









4.4 Contours for Turbine blade multi cooling channel with turbulators

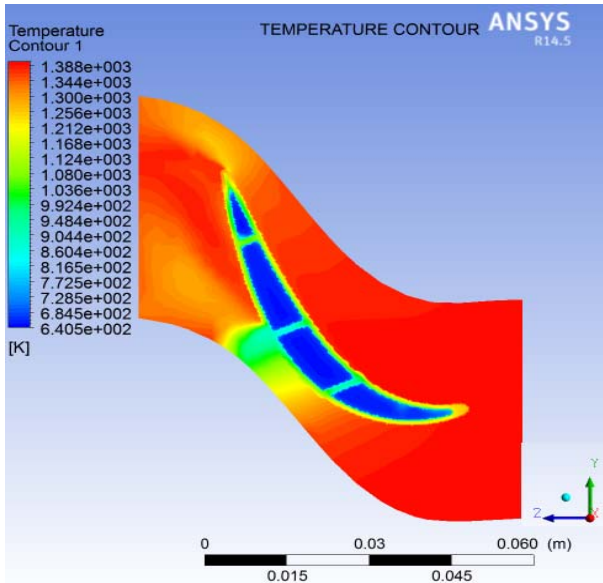


Figure 8: Temperature Contour for NGV multi cooling channel with turbulators

Temperature contour for NGV four cooling channel with turbulators is as shown in fig 8. Blade temperature distribution plot is as same as four channel and single channel graphically except at 50% from leading edge because of ribs provided inside the channel at 40% distance from leading edge, the temperature at 40% distance is less compared to 50% distance.

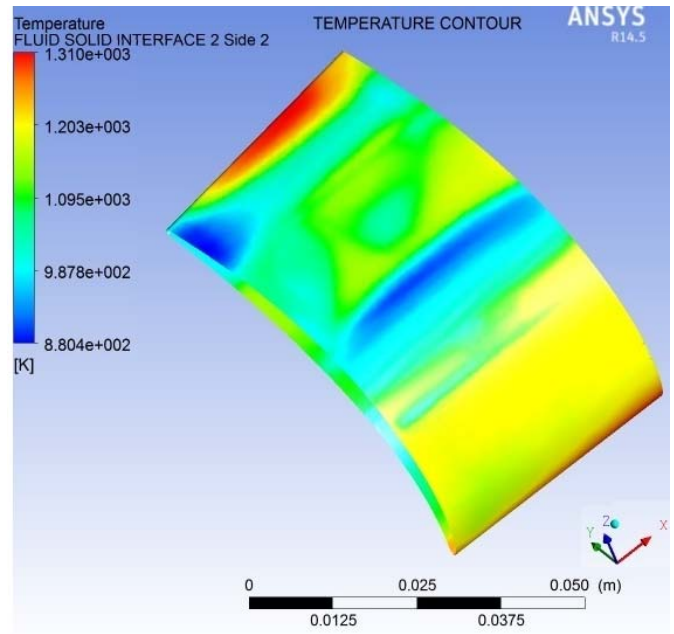


Figure 10: Temperature on Blade Suction Section

Temperature on blade suction section four cooling channel with turbulators is as shown in fig 10. The heat transfer coefficient on suction side is more compared to pressure side as Velocity of the flow in suction side is more compared to pressure side. So, the blade temperatures are low on suction side compared to pressure side.

