

The effect of punch profile in deep drawing of dual phase steel

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تأثير تقوس الخدامة في السحب العميق للصلب ثنائي الطور

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المستخلص

من نتائج الدراسة وجد انه بزيادة تقوس الخدامة يزداد طول التماس بين الخدامة والغفل ويزداد ارتفاع القذح المنتج مع الترقق عند التقوس بين قاع القذح والجدار. تأثير زيادة قطر تقوس الخدامة على حمل السحب محدود (الحمل يقل بدرجة خفيفة مع زيادة قطر التقوس)

Abstract

From the results of the study found that increasing the radius of the curvature of the nose of the punch increases the contact length between the punch and the blank and increases the height of the produced cup with thinning in the curvature between the base of the cup and its wall. The effect of increasing the radius of the punch's nose on the drawing load was limited (the load decreases slightly with increasing of R).

This work aims to study the effect of the punch's profile (radius of the curvature of the punch's nose) in deep drawing process of dual-phase steel.

Deep drawing: It is a compression-tension metal forming process in which a sheet metal blank is radially drawn into a forming die by the mechanical action of a punch.

Deep drawing of circular blanks is one of the most important industrial processes, which is used in forming of sheet metal for manufacturing parts as cups, cans, box and shells. May be defined this process as a method for producing a cylindrical parts from flat circular blank by drawing it from the middle by flat hemispherical base and it's thickness approximately equal to the original blank. Fig.(1) refers to a simplest type of the dies which used in deep drawing process (flat die) where the original blank diameter is (D_b) and it's thickness is (t_b) and with punch diameter (D_p) A radial clearance with certain value must be between the punch and the die to allow the cup wall to pass through the die throat. The ratio of the blank diameter to the punch diameter (D_b/D_p) is called drawing ratio (D.R) and the ratio of the punch diameter to the original blank thickness (D_p/t_b) is called thickness ratio (T.R).

The larger drawing ratio may be obtained without failure is called limiting drawing ratio (L.D.R). There are two mainly failures in deep drawing process:

1-Fracture in the curvature between cup's wall and the base.

2-Wrinkling in the cup's mouth.

Using the blank holder device does the terminate of wrinkling for the relatively thin sheets, this requires an additional loading source addition to the punch loading.

There are other secondary phenomena which appear in the deep drawing products which are:

1-Unevenness: this is due to some defects in production or assembly of die, punch and blank.

2-Earing: this is due to planner anisotropy (change of metal properties with planner direction) in the blank metal.

