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# NUMERICAL SIMULATION OF HEAT TRANSFER BEHAVIOR AFTER TEMPERATURE MODIFICATION

**Mădălina Cristina Onica**
"Dunarea de Jos" University of Galati,
Faculty of Naval Architecture, Galati, Domneasca Street, No. 47, 800008, Romania,
E-mail: cristina.onica@yahoo.com

**Stefan Florescu**
GEOECOMAR Bucuresti,
E-mail: stefan.florescu@geoecomar.ro

**Costel Iulian Mocanu**
"Dunarea de Jos" University of Galati,
Faculty of Naval Architecture, Galati, Domneasca Street, No. 47, 800008, Romania,
E-mail: costel.mocanu@ugal.ro

**Eugen Găvan**
"Dunarea de Jos" University of Galati,
Faculty of Naval Architecture, Galati, Domneasca Street, No. 47, 800008, Romania,
E-mail: eugen.gavan@ugal.ro

## ABSTRACT

*Research fields on induced thermal welded parts led to rapid development of new methods of calculation based on functional relationships that allow predicting of structural transformations in metals and alloys welded and determining the associated level of stresses and strains.*

**Keywords:** welding, heat, stress

## 1. INTRODUCTION

Of all the various processes of mounting welding parts of a building shows the great advantage of simple design. Welding also substantially reduce the cost of such construction by reducing the masses involved.

Besides these important advantages, the welding heat is very localized and transient thermal fields lead to nonlinear processes of heating and cooling with uneven thermal expansion and contraction. So that the welding and plastic deformation affect areas around welding area. Thus welded elements have residual stresses that are overlapped over the request of the welded construction.

These tensions have sometimes waste valuable assets. The large stresses can lead to the appearance of damages to the structures, especially for variable loads. Residual stresses cause local deformation leading to the appearance of plastic zones that decrease the bearing capacity of the construction elements. It is therefore important to find these residual stresses and to find solutions to remove or at least reduce them. The origin of residual stresses can be classified such as: thermal, mechanical and chemical. Because the influence of thermal field has the greatest importance for the transfer of heat from the source to the welding parts, the subject of this paper is its numerical study.

## 2. RESEARCH IN WELDING

### 2.1 History

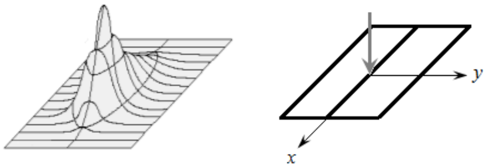
The electric arc occurred shortly after the appearance of electricity. In the last decades numerous welding processes have been developed.

The calculation methods have been developed in parallel. The finite element method has been formulated 100 years ago, but the other fifty were required to become useful. In 1906 a paper was presented that analysed tensions welding products in a bar pattern.

Numerical modelling of the welding process is a difficult one because it involves creating a model for all physical effects and their coupling is a large and complex task. Therefore, research into welding is characterized by choosing an area of interest for further analysis and use of appropriate assumptions. Because the welding phenomenon is complex for the technological process of welding the numerical simulations are done with simplified assumptions.

### 2.2 Heat variation induced by welding

Welding induce a variation of temperature across the table welded distribution through the effects they produce. This heat variation produces deformations on longitudinal and transversal directions, with important values The heat variation 1.a) and major deformations directions 1.b) are presented in Fig. 1.




**a)** **b)**

**Fig. 1**

Strong temperature variation during the welding process causes significant local variations local state of tension. So close to the heat source voltages vary differently as it can be seen in Fig. 2.

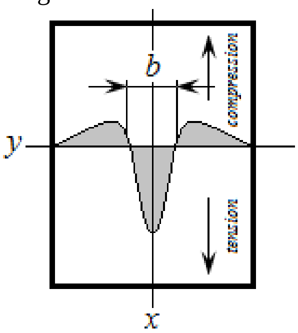



**Fig. 2**

In the literature, the relationship for tension variation along the weld caused by temperature variation is given under the next form [1]:

$$\sigma(y) = \sigma_m \left[1 - \left(\frac{y}{b}\right)^2\right] e^{-\left[\frac{1}{2}\left(\frac{y}{b}\right)^2\right]} \tag{1}$$

### 2.3 Welding induced deformation

As in the case of stresses occurring during and after welding, welding deformation can be transient or residual. Fig. 3 gives an overview of various types of welding deformations to be expected when welding plates.

