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GAS TURBINE LEADING EDGE BLADE FILM COOLING

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Abstract: Throughout the design process, our team decided we wanted to design this turbine in such a way that, if damaged or redesigned, we could easily swap out parts. Not only was this characteristic especially useful for us as designers, but we figured that a real world turbine that is easy to assemble/disassemble would also be easy to repair. In the event of a blade getting broken or a part being worn, the ability to disassemble and reassemble the turbine in a matter of minutes would be especially useful and appreciated by maintenance workers. We believe that this motivation is evident in our design. To reduce high temperatures, high stresses, and a potential environment of high vibration on blades. To reduce blade failures which are potentially destroying the blade. To increase the blade life. To increase the gas turbine plant life.

Key words: About four key words or phrases in alphabetical order, separated by commas.

INTRODUCTION

In a gas turbine engine, a single turbine section is made up of a disk or hub that holds many turbine blades. That turbine section is connected to a compressor section via a shaft (or "spool"), and that compressor section can either be axial or centrifugal. Air is compressed, raising the pressure and temperature, through the compressor stages of the engine. The temperature is then greatly increased by combustion of fuel inside the combustor, which sits between the compressor stages and the turbine stages. The high temperature and high pressure exhaust gases then pass through the turbine stages. The turbine stages extract energy from this flow, lowering the pressure and temperature of the air and transfer the kinetic energy to the compressor stages along the spool. This process is very like how an axial compressor works, only in reverse.

The number of turbine stages varies in different types of engines, with high bypass ratio engines tending to have the most turbine stages. The number of turbine stages can have a great effect on how the turbine blades are designed for each stage. Many gas turbine engines are twin spool designs, meaning that there is a high pressure spool and a low pressure spool. Other gas turbines use three spools, adding an intermediate pressure spool between the high and low pressure spool. The high pressure turbine is exposed to the hottest, highest pressure air, and the low pressure turbine is subjected to cooler, lower pressure air.

PROCEDURE

MOTIVATION

- Thermal fatigue-nozzles, combustor components.
- Environmental attack (oxidation, sulphidation, hot corrosion, standby corrosion)
- Creep damage-hot section nozzles and blades.
- Erosion and wear.
- Thermal aging.

Due to this above problem gas turbine blade life is affected drastically.

NEED OF PROJECT

1. Under these severe operating conditions inside the gas and steam turbines, the blades face high temperature, high stresses, and potentially high vibrations.
2. Steam turbine blades are critical components in power plants which convert the linear motion of high temperature and high pressure steam flowing down a pressure gradient into a rotary motion of the turbine shaft.
3. Turbine blades are subjected to very strenuous environments inside a gas turbine. They face high temperatures, high stresses, and a potential environment of high vibration.
4. All three of these factors can lead to blade failures, potentially destroying the engine, therefore turbine blades are carefully designed to resist these conditions.
5. Turbine blades are subjected to stress from centrifugal force (turbine stages can rotate at tens of thousands of revolutions per minute (RPM)) and fluid forces that can cause fracture, yielding, or creep failures.
6. The high temperatures can also make the blades susceptible to corrosion failures. Finally, vibrations from the engine and the turbine itself (see blade pass frequency) can cause fatigue failures.

LIMITATIONS OF PROJECT

1. High rate Compressor is required.
2. Material is high in cost.
3. High temperature is required.

References

JAYEONG AHN ,[1]: Effect of rotation on detailed film cooling effectiveness distributions in the leading-edge region of a gas turbine blade with three showerhead rows of radial-angle holes were measured using the Pressure Sensitive Paint (PSP) technique.

M.T SCHOBEIRI,[2]: Tests were conducted on the first-stage rotor blade of a three-stage axial turbine at three rotational speeds. The effect of the blowing ratio was also studied. The Reynolds number based on the axial chord length and the exit velocity was 200,000 and the total to exit pressure ratio was 1.12 for the first-stage rotor blade. The corresponding rotor blade inlet and exit Mach number was 0.1 and 0.3, respectively.

GC LAYEK,[3]: Free convective boundary layer flow and heat transfer of a fluid with variable viscosity over a porous stretching vertical surface in presence of thermal radiation is considered. Fluid viscosity is assumed to vary as a linear function of temperature. The symmetry groups admitted by the corresponding boundary value problem are obtained by using a special form of Lie group transformations viz. scaling group of transformations.

S MUKOHOPADHYAY,[4]: A third-order and a second-order coupled ordinary differential equations corresponding to the momentum and the energy equations are obtained. These equations are then solved numerically. It is found that the skin-friction decreases and heat transfer rate increases due to the suction parameter. Opposite nature is noticed in case of blowing. With the increase of temperature-dependent fluid viscosity parameter (i.e. with decreasing viscosity), the fluid velocity increases but the temperature decreases at point of the sheet.

I.A. Hamakhan, M.A. Rezaienia,[5]: The purpose of this paper is to present the advantages of the direct prescribed surface Curvature distribution blade design (CIRCLE) method for the design of high-efficiency turbomachinery blades. These advantages are illustrated by redesigning several examples of axial turbomachinery blades of interest to energy conversion devices, and discussing in detail the aerodynamic performance and efficiency improvements of the redesigned blades over the original geometries.

AB MOSKALENKO,[6]: In this paper the calculation were implemented by u7sing a numerical solution based on the finite elemental method. A comparison of steam and air used as coolants was done, and the calculations were performed using ANSYSY fluent software.

