Applying Computer Aided Designing for Steam Turbine Blade with Different Aerodynamic Profile

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Abstract— Modern industries are using CAD models for the accurately representation of geometry for designing and manufacturing of turbines. The CAD model provide a more realistic analysis of performance of the product, this task included dimensional measurement and geometric modeling. This paper presented the procedure for how to achieve CAD model of turbine blade.
Key words: Cascade; Turbine Blade

I. Introduction

Turbine blade play as an important role in absorbing the energy from the dynamics of fluid and converted into mechanical energy. These Blades are fabricated in the desired size and shape and assembled in a straight line or annular according to the designing of cascade. The designating of cascade is based on the database which contains a set of turbine cascades with their geometry and operating conditions. In general, there are two methods for blade profile design i.e. inverse method, and direct method. The inverse design is faster because it is based on the two-dimensional flow analysis to form the airfoil according to the airfoil pressure profile. However, the location of the profile control points is difficult to control and numbers of arcs are generally large. This makes it difficult to use the same curve definition routine for design and manufacturing. On the other hand, direct design may require more time in the aerodynamic design process, but can generate more accurate designs in the manufacturing process. In turbulent flow analysis is needed to evaluate the blade performance.

II. Blade Profile

The five blade profiles investigated were from the mean-line and near tip sections of the same low-reaction, high-pressure steam turbine blade. Unlike many gas turbine blades, these steam turbine blades did not exhibit large variation in profile ("twist") from hub to tip, s evinced by the profile in figure 1.

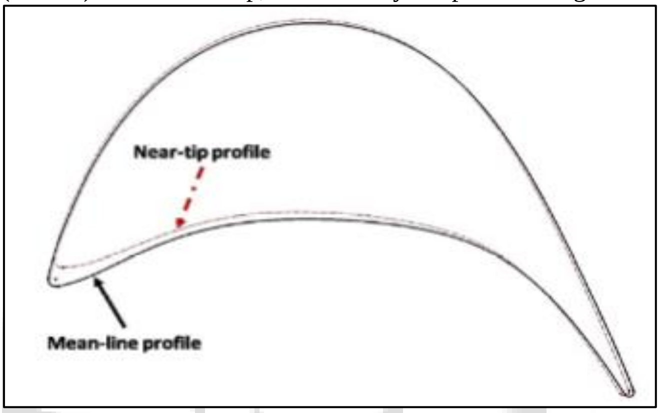


Fig 1: Comparison of blade profile

III. Blade Profile Parameter

	Profile 1		Profile 2		Profile 3		Profile 4		Profile 5	
Parameter	Mean line	Near tip	Mean line	Near tip	Mean line	Near tip	Mean line	Near tip	Mean line	Near tip
True Chord(mm)	65.08	64.16	65.28	64.36	65.48	64.56	64.88	63.97	64.68	63.77
Axial Chord(mm)	62.24	50.45	62.44	50.65	62.64	50.85	62.04	50.25	61.84	50.05
Leading edge radius(mm)	1.85	1.85	2.05	2.06	2.256	2.256	1.656	1.656	1.456	1.456
Trailing edge radius(mm)	0.60	0.61	0.80	0.81	1.07	1.07	0.407	0.407	0.207	0.207
Inlet angle(°)	43.3	50	43.3	50	43.3	50	43.3	50	43.3	50
Exit angle(°)	20.5	20	20.5	20	20.5	20	20.5	20	20.5	20
Blade Span(mm)	126									
Stagger angle(°)	37.048									

IV. Blade Geometry

The geometry of a turbine profile with specified performance is generated with an innovative inverse design technique or direct design, based on independent variables and is in a Cascade. These Variables are many dependent and independent variables. Important variables are Pitch chord ratio, Aspect Ratio, Leading edge radius, Trailing edge radius, Blade Geometry and profile, Boundary layer and degree of turbulence, incidence. All these parameters have a broad range of variations, so a finite test program is obvious impossible. In the development or design of blade row some parameters are fixed by the given conditions and others parameters have marginal effect. Therefore, the variables involved can be reduced to a more practical and manageable member. In this paper our main focus will be concentrated on the blade geometry and profile. In the development of the blades mainly study the effect of blade profiles is important for the performance. In the Profile effects of leading and trailing edge shapes are important in designing of blades because of the high stresses in the blade are influenced by these factors. The CAD is using the data stored in the database and then developed cascade geometry based on output values with a given in performance (total pressure loss coefficient, exit flow angle) during specified operating conditions. In order to guarantee a homogeneous set of performance data in the database, the aerodynamic performance stored in the database for all the cascade configurations have been computed using the same Navier-Stokes method (with the same mesh density) that was also implemented into the optimization procedure

