INFLUENCE OF THE TOOLS GEOMETRY ON THE DEEP-DRAWING FORCE

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ABSTRACT

Deep-drawing processes are usually used in automotive industry. In this area the specimen dimensions are between same millimetres in case of small devices to metres in case of a car body. In this study it is presented a comparative analysis about the influence of the punch geometry on the deep-drawing force. Experimental deep-drawing tests were performed. The material used in experiments was steel sheets with 0.5 mm in thickness. In the experiments were used four different dies with different geometries. The influence of the die radius on the deep drawing force was studied. From the experimental data it was concluded that the punch geometry have the main influence on the deep-drawing force. The small differences seen in the case of using dies with small radius lead to the conclusions that this parameter have no significant influence on the deep-drawing force.

KEYWORDS: deep-drawing force, punch geometry, punch stroke

1. Introduction

In the last years one of the most studied subject in terms of mechanical behaviour of metallic material was the deep-drawing process. Currently, deep drawing represents an important metalworking process for the production of parts such as beverage cans, pots and pans, containers of all shapes and sizes, skinks and automobile panels. Deep-drawing processes are studied in terms of material flow, the influence of the micro-structural features on the mechanical behaviour [Cao, 2004], [Diehl, 2008] the material studied were, Al, steel [Saotome, 2001], [Cotterel, 2002] and their alloys [Cao, 2004].

Succes or failure of the forming process is influenced by many process parameters such as the drawing ratio, the shape of the die including the die radius, the lubrication condition [Kim, 2002].

Experimental tests were carried out in order to characterize the material behaviour when the geometry of the punch it is changed. Two different geometries for the deep-drawing punches were used. The punches and the dies were designed according to [Paunoiu, 2004]. The blancks used in deep drawing experiments were blanked using a blanck die with a punch about 20 mm.

2. Experimental equipment and material

2.1. Experimental conditions

Steel sheets of 0.5 mm thickness were employed in the experiment. The chemical composition is given in table 1. Figure 1 shows a schematic representation of the deep-drawn parts.

The blankholder force has a constant value in all experimental tests.

Table 1. *Chemical composition of the steel sheet*

Chemical composition, [%]			
C	0.041	Cu	0.29
Mn	0.29	Cr	0.039
Si	0.013	Ti	0.0003
P	0.010	Mo	0.002
S	0.19	Nb	0.001
Al	0.07	V	0.001
Als	0.003	B	0.00009
Ni	0.26	As	0.003

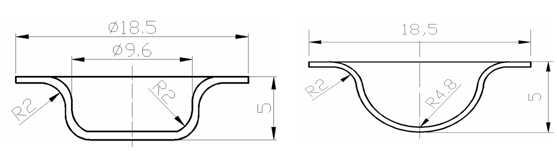
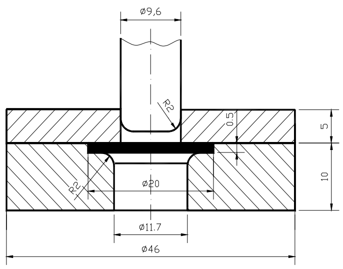
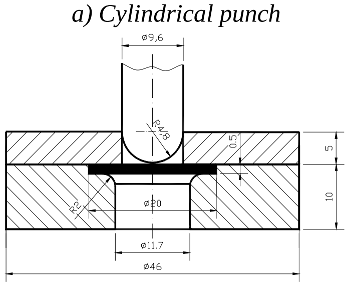


Fig. 1. *Dimensions of the deep-drawn cups*

In the experimental tests was used a deep-drawing die mounted on a hydraulic press with a maximum load force about 20tf. The geometries for the punch are presented in figure 2.



a) Cylindrical punch



b) Spherical punch

Fig. 2. *Tools geometries and dimensions*

In order to gain information about the influence of the die geometry on the deep-drawing force were used four different dies. The difference between these dies was the radii. The values joining radius were 1, 1.5, 2 and 2.5 mm. The punch radius was 2 mm in case of cylindrical punch and 4.8 mm in case of a spherical punch. In figure 3 are presented these four dies.

