ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VII [2014] Fascicule 2 [April – June]
ISSN: 2067 – 3809

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HEAT TRANSPORT DYNAMICS OF VARIOUS WORKING FLUIDS IN HEAT PIPES

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Abstract: A heat pipe is a hermetically closed pipe, filled with working fluid. The heat transport in heat pipe is procured by the change of the working fluid state from liquid to vapor and vice-versa and thus is able the heat transfer several times more such by heat conduction. Phases change depends on the hydrodynamic and thermal processes in the pipe. This paper observes the impact of these processes at startup of heat pipes with various working fluids scanning the surface temperatures of heat pipes by thermovision camera. According thermo vision record of heat pipe operating is possible identify the dynamics of heat pipe working fluid and if the heat pipe operate correct.

Keywords: heat pipes, working fluids, heat transport, thermovision camera

INTRODUCTION

The heat pipe is a hermetically closed pipe which is filled with working fluid. Heating the evaporation section of the heat pipe the working fluid starts to evaporate and flows through to the opposite side of the pipe. Here the vapour condensate and in the form of condensate flow down the walls of the pipe as a result of gravity or the condensate is transported back to the evaporation section of the pipe through the capillary system. The transport of latent heat procured in this way significantly increases the effectiveness of transporting heat by compared to transporting heat by standard pipe. The heat flow transported by the heat pipe depends on the material of the pipe, working substance and their mutual compatibility. In the wick heat pipes maximal possible transport of heat flow depends to capillary system too, but mainly it depends to hydrodynamic and heat processes taking place during function of heat pipe [1, 2].

METHOD OF ANALYSIS

During the functioning of the heat pipe a phase change of liquid state to vapour state and via versa occurs. This work is oriented at observing the hydrodynamic and heat processes which occur inside the pipe and affect the overall transport of heat by heat pipe. Thermography is one of the ways with which it is possible to monitor these processes. Thermography is a method which allows us to observe these processes using an infrared sensor which measure surface temperature without contact of objects and consecutively digitally shows the temperature fields of the objects. The function of hermovision camera is based on this principle. Using thermovision camera was scanning the surface temperatures of the wick heat pipes related to time [3]. This method of monitoring heat pipe surface temperatures can be used to verify and test their correct functioning.

EXPERIMENTAL TECHNIQUES

Experiment of monitoring heat transport dynamics was realized on heat pipes with mesh screen capillary structure. Mesh screen capillary structures are one from the most applied structures in heat pipe. For manufacture of heat pipes are use a finely mesh screens from stainless steel with mesh 200. Piece of screen is rolled and inserted in to the pipe, thus is rolled screen by acting expansive forces stable placed in inner surface of pipe. The container material is copper and overall length of heat pipes is 0,5 m. The working mediums in heat pipes were used distilled water, acetone and ethanol [4, 5]. On figure 1 is shown monitoring method of heat pipes by thermocamera.

Experiment was realized in laboratory on our department. Heat pipes were placed in to the thermal isolated container with liquid medium and constantly heated from 20°C to 90°C. For better visualization was surface of heat pipes painted with white matt colour before the scanning.

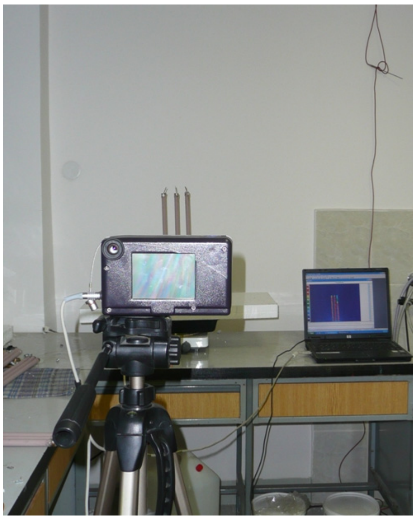
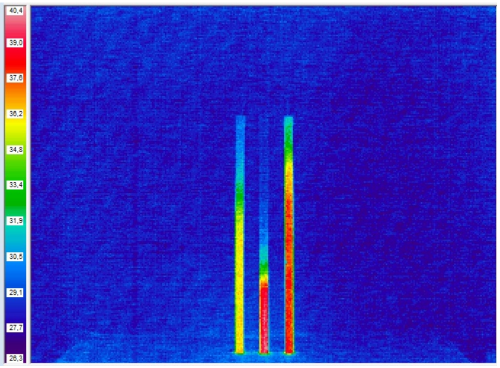


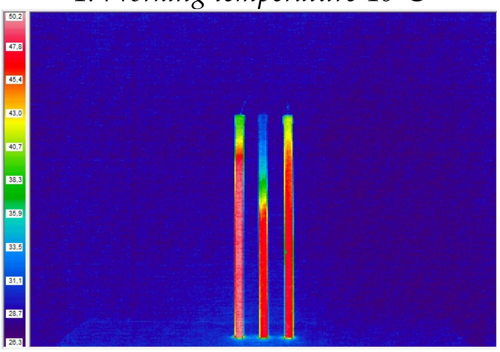
Figure 1. Monitoring of heat pipes by thermocamera

