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A Review on Failure Analysis of Nozzle Guide Vanes of Aero Gas Turbine

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ABSTRACT

Nozzle guide vanes (NGVs) at the inlet of the turbine is the first component that comes in contact with the hot gases. Acceleration of hot gases coming from the combustion chamber are done by the convergent shape of vanes. Aim is to get the higher efficiency from turbine by less exhaust gas emission and low fuel consumption. But for higher efficiency engine has to operate at peak temperature. At high temperature nozzle guide vanes can get fails due to thermal stresses induced in it. Leakage or blocking of cooling passages are also the major cause of failure of nozzle guide vanes. The reasons for the thermal failure of NGVs varies the change in temperature. Failure of analysis of NGVs of aero gas turbine engine are discussed.

Keywords : Nozzle guide vanes, Aero Gas Turbine

I. INTRODUCTION

Nozzle guide vanes are the stator blades of a turbine. They are convex in shape like air-foils. They direct the airflow on to the turbine blades while at the same time converting pressure energy into the kinetic energy. Gases coming out of the combustion chamber pass through the nozzle guide vanes, where because of their convergent shape they accelerate. On passing through the NGVs, where because of their convergent shape they accelerate. On passing through the NGVs, gases are given a “spin” or a “swirl” in the direction of rotation of turbine rotation blades. Aero gas turbines have to fulfil the requirements of an increasing efficiency combined with very low emissions in a robust, cost-effective way. It is done by increasing the turbine inlet temperature. There are some issues regarding in increase of inlet temperature of like failure turbine components due to the high inlet temperature. Presently up to 25 % of the total gas turbine mass flow is used to cool the critical hot gas turbine components. The guide vanes at the combustion chamber exit are subject to the greatest thermal stress in the gas turbine. Localized temperature peaks in the gas flow are especially damaging. Even though these parts are stationary, they are subject to high mechanical loads. These are created primarily through restricted heat strain caused by large changing temperature gradients and **gas bending loads.** Today, high heat-resistant Ni-based alloys are used for these parts. These are more sensitive to overheating than the less heat-resistant Co-based alloys, which do not precipitation harden, and therefore do not suffer permanent strength losses. Guide vanes are generally fixed to shrouds at both ends and cast in **two- or three-piece segments**, or connected with high-temperature soldering.

The thermal loads necessitate intensive cooling (about 5-10% of the total airflow). For this reason, stator vanes in the high pressure turbine have more bores for the cooling air film than rotor blades.

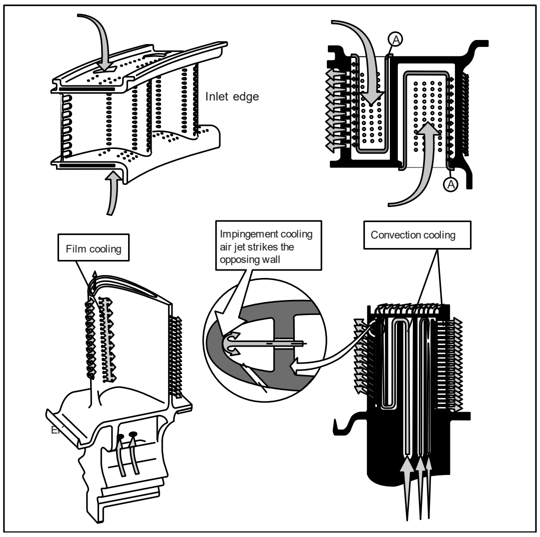


Fig.: Cooling system of NGVs.

Erosion is caused due to operating the engine in dusty environment. It causes the surface profile deterioration of NGVs and rotor blades which leads to reduced engine power. It also damages leading edge profile of blades and vanes. Fouling of turbine vanes also occur due to dusty environment.

Below fig. shows the profile of pressure side of blade showing leading edge.

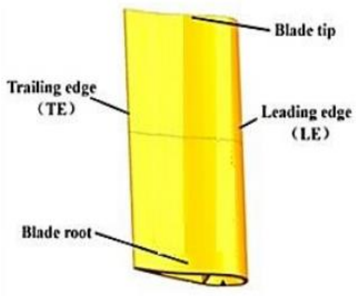


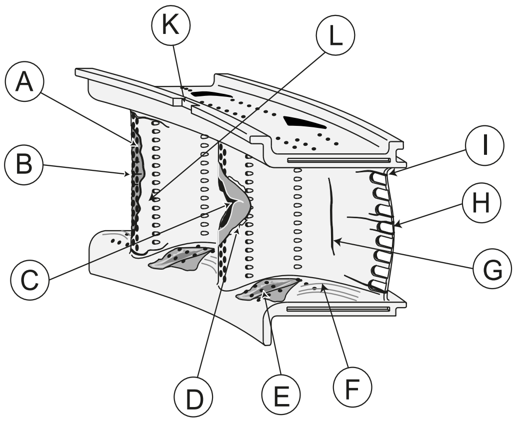
Fig.: Profile of pressure side of blade

II. MAJOR CAUSES OF FAILURE OF NGVs

The vanes are made through investment casting of **nickel base alloys C1023** material which shows high strength at high temperature and has a strengthening effect as temperature increases, within 600^0C-750^0C temperature range.

