



COST 526

**“Automatic Process Optimization in Materials Technology”
(APOMAT)**

Half-Yearly Report

1. Reporting Period	1.7.2002 – 31.12.2002
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	Maciej Pietrzyk
Main collaborators involved	Jan Kusiak Danuta Szeliga Tomasz Kondek Pweł Matuszyk Jerzy Gawąd Andrzej Zmudzki

2. Funding Situation

Amount of money received specifically for COST
Other resources partially used for the project

67,8 kEuros
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 Budapest + 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:

OPTIMUM DIE SHAPE DESIGN FOR EVALUATION OF MATERIAL PROPERTIES

The objective of the experiment is supplying information, which will allow accurate and reliable determination of the friction coefficient and rheological parameters for two phase materials. The flow of these materials depends strongly on friction conditions, which are very sensitive to the temperature and slip velocity between the tool and the die. The conventional methods of determination of friction coefficient are often not reliable enough. Such tests as ring compression are often difficult to perform, particularly for the thixoforming processes.

The present work is focused on searching for the tool design in combined process of direct and indirect extrusion (determination of parameters: two rams' angles – α , β and two gaps between the ram and the die – g_1 , g_2 as shown in Figure 1), which will constrain free spread of the material and which also will involve flow of the material sensitive to friction conditions and to material's rheology.

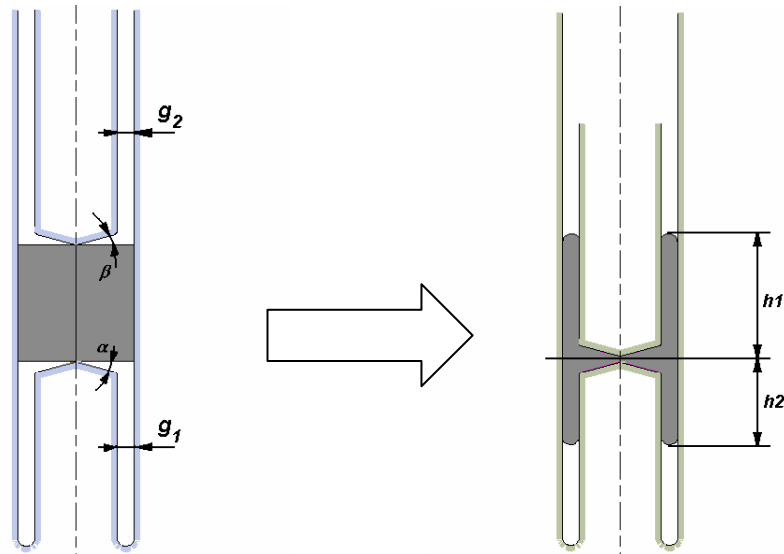


Figure 1: Schematic illustration of tools and the sample before (left) and after deformation (right)

OPTIMIZATION PROBLEM

The objective function of sensitivity to friction was defined as:

$$\Phi = \sqrt{\left(\frac{\partial H(\mathbf{a})}{\partial \mu}\right)^2} \quad (1)$$

where:

$$H = \frac{h_2}{h_1} \quad \mathbf{a} = \{\alpha, \beta, g_1, g_2\}^T$$

Finite difference approximation of the derivative in equation (1) is used:

$$\frac{\partial H(\mathbf{a})}{\partial \mu} = \frac{H_{0.2} - H_{0.05}}{0.15} \quad (2)$$

where: $H_{0.2}$, $H_{0.05}$ – values of the ratio H calculated for the friction coefficients 0.2 and 0.05, respectively.

FORGE 2 code was used for simulation of the investigated process. The rigid-viscoplastic flow rule was applied with the flow stress given by:

$$\sigma_0 = \sqrt{3}K(1 + a \cdot e^n) \quad (3)$$

where:

The second part of analysis aimed at determination of sensitivity of ratio H and extrusion load F to the rheological parameters with the objective function defined as:

$$\Phi = \sqrt{\left(\frac{\partial H(\mathbf{a})}{\partial K}\right)^2 + \left(\frac{\partial F(\mathbf{a})}{\partial K}\right)^2} \quad (4)$$

Finite difference approximation of the derivative in equation (4) is used:

$$\frac{\partial H(\mathbf{a})}{\partial K} = \frac{H_{35} - H_{45}}{10} \quad \frac{\partial F(\mathbf{a})}{\partial K} = \frac{F_{35} - F_{45}}{10} \quad (5)$$

where: H_{35} , H_{45} , F_{35} , F_{45} – values of the ration H and extrusion load F calculated for the rheological parameter K 35 and 45, respectively.

