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DESIGN-EXPERIMENTAL EVALUATION OF DYNAMIC STATE OF AVIATION GAS TURBINE ENGINE PROPFAN BLADES.

Yelenevsky D.S., Malygin V.V. , Chizhova N.M., Pozdeev S.V.

Summary.

Vibration stress of two-stage propfan blades of high-efficient aviation gas turbine engine during full scale engine bench tests has been estimated and its operating regimes have been defined as a result of the studies.

Keywords: propfan, vibratory stress, bench test, tensoresistors, fatigue

The aim of this work was to analyze vibratory stress state of two-stage propfan blades of high-efficient gas turbine aeroengine during full scale engine bench test.

At the first stage propfan blades natural dynamic characteristics (natural frequencies and corresponding vibration modes and relative stress fields) were defined experimentally in laboratory conditions.

Blade natural frequencies and vibration modes have been defined by means

of holographic interferometry method - time averaging. The investigated blades were fixed overhung in a special device, simulating standard blade attachment, and were mounted on holographic bench platform. Excitation was provided with electrodynamic vibrator. Natural frequencies and corresponding vibration modes were defined for each blade in the frequency range of 0...800 Hz.

Investigation of relative stresses distribution along the propfan blades by their natural vibration modes were carried out on electrodynamic vibration table. Each blade was prepared by wire tensoresistors with 5 mm base and attached overhung in a special device, simulating standard bladde attachment, mounted on a horizontal vibration table. The obtained relative stress fields allowed to define the most loaded blades areas by corresponding modes.

Dynamic characteristics of propfan blade stage considered, as a single elastic rotationally-symmetric system with taking into account the effect of centrifugal forces field, have been computed on the base of Wave Dynamic Rigidity and Yielding Method. The obtained results coincided with the experimental ones at zero rotation speed of the propfan and that confirmed the selection of the scheme and limiting conditions of computation.

A scheme of propfan blade stage preparation with tensoresistors has been selected on the base of computation - experimental data on propfan dynamic characteristics. Preparation scheme optimization was based on the criterion: minimum sensors - maximum information.

The second stage consisted of full scale engine bench tests at near typical flight cycle conditions. The measurement and recording program for gas turbine engine condition parameters included a large volume of the propfan strain gauging.

At the third stage operational vibration loading was estimated and propfan dynamic state features were defined on the results of dynamic strain gauging. Strain gauging data were processed and analyzed using multilevel spe-

cial purpose computer system based on IBM PC AT/386 type standard configuration personal computers, united into a local network, and on analogue/digital signal input/output multiplex system. Use of advanced signal digital processing technique allowed to obtain test results in the real time of the engine development test.

Substantiated by statistics results of amplitude and spectral analysis of propfan blades stresses allowed to define engine resonance operating regimes and to plot Campbell diagram for each propfan stage, that provided identification of vibration sources and working out of measures eliminating possibility of dangerous propfan dynamic state in service operation.

Propfan dynamics features, defined during studies, are caused by a complex nature of aerodynamic excitation due to steady circumferencial flow nonuniformity and random dynamic effect dependent on engine inlet conditions (flow turbulence degree). The mentioned features are:

- non-regularity of propfan blade stress amplitude variation character at resonance power settings;
- stress amplitudes versus engine inlet conditions relationship (a number of tests have been carried out using different intakes versions);
- "blurred" character of resonance curve, caused by propfan blade vibrations for several natural modes simultaneously.

Since even propfan resonance power settings are characterized by random amplitude modulation approaches to fatigue strength margin and operating time estimation of the investigated component on the basis of numerical method of stress amplitudes density of distribution evaluations and linear hypotheses of fatigue damage cumulation were defined.

Vibration stress of the gas turbine aeroengine propfan has been estimated and its operating regimes have been defined as a result of the studies. Propfan blades alternating stress level has been reduced due to inlet configu-

ration geometric dimentions optimization.

Sergey Vitalevitch Pozdeev, ingineer-mechanic-investigator,
SSSPE "TRUD"

Russia
443026 Samara
st. Parizhskya Communa,
house 23, flat 37.

Phone: 50-79-19