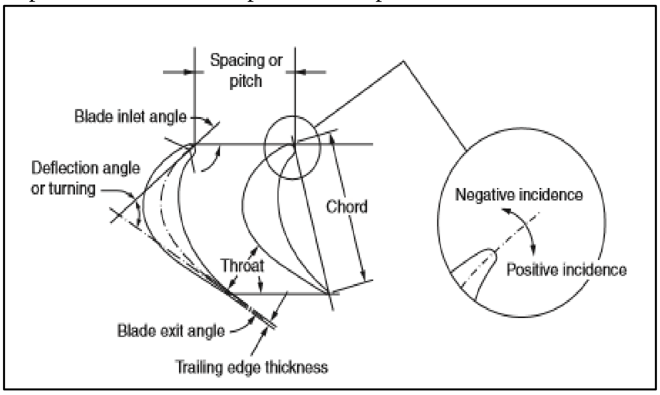


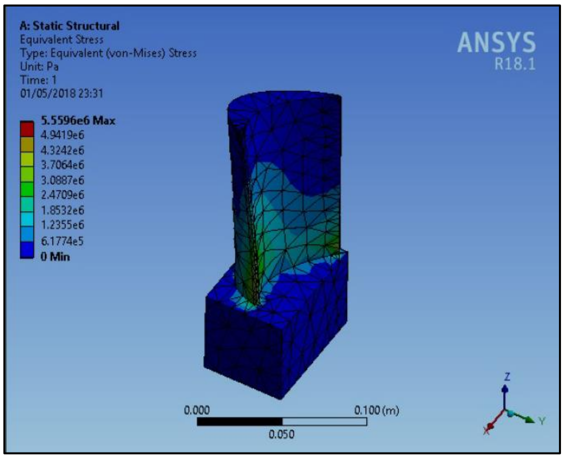
Fig. 2: Basic airfoil geometry definition

V. DESIGN OPTIMIZATION

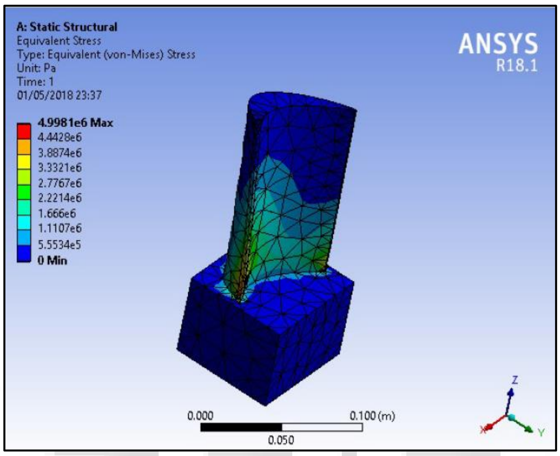
3D blade design using CAD has been introduced to improve efficiency and minimize incident losses. We can develop steam turbine blade of optimized size base on the analysis using CAD software's. An optimization of reaction blade design in the turbine stages is to make blade thickness comparatively thicker and to optimize degree of reaction, number of stages and blade root diameters. At the last stages up stream of fixed design LP stages. When the blade become longer and longer, the difference in ratio between flow velocity and blade rotating speed at hub and tip diameter respectively, becomes larger and larger. Thus the velocity vectors over the blade length change dramatically and it is no longer possible to find an optimized blade with a straight profile. With twisted 3D profile over the length of the blade, incident angles can be kept constant, thus avoiding the corresponding incident losses. Additional effects are achieved in the shroud sealing, where the twisted blade profile gives a stronger support for the integral shroud plate, and an additional number of seal strips can be used to decrease the leakage losses still further.

VI. RESULTS OF FEM USING ANSYS

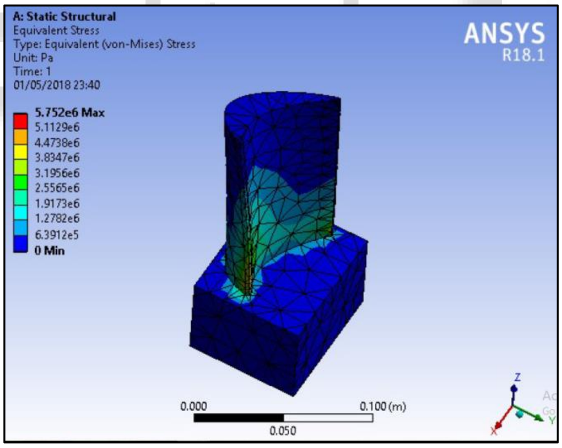
Structural analysis
Material - Stainless Steel



