UDC 621.45.03

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Statistical analysis of the frequency control during the brand changing of the material into production of vanes HTE

This is a work devoted to considering the problem of determining fluctuation frequency of HTE working vanes according to the first bending shape during production from brand material similar to technical requirements of drawing.

In the process of mass production of the gas turbine vanes for marine vessels and energy gas turbine plants enterprises allow changing of the main brand of the material onto analogues which don't assign physical abilities of the main brand material. During this as a rule managing frequency control the checking of every vane done according to the instructions specified in technical requirements (TR) of the drawing. In the case of need a vane frequency is corrected with the help of refinement (polishing) top or bottom part of vane airfoil into the range specified in the same TR drawing except taking into account brand of the material changing.

Tendency ofmaterial brand changing ЧС70-ВИ on to ЧС88У-ВИ for production turbine vanes is peculiar at all those enterprises which produce drive gas turbine engines such types as DR59L, DR59L1, HTD-10V and their similar in characteristics analogues. Mentioned material brands have alike chemical composition, continuous tightness and test data for stretching. Sample density from ЧС70-ВИ and ЧС88У-ВИ is between 8,2 – 8,3 $t/m^3$and depends on heat processing, possible application of homogenizing annealing or application of hot isostatic pressing.

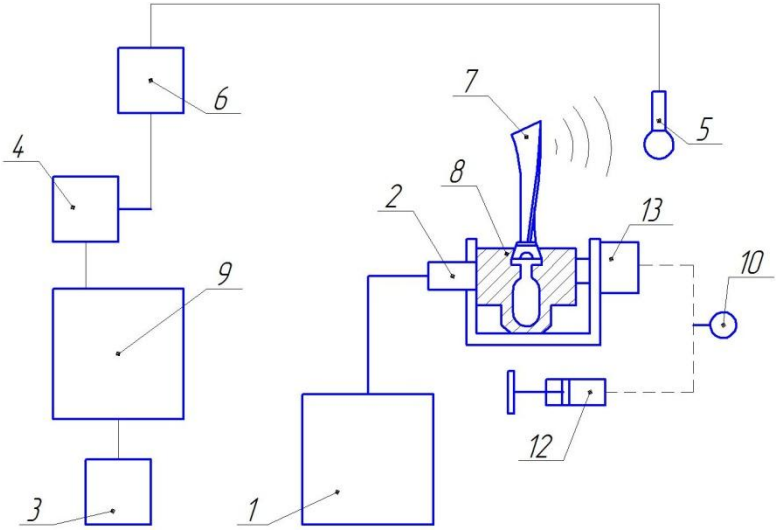
The main requirements specified to materials of such products are high thermal and corrosive attack resistance with low cost. The structure of alloy ЧС88-ВИis a multicomponent solid solution based on nickel, fastened with dispersed bits of intermetallic γ'- phase based on Ni3(Al, Ti) carbides and boride. Total concentration of refractory elements W and Mo is equal 7, 2% (mas.). Increased corrosive attack resistance achieved firstly by high concentration of chrome – 16% (mas.), and some correlation of aluminum and titanium $Al/Ti \geq 0, 7$ [1].That is why in case of production necessity the constructors of enterprises producing vanes allow changes of the material brand ЧС70-ВИ on to ЧС88-ВИ without conducting any additional researchin frequency control.

The aim of this research is to define possible frequency deviation of gas turbine vanes in case of changing material brand ЧС70-ВИ on to ЧС88У-ВИ with the method of statistic data set.

The research objects were four vane sets of the first stage high pressure turbine (HPT) and four vane sets of the second stage HTE engine HTD-10V (upgraded engine DR59L) made of alloy ЧС70-ВИ, and analogical number of complete sets vane made of alloy ЧС88У-ВИ

The research were taken according to methods by M. ZHAKY.103.014-98 on equipment:

1. Sound generator ГЗ-107, ГОСТ 10501-74;
2. Electronic counting frequency meter, Ч3-57;
3. Oscilloscope, СІ-49;
4. Condenser microphone, 4134;
5. Tone generator, ГЗ-33;
6. Microphone amplifier, 2618;



A chart №1 «Vibroexcitation and control of frequencies of oscillation of shoulder-blades of HTE »

1 – feed-in generator, 2 - causative agent, 3 - frequency counter, 4 - oscillograph, 5 - microphone a condenser, 6 - microphonic pre-strengthener, 7 - object of tests (vane), 8 is a proof-of-concept (shoulder-blade) clamp, 9 is a master clock, 10 is a manometer technical, 11- hydraulic clamp device , 12 - hydraulic pump.

The control of all plant units and means of measuring in the research process were accomplished simultaneosly with tests of first stage reference vane HPT (drawing E59040234) of engine DR59L made of material brand ЧС70-ВИ.

Research have shown (Figure 1-4) that when applying the brand of the material ЧС88-ВИ is identical in geometric ratio, the working vanes of the first stage HPT of engine HTE-10V have on average 25-35 Hz frequency more in comparison with identical working vanes made of brand of a material ЧС88-ВИ. The same tendency was observed when measuring the frequency from the second stage vanes.

