STUDY ON MEASUREMENT THE TEMPERATURE OF A SKATING RING BY THERMOGRAPHY METHOD

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Rezumat. *Lucrarea prezinta un studiu legat de masurarea temperaturii pe suprafata unei piste de patinoar prin metoda termografierii dar. Utilizarea programului ThermaCam Researcher Professional 2.8 permite înregistrarea şi prelucrarea datelor, precum şi fotografierea procesului de solidificare la diverse momente de timp.Cu ajutorul datelor inregistrate putem determina evolutia temperaturii in anumite zone ale pistei*
Cuvinte cheie. Termografiere, pista de patinoar, gheata, solidificare

Abstract. This paper presents a study regarding measuring the temperature of a skating ring by thermography method. Using ThermaCam Researcher Professional 2.8 software it allows recording and processing of data and photographing the solidification process at various moment. Using the saved data we can show the temperature variations in certain zones of the ice rink pad.
Keywords Termography method, artificial skating rink, ice, solidification

1. Introduction

The heat transfer in the skating rink track is nonstationary and phase changing. In case of skating rinks equipped with pipe registers, the temperature field during the ice formation process can't be modeled by analytical methods. Also, the paper presents the experimental study for temperature distribution around the cooling pipes of an ice rink pad.

The experimental research was targeted on finding the temperatures in several points of the pad and also details on the ice shape and quality around the pipes. The experimental results were compared against the numerical modeling using finite elements.

2. Problem Formulation

The problem of melting and solidification of substances, from the point of finding the temperature distribution within solid and liquid phases and of the movement of the solid – liquid interface, is very interesting (both from theoretical and practical point of view), because heat transfer conduction accompanied by phase change occurs in many applications, such as ingots solidification, directional solidification of alloys in order to obtain a certain metallographic structure, freezing of foods, soil freezing and thawing, phase change thermal storage, etc.[1,2]

For the experimental study was used a thermography camera Flir A20 which belongs of the Department of Thermal Systems & Environmental Engineering (Figure 1).

For the experimental study of temperature distribution around the cooling pipes of the pad, an experimental test bench was built in the Refrigeration laboratory.

The experimental study was divided in two phases:

Phase I - study of temperature distribution around water immersed pipes;

Phase II - study of temperature distribution around sand buried pipes.

The main components of the experimental test bench are:

- Refrigeration system;
- Ice rink pad;
- Secondary cooling agent loop;
- Data (temperature) recording system

The layout of the experimental test bench is shown in Figure 1. The refrigeration system is a single stage vapour compression system using R134a. The pad is cooled using a secondary agent (ethylene-glycol) loop, which it is first cooled in a tank. [3,4]

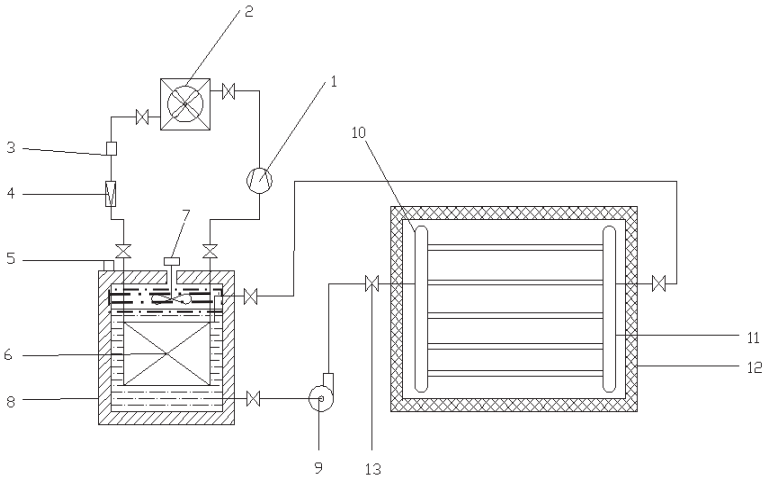

Fig.1 *Experimental test bench*
1- compressor, 2 – air cooled condenser, 3 – dehydrating filter, 4 – throttling device, 5 – thermostat, 6 – flooded evaporator, 7 – secondary coolant stirrer, 8 – secondary coolant tank, 9 – secondary coolant pump, 10, 11– headers, 12 – ice rink pad, 13 – valves.

To measure the temperatures on the skating ring surface using thermocouples is impossible due to the larger diameter of the thermocouple bulb compared with the air- water surfaces thickness. For this reason we used to measure the temperature by thermography method, thus reducing the errors (Figure 2)

Thermographic measurement technique is a modern method of temperature measurement and is used in many areas and is based on infrared radiation emitted differently by bodies [6].

