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Technical Solutions Developed for Increasing the Turboengines Performances

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Abstract

This paper presents the considerations on the technical solutions developed in order to increase performances of turbo engines. In the industrial turbo engines the resource is very important, namely the time of operation between two repairs, as a great resource leads to low operating costs. It is imperative the constant monitoring of gas turbines, to prevent accidents, destroying them and stopping the entire system.

Key words: *turboengine, performances, blade*

Introduction

In industrial turbine the resource has a special importance, besides the characteristics and functional parameters, namely the operation duration between two capital repairs since a great resource leads to low operating costs. The resource of a gas turbine engine is given by the most requested component resource.

Also, a very important aspect to be taken into consideration is the need for a constant monitoring of gas turbines, to prevent the accidents, their destroying and the stop of the entire system. Two examples appeared to an application show the importance of monitoring. In a technical overhaul in 1500 hours of operation of a group of power compression plant by making a visual boroscopic inspection was found that seven rotor blades of the first stage compressor were hit, pinch, with cracks initiation.

The blade damage occurred due to the impact with some hard bodies, small, drawn by sewer inlet.

On a closer analysis these bodies were identified as residues from solder inlet intake. Mounting a fine sieve before the suction outlet led to the elimination of the access in the engine of any other foreign body particles. Another problem appeared at the revision of 10,000 hours of operation. The turboengine does not work because the complete destruction of the first stage of turbine engine blades were truncate from the middle to the upper region, and free turbine blades were showered with a silver paste, probably the destroyed blade material. This destruction was caused by both temperature gradient along the blade and the turbine circumference. Solving the problem needed the movement of the maximum temperature values to the tip of the blade through constructive modifications made to the combustion chamber and turbine engine stator. Also temperature resistance has been increased of the stressed components by thermal protective coatings. These changes lead to increased resource engine (run time).

Increased resource stator of the first stage turbine blade

In Figure 1 is presented the constructive solution to the first stage stator blade of gas turbine generator.

It consists of two parts: pallet grid (a) and tail blade (2). Both are embedded by welding between the outer ring and inner ring of the turbine casing. Blade grid is empty on the inside so that air circulating through it cools the air taken out of the compressor. The direction of flow of cooling air is from outside to inside. Because of cooling, mix well to withstand high temperatures, so it does not suffer heat corrosion.

The blade tail is under full construction so it cools only by the heads, given the accumulated heat from flue gases to the two rings of the carcass. Therefore, the hottest area of the tail is in the middle of its range, with critical point to dashboard that it is thinner too. In Figure 1 this point is followed by an arrow "a".

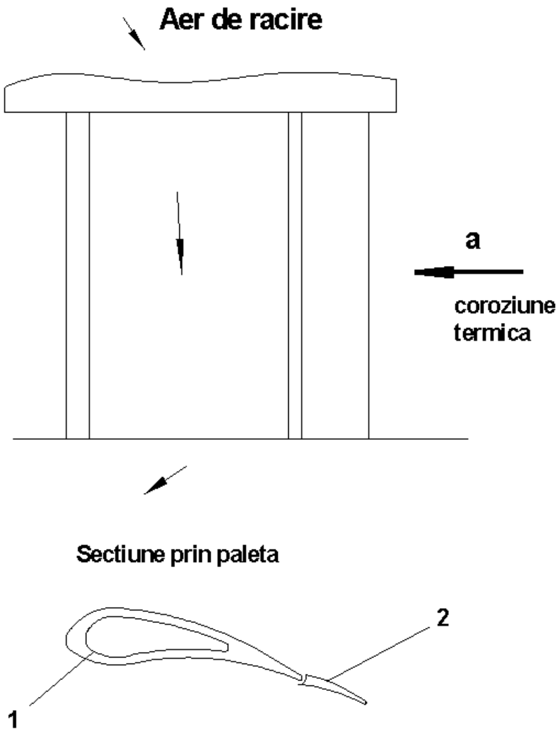

Fig. 1. First stage stator blade of gas turbine generator
1 - grid range, 2 - tail blade

Within the inspections performed, thermal corrosion were identified on the most frequently blades, exactly in the expected region: point 'a'.

From the data presented above, to minimize corrosion of the thermal corrosion of the blade tails two main approaches were proposed:

- One approach is trying to increase the degree of uniformity of flue gas temperature gradient through the gap on the circumference of the stator vane system of first-stage turbine, fixed points of the warmest and coldest.
- Another direction is rather an attempt to reduce the average temperature of combustion, without reducing performance power plant, especially power turbines developed free.

Below is the technical solution developed for increasing the uniformity of temperature in the flue gas section stator blades.

It was necessary changes to adapt the fuel injection system for aviation application turboengine of industrial application of power as a group. Turboengine adaptation for industrial applications has never been able to use the original system of liquid fuel as natural gas injection requires a larger volume.

Uniformity of flue gas temperature is determined by two causes: one of them is the distribution of gas pressure fuel injection platform and the second owing to turbulent flow of air through the chassis route gazodinamic chamber flow as it involves a unevenness.

Even turboengine variant of Aircraft unevenness of combustion is high. But in actual application for aircraft between repair resource is much smaller and the effects of uniformity is not annoying.

Increasing the first stage turbine blades resource to turboengine

Creep rotor blades

To increase resource turbine first stage blades of gas generator can act only on the combined mechanical-thermal material they are made blades. For this purpose technical solutions were sought to reduce such demand, so as to achieve a material reduction of creep rate to levels that can reach at least 15000 operating resource hours between repairs.

To estimate the rate of creep of the material trays were used results in a program for calculating the demands (stress) of turbine blades for turboengine TURMO IVC.