The Causes of failure of NGVs are as follows:

1. Turbine vanes and blades generally fail because of creep, oxidation, erosion, and wear, low-cycle fatigue (LCF) and high-cycle fatigue (HCF).
2. Failure in the cooling system in the NGV due to crack in the sealing plate is the cause of NGV getting burnt.
3. Thermal fatigue due to the variable surface temperature.
4. Variable surface temperature also cause the deformation on surface of NGVs.
5. Hot spots are generally formed at guide vanes.



Some typical damage symptoms:

"A": **Orange peel effect** due to increased oxidation in zones with high part temperatures.

"B": **Cracking due to thermal fatigue.** The cracks are usually shallow, but are heavily oxidized and gaping.

"C": Burned (extremely oxidized) and/or **melted zones** due to overtemperature.

"D": **Delaminating diffusion coating** indicates part temperatures in the softening range.

"E": Surface burning and hot gas erosion in the shroud area. This symptom indicates localized weaknesses in the cooling air film.

"F": **Cracks** in the coating that is designed to protect against oxidation and hot gas corrosion.

"G": Radial cracks in the blade on the pressure or suction side along the grain boundaries of parts that are directionally solidified.

"H": Folding and deformation of the blade. This creep effect is caused by large thermal strain differences between the blade and platform.

"I": High thermal strain causes this typical **cracking in the blade/shroud transition.**

"K": Creep overload and fretting wear occurs primarily on the lobes and bolts of the anti-twist device.

III. REMEDIES MEASURES

Several approaches are commonly employed in gas turbine industries to combat the NGV failures. The following remedial measures are recommended to prevent failure of NGVs:

- Better material and manufacturing process can help in withstanding high thermal loads.
- Applying high-temperature coatings like ceramic, especially silicon based carbides which can withstand the temperature up to 1300°C can improve the vane life.
- Adopting a better and fool-proof cooling management system can prevent NGV burning.
- Periodic calibration and monitoring of atomizer fuel flows.
- Residual fuel burning if any should be avoided.
- 100% inspection of critical components prior to assembly for any abnormality or defects due to handling.
- It is important for the **axial gaps** at the circumference between individual vanes or the vane segments to be well sealed. Overheating of the housing or rotor components through **hot gas incursion** must be prevented. Suitable seals are generally made of thin strips of metal that are pushed into slots in the blade platforms.

IV. CONCLUSIONS

As we concluded that the material of nozzle guide vanes and the operating temperature of turbine engine, also the leakage and blocking of the cooling passage, are the causes of failure of nozzle guide vanes. There are lot of systems present to operate the engine below the maximum temperature.

V. REFERENCES

[1]. "Failure Analysis of Nozzle Guide Vane of a Low-Pressure Turbine in an Aero Gas Turbine Engine". R. K. Mishra • Johney Thomas • K. Srinivasan • Vaishakhi Nandi • Raghavendra Bhat. 7 April 2014 / Published online: 15 August 2014. ASM International 2014.

[2]. Aero-thermal redesign of a high-pressure turbine nozzle guide vane Hadi Yavaria, Ali Khavarib, Mohammad Alizadehc, Behrad Kashfid, Hiwa Khaledia. Received 20 May 2018; accepted 7 January 2019 Available online 9 December 2019.

[3]. Life enhancement of Nozzle Guide Vane of an Aero Gas Turbine Engine through Pack aluminization R K Mishra, Prashant Kumar, K Rajesh, C R Das, Ganapathi Sharma and D K

Srivastava. Published by De Gruyter November 28, 2017.
[4]. Failure of Low-Pressure Turbine Blades in Military Turbofan Engines: Causes and Remedies June 2016.Journal of Failure Analysis and Prevention 16(4) DOI:10.1007/s11668-016-0131-0.
[5]. Test-Rig Simulation on Hybrid Thermal Barrier Coating Assisted with Cooling Air System for Advanced Gas Turbine under Prolonged Exposures. Salmi Mohd Yunus, Savisha Mahalingam, Abreeza Manap, Nurfanizan Mohd Afandi and Meenaloshini Satgunam.
[6]. Numerical and Experimental Investigations of Design Parameters Defining Gas Turbine Nozzle Guide Vane Endwall Heat Transfer. Frank G. Rubensdörffer. Doctoral Thesis 2006.

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