RESULTS

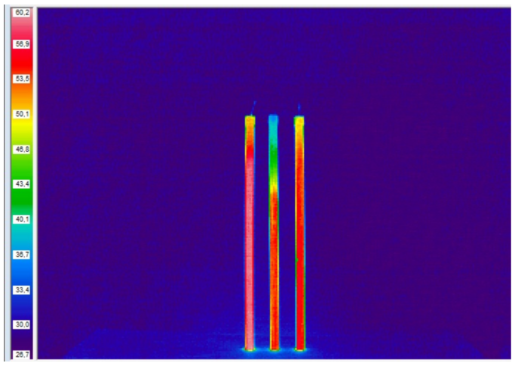
Thermovision photos show the heat transport dynamics of heat pipes with working fluids of acetone, ethanol and water at the same working temperature condition. In Figure 2 are six thermovision pictures of heat pipes according working temperature conditions from 40 to 90 °C.



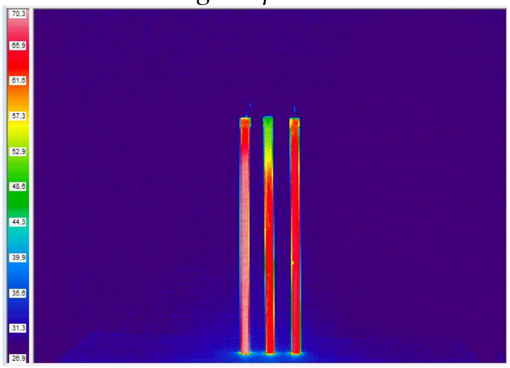
1. Working temperature 40°C



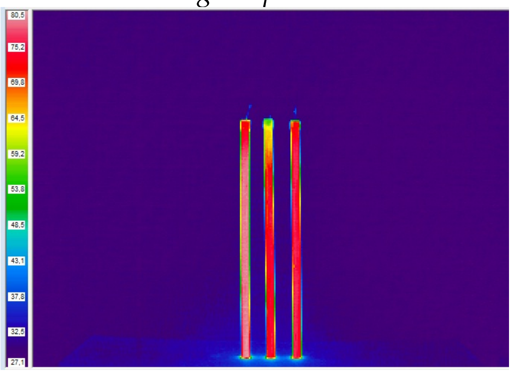
2. Working temperature 50°C



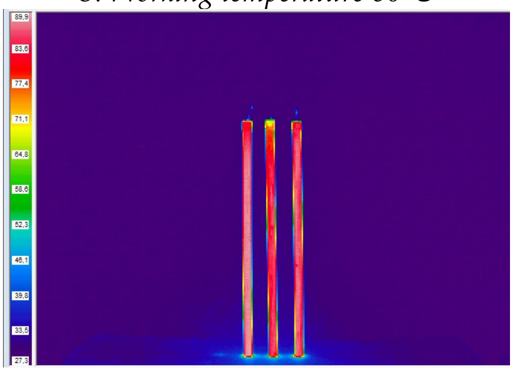
3. Working temperature 60°C



4. Working temperature 70°C



5. Working temperature 80°C



6. Working temperature 90°C

Figure 2. Thermovision visualization of screen mesh wick heat pipes with working fluids acetone, water and ethanol

On the thermovission photos scanned by thermocamera is clearly to see increase of temperature on the surface of the heat pipes depending from heat source temperature. Multicollor scales on the left side of the photos *determine scaned surface temperature. Blue and green collor are low temperatures, yellow and red collors are high temperatures equivalent to heat source temperature. Heat pipe visualization by thermovission camera imagine thermal and hydrodinamical phenomenon inside the heat pipe. Colouring of the scaning surface plane displays speed of the working fluid vapour flow and volume of the mas flow transfer from evaporation to the condensation section of the heat pipe.*

On the Figure 2 where heat source temperature increase form 40 to 80 °C is to see on heat pipe no. 1 filled with ethanol and no. 3 filled with acetone better and faster heat transport reaction than on heat pipe no. 2 filled with water. The slower reaction of the water heat pipe at startup cause different thermophysical properties of the water than acetone and ethanol. On the last photograph at working conditions 90°C every three heat pipes achieve uniform temperature along the length and have a single colour.

This experiment achieve that acetone and ethanol heat pipe operate at lower temperature better than water heat pipe but at higher temperature water heat pipe operate as well as acetone and ethanol heat pipe. Results of scanning surface temperature of the heat pipes by thermovision camera are show how does work heat pipes on the start up, how it does influence their heat transfer ability and if operate correct.

CONCLUSION

Experiment show that the one of the factors, which is influencing on performance of wick heat pipe is choice of the working fluid, because each liquid have different thermo physical properties at equal ambient conditions. The effect of this factor on the dynamics of the heat transfer by heat pipes can be easily identified by thermovision scanning surface temperature of the heat pipes. Photographs scanned by thermovision camera show different behaviour of the heat pipes, which is caused by various working fluids. The fastest start of functioning was monitored in heat pipe with acetone, the slower start has heat pipe with ethanol and the slowest start has heat pipe with water. Even though that the water heat pipe has slowest start, at higher working temperature achieve uniform temperature along the length as well as acetone and ethanol heat pipes and all heat pipes work correct.

Acknowledgment

This article was created within the frame of project KEGA 064ŽU-4/2012

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ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809