APS WHEELER, EJ AVITAL,[7]: The two-dimensional (2D) method, originally proposed for turbine blades, has been extended for use with 2D and three-dimensional (3D) turbine, compressor and fan blades, and isolated airfoils. By specification, the method allows joining line segments between the leading edge (LE) and trailing edge (TE) circles or ellipses so that the stream wise distribution of surface curvature and slope of curvature are continuous everywhere from the LE stagnation point to the TE stagnation point.

Tarek elnady, lyse kadem,[8]: A two-dimensional cascade has been employed to measure the cooling effectiveness of the two-expansion level and the standard hole using the transient thermodynamically liquid crystal technique.

CUN-LIANG LIU ,[9]: Three rows of holes are arranged in a semi cylinder model which is used to model the blade leading edge. Transient heat transfer measurement technique with double thermodynamic liquid crystal are employed in the present experiment.

CHANGHE DU, XIN WU,[10]: 3D viscous steady REYNOLDS AVERAGE NAVIER STOCKS equation are utilized to investigate influence of jet nozzle geometry on flow and thermal behavior of vortex cooling for gas turbine blade. The grid independence analysis is performing to obtain the proper mesh number.

Richa Netto et.al.,[11] gave the concepts, working, advantages and practical applications of programmable logic controllers, along with a comparison with other control systems. A PLC aids in automation of a process by monitoring inputs and controlling outputs after deciding based on its program. It is commonly used for controlling many mechanical movements of heavy machinery and to control the voltage and frequency of power supplies.

ALI TURAN ,[12]: The effect of rotation on film cooling effectiveness and heat transfer coefficient distribution on the suction and pressure surface of a gas turbine blade were numerically simulated using large eddy simulation method. The result indicated that film cooling effectiveness increases with an increase in rotational speed.

PING DONG ,[13]: The accuracy of numerical simulation program for conjugate heat transfer methodology is verified with C3X gas turbine vane cooled with leading edge and downstream film holes. Eulerian -agrarian particle tracking method is adopted to investigate the two-phase film cooling.

XIN WU,[14]: 3D viscous steady REYNOLDS AVERAGE NAVIER STOCKS equation are utilized to investigate influence of jet nozzle geometry on flow and thermal behavior of vortex cooling for gas turbine blade. The grid independence analysis is performing to obtain the proper mesh number.

JUN LI,[15]: In this research paper the effect of upstream steps with unevenly span wise distributed height on film cooling effectiveness are investigated by systematically using ANSYS CFX. Steps of five different span wise distributed heights are selected to study the film cooling adiabatic effectiveness, heat transfer characteristics and flow dynamics of flow structure and vortex vorticity.

AB MOSKALENKO,[16]: In this paper the calculation were implemented by u7sing a numerical solution based on the finite elemental method. A comparison of steam and air used as coolants was done, and the calculations were performed using ANSYSY fluent software.

SEHJHIN PARK,[17]: Experiments using pressure sensitive point (PSP) method were conducted to measure the film cooling effectiveness. The study enhances the film cooling effectiveness holes with two expected effects: control

of vertex interaction between forward and backward injection jets, Entire surface cooling from near hole exit to far downstream region.

KUN DU ,[18]: 3D RANS's equation with shear stress transport turbulence model were solved to conduct the numerical simulation based on the validated turbulence model. The effect of leading edge injection slot on the film cooling and heat transfer of vane leading edge-end wall junction were numerically investigated.

Felix Damrath et.al.,[19] performed experimental validation of a physics-based simulation approach for pneumatic components for production system in the automotive industry. Automated assembly system in automotive industry require through digital validation procedure prior to commissioning and ramp-up process. one essential validation procedure is Virtual Commissioning, a method to test and validate real PLC programs based on virtual 3D model of production system using a Hill- approach. The effect of leading edge injection slot on the film cooling and heat transfer of vane leading edge-end wall junction were numerically investigated.

ALI TURAN ,[20]: The effect of rotation on film cooling effectiveness and heat transfer coefficient distribution on the suction and pressure surface of a gas turbine blade were numerically simulated using large eddy simulation method. The result indicated that film cooling effectiveness increases with an increase in rotational speed.

LIANG LI,[21]: 3D viscous steady REYNOLDS AVERAGE NAVIER STOCKS equation are utilized to investigate influence of jet nozzle geometry on flow and thermal behavior of vortex cooling for gas turbine blade. The grid independence analysis is performing to obtain the proper mesh number.

Jain Chu and Yan Feng,[22]: explained automatic control process of solenoid valve production line based on PLC and touch screen. this article introduces the automatic control p process of solenoid valve production line can produce four types of solenoid valve.

A.I. KOZHEVNIKOE,[23]: In this paper the calculation were implemented by u7sing a numerical solution based on the finite elemental method. A comparison of steam and air used as coolants was done, and the calculations were performed using ANSYSY fluent software.

SEON HO KIM, [24]: Film cooling is a cooling method used to protect the hot components of a gas turbine from high temperature conditions. To protect the vanes/blades from excessive thermal stress, backward injection film cooling holes are proposed as one of the methods for the improvement and uniformity of film cooling effectiveness

B.T. Lebele-Alawa,[25]: The relationship between changes in the incident rotor-blade angle due to compressor blade profile distortions and the required compressor power is investigated. This was achieved by measuring certain performance characteristics of an operational gas-turbine. Corresponding theoretical predictions were obtained from computer simulations. Graphs plotted from both the measurements and theoretical predictions were compared, and showed significant similarities

CONCLUSION

Turbine blades face high temperatures, high stresses, and a potential environment of high vibration. All three of these factors can lead to blade failures, potentially destroying the turbine, therefore turbine blades are carefully designed to resist these conditions

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