RESEARCH OF INFLUENCE OF BLANKS SHAPE TO FORMING LIMIT DIAGRAM USING NUMERICAL SIMULATION

Peter KOVÁČ, Ľudmila KRŠIAKOVÁ, Viktor TITTEL

Authors: ***Peter Kováč, MSc. Eng., Ľudmila Kršiaková, MSc. Eng., Assoc. Prof. Viktor Tittel, PhD.***
Workplace: ***Institute of Production Technologies, Department of Forming, Faculty of Materials Science and Technology***
Address: ***J. Bottu 25, 917 24 Trnava, Slovak Republic***
Phone: ***+421 918646051***
Email : ***peter.kovac@stuba.sk, ludmila.krsiakova@stuba.sk, viktor.tittel@stuba.sk***

Abstract

This contribution deals with a construction of forming limit diagram using numerical simulation. The target was to verify suitability of formed blanks to create forming limit diagram what seems to be the most realistic and applicable methods for evaluation of sheets formability. Experiment was realized by method of stretching of hemispheroidal draw punch (STN EN ISO 12004-2) with specimens with various radius and with various width blanks. There was found out both specimens cover whole area of diagram, however specimens with various radius has bigger and clearly dispersion of deformation and that's why they are more suitable for the diagram construction.

Key words

drawing, deep-drawing, sheet, simulation, forming limit diagram

Introduction

Numerical simulation development of flat forming has significant improve lately. At the present is important to implement to production new products in shortest time, consequently is neccesary to use numerical simulation and prevent any failure in process.

Forming limit diagram (FLD) seems to be the most realistic and applicable method for evaluation of sheet formability. This method has been introduced in sixties of last century by Keeler, Backofen and Goodwin. They show the critical combinations of major strain and minor strain. Area under the curve (red colour) represents allowable strain and area above the curve represents not permissible deformations.

FLD in Dynaform software is shown on Fig.1 with FLD curve option. There are two ways how to create FLD: by n (hardening exponent), r (normal anisotropy), t (thickness) parameters or input FLD from file. In our case, FLD is created by first way. The different colour lines means different states such as crack, risk of crack, severe thinning, safe, wrinkle tendency, wrinkle, severe wrinkle and insufficient stretch which can be setup in the curve filter menu shown on Fig.1 [1, 2].

