TEMPERATURE EFFECTS DURING IMPACT OF WC/Co COMPOSITES

E. Postek[1], T. Sadowski[2]

[1]*Institute of Fundamental Technological Research of the Polish Academy of Sciences, ul Pawińskiego 5B, 02-106 Warsaw, Poland*

[2]*Department of Solid Mechanics, Lublin University of Technology, Nadbystrzycka 40 str, 20-618 Lublin, Poland*

e-mail: epostek@ippt.pan.pl

1. Introduction

Generally, the papers on dynamic loading of composites more focus on the layered composites, for example [1]. High attention is paid to blast load. However, in our opinion, the process of impact a gap for analysis of WC/Co composite during impact conditions. During impact of WC/Co composite objects and the other composites with metallic binder heat of plastic work is generated. If the process is fast enough the problem can be treated as adiabatic. However, more common situation is slower process when the heat is generated in metallic interfaces and the neighbouring grains are heated due to conduction. The process should be rather considered as coupled [2]. We developed our model of WC/Co composite towards impact load, [3].

2. Problem statement

The thermal problem is described by the discretized finite element equation, as follows:

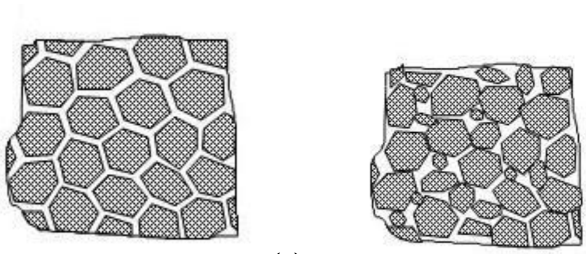
(1) $$\mathbf{KT} + \mathbf{C}\dot{\mathbf{T}} = \mathbf{F}$$

where **K** is the conductivity matrix, **C** is the heat capacity matrix, **T** is the nodal temperatures vector and **F** the thermal sources and fluxes vector. The contribution to the vector F due to plastic dissipation is given by the formula:

(2) $$\mathbf{f} = \chi \boldsymbol{\sigma} : \mathbf{e}^{pl}$$

where **f** is the rate of heat generation (heat flux), $\boldsymbol{\sigma}$ is the Cauchy stress tensor, $\mathbf{e}^{pl}$ is the rate of plastic deformation tensor and χ is the Taylor-Quinney coefficient that indicates fraction of plastic work converted into heat, [3].

There are two kinds of two-phase CM materials, Figure 1. In the given example below, we investigate the case in Figure 1 (a), i.e., the CM material with continuous interfaces.



(a) (b)

Figure 1: Different types of two-phase CM internal structures having a small content of the second phase (up to 10%): a) with a small thickness and continuous interfaces, b) without continuous interfaces

3. Outline of numerical results

The physical model and the discretized system of thin binders is given in Figure 2 (a) and (b), respectively. We show the deformed shape of the composite plate in Figure 2 (c). The composite hits the rigid wall with velocity 100 m/s. The shape is presented at time instant 3.5 ns of the process.

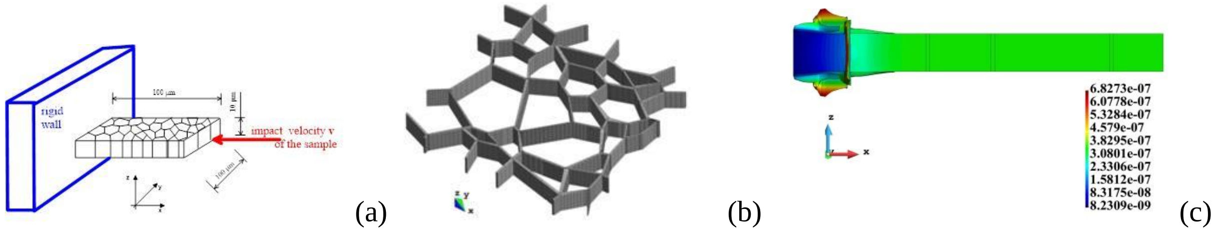


Figure 2: Physical model and boundary conditions (a) discretized system of interfaces (b) deformed structure (m) scaled 10 times at time instant 3.5 ns.

The effects of the impact are shown in Figure 3. We compare the adiabatic solution with the coupled thermo-mechanical solution. Obviously, temperature distribution for the adiabatic solution is exactly the same as plastic strains distribution, Figures 3 (a) and (b). In the case of the thermo-mechanical solution we note that even for the short duration of the process temperature varies in the neighbouring grains. Moreover, maximum increase of temperature in the adiabatic process is 200.73 deg, Figure 3 (b), while during the coupled solution the maximum increase of temperature is 65.93 deg, Figure 3 (c).

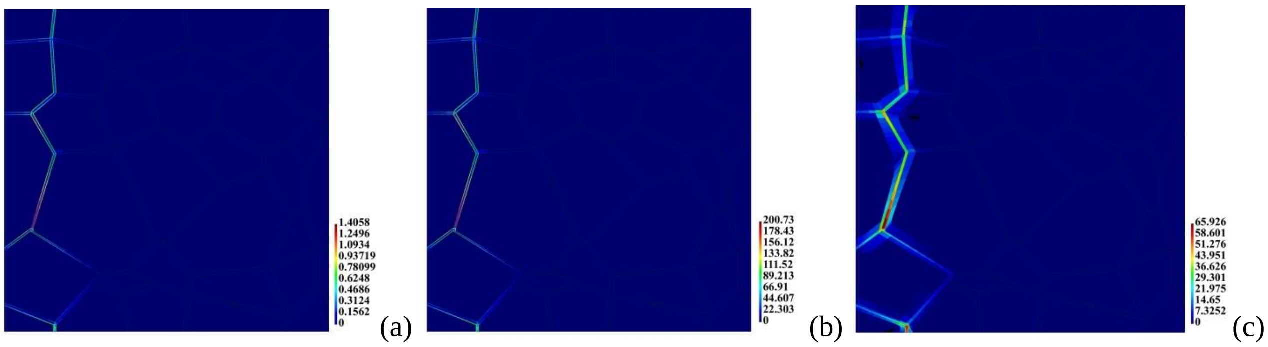


Figure 3: Time instant 3.5 ns; equivalent plastic strain field (a) adiabatic solution - temperature field (b) transient solution – temperature field (c).

4. Conclusions

We note that the calculated maximum temperatures during short duration of impact are significantly lower when the process is considered as coupled than while the process assumed to be adiabatic. The neighbouring grains are affected by the temperature increase immediately. During the analysis the effect of heat conduction should not be neglected.

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