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Numerical Analysis of the Effect of Turbine Coverplate Geometry on the Cavity Flow

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ABSTRACT

CFD analysis has been studied on the flow in a cavity between the turbine disk and the coverplate of a gas turbine engine. Two different flow cases have been studied. The CFD results revealed detailed variation of pressure, temperature, swirl factor which provide as the basis for engine air system simulation. The influence of coverplate hole location on the cooling system has been studied.

Key words: **cavity, coverplate, swirl factor, cooling system**

1 Introduction

Gas turbine engines include internal passages which serve to channel the cooling air from compressors to the different components to be cooled. These internal flows are required to be metered in order to minimize the pressure loss associated with the metering needs and allow for sufficient purge pressure.

The research on the flow in a corotation radial inflow cavity was pioneered by Owen et al. [1]. They used integral momentum techniques for flows in a rotating cylindrical cavity. Firouzian et al. [2, 3] studied the flow and heat transfer in the cavity. Their results revealed the complicated source-sink flow feature in a radial inflow rotating cavity. One of the concerns in turbomachine is the pressure loss in the cavity; different ways to minimize the pressure loss have been explored. Chew et al. [4] has used fins to reduce the pressure loss. On the other hand, X. Liu [5] has studied the flow in a corotation radial inflow cavity between turbine disk and coverplate.

2 Problem

This work is focused on the flow in the cavity between the turbine disk and coverplate. The turbine disk and the coverplate are rotating at the same speed. The air enters the cavity from the coverplate hole and exits through the holes at the top of the cavity as shown in figure1.

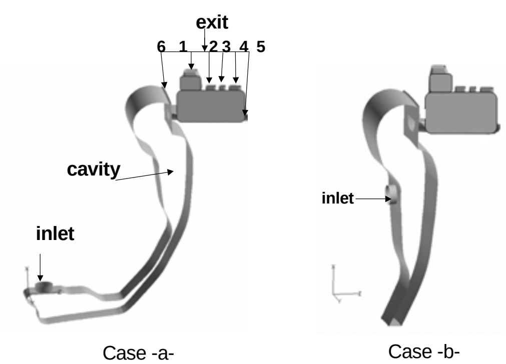

Figure1. The flow in the cavity between turbine disk and coverplate

It is crucial to understand the flow in the cavity with respect to the variation in the temperature and the pressure. The present work will extend the previous studies to investigate the effect of modified coverplate geometry on the pressure loss and temperature rise. In order to increase the engine durability and performance, it is essential to modify the coverplate geometry and the location of coverplate hole as shown in figure 1.

2.1 Numerical Solution

In the present simulation, In house code (PRATT AND WHITNEY) was used. The code solves the 3-D Navier-Stokes equations. In this case, the rotational Reynolds number is very high for the validity of the turbulence model. The governing equations are solved by finite-element method on unstructured grid as shown in figure2. The number of elements has been used 1236719.

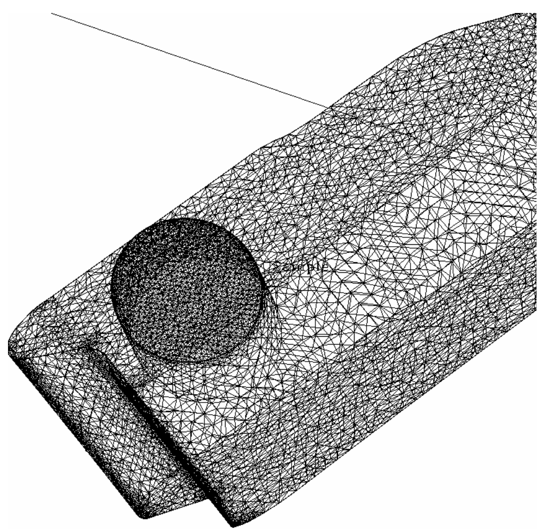

Figure 2. The mesh at the inlet of the cavity

The flow direction is shown in figure 3.

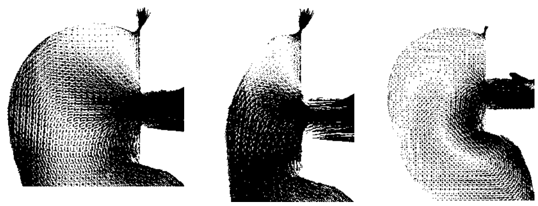

Figure 3. Flow direction in the upper part of the cavity.

A comparison between the results after 1000 iterations to 2000 iterations showed no noticeable difference. This indicates that good convergence has been achieved.

3 Results and Discussion

The contour plots of that air tangential velocity are shown in figure3.

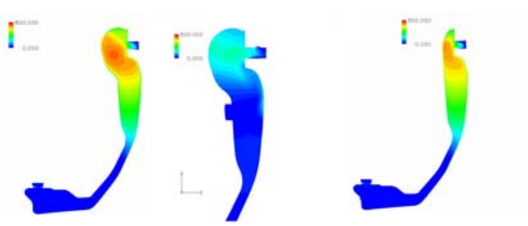

Figure 4. contour of the air tangential velocity.

It can be noticed that the flow after specific point starts to rotate faster than the disc at the upper part of the cavity as shown in figure 4. Also, CFD results revealed that increase the width of the upper part of the cavity has insignificant effect on the pressure drop and temperature rise. On the other hand, when the radius from the engine center line and the coverplate hole increase, the area of the upper part should be reduced. Also, increasing the width of the upper part will create big vortex.

4 Conclusion

A comprehensive CFD analysis has been carried out on the flow in a cavity between the turbine disk and coverplate of a gas turbine engine. The results showed that the width of the upper part should be reduced when the radius between the coverplate hole and the engine center line increase.

References

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