To measure temperature accurately, it is necessary to compensate for the effects of a number of different radiation sources. The following object parameters must, however, be supplied for the camera:

- The emissivity of the object
- The reflected temperature
- The distance between the object and the camera
- The relative humidity.

Fig.2 *The thermography camera Flir A20*

One advantage of using the softwear ThermaCam Researcher Professional 2.8 (Figure 3) is that the temperature can be measured in specific points (SP1,SP2….SP5), or a line which intersects several areas (LI 01)

The points and line were placed on the study area so that their positions correspond to points coordinates on the numerical simulation model geometry.(Figure 4)

The time for measuring the temperature was set to 420 minutes.

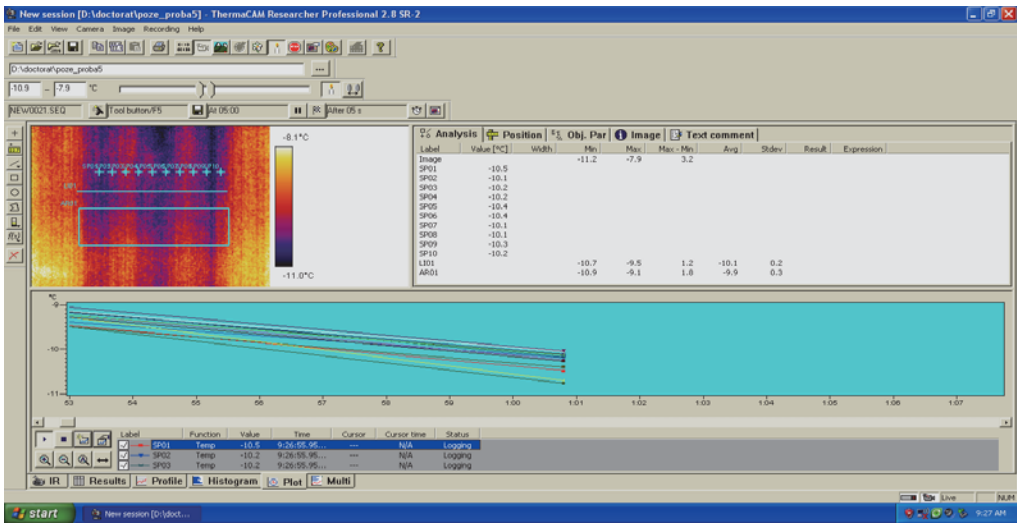

Fig.3 *ThermaCam Researcher* Professional 2.8 softwear

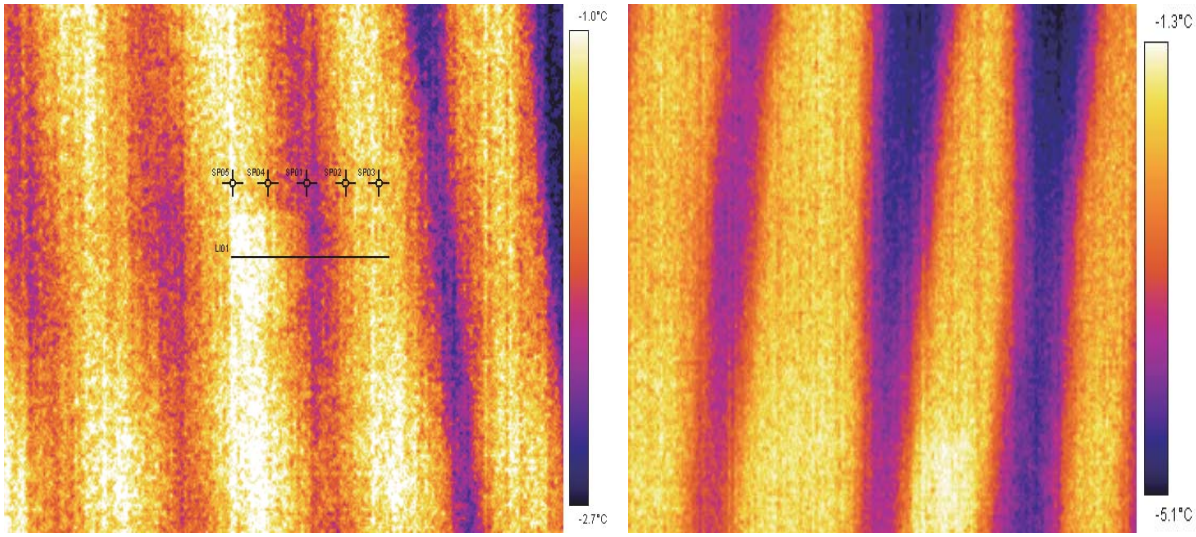

Fig.4 *Termografierea pistei patinoarului*

Fig. 5 shows temperature variation vs. time for points SP1, SP2, SP3. One can notice that temperature variations at the pipe wall (SP1) and at half distance between the pipes (SP3) are different.

