Design And Analysis of Last Stage Blades of Low Pressure Turbine

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ABSTRACT

A Steam Turbine functions to convert energy from Thermal Form to Pressurized Steam and then the steam is utilized for obtaining useful mechanical work.This paper deals with the energy drop occurring at last stage of Low Pressure Stem Turbine. Although many researches have been carried out on the Low Pressure Turbine for getting the maximum efficiency, Steps and methods displayed hereby are solved challengingly. Details are obtained by assigning various input parameters to Steam Turbine Blades and Shaft. CAD Model of Shaft carrying several blades is prepared in SOLIDWORKS. After designing a shaft with blades, The ready CAD model is called for Computational Fluid Dynamics and Finite Element analysis in Ansys. The result of FEA and CFD Analysis in comparison with the analytical values gave the best suitable angle of blades for last stage of Steam Turbine.

Keyword : - *Low Pressure Steam Turbine, Ansys, FEA and CFD Analysis, Angle of blades, Last Stage of LP Turbine*

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1. INTRODUCTION

Blades are the heart of a turbine, as they are the principal elements that convert the energy of working fluid into kinetic energy. The efficiency and reliability of a turbine depend on the proper design of the blades. It is therefore necessary for all engineers involved in the turbines engineering to have an overview of the importance and the basic design aspects of the steam turbine blades, Blade design is a multi-disciplinary task. It involves the thermodynamic, aerodynamic, mechanical and material science disciplines. A total development of a new blade is therefore possible only when experts of all these fields come together as a team. The number of turbine stages can have a great effect on how the turbine blades are designed for each stage. The number of stages depends upon the load we have and the quantity of power we required. Too many stages may also develop bending moment and high torque which in turn the reason of failure of the entire unit of the plant.

Efficiency of the turbine depends on following parameters :

i) Inlet and Outlet angles of the blade
ii) Surface finishing
iii) Profile of the blade

Last stage blade of steam turbine, which is being analyzed for stress and vibration is a highly twisted blade due to the variation if the blade speeds across the height of the blade. The deflection in the blade passage also reduces from hub to tip to vary the loading on each section. Thus the pressure distribution on the suction and pressure surface of the blade changes considerably from hub to tip to match

Fig. 1 Actual View of Low Pressure Turbine

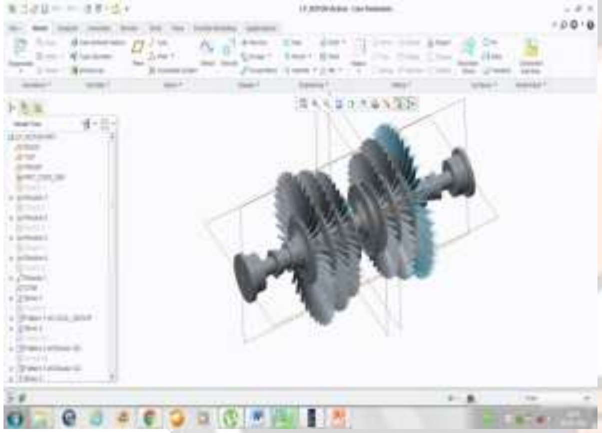
the loading at that suction. It is known fact that the area of pressure distribution curve representing the blade loading.

2. PROBLEM STATEMENT

The last stage of Low Pressure steam Turbine Blades are highly prone to loss of energy due to change of stage. The energy dropped hereby in last stage ultimately results towards less output from the turbine. The Stage efficiency is thereby reduced to some extent.. Also by keeping Blade efficiency in consideration, Change of shape for the blades is must needed. Here in order to get maximum output (by minimizing or reducing loss of energy at last stage), design of blade is made by changing it's shape. It is found that upon changing the blade profile, the Low Pressure Turbine will respond towards no drop of energy.

