# THE COMPLEX WELDING PROCESS SIMULATION USING FEM, PARALLEL COMPUTING AND GRID BASED EVOLUTIONARY OPTIMIZATION

***G. Kokot, A. John, W Kuś***
*Silesian University of Technology, Gliwice, Poland*

## 1. Introduction

A complex numerical simulation of a welding process using the finite element method [1,2] is presented in the paper. Results for full coupled thermo-mechanical problem are prescribed. As the simulation and optimization of welding is very time and resource consuming the parallel calculation technique (the domain decomposition method (DDM)) and grid based evolutionary optimization are applied.

The objective of the welding simulation is to study the temperature generated during the welding process and investigate residual stresses in the component after welding. Such results give the possibility to determine properties of materials in welding zones, stress and strain state of welded parts. From other side it is possible to perform optimization process looking for welding parameters (welding speed, welding power source etc.) or initial shape of welded sheets according to displacement state (welding of thin metal sheets with stiffeners – T joints). Those results are the base for fatigue analysis too.

## 2. Welding simulation

Welding is one of the most commonly used join process but till now it is still difficult to simulate it in standard CAE systems based on finite element method. In most of them this requires the writing of specialized, additional user subroutines for specific boundary conditions (a heat source, a weld path, a filler element treatment, a material behaviour etc.) what makes it difficult and inconvenient in use. It causes the simulation of welding is extremely difficult. From other side such a simulation gives a lot of information very important for engineers. An undesirable side-effect of welding is the generation of residual stresses and deformations in the component and the quality of the weld has a substantial impact on the fatigue life of the structure. These resultant deformations may render the component unsuitable for further use. Also, the residual stresses form the input for subsequent manufacturing or structural processes.

Considered simulation allows to determine the cooling period from 800°C to 500°C (so-called cooldown rate t8/5) [2], which is used to model the strength parameters in a heat-affected zone. Finding the optimal value of t8/5 is one of the primary goal of simulation and optimization of the welding process [3]. Obtained results can be also the base for optimization process of welding parameters for e.g. thin metal sheets with T stiffeners (cars body, airplane panels, shipbuilding, frame construction) and for a fatigue analysis of welded structures.

It should be mentioned that nearly full set of welding parameters are considered during simulation. Those parameters are: moving heating source, velocity, source power, cooling temperature and time, shape of the source, heat input, weld flux etc.

## 3. Results

In the fig. 1. results for complex simulation for welding are presented. The results consider all the simulation mentioned above.

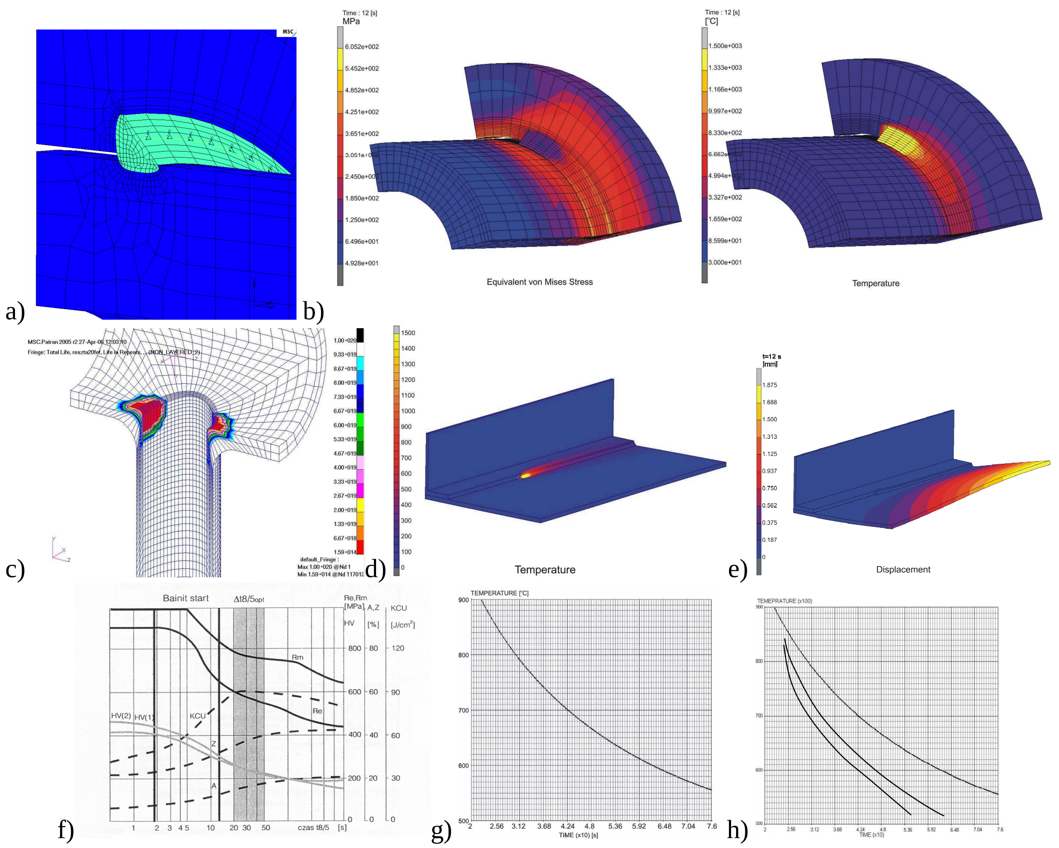


Fig. 1 The complex set of results of the welding process simulation: a. the model, b. von Mises stresses and temperature distribution during welding, c. fatigue analysis results, d., e. results of optimization of T join, f. cooldown rate t8/5 in the HAZ – the reference diagram, g. calculated t8/5, h. example of t8/5 after optimization of welding parameters.

Using modern CAE systems connected with parallel and grid based evolutionary computing it is possible to perform an advanced complex simulation of welding process and analysis of welded parts. It is possible to perform: a static linear analysis of welded components, a coupled termo-mechanical simulation of welding process, fatigue analysis of the welded component, an optimization process of welding parameters etc. [2,3].

## 4. References

[1] Goldak J., Chakravarti A., and Bibby M., A New Finite Element Model for Welding Heat Sources, Metallurgical Transactions B., Volume 15B, June 1984, 299 – 305.

[2] Kokot G., John A., Górka J. Welding process simulation using FEM. Proc. of the 17-th International Conference on Computer Methods in Mechanics CMM-2007, on CD, Lodz-Spala, 2007.

[3] Kokot G., John A., Kuś W., Grid based evolutionary optimization of strength parameters in heat affected zone of welded joints, 8th. World Congress on Computational Mechanics (WCCM8), 2008, (accepted paper).