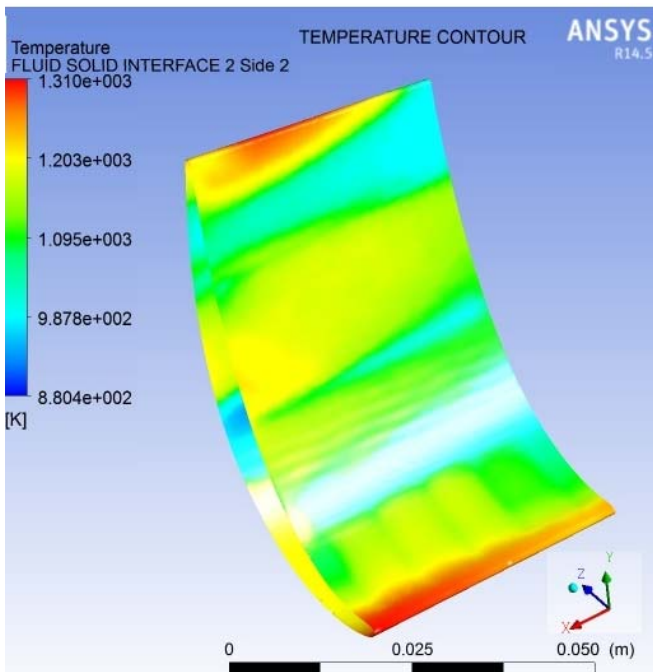


Figure 9: Temperature on Blade Pressure Section

Temperature on blade pressure section four cooling channel with turbulators is as shown in fig 9. The heat transfer coefficient on pressure side is low compared to suction side as Velocity of the flow in pressure side is more compared to suction side. So, the blade temperatures are high on pressure side compared to suction side.

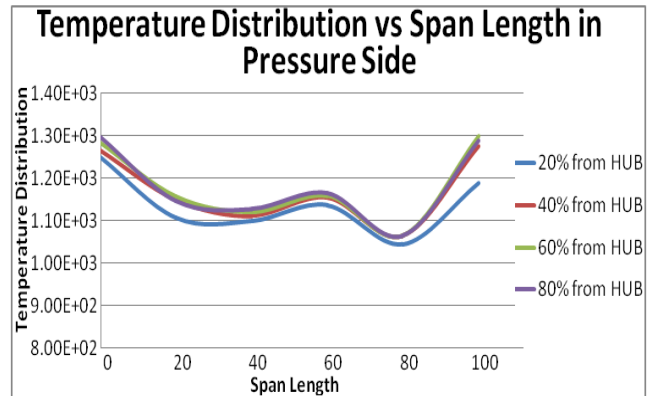


Figure 11: Temperature Distribution v/s Span Length on Pressure Side

The variation of Temperature distribution v/s Span length on pressure side for turbine blade multi cooling channel with turbulators is as shown in the fig 11. Temperature falls to slightly above 1000k at a span length of 80. From that point, wake formation takes place and temperature goes on increasing with respect to span length.

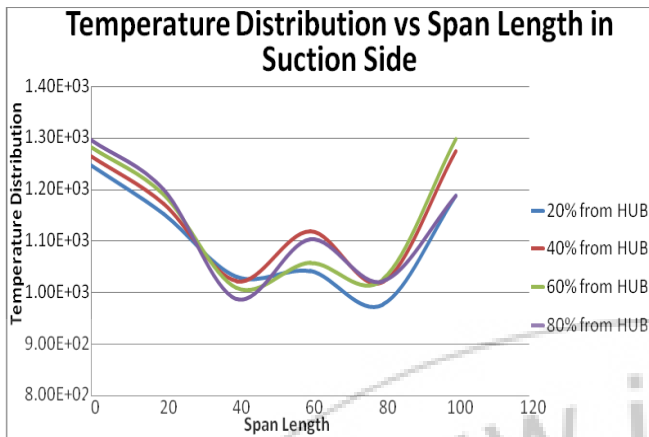


Figure 12: Temperature Distribution v/s Span Length on Suction Side

The variation of Temperature distribution v/s Span length on Suction side for turbine blade multi cooling channel with turbulators is as shown in the fig 12. Here variation of temperature distribution v/s span length is formulated at 20%, 40%, 60% and 80% from the hub. Temperature falls to 1000k at a span length of 40. From that point, wake formation takes place and temperature goes on increasing with respect to span length. Again at a span length of 80, temperature falls to 1000k and increases with respect to span length due to the formation of wake.

Contours for turbine blade multi cooling channel with turbulators (7.5% coolant mass flow rate) is almost same as that of 10% coolant mass flow rate. Hence I have shown contours for only 10% coolant mass flow rate. But has taken the results for 7.5% coolant mass flow rate and tabulated.

