COMETa 2012
1st INTERNATIONAL SCIENTIFIC CONFERENCE
28th - 30th November 2012.
Jahorina, B&H, Republic of Srpska
University of East Sarajevo
Faculty of Mechanical Engineering
Conference on Mechanical Engineering Technologies and Applications

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Istoļ no Sarajevo ï Jahorina, BiH, RS
28-30. Novembar 2012.

East Sarajevo ï Jahorina, B&H, RS
28^{th} ï 30^{th} November 2012.

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PREFACE

Production in developed countries is based on the modernization and optimization of the production processes with the application of new technologies that are the result of scientific research. The application of new technology enables company's efficient production and competitiveness in the world market.
Faculty of Mechanical Engineering, University of East Sarajevo, organizes the First international conference "COMETa2012 - Conference on Mechanical Engineering Technologies and Application", which has tasks: to increase economic competitiveness in the region and the create a unique European Research Area.

Globally, the worldwide we are witnessing a rapid development and a host of new technological solutions, which occur primarily in the multidisciplinary development (mechatronics) but also in development of completely new technologies, such as nanotechnology, new energy sources, intelligent machines and processes, micro-technique, etc. All of this puts researchers and engineers in the new challenges and creates opportunities for products and technologies that provide a precondition for economic recovery and creation of new jobs.

COMETa2012 conference program structure is consisted of the following thematic areas: Production technologies and advanced materials, Applied mechanics and mechatronics, Development of products and mechanical systems, Energetics and thermo - technique, Renewable energy and environmental protection, Quality, management and organization, Maintenance and technical diagnostics.

Participation in international conference COMETa2012 was achieved by: 182 authors from 9 countries, with a total of 90 papers, including 4 plenary and 3 of introductory, 4 leading commercial companies and many small and medium enterprises. Bruel & Kjear Workshop: "Measurement of noise and vibration", was also organized at the conference, as well as a round table discussion: "The importance of quality infrastructure of B&H within the European integration".

The presence of a large number of participants from Bosnia and Herzegovina and abroad as well as the problems which are processed at the conference, coincide with the themes promoted by the European Union in its development programs.

On the basis of previous exposure, a gathering of scientists and researchers at the international conference COMETa should be understood not only as an exchange of knowledge and achievements of the narrower set of scientists and researchers, but also as a constant and serious attempt to focus social consciousness and social life on activities that ensures progress and prosperity of any society, and that is productive work, creating new knowledge and economic development.

On behalf of the Organizing Committee of the Conference COMETa2012, thank all authors, reviewers, as well as institutions, companies and individuals who contributed to realization of the Conference.

East Sarajevo, October 28th, 2012. *President of the Organizing Committee*

Prof. dr Ranko Antunović

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ANALYSIS OF HEAT TRANSFER THROUGH THE BEAM SUPPORT *OF THE WAGON STRUCTURE CALCULATED BY* SOFTWARE *PAK* MULTYPHISICS

Aleksandar Nikolić[1], Milan Blagojević[2], Vladimir Milovanović[3], Miroslav Živković[4], Miroslav Milutinović[5]

Abstract: *Paper deals with heat transfer through beam supports of wagon structure for transportation of hot steel ingots. It is well known that changing of the material properties at high temperatures leading to reduced carrying capacity of structures. Therefore, it is necessary to know the temperature distribution in the carrying element to avoid disturbing the integrity of construction. Basic equations which governs the problem of heat transfer in terms of finite element method (FEM) are presented taking into account the initial and boundary conditions. Heat transfer through beam supports of wagon structure for transportation of hot steel ingots is solved by software PAK Multyphisics. It is shown that the temperature of carrying elements is slightly elevated, which does not affect the normal operation of wagon construction.*
Keywords: heat transfer, finite element method, PAK, shell

1. INTRODUCTION

A number of numerical methods are developed to solve problems in the field of structural mechanics, heat transfer, fluid mechanics and coupled problems. Among the numerical methods, the fastest growth was experienced in finite element method (FEM) with many commercial software packages. FEM calculations in wagon design has a very significant role in the calculation of static and dynamic strength of wagon structure, heat transfer and failure criterions.

