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SIMULATION OF FRICTON RATIOS AT DEEP-DRAWING PROCESS

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ABSTRACT
Friction between sheet and tool is important phenomenon in sheet deep drawing process. The paper provides the analysis of impact friction coefficient on a deep-drawing force change.
3D numerical simulation was applied by using PAM-STAMP software.
Key words: deep drawing, simulation, analyze

1. INTRODUCTION
The result of deep-drawing process (Figure 1) depends on various factors. The material characteristics (yield strength, hardening properties, formability, grain size, homogeneity of the structure, surface micro geometry etc.) are among the most important input parameters into deep drawing process. To predict the influence of material properties, geometry of die, stamping conditions on sheet formability is possible by simulation methods which enable us to optimise the utilisation of material properties under concrete conditions.
The result of simulation make possible:
- prediction of tearing or evaluation of sheet metal;
- prediction of surface defects;
- prediction of wrinkling sheet metal;
- prediction of finite sheet metal thickness;
- prediction of final dimensions of the part (after spring-back),
- evaluation of loads on the tool, etc.

Specialized CAE software's [1] for simulation of sheet metal forming processes use the explicit formulation of FEM for solution of motion equation of equilibrium.
For description of material behaviour the Hill's condition of plasticity is used:

$$f(\sigma)=\sqrt{\frac{r_{90}\cdot\sigma_{11}^2+r_0\cdot\sigma_{22}^2+r_{90}\cdot r_0\cdot(\sigma_{11}-\sigma_{23})^2+(2r_{45}+1)\cdot(r_{90}+r_0)\cdot\sigma_{12}^2}{r_{90}\cdot(r_0+1)}}$$

where:
r_0, r_{90}, r_{45} are the values of normal anisotropy coefficients due to rolling direction.

When surfaces are in contact they usually transmit shear as well as normal forces across their interface. There is generally a relationship between these two force components. The relationship, known as the friction between the contacting bodies, is usually expressed in terms of the stresses at the interface of the bodies.

2. NUMERICAL SIMULATIONS OF DEEP DRAWING PROCESSES

The software for numerical simulations represent powerful tool for prediction of forming process[2]. Example of simulation is performed wheel protection sheet metal, made of steel Č. 0147 and thickness 2 mm. Simulation is performed by PAM-STAMP software for numerical simulation of the sheet metal forming process.