#### 4.5 Comparative analysis of cooling channels

Table 1: Area average temperature value for all Blade configurations

| S. No | Configuration name                                  | Area average (Temperature) BLADE at 10% | Area average (Temperature) BLADE at 7.5% |
|-------|---|---|--|
| 1     | Turbine blade without cooling channel               | 1349.43 [K]                             | 1375.56 [K]                              |
| 2     | Turbine blade with Single channel                   | 1148.09 [K]                             | 1174.57 [K]                              |
| 3     | Turbine blade with four cooling channel             | 1157.54 [K]                             | 1182.99 [K]                              |
| 4     | Turbine blade four cooling channel with Turbulators | 1120.11 [K]                             | 1148.98 [K]                              |

From the results and discussion, Comparative analysis of Area average temperature of blade at 10% and 7.5% between turbine blade without cooling channel, with single cooling channel, with four cooling channel and four cooling channel with turbulators has been tabulated.

#### 5. Conclusion

- The present work aims to determine a better internal cooling configuration which gives optimal temperature distribution on blade surface.

- From the results, it is revealed that the turbine blade multi-channel with turbulators shows better cooling compared to four channel and single channel. The average temperature of the blade without cooling is 1349.43 K. The temperature has come down to 1120.11 K due to turbulators with four cooling channel.
- It is also seen that, area average temperature at 10% coolant mass flow rate is less than that of 7.5% coolant mass flow rate. Hence, 10% coolant mass flow rate shows better cooling compared to 7.5% coolant mass flow rate.
- In turbine blade with single channel method, the blade temperature is low compared to multi-channel because in single channel flow, cumulative effect of the cooling is little bit more compared to multi-channel where each channel is divided by walls.
- Four cooling channels with turbulators provided better cooling compared to the configurations, because the presence of turbulators provides additional turbulence and increases heat transfer surface area.

#### References

- Dr D.A. Rowbury, Dr S. Parneix, Mr D. Chanteloup and Prof. A. Lees, "Research into the Influence of Rotation on the Internal Cooling of Turbine Blades", Paper presented at the RTO AVT Symposium on "Advanced Flow Management: Part B – Heat Transfer and Cooling in Propulsion and Power Systems", held in Loen, Norway, 7-11 May 2001, and published in RTO-MP-069(I).
- Jenny Sunderburg, Sandor Woldendorp and Tiedo Tinga, "Analysis of Combined Convective and Film Cooling on an Existing Turbine Blade", RTO AVT Symposium on "Advanced Flow Management: Part B – Heat Transfer and Cooling in Propulsion and Power Systems", held in Leon, Norway, 7-11 May 2001.
- Hasan Nasir, Ph.D Thesis, TURBINE BLADE TIP COOLING AND HEAT TRANSFER, B.S., Bangladesh University of Engineering and Technology, 1997, December 2004.
- Je Chin Han, Sandip Dutta, and Srinath V Ekkad, "Gas Turbine Heat Transfer and Cooling Technology," Taylor & Francis, Inc., New York, New York, December 2000, ISBN # 1-56032-841-X, 646 pages.
- Grzegorz Nowak, Włodzimierz Wroblewski, 2009, Cooling system optimization of turbine guide vane: 567–572, Applied Thermal Engineering 29
- Hylton, Milhec, Turner, Nealy and York.(1983) "Analytical and Experimental Evaluation of the Heat Transfer Distribution Over the Surface of Turbine Vanes". NASA CR 168015.
- York, D. W., and Leylek, J. H.,( 2003),"Three-Dimensional Conjugate Heat Transfer Simulation of an Internally-Cooled Gas Turbine Vane", ASME Paper No. GT2003-38551.
- V Ganeshan, Internal Combustion Engines, Tata McGraw-Hill Education, Second edition, 2002, 777 pages.
- S.Z. Shuja, B.S. Yilbas, (2001) "A laminar swirling jet impingement on to an adiabatic wall - Effect of inlet velocity profiles", International Journal of Numerical

Methods for Heat & Fluid Flow, Vol. 11 Iss: 3, pp.237 – 254.

- [10] Waseem Siddique, Design of Internal Cooling Passages: Investigation of Thermal Performance of Serpentine Passages, Doctoral Thesis 2011, Royal Institute of Technology, Stockholm, Sweden.

### Author Profile



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