3. CAD MODEL, CALCULATIONS AND ANALYSIS

3.1 CAD MODEL



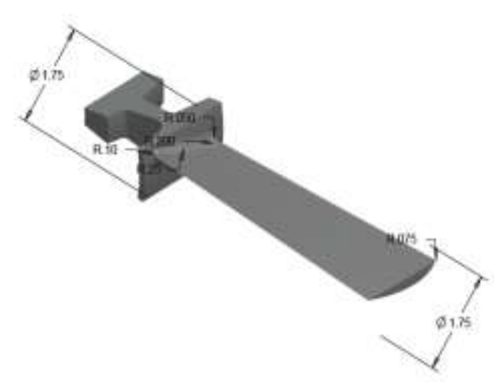
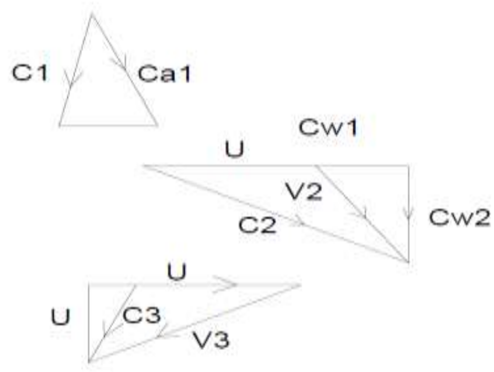


Fig.2 Part View of Low Pressure Turbine Fig.3 : Isometric view of blade with changed Shape

3.2 INPUT PARAMETERS AND CALCULATIONS

Input Parameters used in estimation of Result is as shown below.

- Type of turbine : Impulse-reaction turbine
- Turbine Capacity : 600MW
- Inlet steam Pressure : 65bar
- Inlet steam Temperature : 4850c
- Turbine Speed : 3000 rpm
- Exhaust steam Pressure : 0.1765bar
- Outlet steam Temperature : 57.400c
- Number of Stages : 12
- Working medium : Steam



1^{st} Condition : Blades with Original Shape

$Ca_1 = Ca_2 = Ca_3 = Ca = 456.05$ m/s

From velocity triangle (b) , C2 = Ca2/cosa2 = 456.05/cos 65 = 1080m/s

From figure (c), $C_3 = Ca_3/ \cos a_3 = 456.05/ \cos 73.5 = 1628$ m/s

$Cw_3 = Ca_3 \tan a_3 = 456.05 \tan 98 = 80.41$ m/s

$\tan b_3 = (U + Cw_3) / Ca_3 = (25 + 80.41)/25 = 4.51$

Thus, $b_3 =$ 57:318

From figure (b), $Cw_2 = Ca_2 \tan a_2 = 456.05 \tan 10 = 80.41$ m/s

$\tan b_2 = (Cw_2 – U)/Ca_2 = (80.41 – 25)/25 = 0.492$

Thus, b2 = 29.21

Power output, $W= mUCa(\tan b_2 + \tan b_3) =390*25*25*(0.492 + 1.14)/1000 = 1470$ Kw

2nd Condition : Blades with Changed Shape

$Ca_1 = Ca_2 = Ca_3 = Ca = 456.05$ m/s

From velocity triangle (b), $C_2 = Ca_2/\cos a_2 = 456.05/\cos 63.8 = 1036.77$m/s