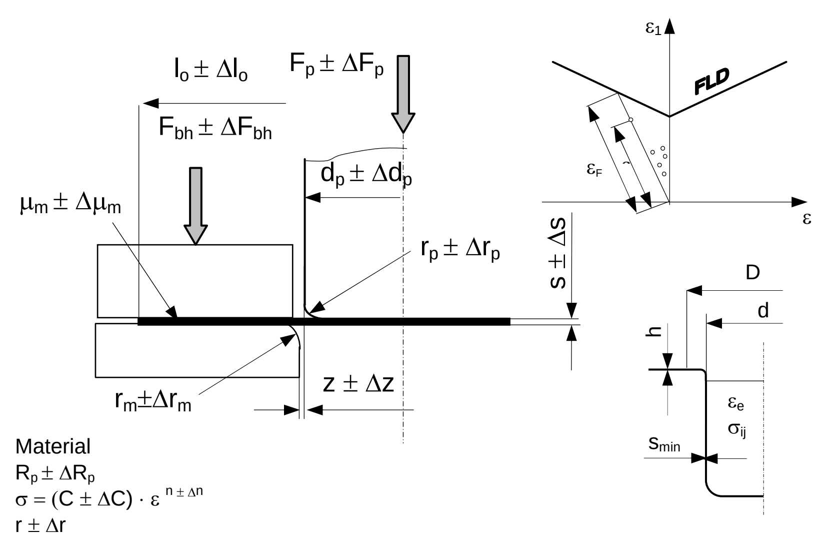


Figure 1. Deep drawing production process

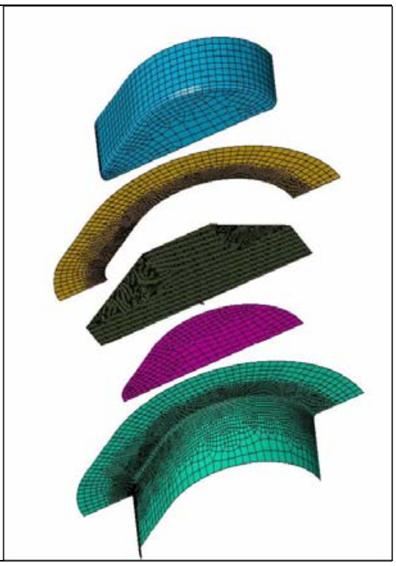


Figure 2. FEM model

FEM models (Figure 2) of tool parts and the blank were designed and meshed in a CAD environment. The FEM meshes (IGES file) were imported from IDEAS to the PAM - STAMP. The surface of tool parts (punch, ejector, die and blank holder) were meshed with quadrangular surface elements (Shell Mesh). They were assumed to be perfectly rigid. The blank was discredited with four-node elements, representing a material with an elastic-plastic behaviour. Symmetry of wheel, as well as of tool, is taken into account, so that simulation was made for half of the model, by which the simulation – time was been reduced.

It's necessary to define features as well as coefficient of material obtained in laboratory. The most important features are: flowing curve (φ)=f(σ), coefficients of anisotropy (one of three Lankford's coefficients), forming limit curve (Flow Limit Diagram) and elastic features of material.

For the material hardening determination the Krupowsky's law was used. Other material date were: Young's module E= $2{,}068 \cdot 10^5$ [N/mm^2]; Density ρ= 7800[kg/m^3] Poisson's coefficient ν= 0,3; Density ρ= 7800 [kg/m^3] and Lankford's coefficients (r_0= 0,96; r_{45} =1,17; r_{90}=1,05).

Approximate values of the friction coefficient μ are defined for various greasing condition, by recommended values[3]

- Special friction condition (μ= 0.05),
- Standard friction condition (μ=0.15), and
- Dry friction condition (μ=0.25).

Variations in the input parameters cause variations in the output parameters.

3. PRESENTATION OF SIMULATION RESULTS

Simulation result (output data) are viewed as: deformation forces achieved during deep – drawing process (Figure 3, Figure 4) and stress distribution after finishing deep drawing process (Figure 5) and deformations obtained for demanded boundary conditions in pre-processing of the performed simulation.

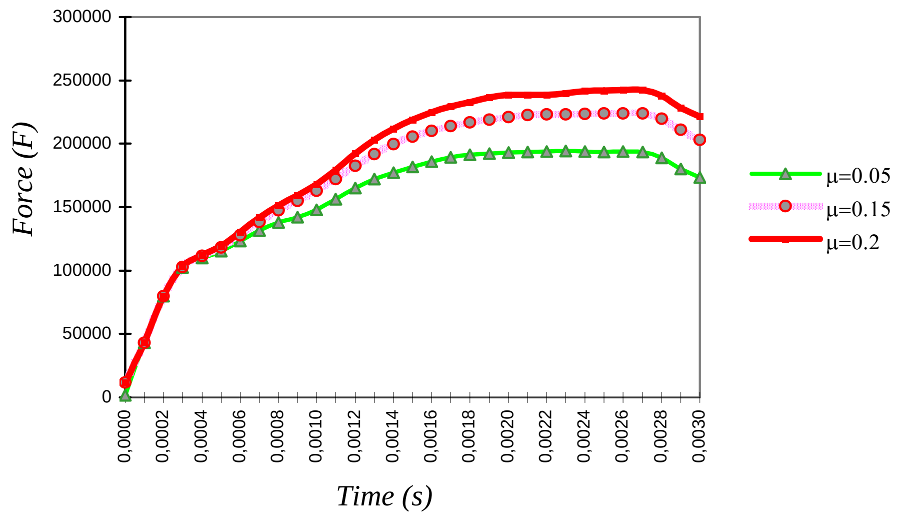


Figure 3. Diagram of distribution contact force blank- punch during deep drawing process for diferent friction coefficient

