HEAT PIPES WITH COMPOSITE FIBER-POWDER STRUCTURES FOR HEAT-TRANSMITTING DEVICES OF HYDROGEN POWER

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Introduction

Researches of processes of two-phase heat transfer in heat pipes (HP) are actual. The purposes of researches are caused by development of heat pipes and thermo-siphons with capillary structures (CS). Such high-heat-conductivity heat-transmitting devices are perspective for modern thermo-technical equipment of hydrogen power. Using the fibrous metal materials which developed in Institute for problems of materials science of Ukraine NAS is expedient. Fibrous CS are one of the best capillary structures nowadays. The works on perfection of CS performances have led to creation the composite fiber-powder CS. The ideas of conducting of heat pipe parameters depending on specific targets of application of HP are realized in IPMS with using of synthesis of initial materials' properties.

Results and discussion

The basic directions of IMPS of Ukraine NAS researches in the domain of workings out of heat pipes and capillary-porous structures for HP are: 1) researches of pore space parameters of new type capillary structure which received on basis of fiber composite materials; 2) researches of hydrodynamic characteristics of layered and frame gradient capillary structures; 3) researches of thermo-physical characteristics of various type capillary structures which received from fibers and compositions on their basis. The carried out complex researches and developments have allowed to create composite fiber-powder capillary structures. The positive properties of these structures combines efficiently for capillary structures fulfilled from mono-powder and mono-fiber materials.

Correlation of dependences of all CS properties from porosity exist in traditional porous materials (mesh, powder, fiber). The combination in one material of structural elements with different geometrical sizes and a different denseness of packing allows to eliminate such association. The new composite layered materials containing linear (filaments) and pointwise (powder) structural elements are used in the present work. Various mechanisms of obturating are realised in such materials.

Contact character of obturating of powders, at the facilitated transition of particles by mutual sliding, and is flexible-rigid character of obturating of filaments when takes place not only contact, but also a reversible elastic and irreversible plastic strain is typical property in such process. The range of structural performances modification of such materials essentially extends depending on relation of powder and fiber particle sizes . It also depends on a fiber and powder stratum thickness. Process of gravitational formation of high-porosity composite materials from metal powders and filaments is investigated. Various types of materials' macrostructure are formed depending of powder and fiber particles sizes relation and also depending on a thickness fiber and powder stratums. At manufacturing of composite CS the powder partially or completely besieged in beforehand high-porous fibrous frame.

The fulfilled researches have shown that the most perspective for use in HP are the materials fulfilled in the form of high-permeability and strong fiber of frame, containing one or several thin fiber-powder stratums. These stratums ensure an intensification heat transfer and mass transfer of liquids. In the course of working out of new capillary structures we investigated three types of layered CS: 1) fibrous CS containing a stratum from filaments in diameter 50 microns; thickness of 0,75mm; and a stratum from filaments in diameter 30 microns; thickness of 0,25mm; 2) fiber-powder CS in the form of frames from filaments in diameter 50 microns and thickness of 1mm; 0,25mm filled on depth a powder with a size of particles 60 microns; 3) fiber-powder CS, representing fiber frames (diameter 30 microns and thickness about 1 mm), filled (on depth about 0,25 mm) a powder with a size of particles 40 microns.

Results of researches of pre-production models hydrodynamic and structural performances have shown, that composite materials possess the worst permeability in comparison with monofilament CS. Such composite materials have a number of a pores with smaller sizes (in about 2 times). Sizes of a pores in monofilament materials decrease at reduction of filaments diameter. But these sizes do not reach those values which composite materials possess. The maximum capillary pressure in CS depends on magnitude of average hydraulic diameter of a pores. Therefore prospects of the developed composite materials application in heat pipes are ponderable. Advantages of composite capillary structures are effectively exhibited in extreme working conditions of a HP when forces of capillary pressure and gravitation are directed in opposite directions.

