Design And Calculations of Last Stage Blades of Low Pressure Turbine

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ABSTRACT

It is found that the effectiveness of a Steam Turbine depends upon the stages and profile of blade present in a turbine. When Steam Turbine converts energy from Thermal Form to Pressurized Steam, that steam is used for getting useful mechanical work. Motto of this project is to rectify the energy drop occurring at last stage of LP Turbine. Many researches were carried out for efficiency improvement of the turbine . This paper deals with the change of blade profile in some extent for reducing the energy drop at last stage of Low Pressure Turbine. Certain input parameters are assigned and then later to it Design Calculations are performed analytically and CAD Model for Shaft with blades for LP Turbine is made. SOLIDWORKS is used for making a CAD Model.

Keyword : - *Energy drop, , Last Stage of LP Turbine, SOLIDWORKS.*

1. INTRODUCTION

Blades of turbine are considered to be the heart of a turbine. In Reaction Turbine, the design of blade profile matters more for getting better efficiency and reliability. Importance of blade profile for efficiency improvement is always proved to be one of the challenging part in Design Engineering. Proper calculations after assigning exact parameters are the key to Design and Development of Steam Turbine.

Normally Steam Turbine is further more divided into two categories

- High Pressure Turbine
- Low Pressure Turbine

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

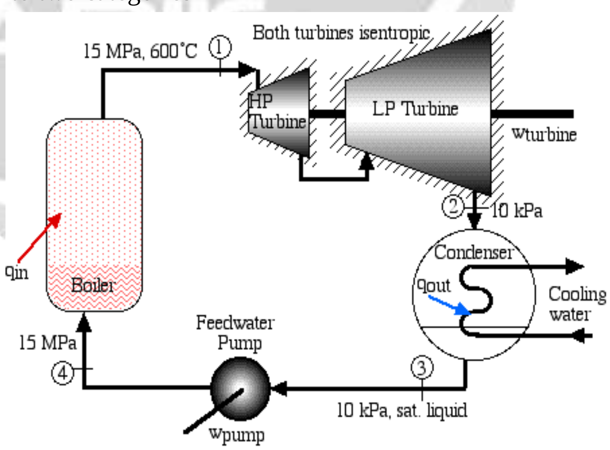

Fig.1 Diagramatic View of Steam Turbine

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 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

3.1 CAD MODEL

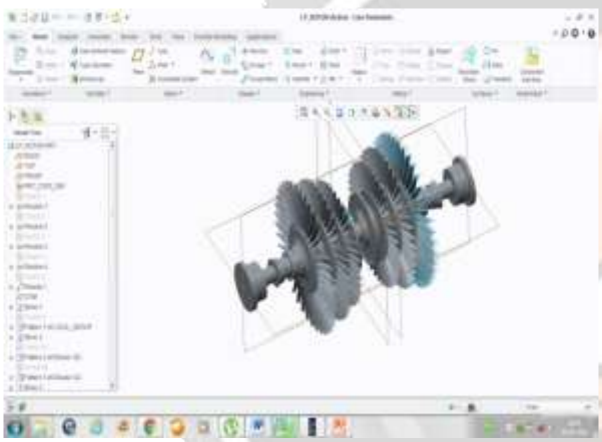

Fig.2 Part View of Low Pressure Turbine

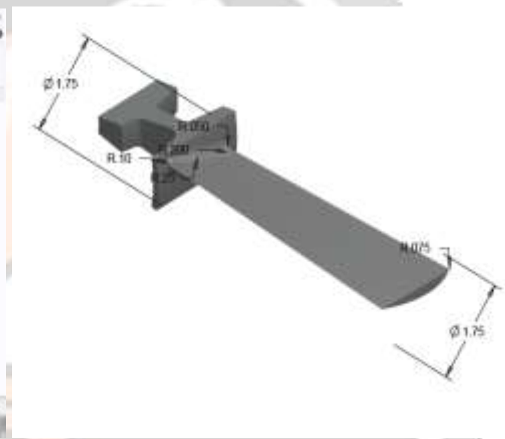

Fig.3 : Isometric view of blade with changed Shape

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

1st 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/ $cosa_3$= 456.05/ cos 73.5 = 1628 m/s

$Cw_3 = Ca_3 \ tana_3$ = 456.05 tan 98 = 80.41 m/s

$tanb_3 = (U + Cw_3) / Ca_3$ = (25 + 80.41)/25 = 4.51

Thus, b_3 = 57:318

From figure (b), $Cw_2 = Ca_2 \ tana_2$ = 456.05 tan 10 = 80.41 m/s

$tanb_2 = (Cw_2 – U)/Ca_2$ = (80.41 – 25)/25 = 0.492

Thus, b2 = 29.21

Power output, W= $mUCa(tanb_2 + tanb_3)$ =390*25*25*(0.492 + 1.14)/1000 = 1470 Kw