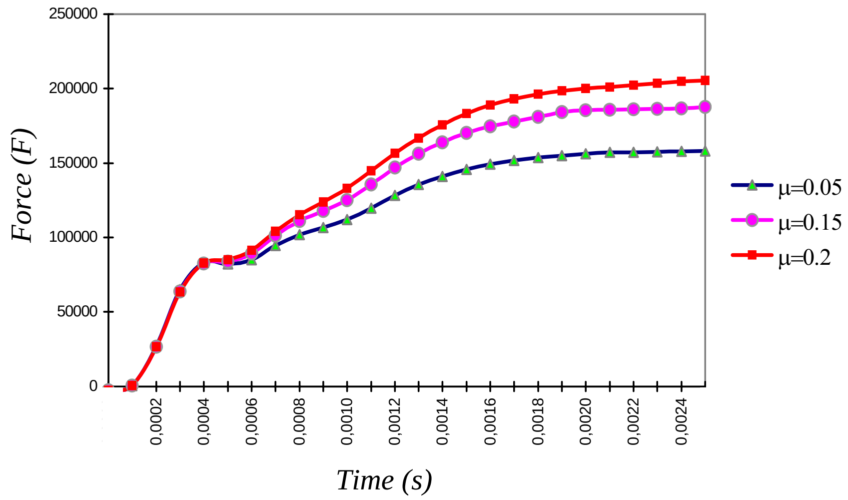
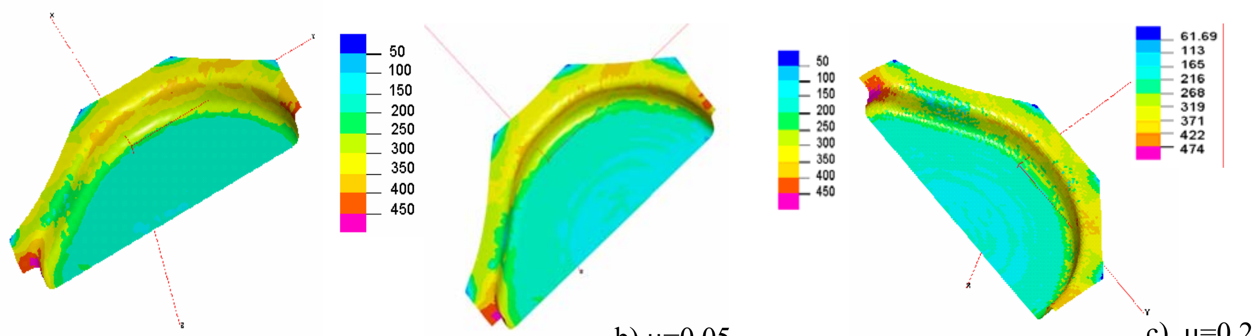


Figure 4. Diagram of distribution contact force blank – die during deep – drawing process process for diferent friction coefficient



a) μ=0,15 b) μ=0,05 c) μ=0,2

Figure 5. Stress distribution after finishing deep drawing process

Flow Limit Diagram (Figure 6) give us opportunity to systematically approach solving of the problem in the case process unsteadiness (tearing and wrinkling of sheet metal).

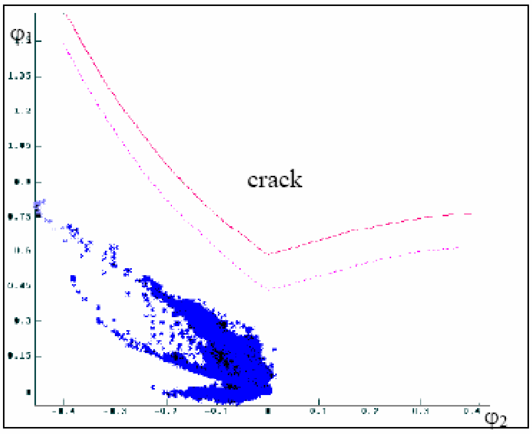


Figure 6. Flow limit diagram

The upper line of the boundary deformation zone refers to the moment of material cracking and the lower line designates a start of localized deformation. From the diagram we can conclude that the distribution of deformation doesn′t cross the limit curve and that process flow without any crack or surface defects. The afore mentioned conclusion is valid for all of three values of friction coefficient.

4. CONCLUSIONS

Based on the text above it is possible to conclude:

- Increase a friction coefficient between working surfaces of tool and blank leads to the increase of the deformation force, by which approves theoretical presumptions of this problemacy [3];
- The final results of: the material thickness distribution, distribution and value of deformation forces and the flow limit diagram are in a direct connection.
- Obtained results show that programme product PAM-STAMP enables us to simulate the influence of parameters of deep drawing process with acceptable accuracy, however it is required continuously to make more accurate the input material and technological data.
- Provenance friction coefficient on contacting surfaces result increasing stress and that is expressed the most on critical crossing places from straight to cylindrical part.

5. REFERENCES

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