Flat wagons are special wagons' type for transportation of steel ingots. Hot steel ingots transfer heat by conduction, convection and radiation to the structure of the wagon. Flat wagons have no walls or low walls not higher than 60 cm. The influence of heat transfer must be calculated in order to avoid cracking and failure of certain parts of wagon structure.

This paper presents the basic equations of heat balance taking into account differential equation of the internal energy changes, Fourier's law of heat, initial and boundary conditions of the problem. As an application of the theoretical part, it is

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showed problem of the heat transfer through beam support of wagon structure. Finite element model is solved with finite element solver PAK-T [1] which is one of the software modules of PAK Multyphisics.

2. BASIC EQUATIONS OF HEAT BALANCE

Differential equation of heat balance through solid bodies consists of Fourier's law of heat and equation of change of internal energy as described in [2] and [3]. Differential equation of heat balance can be shown using matrix notation as:

$$-\rho c\frac{dT}{dt}+\nabla^{T}\left(k\nabla T\right)+q=0$$

Solution for temperature field $T\left(x,y,z,t\right)$ that satisfies given initial and boundary conditions is to be found, in scope of practical solving of the problem. Initial conditions are given only for transient problems. Boundary conditions can be:

a) given temperature at S_1 part

$$T=T_s\left(x,y,z,t\right)$$

b) given flux at S_2 part

$$q_n=q_n\left(x,y,z,t\right)$$

c) given heat convection at S_3 part

$$q_h=h\left(T_0-T_s\right)$$

d) given radiation at S_4 part

$$q_r=h_r\left(T_r-T_s\right)$$

where S_1,S_2,S_3 and S_4 are parts of the surface S, as symbolically represented in fig. 1. Temperature T_s is surface temperature, q_n,q_h and q_r are fluxes through the surface, T_0 is environment temperature, h is coefficient of convection, h_r is coefficient of radiation and T_r is the temperature of radiation source.

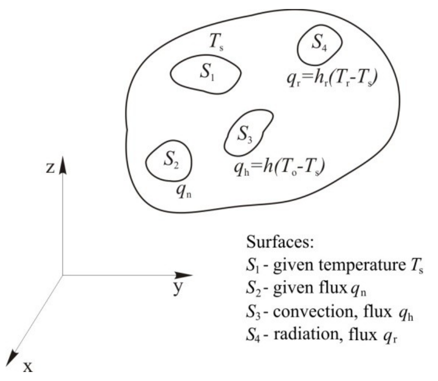

Figure 1 Boundary conditions for heat transfer through solid

Since the wagon structure is exposed to high temperatures, there is a significant change in the coefficients of heat depending on the temperature. Therefore, non-linear thermo-mechanical analysis can be implemented with implicit iterative method of solving non-linear problems:

$$\left(\frac{1}{\Delta t}\mathbf{C}^{(i-1)} + \mathbf{K}^{(i-1)}\right)\Delta\mathbf{T}^{(i)} = {}^{t+\Delta t}\hat{\mathbf{Q}}^{(i-1)}$$

where $\hat{\mathbf{Q}}^{(i-1)}$ are determined as:

$${}^{t+\Delta t}\hat{\mathbf{Q}}^{(i-1)} = {}^{t+\Delta t}\mathbf{Q}^{(i-1)} - \mathbf{K}^{(i-1)}\,{}^{t+\Delta t}\mathbf{T}^{(i-1)} - \frac{1}{\Delta t}\mathbf{C}^{(i-1)}\left({}^{t+\Delta t}\mathbf{T}^{(i-1)} - {}^{t}\mathbf{T}\right)$$

Matrix $\mathbf{K}^{(i-1)}$ contains matrices for conduction, convection and radiation respectively. Procedure of solving equation (6) is rather described in [2] and [3].

3. CALCULATION OF HEAT TRANSFER THROUGH BEAM SUPPORT OF WAGON STRUCTURE

This example considering a beam supports for steel ingots simultaneously exposed to thermal loads (fig. 2). In observed case of loading steel ingot have a temperature up to 500 ºC. Steel ingots are placed on 8 beam supports. There is a floor panel as a thermal shield between beam supports and wagon structure.

