Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 176 (2017) 175 – 183

Procedia Engineering

www.elsevier.com/locate/procedia

Dynamics and Vibroacoustics of Machines (DVM2016)

Comparison of different methods of non-contact vibration measurement

Lezhin D.S., Falaleev S.V., Safin A.I., Ulanov A.M.*, Vergnano D.

Samara National Research University, 34, Moskovskoe Shosse,Samara, 443086, Russia

Abstract

Practical problems of vibration measurement and calculation are considered. Different non-contacts methods of vibration measurement (with Polytec® OFV-534 1D laser vibrometer, Polytec® PSV-400-3D scanning vibrometer, ARAMIS® system) and a comparisons between each other and with Finite Element Method modeling (by ANSYS® software) are presented. The experiment is fulfilled for high pressure shaft of NK-8 gas turbine engine. Difference of middle value for first resonance frequency obtained by three different ways is less than 0.2% only. Difference of second resonance frequency is less than 0.4%. It means it is possible to use 1D laser vibrometer for measurement of vibration of detail for limited access directly in engine structure, which is more correct. ARAMIS® gives a limited but precise picture of deformed shape and simultaneous displacement of all surface points of researched object in the researched place. It allows applying of boundary condition for software calculation more correctly.

Peer-review under responsibility of the organizing committee of the international conference on Dynamics and Vibroacoustics of Machines

Keywords: vibration measurement; ANSYS; Polytec; ARAMIS

1. Introduction

The solution of the problem of vibration of aircraft gas turbine engine details is currently of great interest. Reduction of engine weight and increase of engine parameters at the same time lead to the necessity of large theoretical researches of engine details dynamic [1 – 5], and to the development of different vibration dampers [6 – 11]. Today there is an always increasing number of papers, concerned with research and design of dampers for shroud and anti-vibration shelves of aircraft gas turbine engine blades [12 – 17]. Choosing correctly the damper structure parameters is necessary to develop calculation methods of engine details dynamic. Shells are used widely in stator and rotor of aircraft engine too.

A calculation of vibration by any software (ANSYS, NASTRAN etc) is simpler and not very expensive. However it is difficult to apply right boundary conditions. Vibration of separate detail and the same detail in engine

Peer-review under responsibility of the organizing committee of the international conference on Dynamics and Vibroacoustics of Machines
doi:10.1016/j.proeng.2017.02.286

structure may be different. Thus experimental researches are necessary. Measurement of vibration is a very important problem. Till the present time different contact methods are used for this [18 – 20]. However a vibration sensor on the surface of detail changes the picture of detail vibration. Problems of measurement are considered separately from problems of modeling [21 – 24]. Even if a research uses non-contact method of vibration measurement [25 – 26], there is no comparison of different vibration measurement systems. Some of vibration diagnostic systems use simple non-contact methods [27 - 28] but there is no comparison of these systems with more complex and more precise methods.

Non-contact measurement methods need visual access to the surface of detail. Sometimes it is difficult for detail in engine structure. Thus a choice of non-contact method for limited access to detail is necessary. Of course 3D vibrometer provides more information about detail vibration, but 1D vibrometer can explore vibration of detail directly on engine through technology holes of engine. Calculation by ANSYS or other software helps in this case to choice a point of measurement for different modes.

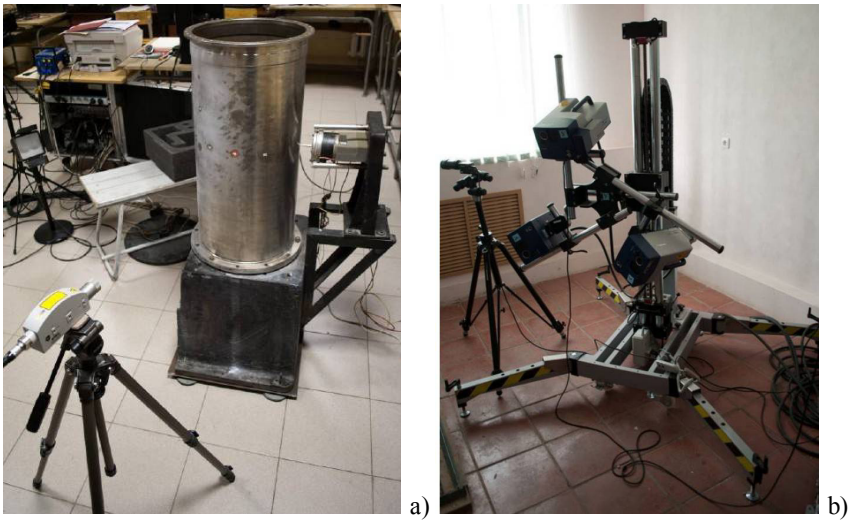
Some equipment, such as ARAMIS®, is good for measurement of displacement. It allows to find correct boundary conditions for software calculation, however it is necessary to check ability of this equipment for measurement of vibration processes.

2. Measurement

The experiment is fulfilled for high pressure shaft of NK-8 gas turbine engine. It has a maximum external diameter of 420 mm and total length of 779.5 mm. It has a cylindrical shape and 2 flange-type joints at its two ends, which connect it respectively to the high pressure compressor and the high pressure turbine modules. In this experiment, the NK-8 shaft was constrained to a cast iron base, to which the rear flange of the shaft was rigidly anchored with bolts in vertical position.

For the numerical analysis a 3D model of shaft was developed with the CAD software suite Siemens® NX, then imported on ANSYS® Mechanical. A shell-type model of the shaft is meshed with a total of 50000 shell elements, each of them associated with a thickness constant value.

First used equipment is Polytec® OFV-534 compact sensor head with a laser-Doppler vibrometer (LDV) combined with a CLV-2534 laser vibrometer control unit (it is presented on Figure 1, a).



a) b)

Fig. 1. a - Polytec® OFV-534 vibrometer; b - Polytec® PSV-400-3D scanning vibrometer

The OFV-534 design includes a laser unit and a sensor head. The laser unit contains a Helium-Neon laser delivering its 633 nm laser light via an optical fiber to a high precision interferometer in the vibrometer head. The