This leads to a fast formation of ice next to the pipe and a slower one between the pipes.

After 330 minutes, the temperatures in the points (SP1…SP5) are approximately equal.

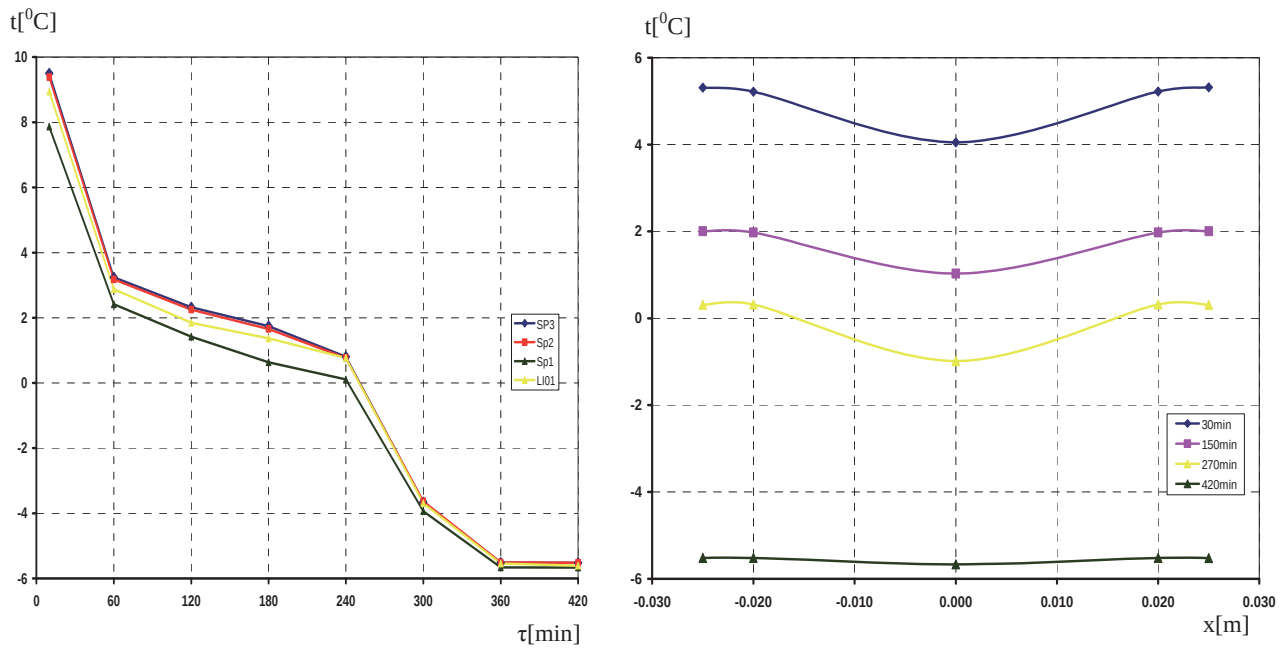

Fig.5 *Temperature variation vs. time for points SP1, SP2, SP3 and line LI 01*

3. Conclusion

One can notice that the largest deviations between experimental and numerically modeled temperatures are at the beginning of the process, when water is in liquid form and are due to the fact that the cooling load is maximal and the temperature of the secondary cooling fluid has small variations.

After complete solidification of water, temperature differences drop, showing a decreasing cooling load and a stable operation of the refrigeration system. Experimental results match numerical ones so the mathematical model used for numerical simulation is validated by the experimental study.

REFERENCES

[1] LEWIS R.W., ROBERTS P.M. - *Finite element simulation of solidification problems*. App. Scientific Research, Vol. 44, pp 61-92,1987.

[2] SASAGUCHI K., VISKANTA R. - *Phase-change heat transfer during melting and resolidification of melt around cylindrical heat source(s)/Sinks*, Jl. of Energy Resources Technology, vol.111, 1989

[3] Coman Gelu, Cristian Iosifescu, Calin Ciufudean "*Modeling of Heat Transfer for an Ice Rink Track using Finite Elements*" - 11th WSEAS International Conference on SYSTEMS THEORY AND SCIENTIFIC COMPUTATION (ISTASC '11) Florence, Italia 2011, ISBN-978-1-61804-026-8, pp 225-229.

[4] Gelu Coman, Valeriu Damian, *The heat transfer inside an artificial skating rink*, THE 5TH INTERNATIONAL CONFERENCE ON ADVACNED CONCEPTS IN MECHANICAL ENGINEERING , June 14-15, 2012, Iasi, Romania, ISSN 2285-2301

[6] Thermovision A 20, Flir Systems Inc, Operator's manual, 2004.