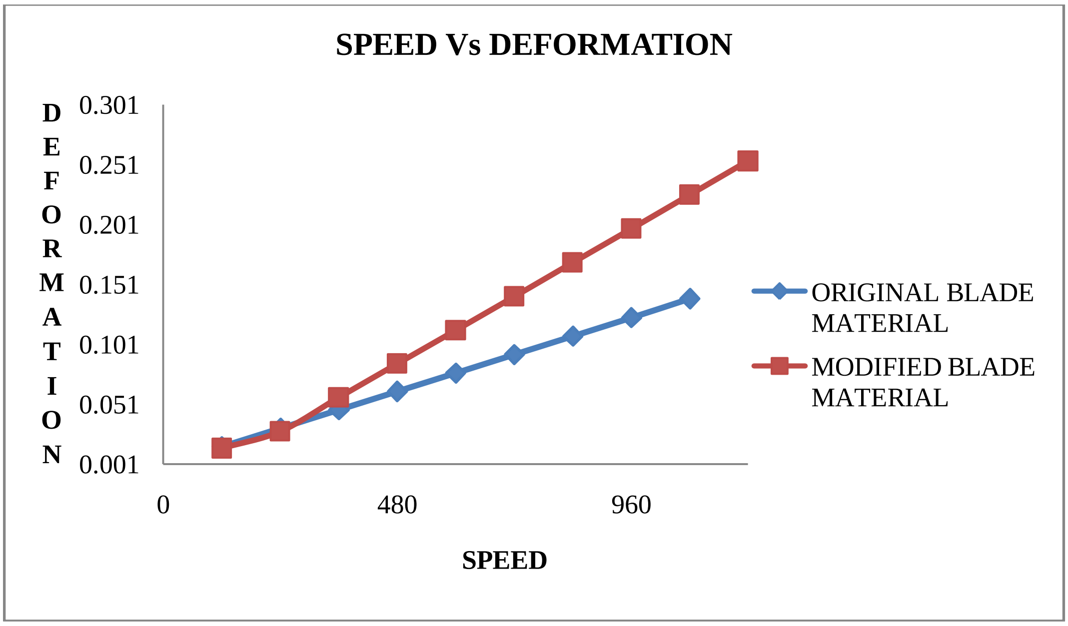

Fig 14: Speed Vs Deformation

From fig. 14, by comparing deformation behaviour for original and modified blade material at speeds 120rpm, 480rpm, 960rpm and 1200rpm of pyro turbine the deformations obtained are 0.0mm-0.046131mm -0.10764 mm -0.1389 mm and 0.0 mm -0.084573 mm -0.19734 mm -0.25372 mm. The deformation on both original and modified blade material gradually increases which is minimum at 120 rpm of 0.33958MPa and maximum at 1200rpm of 228.68MPa. The effect of deformation is found to be nominal. This can be attributed to be a safe design.

VI. CONCLUSION

After comparing the Static Analysis results with respect of original and modified blade materials being used, the following conclusions are made.

i. Observed that the turbulence was effectively tackled.
ii. Modifications are incorporated successfully with respect to inlet nozzle.
iii. Compared the Pressure, Von-Mises stress and Total deformation for original and modified materials of blade and concluded that ASME Stainless Steel SA516 Gr. 70 is the best suited blade material for safe design as it is withstanding the huge turbulence and is within the analysis range.

Acknowledgement

The authors gratefully acknowledge the support of Department of Science & Technology and Power and Energy Research Center, Shri Vishnu Engineering College for Women to undertake this project work

REFERENCES

[1] P.P. Sharma, S. Chatterji and Balwinder Singh, "Matlab Based Simulation of Components of Small Hydro-Power Plants" VSRD International Journal of Electrical, Electronics & Communication Engineering, Vol. 3 Issue 8, (2013), pp 372-380.

[2] J.S.Linsey, I.Tseng, K.Fusss, et al., "A Study of Design Fixation, Its Mitigaion and Perception in Engineering Design Faculty", Journal of Mechanical Design, 132,041003, (2010), Pages: 01-12.

[3] Urvin Rameshbhai Patel, Devendra A Patel and Manish S Maisuria Vol. 3, No. 3, July, 2014 "Analyse the Effect of Mass Flow Rate on the Efficiency of Pico Turbine & Validate with Experimental Results" International Journal of Mechanical Engineering & Robotic Research 2014

[4] Patrick Ho-Yan (2012), "Design of a Low Head Pico Hydro Turbine for Rural Electrification in Cameroon", A Thesis presented to the University of Guelph, Ontario, Canada, April, 2012

[5] Sushant Waghin, Dhananjay Panchagade, **"**Analyzing Effect of Impeller Width on Mass Flow Rate of Centrifugal Blower using CFD"**,** International Journal of Electrical, Electronics & Communication Engineering, Vol. 3 Issue 8, (2013), pp 372-380.

[6] Sam Y. Zamrik, Ph.D. ASME President 2007-2008, "2028 Vision for Mechanical Engineering: A report of the Global Summit on the Future of Mechanical Engineering ", July (2008), ASME, Three Park Avenue, New York, NY 10016, USA

[7] J H Park, N J Lee, J V Wata, Y C Hwang, Y T Kim and Y H Lee, "Analysis of a pico tubular-type hydro turbine performance by runner blade shape using CFD" ,26th IAHR Symposium on Hydraulic Machinery and Systems IOP Publishing, IOP Conf. Series: Earth and Environmental Science **15** (2012) 042031doi:10.1088/1755-1315/15/4/042031

[8] Sourabh Khurana, Varun Goel and Anoop Kumar, "FEM Analysis of Turgo Impulse Turbine Blade", Walailak Journal of Science & technology 2013; 10(4): 363-368 http://wjst.wu.ac.th

[9] R.G. Simpson, A.A. Williams, "Application of computational fluid dynamics to the design of pico propeller turbines" Nottingham Trent University, *Proceedings of the International Conference on Renewable Energy for Developing Countries - 2006*

[10] K.P. V. S. R. Vinay Kumar et.al., Certain Aspects of Framework for Handling Design Nonlinearity, *38th National Systems Conference Real Time Systems - Modeling, Analysis and Control JNTU College of Engineering Hyderabad (Autonomous), Hyderabad , Telangana, 5-7 November -2014*