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HOW TO EXTRACT QUANTITATIVE DATA OF GTE COMPRESSOR BLADE DYNAMIC STRESS OUT OF HOLOGRAPHIC INTERFEROGRAMS

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Problem of calculation of aircraft GTE compressor and turbine blades dynamic stress fields according to holometry data is discussed.Optical scheme of interferometer and structure of computer-aided system are given. Mathematical methods of holographic interferograms processing and approoriate algorithms used for calculation are described. The resultant data are the basic ones to calculate stress in final element blade model.

Keywords: Holography; Interferometry: Stress Analysis

Investigation of aircraft gas turbine engine units resonans frequencies and vibration modes was significantly simplified when methods of holographic interferometry appeared. Interferograms got as the result of the investigation processes contain information both of vibration mode of explicit kind and of stress-strained object state in the form of interference fringes distribution.

The process of such information extraction is subdivided into two independent tasks:(1) calculation of displacements field on the basis of interferogram; (2) caculation of distortin and stress of investigated object on the basis of the results of the first task solving.

Calculation of blade vibration amplitude given in this report is based on Ennos method /1/. For more precise and complete calculation of vibrational displacement vector it is necessery to have three rather different sensitivity vector in every point of the surface. A quite simple optical scheme of holographic interferometer was developed which provided using only one Fresnel hologram in order to have simultaneously three interferograms with different sensitivity vectors. The illumination and observation directions are collinear in this scheme. In hologram restoration one can see from one point simultaneously three patterns which are input to computer with the help of TV camera.

To calculate blade vibrational displacement fields it is convenient to take as coordinates system an orthogonal blade coordinate system. Like in the process of aircraft engine blade production the geometric dimensions are given as tables of surface points coordinates values of certain blade sections so the preliminary term of vibrational displacements calculation beginning is to input to computer blade section points coordinates and to simulate the surface with spline-approximation.

The next step in the vibrational displacement calculation process is definition of each of three sensitivity vectors orientation. For this purpose four reference points are marked on the surface of an investigated blade, the coordinates of these points are known after physical measurements. According to mutual orientation these points in every fringe pattern watched from one point it is easy to calculate coordinates of this point in local coordinate system of every pattern hence the orientation of every sensitivity vector.

The problem of interferograms analysis is to restore vibration amplitude field according to the watched interferogram .The investigation showed that the most reliable and resistand to noise and distortions approach to the problem solving is the following one. First of all using methods of digital image processing extrema lines are isolated in interferograms.To find displacement vector field one should to fringe equation add an equation connecting coocdinates on the surface of an investigated object with points coordinates on interferogram image. Besides one should consider equation describing the surface of the investigated object.Solution of system of those equations permits to calculate vector field of displacements in the points corresponding to extrema lines on interferogram.The value of displacements field in the other points can be get by means of various methods of three variables function interpolation.

The first stage of the considered method is the most difficult from the point of view of time-consuming processing because it requires isolation and numeration of extrema lines on interferogram image.The difficulty of extrema lines isolation is due to presence of significant noise and distortion while interferogram recording (non-linearity of unit for image input to computer memory, non-uniformity of contrast, speckle-noise and so on).For extrema lines isolation the method of local quadratic approximation is proposed /2/.

Finite element method was used for calculation of stresses field according to known displacements.To solve the set task there were considered two approaches defined as "kinematic loading" and "loading by force".

As it is known from experiment at "kinematic loading" there should be vibrational displacements of some blade final element model nodes.But there are none of them.Rigid "kinematic loading" is applied then. In this case in order to get satisfactory solution one should select location and number of nodes with displacements to be happend. The main drawback of this "kinematic loading" is the subjectivity of such selection that makes calculation formalization difficult.

At "loading by force" inertia forces proportional to displacement, relative nodal mass and square of frequency are applied to all finite element model nodes.It is the "by force" character of loading that provides evenness and stability of solution in this case allowing blade model strain to be in accordance with the shell theory under nodal loadinds.

A series of computation of source objects strained state were made for various vibration modes to prove the proposed approaches.The results of computation and tensometry were compared.It was found that "loading by force" results correlate more better with tensometry data.

References

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