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THE INFLUENCE OF THE PUNCH GEOMETRY IN BACKWARD EXTRUSION OF ALUMINIUM CANS

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Abstract: Backward can extrusion punch are commonly made with a cylindrical punch land. A new punch design is proposed in which the cylindrical punch land is replaced with a circular profiled punch land. Experimental results in backward extrusion of a high thin walled aluminium can show that cans produced with the circular profiled punch land have a lower variations in wall thickness than the cans produced with the punch with the cylindrical punch land.

1.INTRODUCTION

This paper refers at some technological factors influence on dimensional precision of products with can shape, obtained at backward extrusion. This paper represents a bibliographic research form article "Backward can extrusion" [1].

The design of the punch nose in backward can extrusion has significant influence on the material flow and thus a significant influence on the tendency to break down of the lubricant. The punch nose is commonly made with a cylindrical punch land as shown in Figure 1 as recommended by the ICFG.

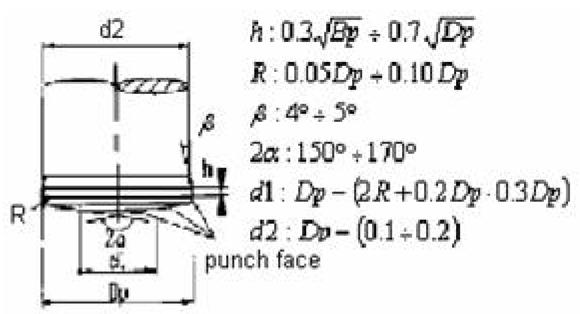


Figure 1 Punch geometry recommended by the ICFG

Between factors with significant influence, the most important are:

a. Radial pressure on the punch land

The radial pressure on the punch land was determined using the slab method assuming that the deformation in the region near the punch land takes place under plane strain condition; an assumption which is reasonable if the can wall thickness is small compared to the punch radius. Assuming that the stresses in the can wall above the punch land are zero, the horizontal force P on the punch land per unit width in circumferential direction can easily be obtained as:

$$P \cong 2kh\left[1 + \frac{mh}{t}\right] \qquad (1)$$

Respectively

$$P \cong 2kh\left[1 + \frac{mh}{2t}\right] \qquad (2)$$

Where the expression (1) is for Coulomb friction with the friction coefficient μ. The expression (2) is obtained if constant friction with the friction factor m is assumed. In this relation:

- k – is the shear yield stress on the can material;
- h – is the length of the punch land (see Figure 1);
- t – is the thickness of the can wall.

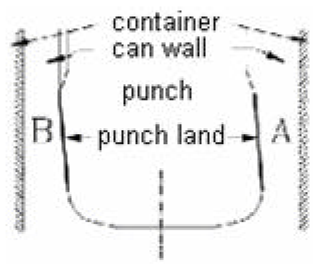


Figure 2. Punch with a titled punch land

From equation (1) it can be seen that the radial force is proportional to the yield stress of the can material and it increases with increasing friction and with increasing value of h/t.

b. The tilt of the punch

The tilt of the punch land may be caused by:

- deviations from perpendicularity in time of punch manufacturing;
- inaccurate mounting of the tools in the press;
- elastic deformation of the press and/or tools during the extrusion.

In Figure 2 is shown a sketch of the backward can extrusion process where the punch land is tilted. Due to the tilt contact between punch land and can wall is completely lost on one side (side A), whereas a slight tilt will only have a marginal effect on the contact conditions on the opposite side (side B). The loss of contact on side A reduces the radial force P (per unit width) on the punch land to zero here, whereas the radial force on side B remains nearly unaffected and is given by equation (1). This difference in radial force on the punch land will try to deflect the punch elastically to the right leading to an increase in the reduction ratio on side A and a corresponding decrease on side B.