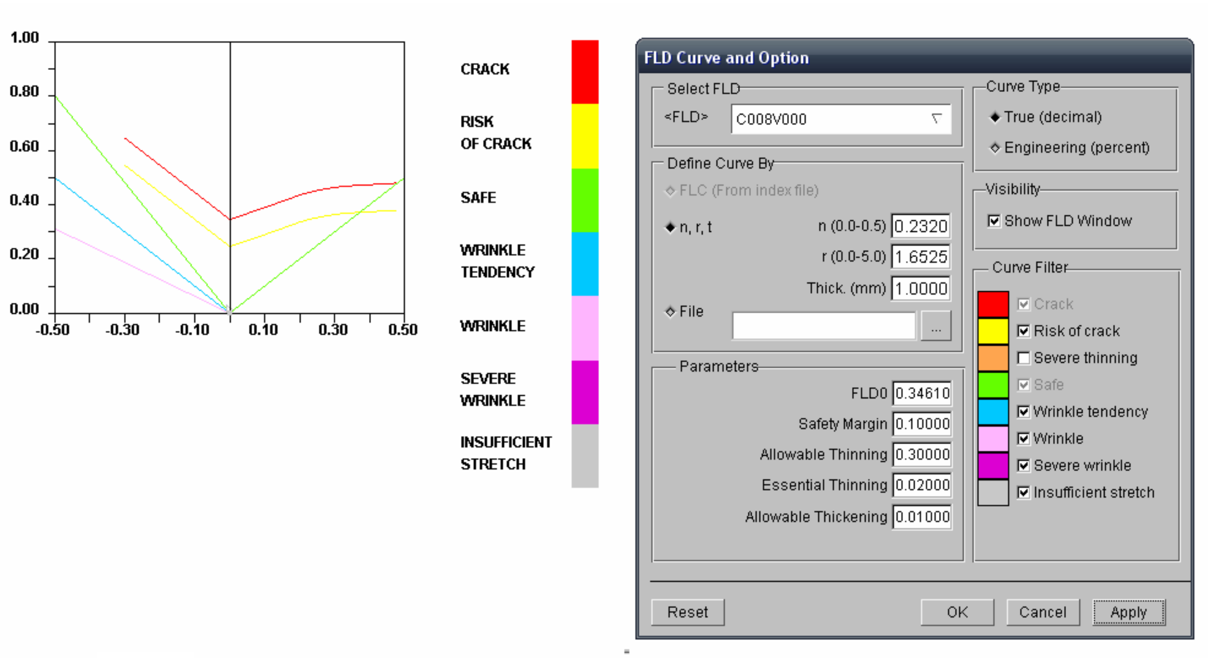


Fig. 1. *Forming limit diagram in Dynaform software*

Proposition of experiment using simulation

FLD may be created by several methods, in this case it is the stretching by drawing tool with spheroidal draw punch (ø100), up to the breaking of specimen (by Nakajima test according to STN EN 12004-2) using the Dynaform simulation software is concerned (Fig. 2). In the case of stretching, there should not be deformations in flange in comparison with typical deep-drawing. [3]

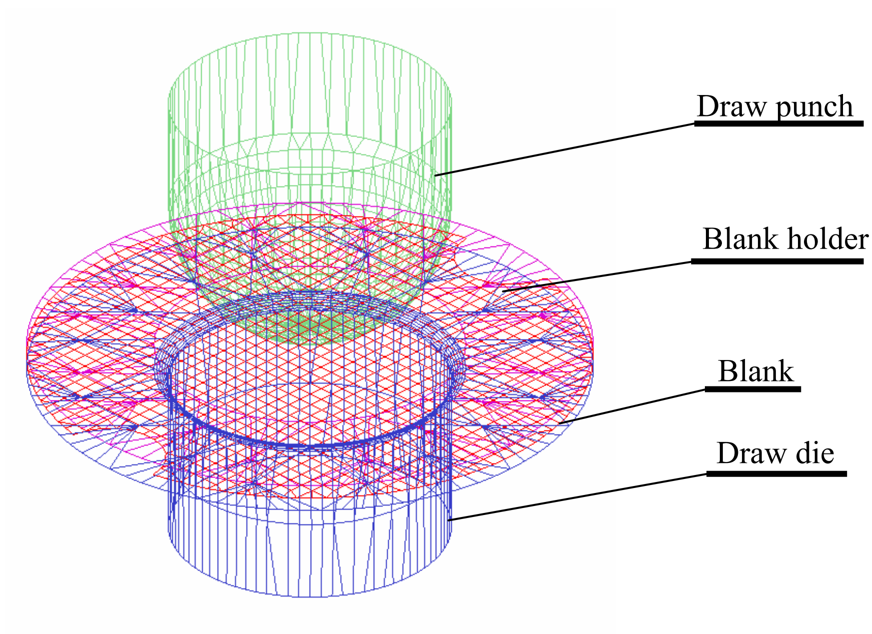
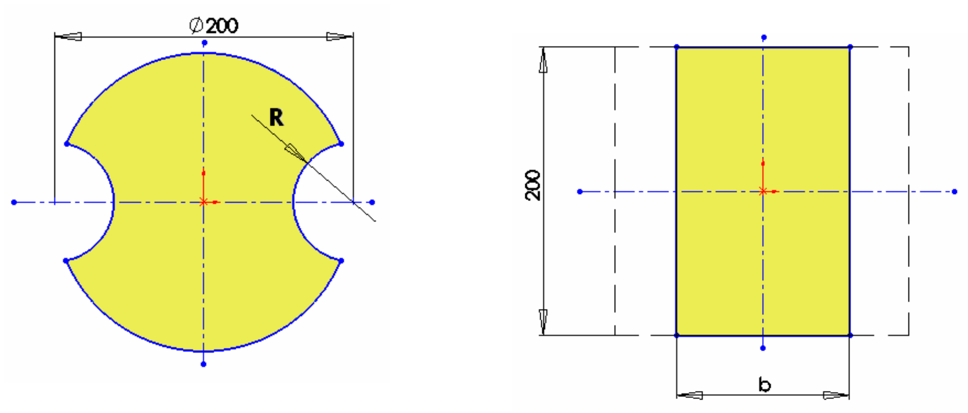


Fig. 2. *Stretching schema*

By using of specimens with various radius or with various width blanks the whole diagram area may be covered (Fig.3). Dimensions of blanks according to STN EN 12004-2 are referred in Tab.1 and Tab.2.