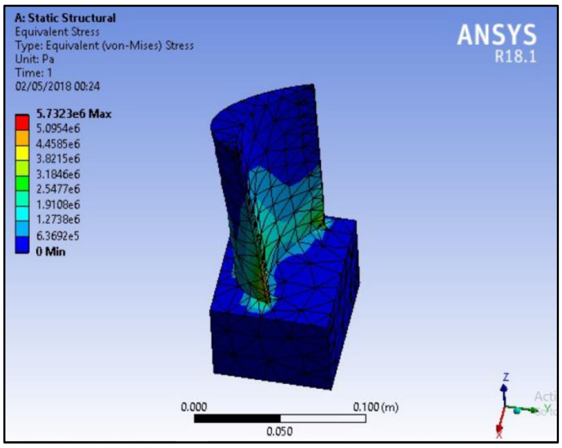
Profile 1:



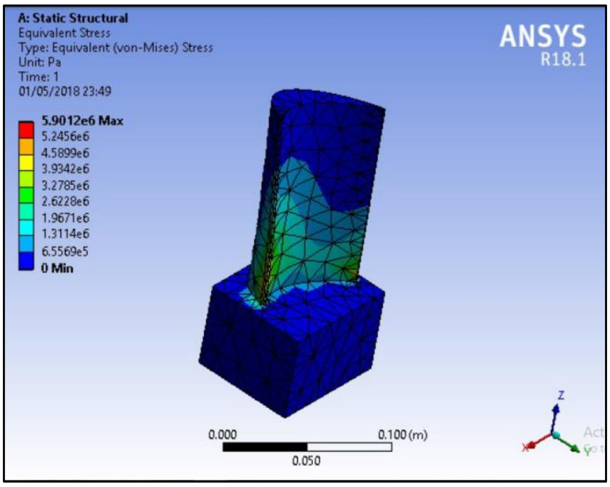
Profile 2



Profile 3

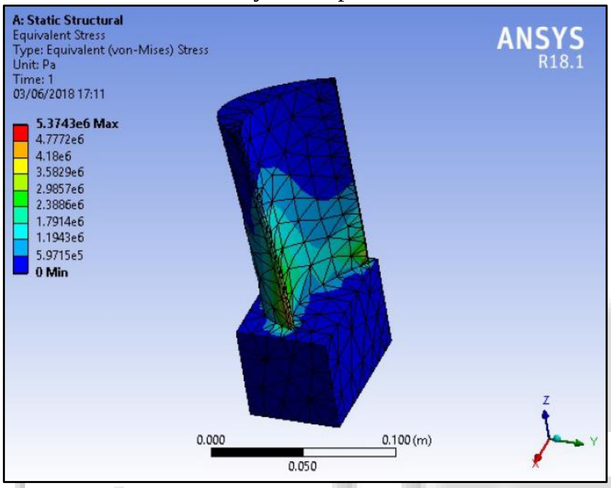


Profile 4

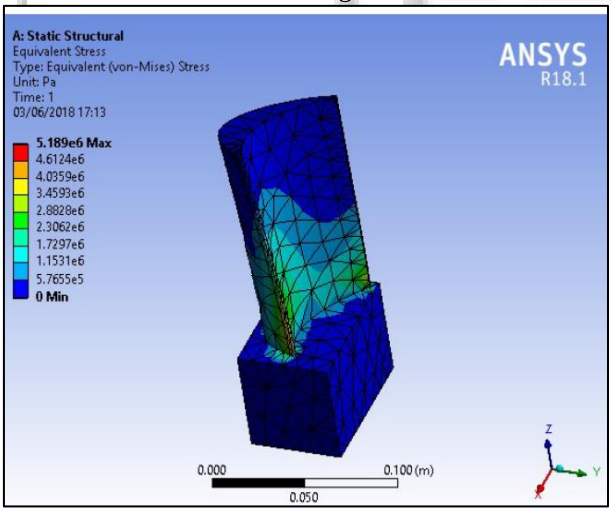


Profile 5

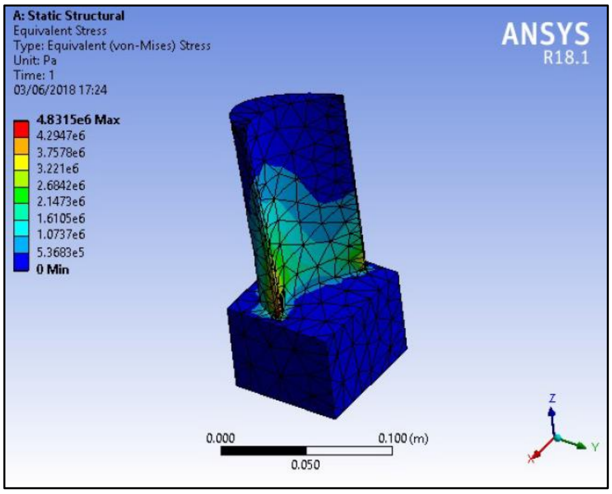
Fig. 1: Von Mises stress for blade with different aerodynamic profile.



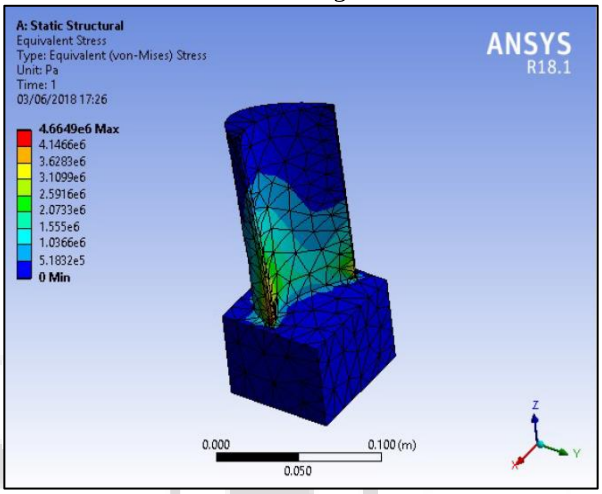
Profile 1: with length 124 mm



Profile 1: with length 122 mm



Profile 2: with length 124 mm



Profile 2: with length 124 mm

Fig. 2: Von Mises stress for blade with different length.

Finite element results for free standing blades give a complete picture of structural characteristics, which can utilized for the improvement in the design and optimization of the operating conditions. Initially a Study on different materials performed to choose best for the optimized turbine blade.

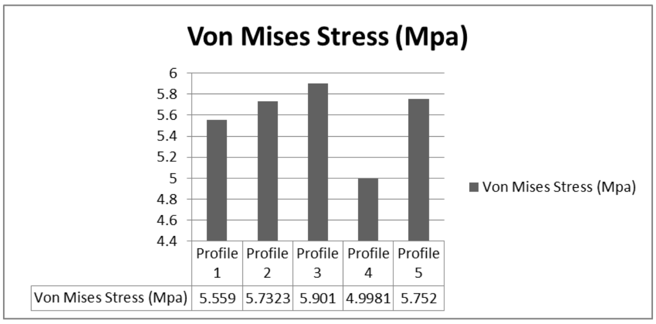