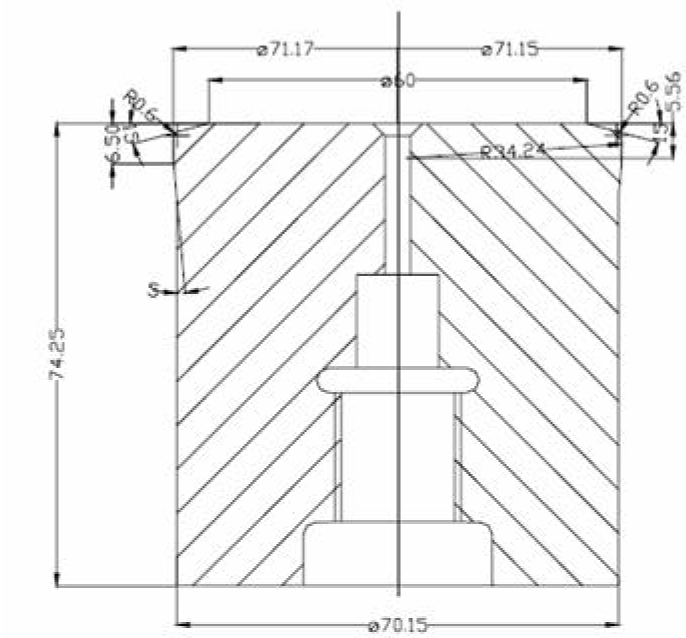
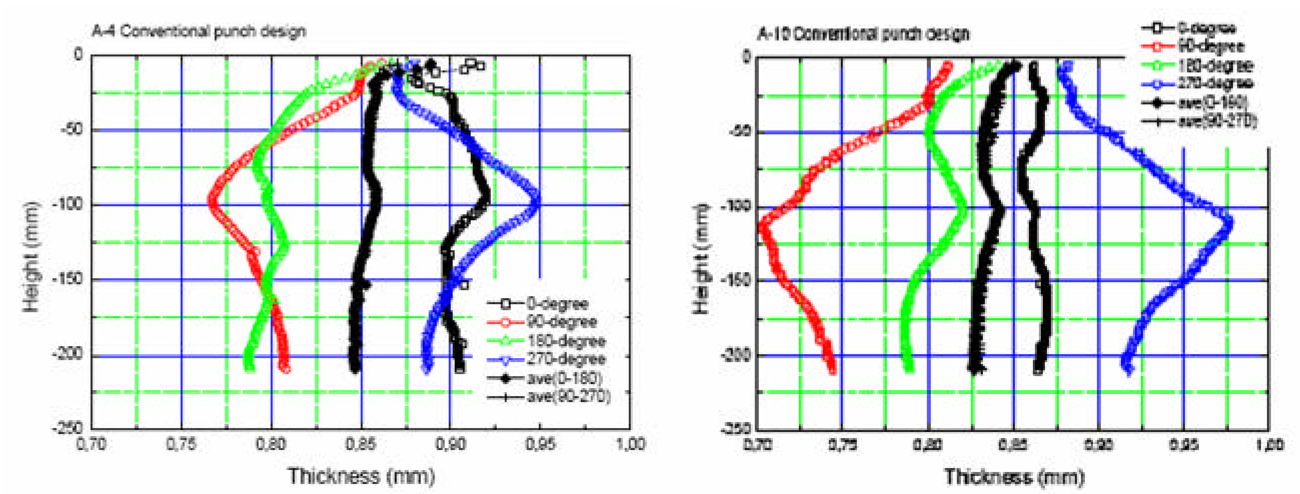


Figure 3. Geometry of the punch noses used in the experiments. Left: with a cylindrical punch land. Right:With a circular profiled punch land.

To reduce the effect, which a slight tilt of the punch land has on the contact conditions between punch land and can wall, the punch land can be made profiled, by example with a circular profile as show in Figure 3 (right) because in this case a slight tilt of the punch will only give rise to minor changes in the contact conditions.

2. EXPERIMENTAL INVESTIGATION

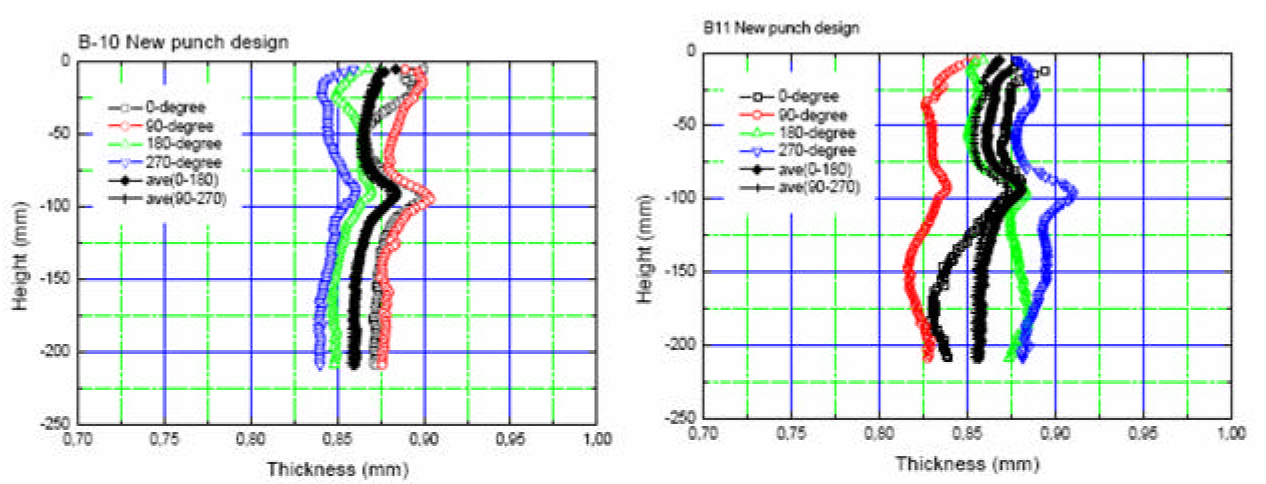
The backward can extrusion of a thin walled can was carried out experimentally with punch nose geometry with a cylindrical punch land and with a circular profiled punch land as shown in Figure 3. 10 cans were produced with the conventional punch nose and after that, 12 cans were produced with the punch nose with the circular profiled punch land. In order to be able compare the cans made with the two punch noses, main emphases was placed on keeping everything the same besides from the geometry of the punch noses.