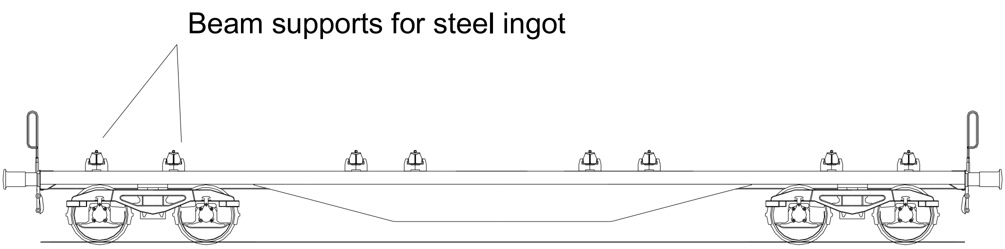

Figure 2 Drawing of wagon for transportation of steel ingots

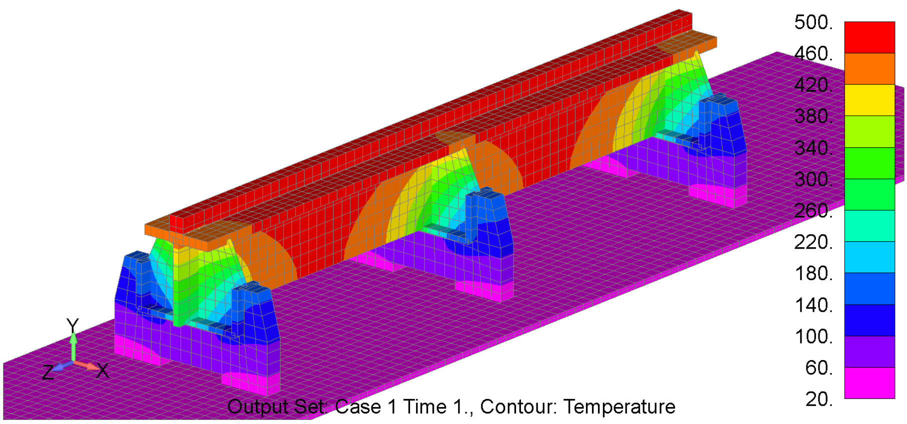

Figure 3 Temperature field of beam support-isometric view

Finite element mesh of beam support was created by shell and 3D elements. There are the following boundary conditions for this problem: (a) temperature of 500 ºC at the surface where the ingots are loaded and (b) convection on surface where beam support is in contact with the floor panel of wagon structure. In figs 3. and 4. tempearature field of beam support is shown.

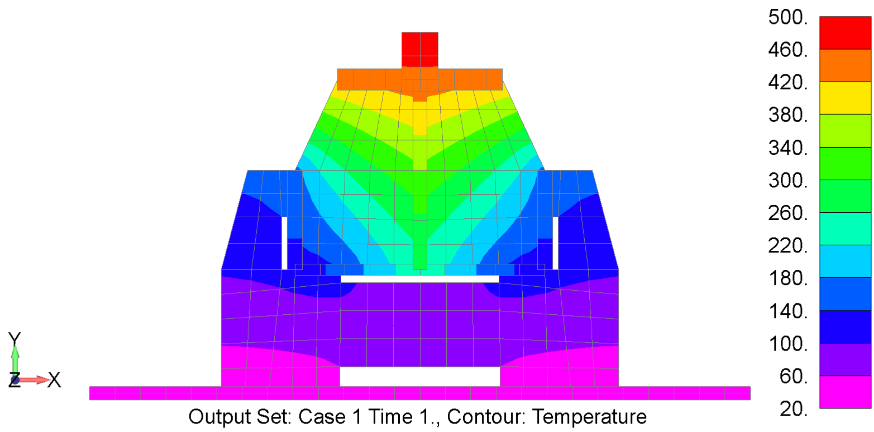

Figure 4 Temperature field of beam support-XY view

4. CONCLUSION

Analysis of wagons for transportation steel ingots is an example of how to successfully solve heat transfer problems in a practical example that is very commonly found in the railway industry.

Presented results proved that heat transfer analysis of beam support structure satisfy the criteria defined by mentioned standards and proposed boundary conditions. It can be seen that the effect of heat transfer throught steel ingots has no influence on a floor panel at the given boundary conditions. Also, paper presents successful solution problem of heat transfer in software PAK-T.

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