2^{nd} Condition : Blades with Changed Shape

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

From velocity triangle (b), $C_2 = Ca_2/cosa_2$ = 456.05/cos 63.8 = 1036.77m/s

From figure (c), $C_3 = Ca_3/ \ cosa_3$ = 456.05/ cos 72.5= 1520 m/s

$Cw_3 = Ca_3 \ tana_3$= 456.05 tan 98 = 80.41 m/s

$tanb_3 = (U + Cw_3) / Ca_3$ = (25 + 80.41)/25 = 4.21

Thus, b_3 = 57:318

From figure (b), $Cw_2 = Ca_2 \ tana_2$ = 456.05 tan 63.8 = 80.41 m/s

$tanb_2 = (Cw_2 – U)/Ca_2$ = (80.41 – 25)/25= 0.492

b_2 = 29.21

4. CONCLUSIONS

Result	**Analytical**
Power developed in the stage	1470 kW
Blade efficiency	81.74 %
Stage efficiency	79.24 %
Pressure at stage outlet	0.1765 bar
Absolute velocity at the outlet of the moving blade	241.93 m/s
Temperature at the outlet of the stage	57 ^{0}C

Upon performing analytical calculations, results are obtained. 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.

5. REFERENCES

[1] Subramanyam Pavuluri1, Dr. A. Siva Kumar, "Experimental Investigation on Design of High Pressure Steam Turbine Blade" IJIRSET, ISSN: 2319-8753, Vol. 2, Issue 5, May 2013

[2] Sivakumar Pennaturu, Dr P Issac Prasad, "Evaluating Performance of Steam Turbine using CFD" IJLTET, ISSN: 2278-621X , Vol. 4 Issue 2 July 2014.

[3] Amit Kumar Gupta, Mohd. Rehan Haider, Rohit Pandey, "Analysis of Creep Life of Steam Turbine Blade by Using Different Material", IJESRT [571-575], July 2014, ISSN: 2277-9655

[4] Colin Bradley, Bernadette Currie (2005), "Advances in the Field of Reverse Engineering", Computer Aided Design & Applications, Vol. 2, No. 5, pp 697- 706.

[5] R.W. Edmonson, "Dimensional Changes in Steel during Heat Treatment", Met. Treat.,Vol 20 (No 6), 1969, pp 3–19.

[6] R. Nagendra Babu, K. V. Ramana, and K. Mallikarjuna Rao (2008), "Determination of Stress Concentration Factors of a Steam Turbine Rotor by FEA" World Academy of Science, Engineering and Technology, 39.

[7] Chunlin Zhang, Niansu Hu, Jianmei Wang, Qiping, chen, Feng He,Xiaoli (2010), "Thermal Stress Analysis for Rotor of 600MW Steam Turbine" 978-1-4244-4813-5/10/&25.00c/2010/IEEE.

[8] Kolhe M R, A. D. Pachchhao, H.G. Nagpure (2004), "thermal stress analysis in steam turbine rotor - a review" Computer Aided Design & Applications, Vol. 1 (4).

[9] M. Chandra Sekhar Reddy and Talluri Ravi Teja. New Approach to Casting Defects Classification and Optimization by Magma Soft. International Mechanical Engineering and Technology, 5(6), 2014, pp. 25-35.

[10] Prof.Nasar A, Dr. N E Jaffar and Sherin A Kochummen.Lyapunov Rule Based Model Reference Adaptive Controller Designs For Steam Turbine Speed. International Mechanical Engineering and Technology, 5(6), 2014, pp. 25-35

[11] Gatzweiler R, 2012, Investigation of a Supersonic Axial Turbine in the Organic-Rankine-Cycle, UniversitatPolitècnica de València, Project Theses

[12] ANSYS, ANSYS FLUENT 12.0/12.1 Documentation, accessed: 2012-08-22, last edited: 2009-01-29, https://www.sharcnet.ca/Software/Fluent12/index.htm

[13] CFD-Online, Best practice guidelines for turbomachinery CFD, accessed: 2012-08-22, last edited: 2012-01-20, http://www.cfd-online.com/Wiki/Best_practice_guidelines_for_turbomachinery_CFD#Frozen_rotor_simulations

[14] ANSYS, ANSYS FLUENT 6.3 Manual, accessed: 2012-08-22, http://hpce.iitm.ac.in/website/Manuals/Fluent_6.3/fluent6.3/help/pdf/ug/chp12.pdf

[15] Wikipedia, List of refrigerants, accessed: 2012-03-26, last edited: 2012-02-27, http://en.wikipedia.org/wiki/List_of_refrigerants