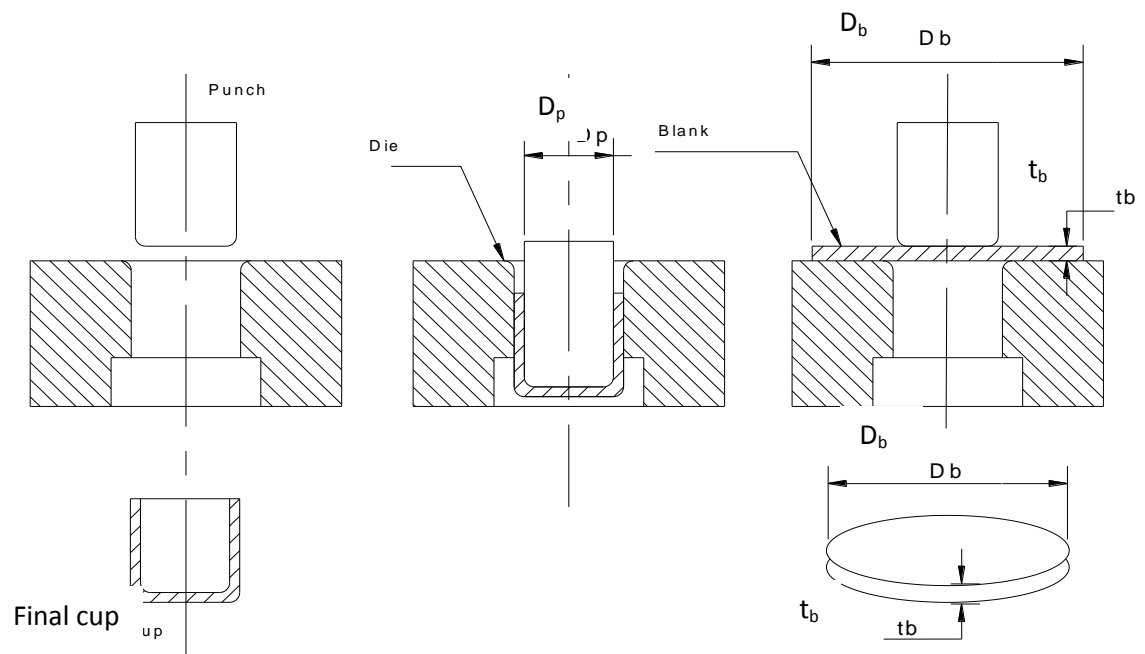


Fig.(1)

Deep drawing using flat die

Dual phase steel

The dual-phase steel is one of the most metals that used in the industry. This type of steel has been known after 1970 which has a good formability comparing with low carbon steel and with high strength low alloy steel (H.S.L.A).

The formability of dual-phase steel which maintain the ability of bending and high resistance of mechanical wear that is similar with low carbon steel, helped to use it in the body of automobiles and other parts, in response to the direction of economic by reducing the weight without losing the strength.

The basic structure of dual-phase steel is a mixture of ground of ferrite spread through fibers of martensite. The stress-strain curve behavior of this steel is different than that of low carbon steel and than that of (H.S.L.A)⁽¹⁾.

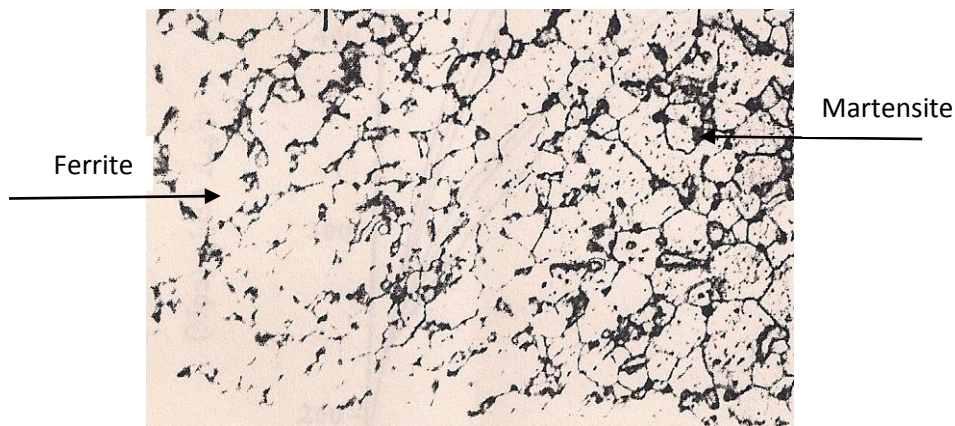


Fig.(2): Dual-phase steel ⁽⁸⁾

The need for dual-phase steel as response with bilateral economic trend in the auto industry by reducing the weight and increase fuel economies and increase the effective load and reducing of the weight by reducing the size of the mean of transport or by reducing the ratio of the strength/weight, there is no doubt that the last factor is possible for the purpose of maintaining the size of the mean of transport ⁽²⁾.

In 1960 began introduced the ferrite-martensite steel in United kingdom by a British company (B.I.S.R.A) which has been aimed at development of steel for strength equal (500Mpa) through the development process of annealing by heating low carbon steel to the critical heat point and quenching it in water then tempering it at low temperature in a salt medium ⁽³⁾.

The nomination of the steel as dual- phase inaccurate because there is lower bainite and retained austenite beside the two phases ferrite and martensite ⁽⁴⁾.

Dual-phase steel applications in industry

The good formability and low weight as advantage of this steel were the main reason to use it directly to manufacturing means of transport instead of (H.S.L.A)⁽³⁾.

The most important areas of use of dual-phase steel are:

- 1-Motor manufacturing.
- 2-I bars.
- 3-Strong pillars.
- 4-Supportive hooks.
- 5-Break elements.
- 6-Wheels.
- 7-Wheel hoops.
- 8-Disks.