Fibrous-powder compositions are characterised by the typical for fibrous CS high capillary-transport ability. They exceed porous one-sheeted monofilament materials on height of liquids (ethanol) lifting in 1,5-2 times, at work against gravitation forces. Thus compositions of filaments ∅ 50 microns and a powder with dispersibility 80 microns with the best combination of permeability characteristics and sizes of a pores possess limiting height of ethanol lifting.

The experimental stand for researches of heat physics characteristics of heat pipes contained such systems: system of a supply, regulation and measurement of a heat flux stream capacity; system of high-precision measurement of temperature in control points of a HP; system of security and measurement of a heat-conducting path parametres; some auxiliary systems.

In horizontal position fibrous CS transport a liquid to a heat zone in comparison with powder CS much faster. However highly porous monofilament CS not always can ensure great values of height of a capillary raising of a liquid in working conditions of a HP against gravitation forces (in position «HP heat - above»). Such structures possess a number of a large pores which badly keep a liquid. Junction of positive properties of two different types of capillary structures in one composite structure capable to ensure high characteristics of the created heat pipes. It is possible at working HP in horizontal position and at working HP in the conditions of counteraction of gravitational forces.

Results of our researches have confirmed such statement. Heat pipes with composite CS worked steadily in positions **"A"** (a declination angle $\varphi = -90^0$, HP heat "from below") and **"B"** ($\varphi = 0^0$, horizontal position of a HP). Thus HP ensured temperatures of a transport zone in such range which was similar for a range of temperatures of a HP with monofilament CS (a HP № 1).

Heat pipes with composite CS (a HP № 2 and a HP № 3) in position "C" (a declination angle $\varphi = +90^0$, HP heat "from above") ensured more higher values of an assigned heat flux ($\mathbf{Q_{max}}$ = 20 W) in comparison with monofilament heat pipe № 1 (value $\mathbf{Q_{max}}$ = 10 W). This fact speaks presence in composite structure of a powder making part. Such porous structure possesses a pores with essentially smaller sizes on magnitude and ensures the best conditions for capillary lifting of a liquid in a zone of a HP heat.

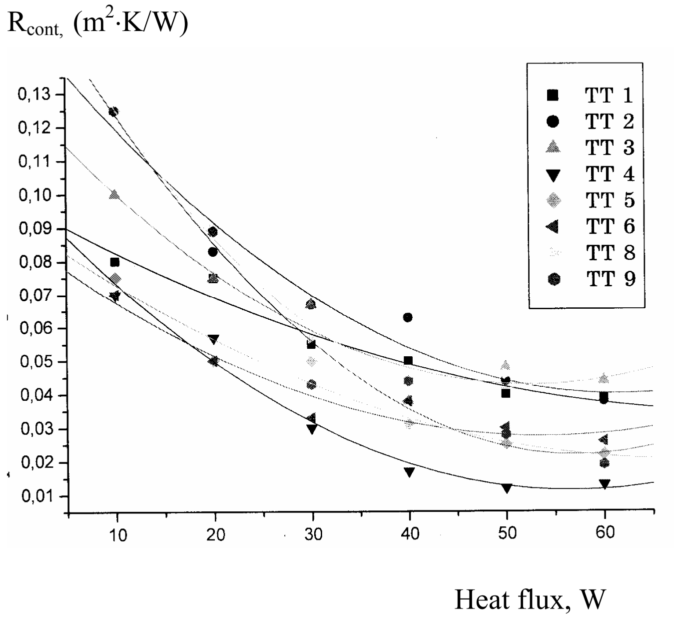

Fig. 1. Dependence of heat pipes thermal resistance (the basic characteristic) with composite capillary structures from a brought heat flux at HP work against gravitation forces (HP heat - "from above").

Conclusions

Heat pipes with composite capillary structures of new type are created and investigated. They ensure high thermal physics and operational characteristics. The created heat pipes are capable to function effectively in any positions at their determination in a gravitational field.

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