COST 526

"Automatic Process Optimization in Materials Technology"

(APOMAT)

Half-Yearly Report

To be sent to **V.Tesch@access.rwth-aachen.de** until **August 31, 2002**

1. Reporting Period	**1.1.2002 – 30.6.2002**
Project title	Optimization of Tool Shape in the Tests Aiming at Identification of Models Describing Rheological and Mechanical Properties of Metallic Alloys
Project leader Organization	Prof. Maciej Pietrzyk
Main collaborators involved	Prof. Jan Kusiak Dr Danuta Szeliga MSc Tomasz Kondek MSc Pweł Matuszyk MSc Jerzy Gawąd MSc Andrzej Zmudzki

2. Funding Situation	
Amount of money received specifically for COST	67,8 kEuros
Other resources partially used for the project	0 kEuros

3. International Collaboration (mention group and type of work done in collaboration during the reporting period)
Participation in the Working Group Meeting in Saint-Dié des Vosges + project progress report ❒ **YES** ❒ ~~NO~~

4. Industry participation (mention name of companies and work done in collaboration during the whole project)
No

5. Meetings, visits, exchange of scientists, short-term scientific missions	**Location, date**

6. Progress within the reporting period
(Not exceeding 3 pages, including tables and figures)

Parts of work done in reporting period:

- **3D Solver**
  - Structural mesh generator for simple body geometries (cube and cylinder).
  - Mixed FEM formulation for:
    - rigid-plastic (Lee & Kobayashi) model of compression,
    - velocity dependent friction stress (Chen & Kobayashi) model.
  - Newton-Raphson linearization of nonlinear FE equations system.
  - Fast iterative methods for solving linear equations systems based on Krylov's methods.

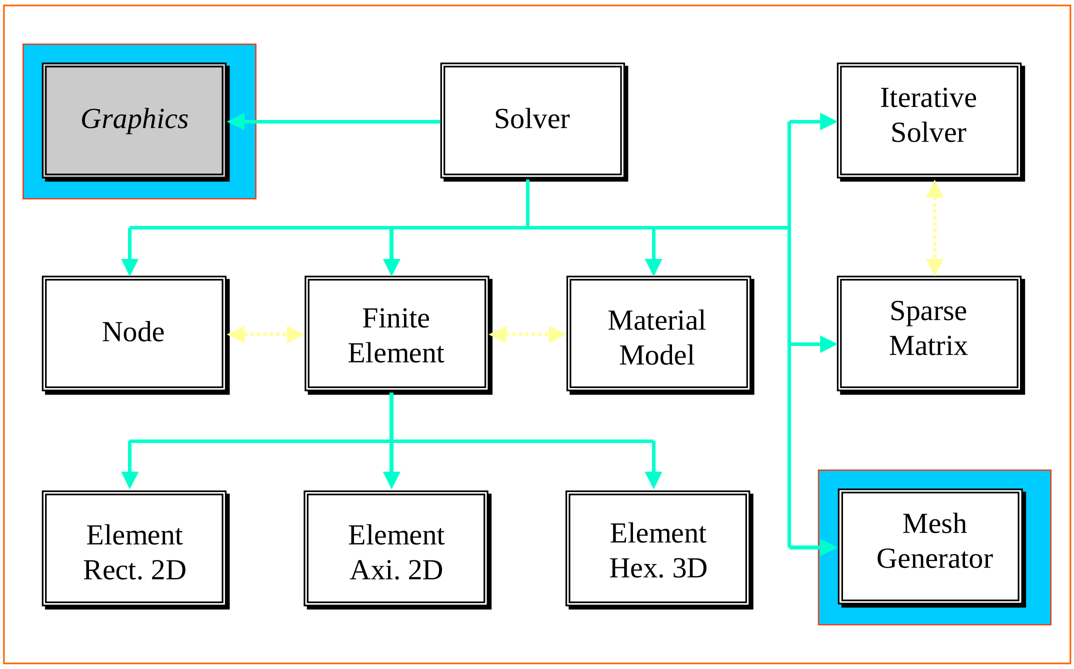

Figure 1. 3D solver structure

- **Development of constitutive law for two phase materials**

Flow stress

$$\sigma = \frac{1}{f_0}\left[f_2\left(3J_2 - f_3 J_3^{2/3}\right) + \left(\frac{\sigma_m}{f_1}\right)^2 \right]^{1/2}$$