Deformations caused by welding can be classified by three characteristics: according to the lifetime, welding deformation can be temporary or residual. The temporary deformations can exists only in a certain moment of non-stationary process heating and cooling.

Residual deformation can be found after all the welding process is completed and the structure is cooled to room temperature.

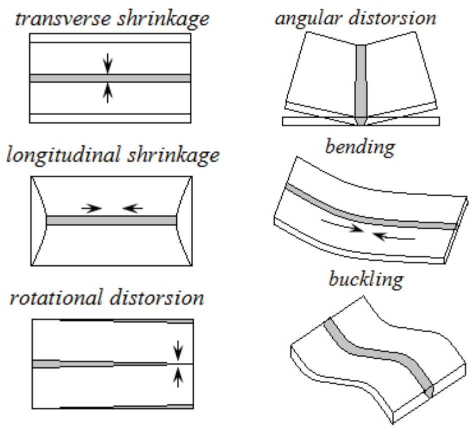



**Fig. 3**

This deformation is visible on the ships hull after the end of the welding process as presented in Fig. 4.

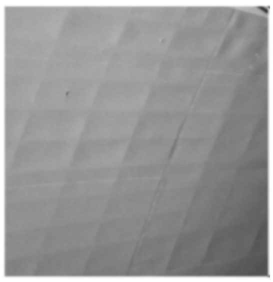


**Fig. 4**

### 2.4 Heat source model establishment

In this study, two heat source models were investigated, then correlated on fitting a practical welded sample for distinguishing the better one, so it can be used to detect other analysis. The first one is disc model proposed [2], the mathematical expression of the model being present in below.

$$q(r)=\frac{3Q}{\pi r^2}e^{-\frac{3}{r_0^2}r^2} \qquad (2)$$

Where:

- $q(r)$ is the surface heat flux at radius $r$ $\left(W/m^2\right)$;
- $r_0$ is the region in which 95 % of the heat flux is deposited;
- $r$ is radial distance from centre of the heat source;
- $Q$ heat input.

Intensity of heat source model can be Gaussian distribution or Double ellipsoid.

## 3. FEM HEAT ANALISYS

The model taken into account is a steel plate size 100x100x6. Because of the symmetry only half of it was worked. Numerical modelling of thermal processes during welding was performed using FEM analysis using ANSYS transient module. Meshed plate is shown in Fig. 5.

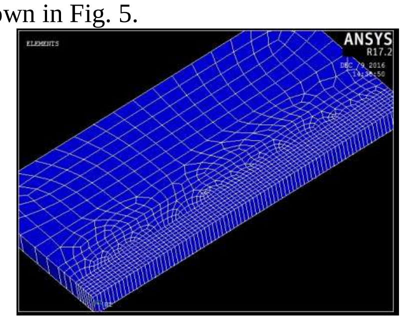
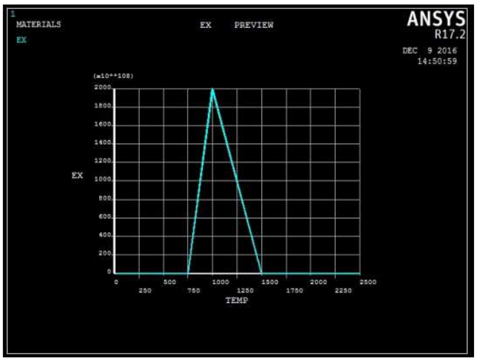



**Figure 5**

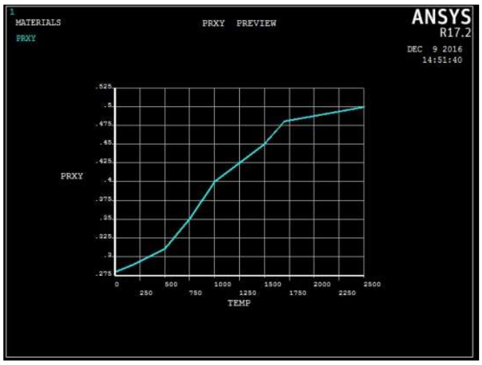
It can be seen that the mesh is finer in the area of interest (heat affected zone). This afforded 2339 nodes and 2207 elements.