From figure (c), $C_3 = Ca_3/ \cos a_3 = 456.05/ \cos 72.5= 1520$ m/s

$Cw_3 = Ca_3 \tan a_3= 456.05 \tan 98 = 80.41$ m/s

$\tan b_3 = (U + Cw_3) / Ca_3 = (25 + 80.41)/25 = 4.21$

Thus, $b_3 =$ 57:318

From figure (b), $Cw_2 = Ca_2 \tan a_2 = 456.05 \tan 63.8 = 80.41$ m/s

$\tan b_2 = (Cw_2 – U)/Ca_2 = (80.41 – 25)/25= 0.492$

$b_2 = 29.21$

3.3 CFD AND FINITE ELEMENT ANALYSIS

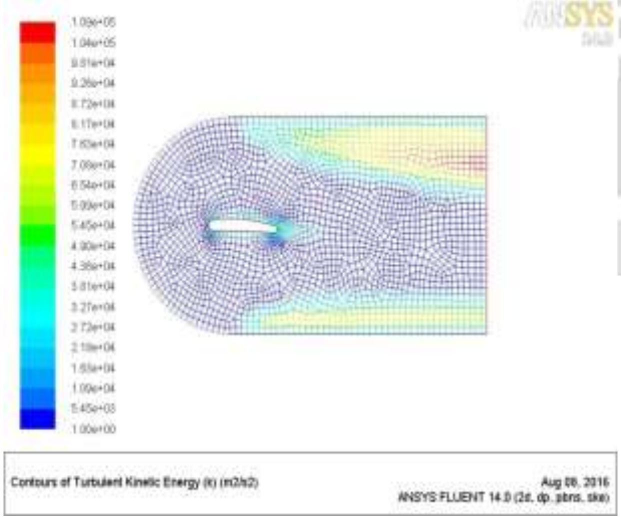


Fig 4: Contour plot of static pressure

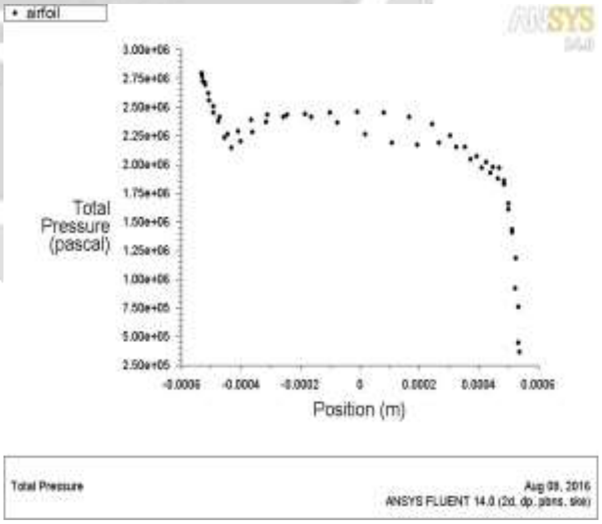


Fig 5: Graph of total pressure

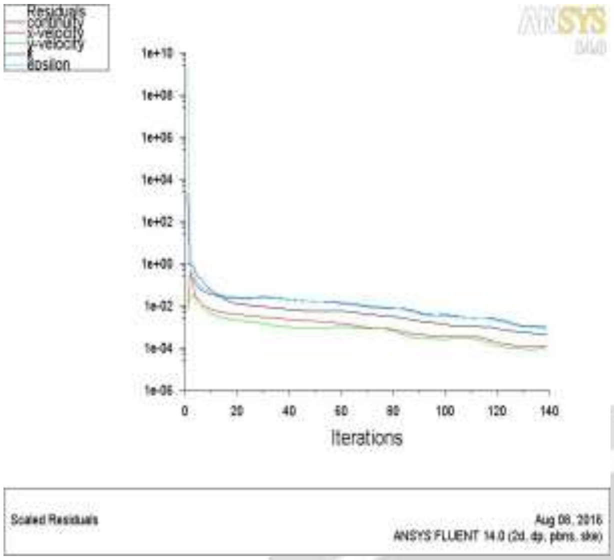


Fig 6: Graph of residuals

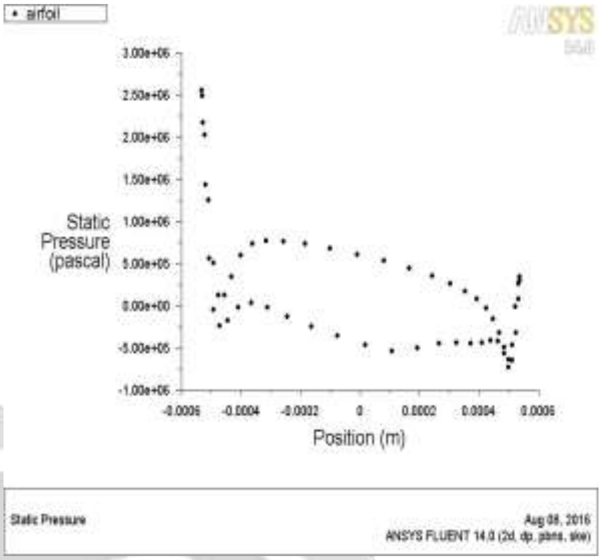


Fig 7: Graph of static pressure

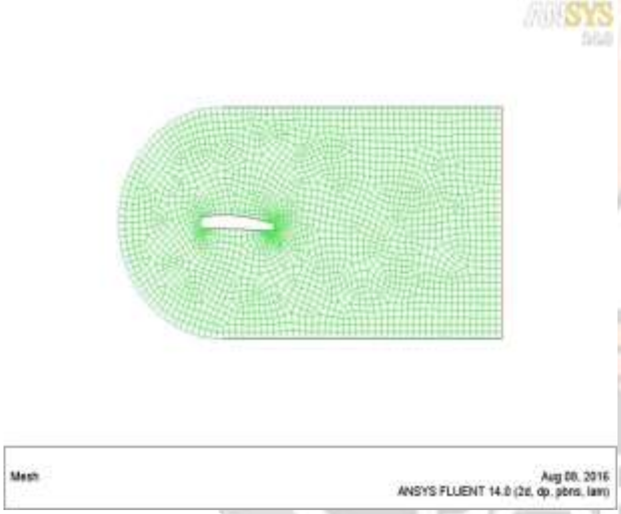


Fig 8: Contour plot of static pressure

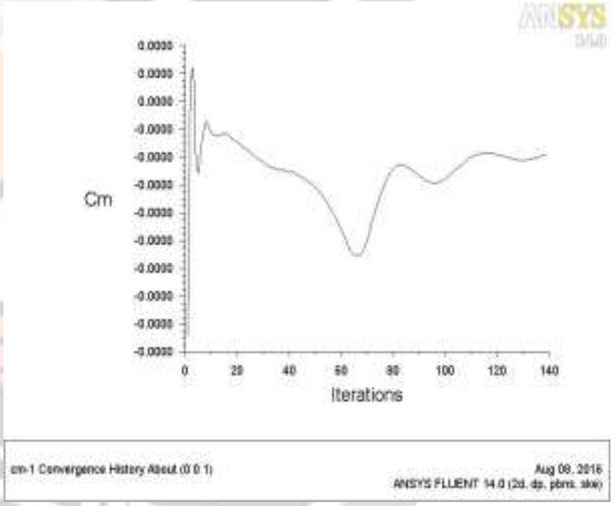


Fig 9: Graph of C_m

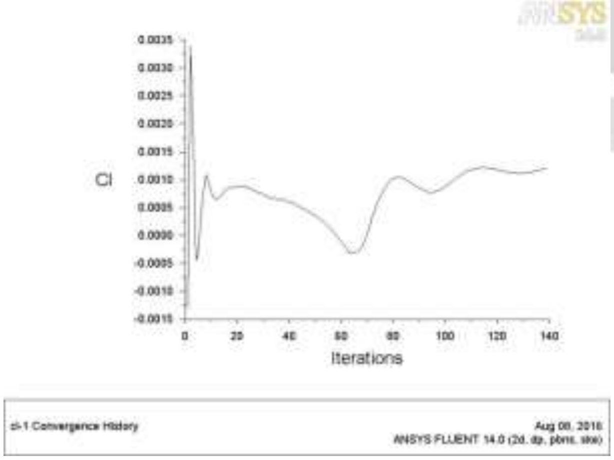


Fig 10: Graph of C_l

4. CONCLUSIONS

Result	Analytical	CFD
Power developed in the stage	1470 kW	1386 kW
Blade efficiency	81.74 %	79.8 %
Stage efficiency	79.24 %	78.2 %
Pressure at stage outlet	0.1765 bar	0.172 bar
Absolute velocity at the outlet of the moving blade	241.93 m/s	224 m/s (Avg)
Temperature at the outlet of the stage	57 ^{0}C	59.5 ^{0}C

Upon analyzing analytical and CFD values, It is possessing an error of less than 5 %. Thus the values hereby stated can be adopted most possibly. It is found that upon making some essential changes in a blade design, the results are better effective and efficiency is more than that of the older blades of last stage LP Steam Turbine.

Considering problem this project was successfully executed in stipulated time. Design and Analysis of turbine blades of Last stage of Low Pressure Steam Turbine is done here. Since there stands some scope to increase the efficiency of the turbine, a step was initiated in this project. The drop of energy is observed at last stage of the Low Pressure Steam Turbine, for eliminating this energy drop a profile of blade was changed . Thus in this paper the study of project concludes that the design of blades stated hereby is best suitable in order to increase efficiency.

5. REFERENCES

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