a b

Figure 4. Can thickness as function of the distance from the can rim for the can produced with the punch nose with the cylindrical punch land. a – results for the can with the smallest variation in can wall thickness, b – results for the can with the largest variation in can wall thickness.

All cans were measured with a coordinate measuring machine. The cans were aligned such that the axis of symmetry was made as the Z-axis and with Z=0 at the lowest point on the can rim. The thickness of the can wall was measured in the vertical direction for every 2 mm in 0, 90, 180 and 270 degree from 5 mm to 209 mm below the can rim. Wall thickness measurements were also carried out by scanning circles on the inside and outside of the can wall from 5 mm below the can rim and for every 25 mm down to 200 mm below the can rim.



a b

Figure 5. Can thickness as function of the distance from the can rim for the can produced with the punch nose with the circular profiled punch land. a – results for the can with the smallest variation in can wall thickness, b – results for the can with the largest variation in can wall thickness.

3. RESULTS

It was not apparent from just looking at the can rim that there should be any significant variation in the can wall thickness. All the cans had a fairly even can rim; the difference between the highest and lowest point on the can rim was for all cans in the order of 1 to 2 mm.

Only the results for the best and worst can produced with the two punch noses will be shown. Figure 4 shows the measured wall thickness in 0, 90, 180 and 270 degree and the average of the thickness in 0 and 180 degree and in 90 and 270 degree as function of the distance from the can rim for cans produced with the punch nose with the cylindrical punch land. In figure 5 are shown the corresponding thickness distributions for cans made with the punch with the circular profiled punch land.

Main emphasis was placed on keeping everything the same besides the geometry of the punch nose and it is thus believed that the difference in thickness distribution can mainly be attributed to the difference in the punch nose design.

Comparing the thickness distributions shown in figure 4 to 5 it is obvious that the thickness variations in the cans produced with the circular profiled punch land are significantly smaller that in the cans produced with the punch with the cylindrical punch land.

The average thickness variation ? t_{ave} for all the cans in each series was:

- cylindrical punch land

? t_{ave} =0,238 mm (s.d. = 0,016 mm)

- circular profiled punch land

? t_{ave} =0,092 mm (s.d. = 0,018 mm)

where:

$$\Delta t_{ave} = \frac{\sum_{1}^{n} t_{\max,i} - t_{\min,i}}{n} \quad (3)$$

n – number of cans in the series

$t_{max,\,i}$, $t_{min,\,i}$ - the maximum, respectively the minimum wall thickness in can number i.

In cans made with the cylindrical punch land, the largest variation occurs around 100 mm below the can rim. In the cans produced with the circular profiled punch land there is also a kink in the wall thickness, however much smaller, around 100 mm below the can rim. The reason for the change in thickness variation around 100 mm below the can rim is not fully understood. It is believed that this variation can be attributed to a change in friction condition.

4. CONCLUSIONS

The punch used in backward can extrusion is commonly made with a cylindrical punch land. It is shown that with such a punch design a slight tilt of the punch land will give rise to a net force on the punch, which will deflect the punch off centre leading to variations in the can wall thickness. A new punch design where the punch land is made profiled, e.g. circular profiled, is suggested. If the punch land is made profiled, a slight tilt of the punch land will only give rise minor changes in the contact conditions between punch land and can wall and thus only give rise to minor variations in the can wall thickness.

The backward can extrusion on a high thin walled aluminium can has been investigated experimentally using a conventional punch design with a cylindrical punch land and using a punch with a circular profiled punch land. The results show that the variation in can wall thickness is reduced significantly when using a punch with a circular profiled punch land compared to the variation in wall thickness in the cans produced with the punch with a cylindrical punch land. In the cans produced with the circular profiled punch land the maximum variation in the thickness was in average 0.092 mm (corresponding to approximately 10% of the average wall thickness) and in the cans produced with the cylindrical punch land the maximum variation was in average 0.238 mm (corresponding to approximately 28% of the average wall thickness).

5. REFERENCES

1. Danckert J., Backward can extrusion, Research Report, Department of Production, Aalborg University Denmark 2005