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The Von Mises Analysis of Al2014-T6 Material Structure for Centrifugal Compressor Impeller Engineering

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The centrifugal compressor impeller is crucial to several automated systems in generating energy power. This paper focuses on the von Mises stress and deformation analysis of centrifugal compressor impeller blade aluminum alloys 2014-T6 materials for gas turbine to find the blade crack accident reasons. A new approach for the gas flow within the centrifugal compressor impeller was studied by considering various performance parameters, i.e. pressure and velocity effect on the material surface and constructing of 3D flow visualizations and simulations. This computational research results shows, that unsteady simulations significantly increased the accuracy of centrifugal compressor impeller performance calculations.

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PACS/topics: centrifugal compressor impeller, aluminum alloy 2014-T6 material, von Mises analysis

1. Introduction

The aerodynamic loads in centrifugal compressor impeller (CCI) causes the stresses during operation of rotor blades that contains tensile stress, flexural stress and the centrifugal forces [1]. The von Mises maximum distortion energy criterion under variable circumstances well correspond with coupling technology of the fluid-solid loading [2] of impeller blade in harsh unpredictable condition. Xuanyu [2] and Sun [3] applied computational fluid dynamics theory to engineering analysis axial aero engine compressor of fracture in the blade stress under the winter condition [4]. This research aimed to study gas pressure and velocity simulation in CCI, as shown in Fig. 1. Next section explains the von Mises criteria with CFD method applied to CCI blade.

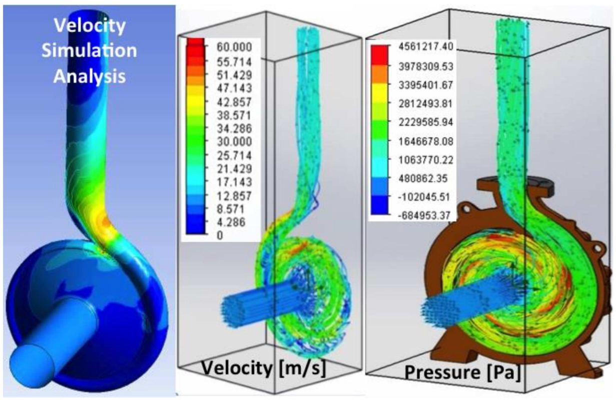

Fig. 1. Pressure and velocity in CCI system.

2. Experimental procedure

A new method for CCI blade stress-strain was implemented to analyze by the finite element analysis technique. The aerodynamic and power requirements were calculated in the initial stages of the design process

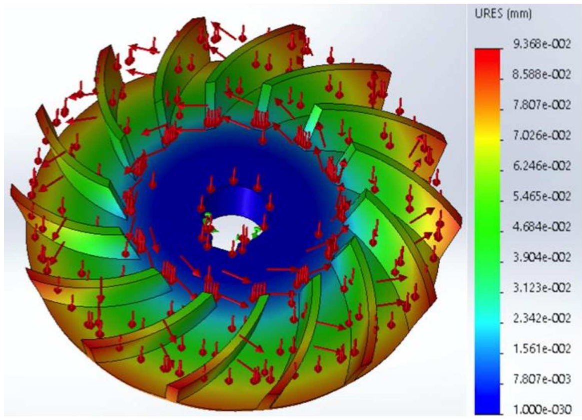

Fig. 2. Displacement in CCI.

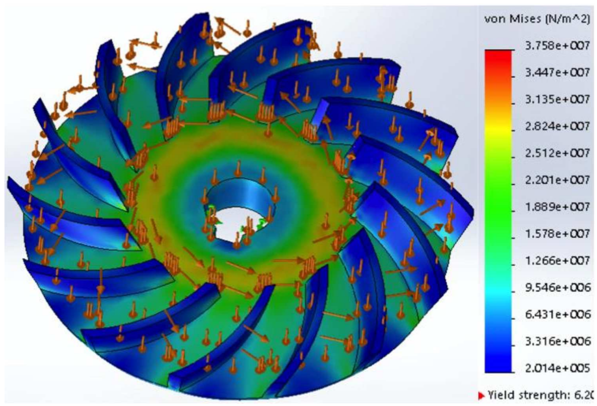

Fig. 3. The von-Mises analysis in CCI.

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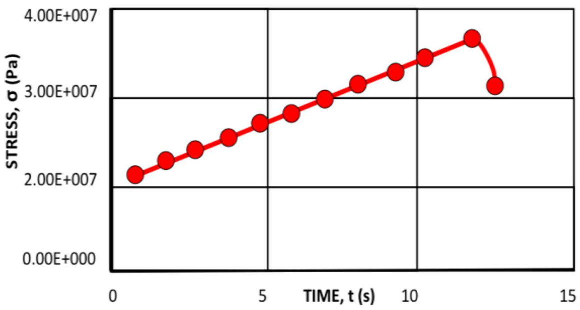

Fig. 4. The von-Mises stress in CCI impeller.

by calculating the power and stress and the life of the blade. In this, displacement modeling was performed as shown in Fig. 2. In the design process, the purpose of the von Mises stress analysis that meets the aerodynamic criteria is to calculate and model the real stress as given in Fig. 3. In this way, it is possible to predict the possible damage. In von Mises stress calculation, 27% of the stress was more on the blade than on the blade disc. In the last step, the three-dimensional blade disc was modeled with FEA stress and CFD flow analysis at the measured time, as shown in Fig. 4. The von Mises elastic stress σ_{vM} computed from CCI impeller disc as given in formula (1):

$$\sigma_{\text{vM}} = \sqrt{\frac{(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2}{2}} \quad (1)$$

3. Results and discussion

Finite element analysis modeling methodology was implemented for CCI impeller research. The CCI propeller meshed part was generated and a complete flow of turbulence model was performed to determine the magnitude of potential faults by CFD at design speed. The von Mises stress of CCI impeller calculations resulted with maximum 3.758 MPa as shown in Fig. 4. The outcomes were associated with experiment and examined for enhanced flow physics before working circumstances.

4. Conclusion

This research presents a new approach of the von Mises computational modeling for CCI bladed disc. The results of unsteady CCI calculations show that fully invariant flow analyzes can provide better performance estimates, especially at high rotational speeds. Confirming the commercial CFD-ANSYS software for the estimation of complex off-design CCI conduct was successful in providing a better understanding of CCI physics.

Acknowledgments

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