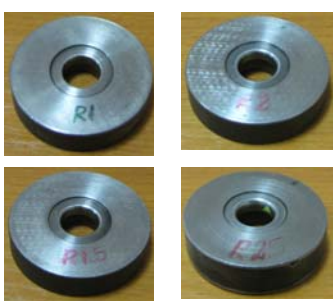


Fig. 3. *Dies with different joining radius*

The deep drawing forces were measured using a force transducer and the punch stroke was obtained using an LKG system with a laser beam. Figure 4 show the LK-G152 system.

Fig. 4. *LK-G152 sensor*

2.2. Material

The material used in this study was steel with 0.5mm in thickness. This material was tested in order to have information about their mechanical properties. Figure 5 show that the mechanical properties on three different loading condition in case of tensile tests. For the tensile tests were considered the following conditions one tensile direction at 90 on the rolling direction, one in 0 and the last one at 45 on the rolling direction.

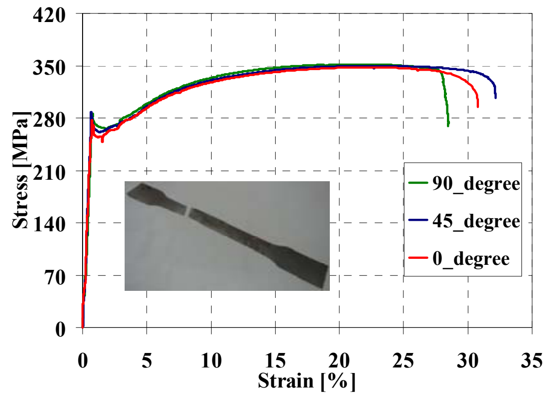


Fig. 5. *Stress-strain evolution in case of three tensile directions*

Regarding figure 5 can be observed that the differences concerning the values of the mechanical properties in these three analysed cases are small. Can be concluded that the mechanical behaviour of this material is the same in all three directions and it can be deformed in deep-drawing process.

3. Results

Figures 6, and 7, show the evolution of the deep-drawing forces versus punch stroke in case of four dies. The geometries of the dies were the same the only difference was that the active part of the punch was changed. The active part of one deep-drawing punch was flat and another one was spherical.

Figure 6 show the evolution of the deep-drawing force for all four dies employed in the experimental tests. The punch employed in these tests was a cylindrical one with a joining radius of about 1mm.

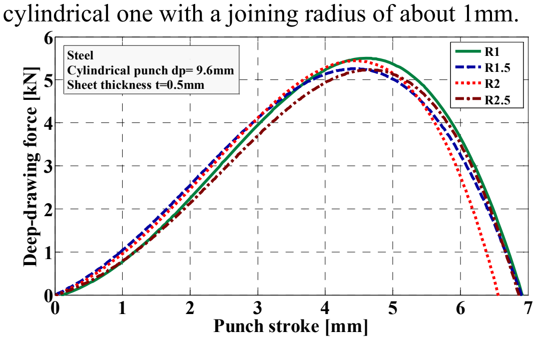


Fig. 6. *Deep-drawing force versus punch stroke for the cylindrical punch*

The punch diameter was about 4 mm. Small differences can be observed between the maximum values of the deep drawing force. This observation leads to following conclusion that the influence of the die radius is not significant for the analysed case.

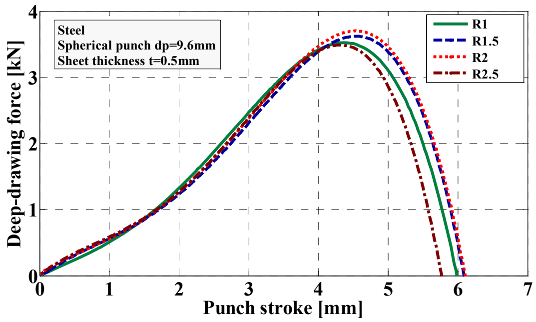


Fig. 7. *Deep-drawing force versus punch stroke for the spherical punch*

Figure 7 show the variation of the deep-drawing force versus punch stroke. The experimental data were measured using a spherical geometry for the punch. Also in this case small differences between the values of the deep-drawing forces are observed.

