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Determination of Rotor Surfacing Time for the Vertical Microturbine with Axial Gas-Dynamic Bearings

N.N. Efimov[a], V.V. Papin[a], R.V. Bezuglov[b,]*

[a] *Platov South-Russian State Polytechnic University (NPI), 132, St. Prosvescheniya, Rostov region, Novocherkassk, 346428, Russian Federation*
[b] *OOO NPP "Donskie Technologii", 164, St. Michaylovskaya, Novocherkassk, 346400, Russian Federation*

Abstract

The rotor surfacing time of a vertical microturbine with the axial gas-dynamic bearings is estimated in this article. The problem of providing low coefficient of friction in vertical turbomachines can be solved by using various types of bearings. The earlier research showed the efficiency of the gas-dynamic bearings at nominal regimes of vertical power installations. However, the rotor does not immediately pop up in the axial gas-dynamic bearing. At the initial speed of the rotor, i.e., in the start mode, the active friction of the shaft and the bearing-rotor petals occurs. Thus, the article presents an estimation of the rotor surfacing time in locally produced gas-dynamic lobe bearings made by means of mathematical modeling method.

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Keywords: microturbine; axial bearing; petalled bearing; air cushion; dynamic characteristics

1. Introduction

The determination the rotor surfacing time is made by the example of wet-steam vertical microturbine as part of a wet-steam microturbine installation. The wet-steam microturbine intended for decentralized consumer supply heat and electricity [1-3]. This microturbine working on the wet steam generated by the steam-generated system. It can be almost any kind of steam generator in the steam-generated system – from the boiler on fossil fuel (gas, coal, wood, pellets, etc.) to waste treatment plants on the effect of cryoablation [4,5]. There were identified some

* Corresponding author. Tel.: +7-928-289-76-67.
E-mail address: romanbezuglov@inbox.ru

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difficulties associated with overcoming the force of sliding friction in the gas-dynamic axial bearings during the pre-experimental investigations of the wet-steam microturbine [5,6].

Nomenclature

P	the force created by shaft, N
m	shaft weight, kg
g	a free fall acceleration, m/s^2
α	the angle between the support plane and the horizontal plane (in this case cos α = cos 0 = 1)
F_{st}	elevating force created by steam inlet in the impeller, N
F_{bear}	force created in the air gap of the bearing while driving, N
φ	the speed factor at a flow movement, is assumed to φ = 0,95
G	steam consumption in the microturbine, kg/s
c_{1a}	vector of axial constituent of absolute flowrate of steam on included in working shoulder-blades, m/s
δ	the angle between the total force and the lifting force, degrees. δ is 2-3 degrees, it can be assumed that cosδ = 1
d_1	the diameters of the inlet into the working grid, m
d_2	the diameters of the outlet into the working grid, m
d_{sl}	diameter of the impeller sleeve, m
l_1	length of shoulder-blade, m
$\vec{c}_{out}$	vector absolute steam flow rate at the outlet of the impeller, m/s
F_{mass}	the mass force, N
u	circumferential speed at an average diameter of a shaft thrust disc, m/s
Δh_{down}	the gap between the lower disc support and the bearing petals, m. Δh_{down} – assumed to be equal 0,00001÷0,000015 m
z	coefficient determining the proportion of the area of the friction surfaces, taking into account the increase in the proportion force exerted by the heel and shaft on the limited surface of petals. z – assumed to be equal 0,01 (coefficient determined based on the analysis construction documentation for microturbine)
μ	dynamic viscosity for air under ambient pressure and temperature, Pa·s. μ – assumed to be equal 0,00002 Pa·s
S_{slog}	the friction area of the thrust disc, m^2
b	the width of the thrust bearing, m. b – assumed to be equal 0,03 m
d_{aver}	an average diameter a disc thrust, m
F^{up}_{bear}	the reaction of the air layer the upper petals of microturbine gas-dynamic bearing, N

2. Relevance and scientific significance of the issue

Modern small distributed power becomes more popularity [7-10]. Its based on the gas piston, gas turbine and steam turbine units of cogeneration and more recently more on the installation of a renewable energy [11-14]. Small power installations are intended for supply electricity and heat to individual consumers, which are characterized by the uneven consumption and have no backup power. So these plants operate in mobile mode of energy production. Most of these installations performed constructively horizontal type. Researches of the dynamic modes of vertical microturbines were carried out a little, in comparison with horizontal installations. Nevertheless, they require careful research of their operating modes in particular of the rotor surfacing time in an axial gas-dynamic bearings. As shown the works [15-19], this type of bearing is the most optimal for the nominal operation mode of the power installations. The calculations of dynamic horizontal turbine performance cannot fully comply with its work with vertical design due to the different character of loads. Therefore it is necessary to calculate the rotor vertical microturbine surfacing time. Figure 1 shows a sketch drawing of the wet-steam microturbine (red indicated the gas-dynamic bearings location).