Starting from the work unit determined in steps of turbine blades and material characteristics NCK 18 TDA (Udimet 710) constituting the blades and using the extrapolation method of operation temperature Larsen - Miller were calculated creep characteristics of first stage turbine blades. In Figure 2 are experimental tests on four samples of material NCK18TDA. Based on these tests have determined the characteristics of parameter variation Larsen - Miller and elongation.

Knowing the material application of turbine blades taking into account their maximum value and were estimated using the method given the characteristics of resource variation function the first stage of turbine blades of function speed and temperature of combustion gases. From the examinations performed on gas turbine generator used in the two operating turbo supercharger GTC -1000 group, found that failure of the material in the first stage turbine blades occurred after about 8000 hours of operation.

Material damage from range is not uniformly done throughout all the blades. He damages, in the area where temperature and pressure are highest. Tip of the blade temperature has been shown that it is at the middle of height. It is obvious that the blade will breaks down where the material will yield the most requested. Must consider also the flue gas temperature plays an important role in determining a functioning resource since the creep speed of the material varies exponentially with the temperature of which is exposed.

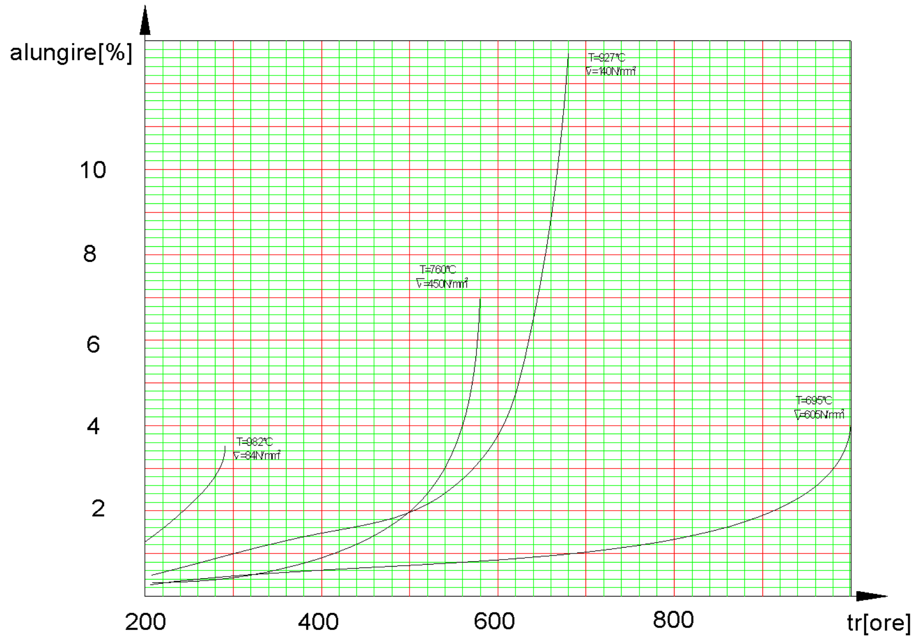

Fig. 2. Diagram resulted from experimental tests on samples of material NCK 18TDA

$$R = \frac{T_{4V}}{T_{4m}} = \frac{740}{660} = 1{,}12 \tag{1}$$

The *R* report can be used to extrapolate the resource of first stage of operation of the turbine blades. So if you want a resource of 30 000 blade operation hours to repair the capital with a safety coefficient $X = 1/2$ lp, blades to function safe to live half the time of breaking the material, determine the characteristics of creep for speed rotation of N_{GG}=94% and $TR = 3 \cdot 10^4/X = 60.000$ hours. T_{4v} maximum peak temperature result, $T_{4v} = 705^0$C. Dividing result with *R* result:

$$T_{4m} = \frac{T_{4V}}{R} = \frac{705}{1{,}12} = 630^{\circ} C \tag{2}$$

In order to have on turbine blades a resource of 30,000 operating hours turboengine Operation must be limited to an average temperature of combustion 630^{0}C maximum operating speed of the gas generator N_{GG} = 94%.

Other technical solutions to increase resource blades

Given those presented in the previous paragraph were looking for technical solutions to increase resource turbine blades without turboengine affected performance. In this sense it acted in three directions as follows:

- Reducing heat load of the blade by thermal barrier coatings for protection type (ceramic enamels);
- Peak position of the temperature change range from ½ of its peak height to the blade;
- Cooling the blade to the cooling stage turbine disk.

Conclusions

Adapted and developed technical solutions to increase resource turboengine lead to positive results. By reducing the peak temperature distribution of combustion temperature, and further by subtracting the average temperature of combustion to increase resource blades, stator blades thermal corrosion can be eliminated. Practical resource substantially increases gas turbine generator, a critical milestone in establishing resource turboengine. Performing engineering changes and adjustments set upper limit for establishing and operating the gas generator speed to the regime defined by 95% and temperature of combustion gas $T_{4m} = 640^{o}C$, turboengine can operate with an industrial application resource industries pushed to 16,000 hours of operation between repairs.

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Soluţii tehnice pentru creşterea performanţelor turbomotoarelor

Rezumat

Această lucrare prezintă consideraţii privind soluţiile tehnice pentru creşterea performanţelor turbomotoarelor. La turbomotoarele industriale resursele sunt foarte importante, mai ales timpul de operare dintre două reparaţii, pentru că o resursă mare duce la costuri de operare reduse. Este imperios necesară monitorizarea constantă a turbinelor cu gaze pentru prevenirea accidentelor, distrugerea lor şi oprirea întregului sistem.