ENGINEERING MECHANICS 2009
National Conference with International Participation
Svratka, Czech Republic, May 11 – 14, 2009

pp. 519–522
Paper **#157**

TECHNOLOGICAL DESCRIPTION OF HEAT AND MASS TRANSFER PROCESSES IN THERMAL TREATMENT CHAMBERS FOR FRUIT

M. M. Janczarek*

Summary: *This paper describes research work on methods concerning heat transfers through walls of thermal technical chambers – fruit storages. The paper presents the analysis of complex problems in the field of energy savings and material selection during long term storage of fruit in thermal chambers in controlled gaseous environment. The purpose for the research is to point out areas subjected to the highest energy losses caused by building's construction and geographical orientation of walls in the aspect of daily atmospheric temperature changes emerging on chamber exterior.*

1. Introduction

The presented new concept of thermal analysis is derived from periodic character of temperature changes in storage environment. The analytical approach seems appropriate to obtain established purposes i.e.: the description of temperature changes and heat transfer within the chamber walls and its gaseous environment. The storage parameters of apple range is the following: temperature 1-3 ^{0}C, oxygen (O_2) concentration 1,5-3%, carbon dioxide (CO_2) concentration 1-5%.

The paper presents also the physical model of heat transfer through chamber walls by means of a mathematical model suitable for sine waveform of internal temperature changes.

The analysis has been performed on the basis of original numerical algorithms. They take into consideration hourly changes of ambient temperature in the central – eastern region of Poland. The accepted methodology of performance takes advantage of temperature dynamics which is necessary to solve physical and mathematical problems related to heat transfer processes occurring in chambers.

2. Research and experimental work of heat transfer through wall

The originally constructed laboratory system consists of fully automatic stands to test construction material thermal characteristics (Fig.1). These characteristics form the basis to formulate the principles of temperature changes between adjacent layers. The laboratory enables also to trace the heat transfer on external border surfaces. The experimentally obtained results have been subjected to computer analysis.

* Ing. Marian Marek Janczarek, CSc., Technical University of Lublin, Department of Fundamentals of Technology; ul. Nadbystrzycka 38; PL – 20-618 Lublin, Poland; tel.: 0048 81 5384491; fax: 0048 81 5259385; e-mail: marekj@antenor.pol.lublin.pl

The verification of the accepted methodology and results have been performed on the data thermal flux density obtained from rural thermal chamber in Radzyń Podlaski (Poland). The small sensor of low inertia has been developed especially for the purpose of the research. This sensor has been used to measure the heat flux density. The experimental analysis proves the necessity to consider the dynamic character of internal temperature when thermal chamber analysis is performed. The thesis includes also the presentation of elaborated methodology of analysis of industrial long term storage.

Two fruit storages have been subjected to the analysis of temperature distribution on the surfaces of technical chambers (Fig. 2). The storages are constructed of materials of different physical properties.

Fig. 1 Registering positions laboratory

The purpose for the research is to point out areas subjected to the highest energy loss caused by building construction and geographical orientation of walls. Thermal detectors have been installed on external surfaces, internal surfaces and inside wall layers to measure temperature. The graphical presentation of temperature field distribution on wall surfaces have been performed by means of a thermal vision camera (Fig.3, 4). The camera enables to distinguish visually the areas of the highest thermal loss from storages. The analysis of temperature distribution on vertical walls of storages makes possible to indicate proper building construction of objects. The analysis results are presented in figures. Moreover, temperature measurements taken on chamber external surfaces let us distinguish rooms that serve for other purpose than storage, e.g. a technical room. This room additionally protects the storage from disadvantageous influence of atmospheric conditions.

Article includes analysis of changeable influence in time of variable weather temperature on internal temperature of construction object depending on thermal inertia of building. Taken advantage influence of sinusoidal change external temperature on internal temperature of thermal technical spaces of thermo stability object will allow to get drop of cost of expendable energy of construction object on keeping of definite thermal condition in

accommodation properly spaces. It shows harmonist of exemplary characteristic depending on length of time of measurement course of temperature and seasons of the year.