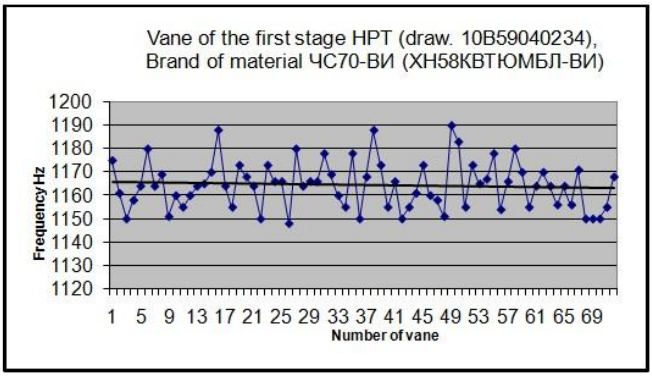


Fig.1 Diagram of frequency control of the first stage HPT HTE-10V made of ЧС70-ВИ

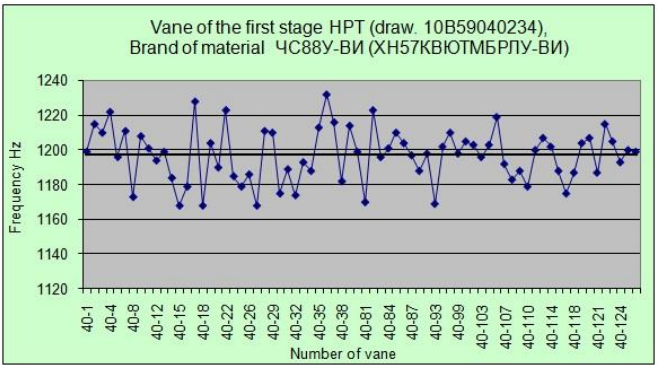


Fig.1 Diagram of frequency control of the first stage HPT HTE-10V made of ЧС88-ВИ

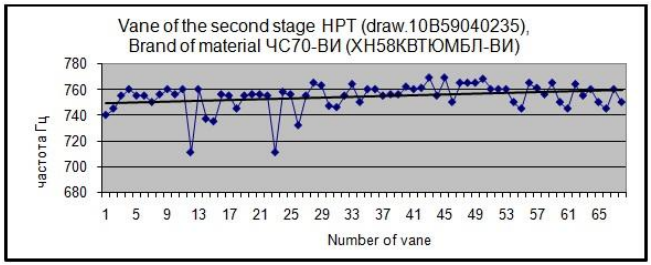


Fig. 3 Diagram of frequency control of second stage HPT HTE-10V made of ЧС70-ВИ

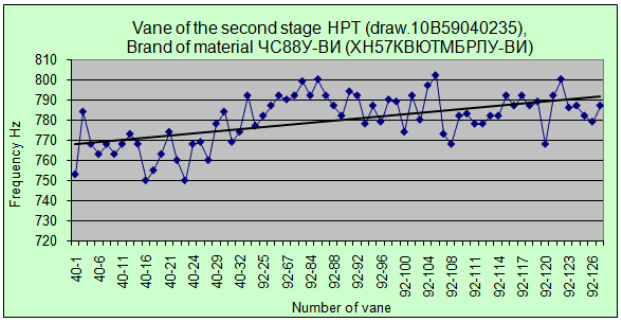


Fig. 4 Diagram of frequency control of second stage HPT HTE-10V made from ЧС88-ВИ

Similarly, diagrams were constructed on three sets of the second and first stage of HPT vanes, which showed similar results of frequency control.

(1)

In the equation, (1) is the actual frequency of oscillations in the first approximation, is the frequency of oscillation of the reference shoulder vane made from the material of the mark in accordance with the technical requirements silhouette; is the average total frequency of vanes fluctuations when replacing the material of a material similar to the technical requirements drawing.

In this regard, to improve the performance of gas turbine engines such as DR59 L, DR59L1 and HTE-10V, and their analogues, in terms of resource, reliability and cost reduction of production and repair enterprises that produce working vanes with the replacement of the brand of material and perform frequency control on the first flexible form is necessary) to conduct statistical studies of frequency control of working vanes by replacing the brand of material with an analogue in order to determine the permissible deviation from the requirements of technical requirements drawings.

References

1. Structure, phase composition and properties of corrosion-resistant, heat-resistant alloy CHS88U./ E. V. Monastyrskaya, G. I. Morozova, Yu.B. Vlasov // metal Science and heat treatment of metals", №8, 2006.

2. Methods for regulating the frequency of natural oscillations of rotor blades of HTE compressor / O. N. Babenko, T. I. Pribora/ / Bulletin of the engine structure, №1, 2016.

4. Methodology " Epy Test of bench Assembly units of gas turbine engines and plantsFrequency control of working blades of HTE on the first bending form " M ZHAKI.103.014-98 / quality management System / npkg "Zorya" - "Mashproekt", 1998., confirmed by the chief designer B. V. Isakov 2006.