- 9-The fan blades of the AC generator.
- 10-Columns of the elements of the steering wheel.
- 11-Internal and external channels of doors.

Experimental work

Fig. (2) illustrates the instruments that have been used in this study, the die was constant with 20° in semi die angle (the conical die has used to avoid using blank holder) while the radius of the punch's curvature (R) which is the most important factor in this work was variable (1.5,2,3,5,7) mm.

Because the thickness of the plate was (1mm) the thickness ratio of 20 has been chosen which leads to punch diameter (D_p) of 20mm and there for the die throat will be (23mm) with suitable clearance of (1.5mm) (50%of the metal thickness) between the cup wall and the die in order to produce cups not subjected to ironing process (which include increasing in the height at the cups and thinning of cup's wall)⁽⁵⁾. Any clearance less than the metal thickness refer to thinning of cup's wall⁽⁶⁾ and the larger value of this clearance lead to extend upper cup diameter⁽⁷⁾.

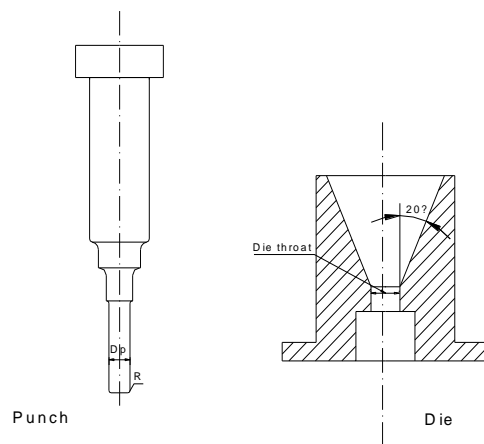


Fig.(3)

The punch and the die that have been used in the work

Used material

Dual phase steel of 1mm thickness has used in this work which was prepared by heating low carbon steel of 0.07% carbon to 780°C and quenching in water.

Results

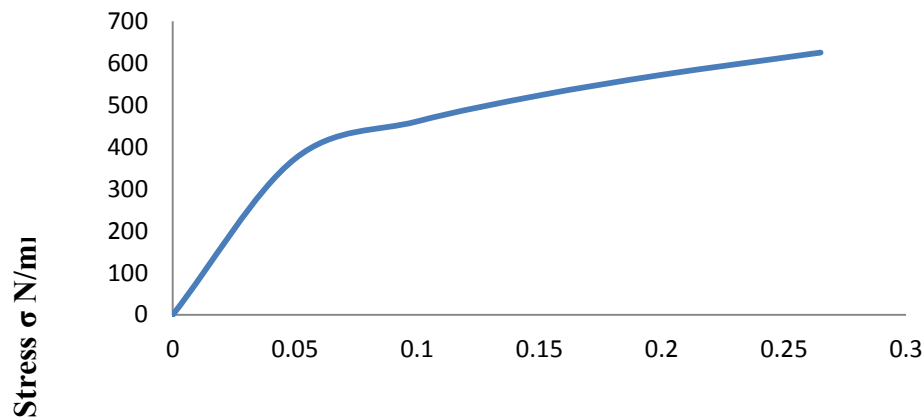
Mechanical properties

Table (1): Some mechanical properties of the metal that has been used:

No.	σ_y (N/mm ²)	σ_u (N/mm ²)	ϵ_{\max}	n	K (N/mm ²)
1	252	495	0.265	0.300	957

Where:

σ_y is yield stress, σ_u is ultimate tensile strength, ϵ is true strain, n is strain hardening index and K is the strength coefficient which is constant.