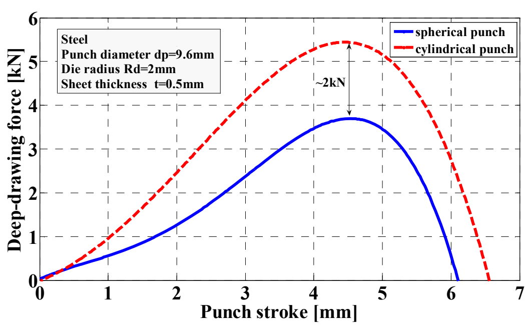


Fig. 8. *Influence of the punch geometry on the deep drawing of steel sheets*

From the experimental results obtained in both cases can be observed that the influence of the punch geometry is more important than the influence of the die joining radius.

Figure 8 show the evolution of the deep drawing force for both punch geometries employed in the experimental tests. It can be observed that in case of a die with 2 mm radius the curves force versus punch stroke has the same tendency.

Deep-drawn parts	Die radius [mm]	Deep-drawn parts	Die radius [mm]	Punch diameter [mm]
	1		1.5	9.6
	2		2.5	

Fig. 9. *Cylindrical deep-drawing parts*

A difference about 2kN can be observed between the two geometries analysed. This difference it is due to the punch geometry on one side and to the dimensions of the contact surface between punch and blank.

Deep-drawn parts	Die radius [mm]	Deep-drawn parts	Die radius [mm]	Punch diameter [mm]
	1		1.5	9.6
	2		2.5	

Fig. 10. *Spherical deep-drawing parts*

4. Conclusions

From the experimental data analysis can be concluded:

1. The punch geometry has the principal influence on the deep-drawing force.
2. At the considered dimensions for the experimental devices and for the blanks the influence of the die joining radius on the deep drawing force it is insignificant. This conclusion can be observed from figure 6 in case of a cylindrical punch and from figure 7 for a spherical punch.
3. The value of the deep drawing force it is influenced by the dimensions of the contact surface in both analyzed cases.
4. Deep-drawing results depend of the different parameters such as blankholder force, lubrication conditions.
5. The surface contact between blankholder and blank increase when the die joining radius decrease which leads to an increase of the deep drawing force.
6. When the die radius decrease the retaining surface increase and this increase leads to difficulties in the material flows which can be observed in wrinkles occurrence.
7. The difference between the deep-drawing force necessary to deform the same material using different punch geometries is around 2 kN in case of all dies geometries.
8. The results obtained from these experimental investigations will be used in the following studies which will have the purpose to design new dies with micro-radii.

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Influența geometriei sculei asupra forței de ambutisare adâncă

—Rezumat—

Procesele de ambutisare sunt utilizate in mod obişnuit in industria auto. In acest domeniu piesele si dispozitivele au dimensiuni cuprinse intre cativa milimetri pana la dimensiuni metrice in cazul corpului unui automobil. In acest studiu este prezentata o analiza comparativa a influentei geometriei poansoanelor asupra fortei de ambutisare. Materialul utilizat in cadrul testelor experimentale au fost table din otel cu grosimea de 0.5 mm. Au fost utilizate patru matrite de ambutisare, cu diferite geometrii. A fost analizata influenta razei de racordare a placilor active asupra fortei de ambutisare. Din rezultatele experimentale a fost observat faptul ca principala influenta asupra valorii fortei de ambutisare o are geometria poansonului. Diferentele mici observate in cazul utilizarii placilor active cu raze de racordare mici conduc la concluzia ca acest parametru nu are o influenta semnificativa asupra valorii fortei de ambutisare.