Investigation of dynamic behavior of auxiliary power unit with rotor in foil gas bearings

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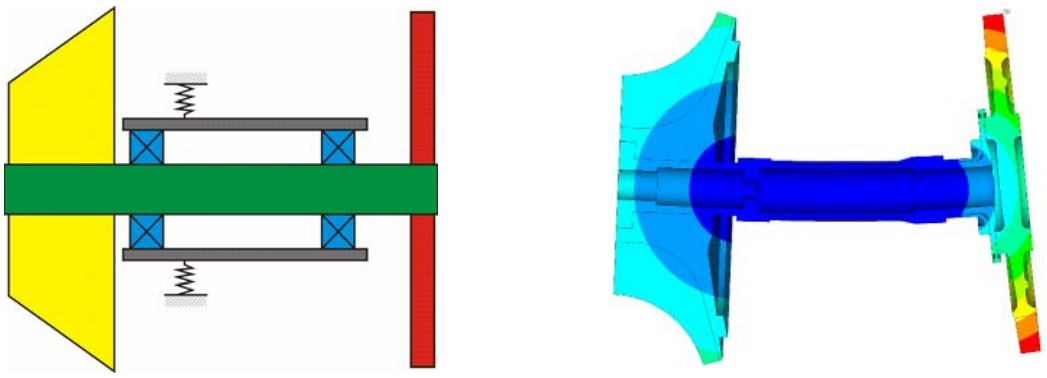
Long Abstract

Introduction

Application of foil gas bearings in supports of small gas turbine engines rotor allows in perspective to create a “dry” engine and changes limits of rotor rotational frequency. That sufficiently influences on engine structure, mass characteristics, reliability, cost of manufacturing and operation. Application of foil gas bearings in rotor supports requires solution of a number of problems such as creating of sufficient carrying force, response on non-stationary loads, reliability at high temperatures etc. Regardless all peculiarity of foil gas bearings at present time they find increasingly greater application in supports of small gas turbine engines [1]. In present paper carried out an investigation of dynamic behavior for replacing of rolling element bearings with foil gas bearings for rotor of existing auxiliary power unit.

1. Engine characteristics

Auxiliary power unit used for supply for air supply systems of thrust engine start. Rotor weight is about 3.5 kg and nominal rotating frequency 38 500 rpm (Figure 1a). Engine have a one rotor with mounted one stage centrifugal compressor and one stage axial turbine. In initial configuration rotor, supported in one ball bearing and one roller bearing. Different designs for modified rotor were investigated. These designs does not changes engine structure sufficiently.



a) **b)**

Figure 1. Auxiliary power unit
a) – model; b) – eigenmode

2. Rotor model and results

Foil gas bearings characteristics calculated on the base of bearing mathematical model uses nonlinear Reynolds equation for compressible fluid [2]. On first stage foil gas bearings dimensions and structure required for designed rotor radial loads on supports are determined. On second stage for new rotor designs with foil gas supports on first stage of investigation rotor stress-strain state under the action of centrifugal forces investigated basing upon rotor axisymmetric finite element model. On third stage, the rotor eigenfrequencies and eigenmodes (Figure 1b) investigated for different rotor support designs including initial rolling element bearings using both rotor solid and beam models. That allows determining if any of eigenfrequencies are in or near rotor operating frequencies range.

Rolling element bearings and foil gas bearings included in rotor model using special finite element considering bearings nonlinear characteristics. For rotor dynamic behavior investigation the beam model verified on previous stage with solid model is used. On fourth stage, the rotor dynamic behavior in whole range of rotating frequencies was investigated and rotor orbits in bearing were determined (Figure 2). Foil gas bearings under the action of dynamic radial loads caused by rotor imbalance and non-stationary loads was investigated.

An opportunity of auxiliary power unit design changing for implementation of foil gas bearing in rotor supports is shown. Bearing parameters including dimensions, geometry, coatings etc for providing required carrying force are determined.

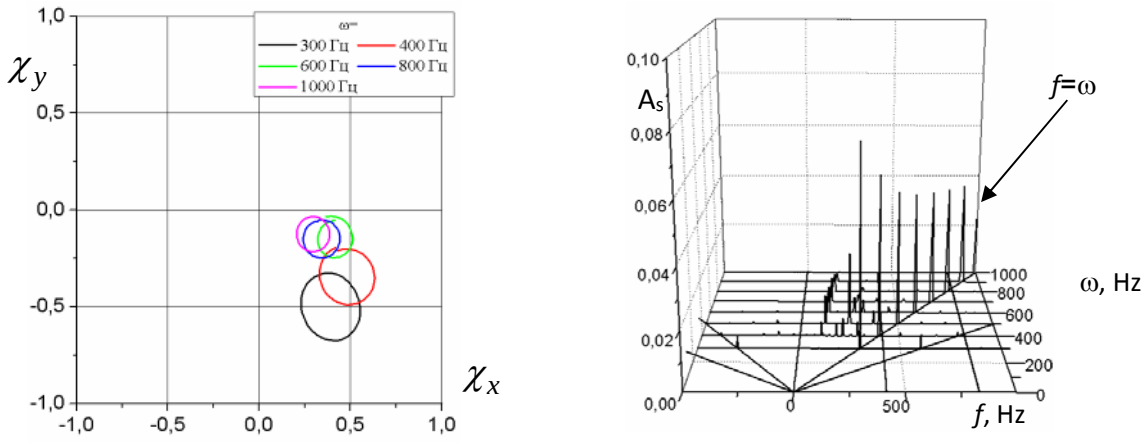


Figure 2. Investigation of rotor nonlinear vibrations in foil gas bearings
a) rotor orbits in bearing; b) orbits full spectrum

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