Material characteristics were also given according to the temperature. It is shown in Fig. 6.a) Young module variation, in Fig. 6.b) Poisson coefficient variation with temperature, and in Fig. 6.c) Bilinear Isotropic Yield Stress.

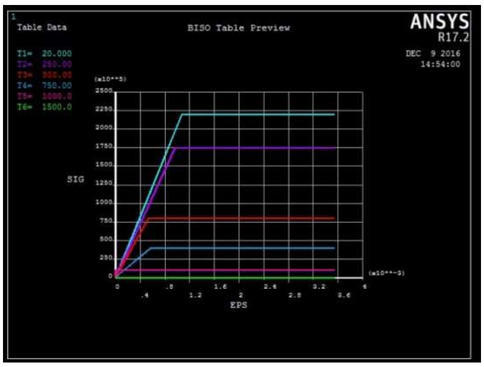
The resulting temperature distribution of thermal analysis of the welding process was studied for 25 s during welding.




**a)**




**b)**




**c)**

**Fig. 6**

## 4. RESULTS OF HEAT VARIATION

Fig. 7 shows the distribution of temperature at various points in the movement of the heat source at a speed of 0.07 m / s along the side of 100 mm.

Contour plots of the temperature distribution are presented in the next figure.

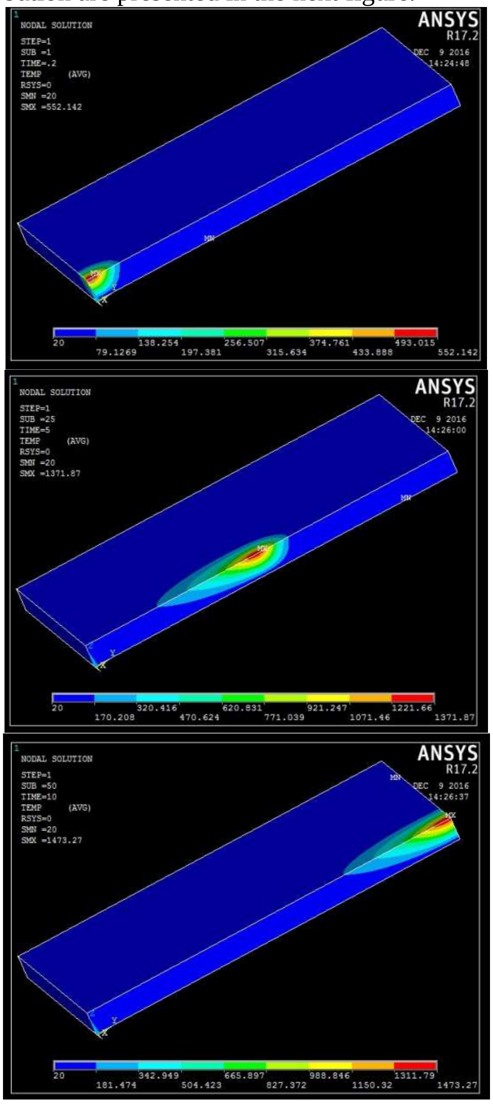



**Fig. 7**

As it can be seen from the images in Fig. 7, behind the heat source develops abnormally high temperatures that can affect the balance of power against heat stress.

## 5. CONCLUSIONS

As it can be seen the temperature at the beginning of welding processes is 5520 Celsius. After the heat source has travelled half the length of the plate, temperature reached 13710 Celsius. At the end of the welding process (at the end plate) temperature was 14730 Celsius. Also it must be noticed that we have around the source welding areas with different temperatures. These drastic variations in small areas cause surface deformations and high local stresses.

The results of this study can be summarized as follows:

- Changing the temperature leads to a change in track temperature topography.
- Changing the temperature distribution generates different strains that direction in the play.
- One of the major advantages of FEM is to optimize the welding process by allowing consideration of transient phenomena that arise. This greatly simplified the process of understanding and optimization of welding.

**Future work analysis:** The stress and strain in different directions (Y and Z) will be computed using the techniques from this study. Also the mass transfer in welding process time will be checked.

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