RESULTS

The following process parameters were assumed in optimization of function (1) and (4): material aluminium, constant die velocity 1 mm/s and Coulomb friction law. The search was constrained to $0 < \alpha < 30^\circ$, $0 < \beta < 30^\circ$, $2 < g_1 < 30$ mm, $2 < g_2 < 30$ mm. Hooke-Jeeves method was used in searching for maximum of function (1) and (4).

Sensitivity to friction

The following results were obtained: $\alpha = 0^\circ$ (at the boundary), $\beta = 0.64^\circ$, $g_1 = 27.66$ mm, $g_2 = 2$ mm (at the boundary). Figure 2 shows the shape of the cost function (1) for two parameters constant, $\alpha = 30^\circ$ and $g_1 = 27.66^\circ$.

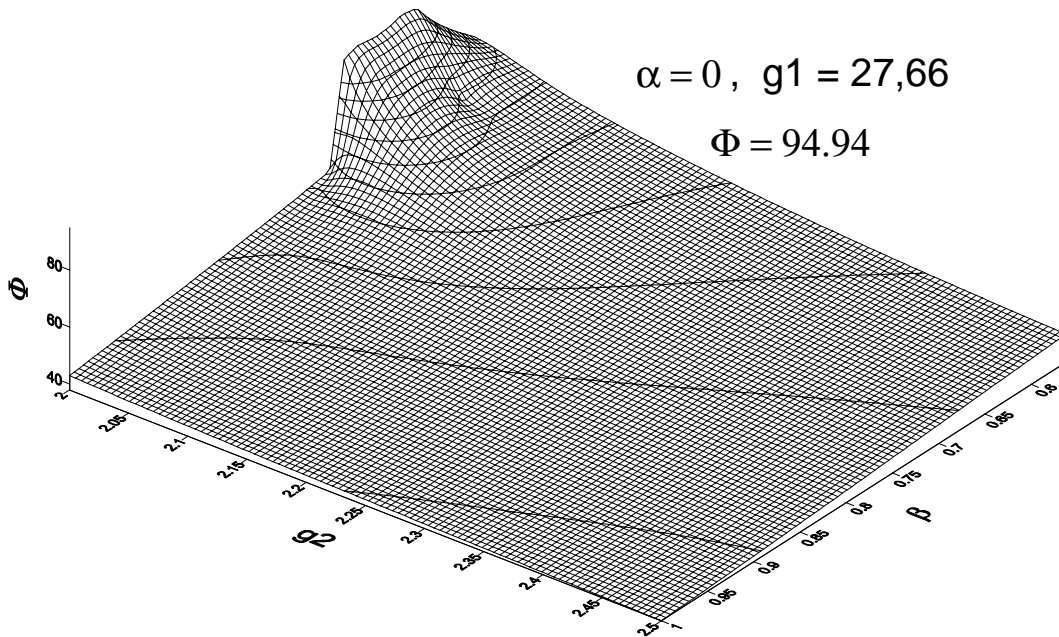


Figure 2: Shape of the cost function (1) for constant values of $\alpha = 0^\circ$ and $g_1 = 27.66$ mm.

Sensitivity to rheology

The following results were obtained: $\alpha = 7.5^\circ$, $\beta = 0^\circ$ (at the boundary), $g_1 = 15$ mm, $g_2 = 2$ mm (at the boundary). Figure 3 shows the plot of the cost function (4) for two parameters constant, $\beta = 0^\circ$ and $g_2 = 2$ mm. It is seen in this figure that the cost function is not smooth in the surrounding of the maximum. Schematic view of optimum dies for two investigated cost functions is shown in Figure 4. It is seen In this figure, that maximum sensitivity to friction and to rheological parameters is obtained for different shapes of dies.