where:

$$f_0 = f_s^n$$

$$f_1 = a(1 - f_s)^m$$

$$0 < f_3 < 9 \times 2^{-2/3}$$

$$f_2 = \left[1 - \frac{f_3}{9 \times 2^{-2/3}}\right]^{-1}$$

f_s – solid fraction of semi-solid alloy, f_0 – ratio of apparent (average) stress working to semi-solid alloy – to – effective stress working to solid skeleton

σf_0 - normal yield stress of semi solid alloy

σ_m – mean normal stress (hydrostatic pressure)

J_2, J_3 – invariants of deviatoric stress tensor

a, m, n – material parameters

f_1, f_2, f_3 – effect parameters

Constitutive law:

$$\dot{\varepsilon}_{ij} = \dot{\lambda}\left[\sigma'_{ij} + \frac{2\sigma_m \delta_{ij}}{9 f_1^2 f_2} - \frac{2 f_3}{9 J_3^{1/3}}\left(\sigma'_{ik}\sigma'_{kj} - \frac{2}{3} J_2 \delta_{ij}\right)\right]$$

$$\dot{\lambda} = \frac{3}{2} \frac{f_2 f_s}{f_0^2} \frac{\dot{\varepsilon}_i}{\sigma_i}$$

$\dot{\varepsilon}_i$ - effective strain rate, σ_i - effective stress

- **Die design for inverse analysis – sensitivity analysis on the parameters of the rheological and frictional models**

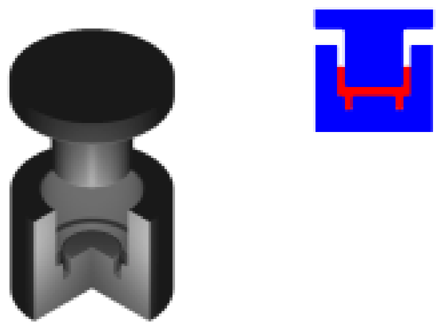

Figure 2. Sample die for inverse analysis

- **Implementation of Parallel computations for:**
    - Almost linear speed-up
    - Reliability
    - Scalability
    - FairnessElimination of redunadant data transmissions

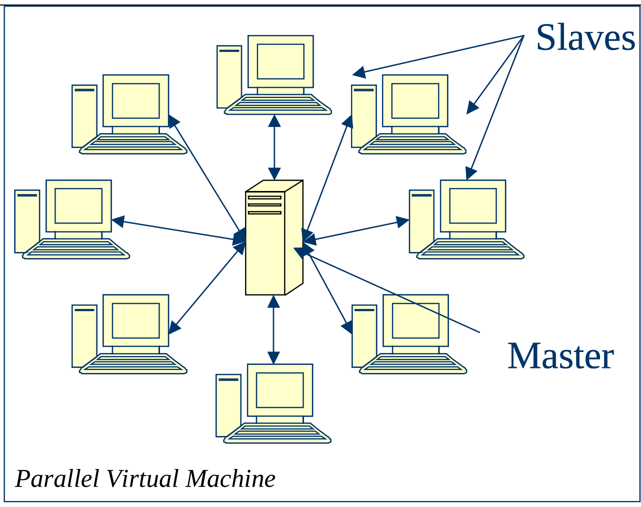

Figure 3. PVM system scheme

7. List of publications a) Published
No
b) Submitted for publications
Application of sensitivity analysis to die shape design for inverse analysis of two-phase materials, Proc. Conf. COMPLAS 2003, Barcelona **D. Szeliga, T. Kondek, J. Kusiak, M. Pietrzyk**
c) In preparation
No