Strain ϵ

Fig. (3)

True Stress - Strain using Holoman equation $\sigma = K \cdot \epsilon^n$

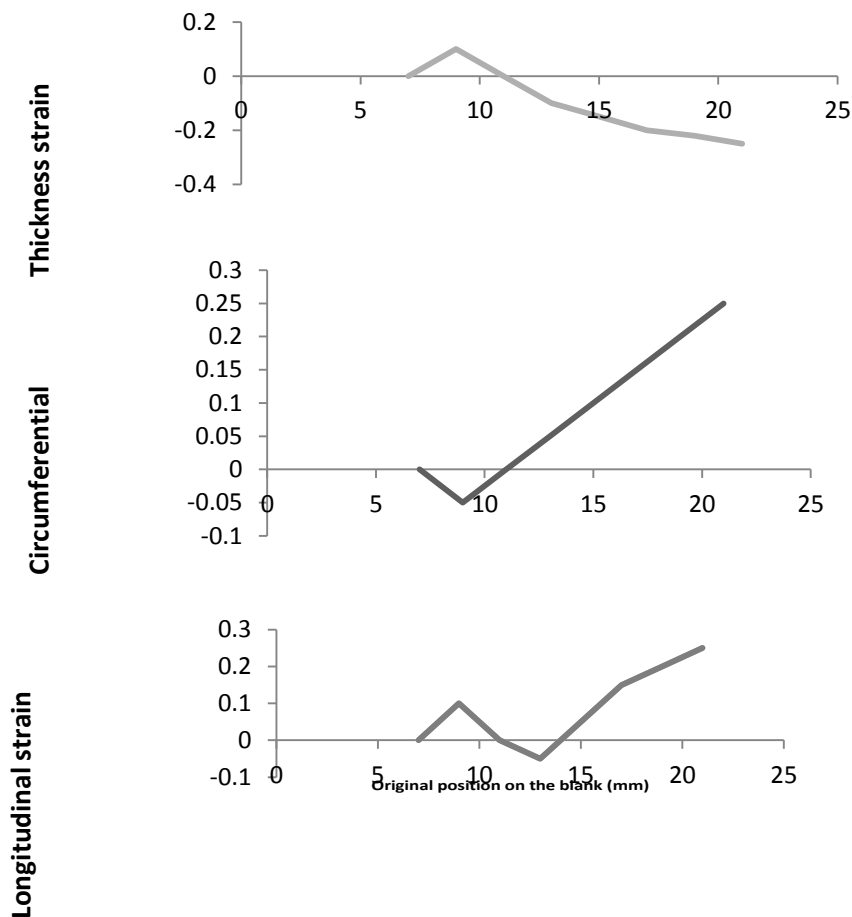


Figure (4): Distribution of the strains for the blank of (42 mm

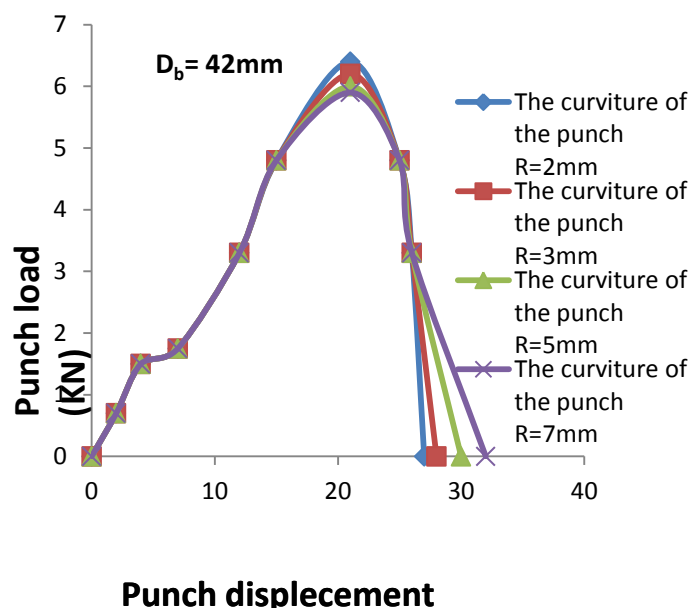


Figure (5): Relationship between punch load and it's displacement

Discussion

Table No. (1) Shows some mechanical properties of the metal that has used in this work which have been obtained from tension test, fig. (3) Illustrate the true stress-strain curve and fig. (4) shows the distribution of strains on the produced cup (the thickness strain decreases to the negative value in the transformation curvature from the base of the cup to the wall the return increases through the cup's wall while the circumferential strain increases through the curvature area between the cup's base and the wall and the longitudinal strain increase in the curvature area then decreases to small amount in negative direction and return increases through the cup's wall).

while fig. (5) showing the relationship between the punch's load the displacement.

References

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