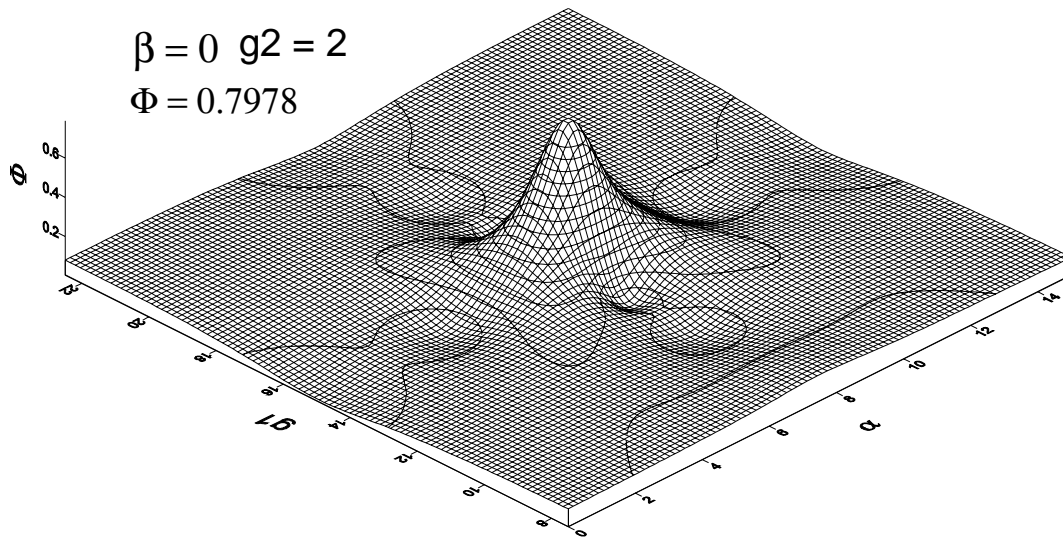


Figure 3: Shape of the cost function (4) for constant values of $\alpha = 0^\circ$ and $g_2 = 2\text{mm}$.

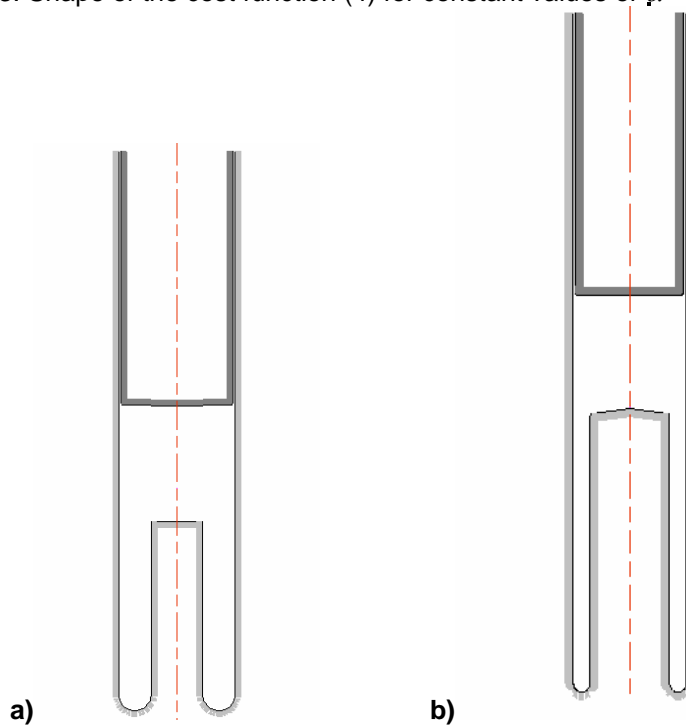


Figure 4: View of the tool, which gives the largest sensitivity of flow to the friction coefficient (a) and the rheological parameter K (b).

7. List of publications

a) Published

b) Submitted for publications

**Optimum die shape design for evaluation of material properties. Conf.
ESAFORM 2003, Salerno.
A. Żmudzki, M. Papaj, R. Kuziak, J. Kusiak**

c) In preparation