Fig. 3 Maximum Von Mises stress for blade with different aerodynamic profile.

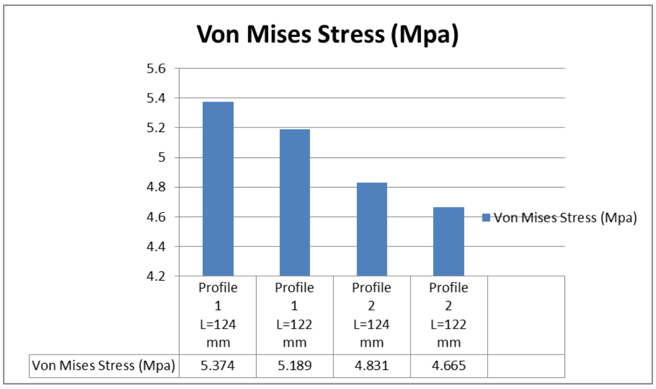


Fig. 4: Maximum Von Mises stress for blade with different length.

VII. CONCLUSION

The blade with complicated airfoil construction is benefited designed by CAD technology which is allowing the airfoil shape to be enhanced to the varying steam conditions between the base and tip of the blade. It was found that changing the geometry of turbine blade including axial chord, true chord, leading edge radius and trailing edge radius can be useful in decreasing Von Mises stress. Results showed higher stress at the base of blades rather than tips. It can be concluded that using thicker and shorter blades are better to reduce stress, which may provide more durability. The blade profiles themselves have also been improved using numerical optimization methods to provide better flow and strength properties.

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