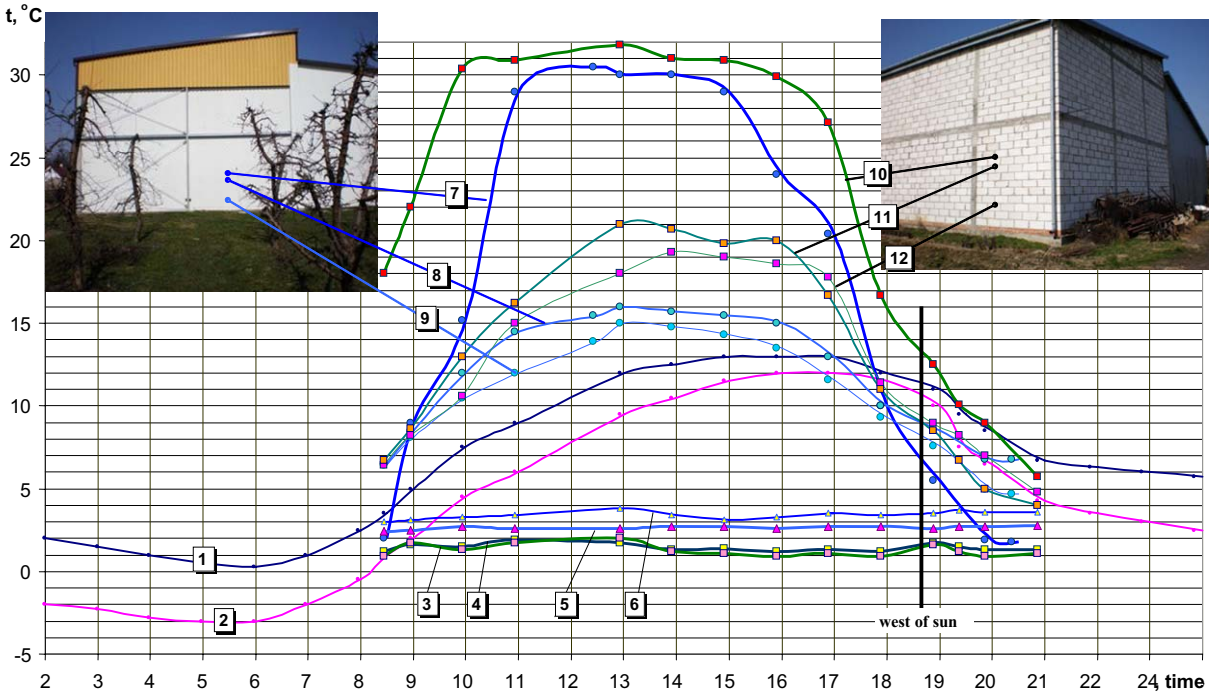

Fig. 2 Presentation of temperature field distribution on wall surfaces

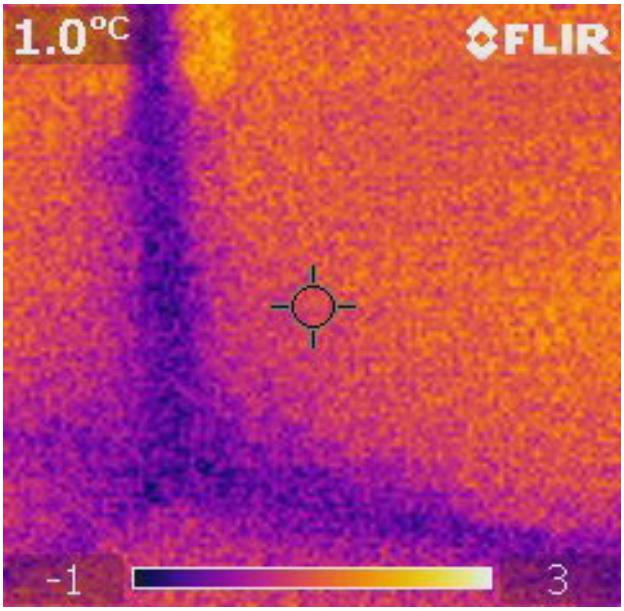

Fig. 3 Temperature field distribution on the corner of wall

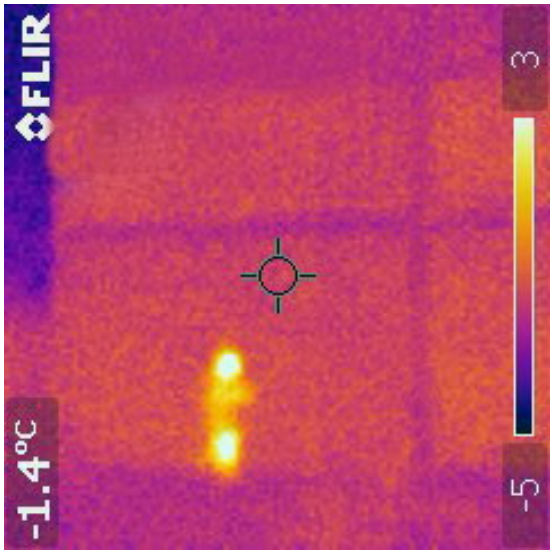

Fig. 4 Temperature field distribution on wall surfaces

3. Conclusion

The paper describes atmospheric temperature analysis and their variability in time in aspect of their influence upon the thermal technical chambers – fruit storages. This analysis shows the periodic variability of outside temperature, changing in periods of each day and also in the year with maximum value in the afternoon or in summer and minimum value in the night or winter time. The influence of this periodically changing temperature on the inside storages climate is depending on thermal inertia of technical spaces. The proper construction of an object with prescribed thermo-stability characteristic can use the phase difference between internal and external temperature and allow to lower costs of energy, necessary for cooling or heating the technical spaces.

4. References

Carlslaw, H., Jaeger, J. (1959) *Conduction of heat in solids*, Oxford University.

Takahashi, Y., Rabins, M., Auslander, D. (1976) *Sterowanie i systemy dynamiczne*, WNT, Warszawa.

Janczarek, M.M. (1992) *Methods concerning conductive heat transfers through walls of thermal technical spaces*, MATAR‘ 92 Prague, pp. 166-170.

Bulyandra, O.F., Yancharek M.M.: (2005) *Analiz peredachi teploti kriz zownischniu stinku skladskowo primischenia z urahowaniam dinamiki zmin atmosfernoi temperaturi* – Harchowa Promislowist, nr 4. UDK 664(04)(082) – Kyiv.

Janczarek, M., Skalski, P., Bulyandra, A., Sobczuk, H. (2006) *Przewodność cieplna zewnętrznych ścian budynków w aspekcie wilgotności i oszczędności energii,* Rynek Energii nr 4 (65) Kaprint – Lublin.

Janczarek, M., M. (2007) *Energooszczędność eksploatacji obiektów budowlanych w aspekcie zmiennej temperatury atmosferycznej*, Rynek Energii nr 1 (68) Kaprint – Lublin.