Investigation of Heating of Rotating Disks in an Electromagnetic Field Using Strong Permanent Magnets

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***Abstract*—A new method for heating of the rotating disks using strong permanent magnets is proposed. The results of studies of the thermal state of a rotating model disk in a magnetic field created by permanent magnets on the spin rig are presented. The developed method can be used for heating small-sized rotating disks and products.**

Keywords—heating, rotating disk, permanent magnets, electromagnetic field, spin rig

INTRODUCTION

The various heating methods are used: induction, aerodynamic, gasdynamic, radiation for the implementation of thermal processes in bodies of revolution for conducting accelerated and thermocyclic tests of disks and parts of aircraft gas turbine engines (GTE) and turbines of power plants on specialized spin rig [1-4]. The induction heating makes it possible to ensure high heating rates and to obtain a predetermined non-uniform distribution of temperatures along the radius of the disk, corresponding to operating conditions during tests on spin rigs [1-3]. A conventional induction heating system consists of several flat ring inductors located at different radii of the disk. Its disadvantage is: the impossibility of obtaining additional thermal energy due to rotation, because axisymmetric inductors. The experiments and acceleration tests with induction heating of rotary disks on the spin rig are associated with significant material costs.

Currently, the development and application of energy-saving heating methods is relevant. One of these new heating methods is the heating of parts using strong permanent magnets with improved characteristics. When a part rotates in a magnet field, the electromotive force (EMF) is induced in it and, thus, thermal energy appears (power of internal heat sources under certain conditions depending on the shape of the magnet).

The development of a heating technique - the generation of thermal energy in disks through rotation (production of power from internal heat sources) in a magnetic field created by permanent magnets is an urgent task. In thermocyclic tests, the maximum rotational speed of the disks can be between 20000 and 60000 rpm.

THE RESULTS OF INVESTIGATIONS

The thermal state of disks rotating in a constant magnetic field at the initial stage was studied using magnets from samarium-cobalt alloys, because they have not only significant magnetic induction up to 1 Tesla, but also operate at elevated temperatures up to 250-300 ° C. However, it should be borne in mind that they are fragile.

EMF is induced when the disk rotates in a magnetic field created by a permanent magnet, in accordance with the law of Faraday's electromagnetic induction. As a result, induced currents occur. At a low speed, the indicated EMF is small. With an increase in the rotational speed, the rate of change (pulsation) of the magnetic flux in the disk increases and the induced emf becomes significant in the range of high rotational speeds. As a result, the power of internal heat sources increases and the intensity of heating of the rotating disk increases.

In this paper, a new method for heating rotating disks (round plates) in a constant magnetic field is considered, taking into account the release of power from internal heat sources at various rotation frequencies [4]. The paper [5] presents a method of heating a rotating pipe using strong magnets.

The thermal state of the model disk (made of stainless steel) rotating in the field of permanent magnets was studied on the spin rig. The disk was prepared with thermocouples at three radii. The disk and mount with magnets mounted in a vacuum chamber are shown in Fig. 1.

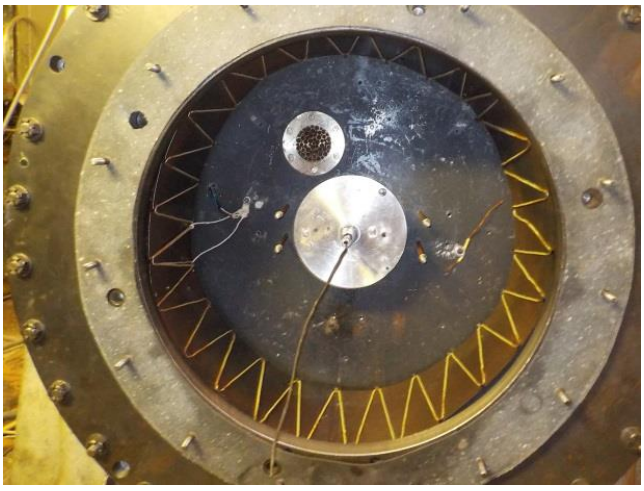

Fig.1. Model disk installed in the vacuum chamber of the spin rig.

A gap of 5 mm is set between the disk and the magnets. Disk temperatures were measured through a mercury current collector using a computer system. In fig. 2 shows the temperature distribution of the disk at different frequencies of rotation of the disk at different radii, depending on the frequency of rotation during the experiment. A maximum temperature was observed at a radius of 100 mm, which was close to the midline of the installed magnets.

In these experiments, the thermal state of the model disk was studied at rotational speeds of up to 15000 rpm. At this speed, the maximum temperature was 440 ° C. From the analysis of the extrapolated dependence 3 (Fig. 2) with a

radius greater than 100 mm, it follows that at the outer radius of the disk the temperature can be 640 ° C. At higher speeds, the discs should be expected to heat up to a higher temperature.

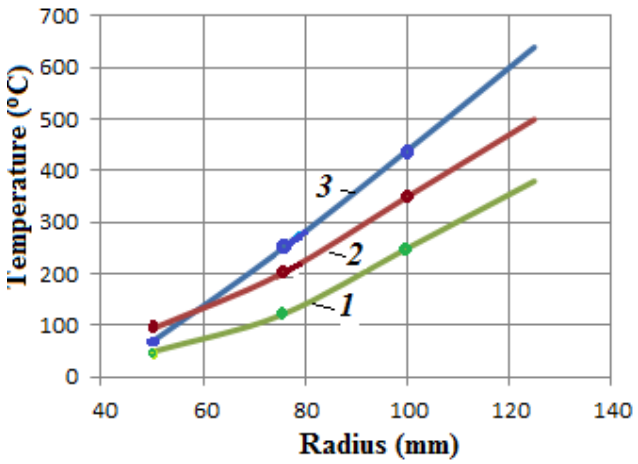

Fig.2. The temperature distribution of the disk at different speeds: 1 - 5000 rpm, 2 - 8000 rpm, 3 - 15000 rpm.

CONCLUSION

A new method (energy-saving) of heating of the rotary disks using permanent magnets is proposed. The results of studies of the thermal state of a model disk rotating in a magnetic field created by permanent magnets on the spin rig are presented. The developed method can be used for heating small-sized rotating disks and products and aluminum and other cylindrical billets.

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