The material Type 36 from the Dynaform library of materials was chosen as an experimental material. Parameters of this typical deep drawing steel are: hardening exponent n = 0,232, normal anisotrophy r_{00} = 1.73, r_{45} = 1.35 and r_{90} = 2.18. The friction coeficient between the blank holder and blank was set at the maximal value concidering the real-world conditions. The velocity was 5 mm/s and the blank holder force was set at the maximal value as it was necessary to prevent the drawing of material out of the flange to set the conditions equal to the stretching process. Material thicknes was t_0 = 1 mm.



a) b)

Fig. 3. *Shaped blanks*
a) blanks in shape of circle; b) blanks with various width

DIMENSIONS OF SPECIMENS WITH VARIOUS RADIUS Table 1

Sample	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***
R [mm]	0	20	40	50	57.5	65	72.5	80

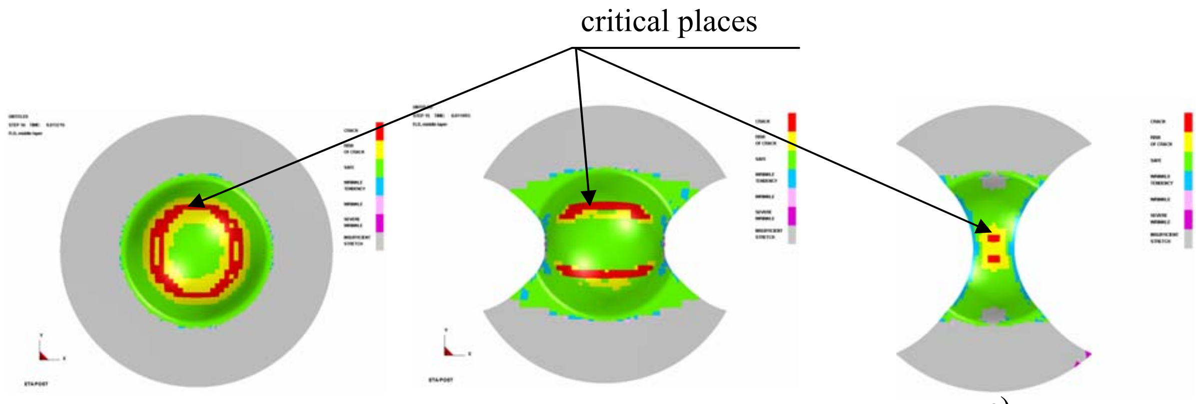
DIMENSIONS OF VARIOUS WIDTH BLANKS Table 2

Sample	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***
b [mm]	200	120	110	90	80	75	60	45

Simulation results

The simulation results gained from the Dynaform post-processor for specimens with various radius are presented in the Fig.4.

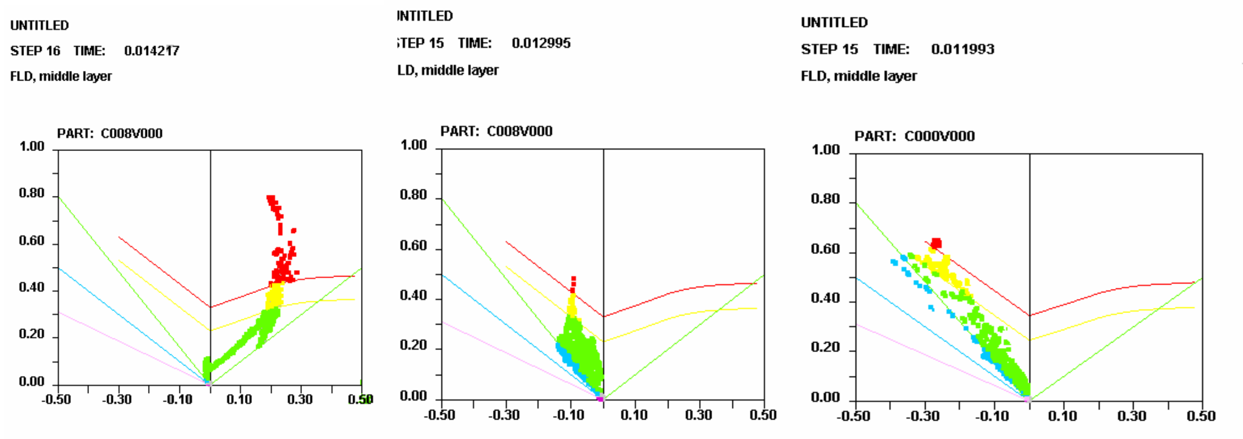
From obtained results may be observed that the specimens with various radius as well as various width blanks suitably cover whole FLD area. In the case of specimens with various radius (as well as blanks with various width), the failure was happened always in top of product (critical places), which means the process of test was correctly.



a) b) c)

Fig. 4. *Specimens with various radius after test*
a) specimen no.1; b) specimen no.4 ; c) specimen no.8

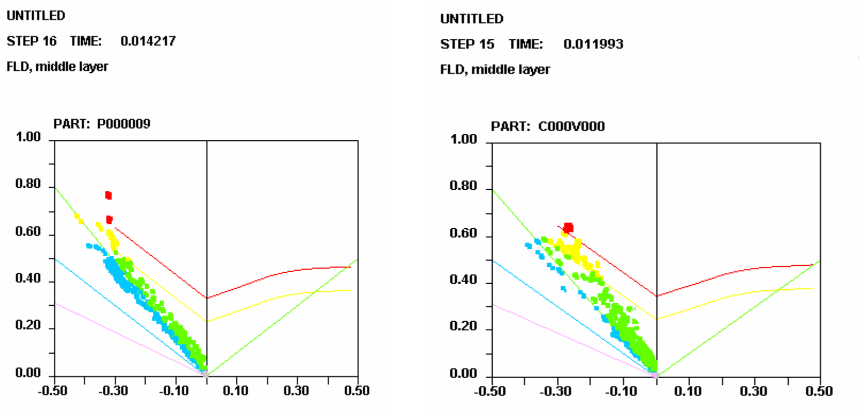
In FLD for specimens with various width shown in Fig.5, there is possible to see gradual transition of stress state from uniaxial to biaxial.



a) b) c)

Fig. 5. *FLD for samples with various width*
a) specimen no.1; b) specimen no.4 ; c) specimen no.8

In the case of circular shape specimen no.8, there is possible to see clearly flow of deformations in compare with specimen with various width (Fig.6).



a) b)

Fig. 6. *FLD for samples no.8*
a) specimen with various radius; b) specimen with various width

The results of major and minor strains in critical places of specimens with various radius and specimens with various width are shown in Tab.3.

RESULTS OF CRITICAL MAJOR AND MINOR STRAINS Table 3

	Specimens with various radius		**Specimens with various width**	
	φ_1 [-]	φ_2 [-]	φ_1 [-]	φ_2 [-]
1	0.469	0.232	0.464	0.237
4	0.399	-0.001	0.515	-0.090
8	0.623	-0.315	0.650	-0.292

Conclusion

The contribution deals with the verification of suitability and comparing of specimens with various radius with various width specimens for creating of FLD. The experiment was performed by method of stretching with semi-spheroid draw punch using the computer simulation (according by STN EN 12004-2). In both cases, i.e. using various radius as well as various width specimens, it was verified that they are suitable for creating of FLD. As using of specimens with various radius allocate higher dispersion of strain rate, it can be stated that they are more suitable for creating the FLD. However, simulation results are considerably linked with input conditions which are e.g. mechanical characteristic of material, drawing method, technological conditions etc. Some factors engaged in real stamping process are hardly describable therefore the fact, that numerical simulation result is always attended by specific deviation, must be considered.

References:

[1] HRIVŇÁK, A., EVIN, E. *Compressibility of sheets. Compressibility prediction of sheets steel with high strenght properties.* Košice: ELFA, 2004.
[2] Available on the internet : http://www.dynaform.com
[3] STN EN ISO 12004-2 *Metallic materials. Sheet and strip. Determination of forming-limit curves. Part 2: Determination of forming-limit curves in the laboratory*. 2008.