Journal for Technology of Plasticity, Vol. 26 (2001), Number 1-2

A CONTRIBUTION TO THE INVESTIGATION OF THE STRUCTURE OF DRAWN SHELLS PRODUCED BY THE METOD OF HYDROMECHANICAL DRAWING

Milan Dvořák, Technical University of Brno, Faculty of Mech.Engineering
Institute of Technology, Dept. of Forming
Technická 2, 616 69 BRNO, Czech Republic

ABSTRACT

Hydromechanical drawing is a new and highli productive technology, not sufficiently used in Czech republic so far.The article informs about the established technologies empoloying fluid medium used in Czech republic as well as abroad. It also deals with the the metallografic analysis of conical drawn shells produced by the method of hydromechanical drawing.

1. INTRODUCTION

The traditionally employed technology of deep drawing done by a fixed tool, the so ca-lled conventional drawing shells in the shape of truncated cone it is necessary to use several drawing tools and consecutive drawings with interstage annealing in order to obtain the shell of the required form. This fact is reflected into the production costs significantly influencing the price of conical drawn shells and thus it is closely connected with the production economy.

In using the method of hydromechanical drawing it is possible to overcome the above mentioned shortcomings. Hydromechanical drawing is the best method both technically and economically of deep drawing with working fluid. In industrial countries the following system have been introdused: Hydroform and ARMCO (USA), Fluid – Form and Lagan (Sweden), Hydro – Mec and Krupp (D) and hydromechanical drawing (CZ) executed on the hydraulic press of the CTM 250A line in the Žďár engineering Works and Foundry (Žďárské strojírny a slévárny) [1]. The development of these established systems is still in process. Basically we might say that similar features are displayed by ARMCO and Krupp on the one hand and the systems of Hydro – Mec, HMT and Lagan on the order. We must examine not only the technology and the method of calculating the characteristic parameters in the surface forming but also the structure of the employed material. This is the reason why in the further text our attention will be drawn to the deformation course in the structure of the material using the method of metallography.

2. METALOGRAPHIC ANALYSIS OF CONICAL DRAWN SHELLS PRODUCED BY THE METHOD OF HYDROMECHANICAL DRAWING

Metallographic method was employed in order to establish the structure of the examined 1 mm thick material of the ČSN 11 305. 1 standart of drawn shells in the shape of truncated cone produced by the method of hydromechanical drawing. For establishing the initial structure we took the samples from a metal sheet 1 mm thick and from the set of undisturbed drawn shells of truncated cone with the dimensions: diameter D = 80 mm, taper ratio 1 : 5, the shell height h = 72 mm and the radius of bottom curvature was R5. Both the samples and the drawn shells were taken from the metal sheets of the same heat.

The drawn shells were produced by the technology method of hydromechanical drawing under optimal forming parameters (2), out of which the most important were: the pressure in the tool P_N = 25 MPa, the force of the blankholder F_P = 0.5 MN and the Wisura lubricant was applied for shaving (roundel, circular). The drawing coefficient was m = 0.464 in all cases. The following areas were determined as being typical: straight bottom section, the transition of the bottom to the shell wall and the transition from the wall to the flange. The preparated samples taken from the above mentioned areas were degreased and pressed into an acrylic pressing agent in the temperature of 170 °C under the force of 35 kN generated by Prontopress – 2. The samples were pressed into transparent disks of the diameter of 40 mm and the minimum distance between them and the outer contour was 3 mm. The transparent material enabled a consequential check on the labelled samples so that their displacement was impossible. The samples were ground and polished in a standard manner. For etching Nital (98 % HNO_3 , 2 % ethyl alcohol) in the concentration of 2 % was used. When magnified 250 times the examined structure permitted the observation of the extent of grain deformations in the individual areas of the drawn shell. For comparison, the fig. 1 a) illustrates the initial condition of the examined deep – drawn metal sheet, 1 mm stick, made of soft carbon steel (ČSN 11 305. 1).

The following figures 1 b), c), d) show the structure of the material after plastic deformation produced by the hydromechanical drawing.

We can clearly see the longitudinal extension of the grains and their narroing in the cross direction. Marked extension of the grains in the stress direction is observed by the lateral area of the conic drawn shell where the tensile stress prevails. The structure of the material in the delivered condition (the initial state) does not in fact differ much from the straight bottom section of the drawn shell, because little deformation takes in this area and the difference was hard to establish even in the magnification of 250 times. In the method of hydromechanical drawing it is necessary to pay a due attention to the transition area between the bottom and the wall (fig. 1 b), to the structure of the lateral area of the conic drawn shell (fig. 1 c) as well as to the transition area between the wall and the flange (fig. 1 d).

The last mentioned area documents a deformed structure (ε > 60 %) in the space condition in the state of stress produced by the drawing under the stress component action from the working fluid in the tool chamber. In this area the contact between the conic drawer and the shell wall is often broken and it is also here that the highest percentage of disrupted shells produced by the method of hydromechanical drawing appears.

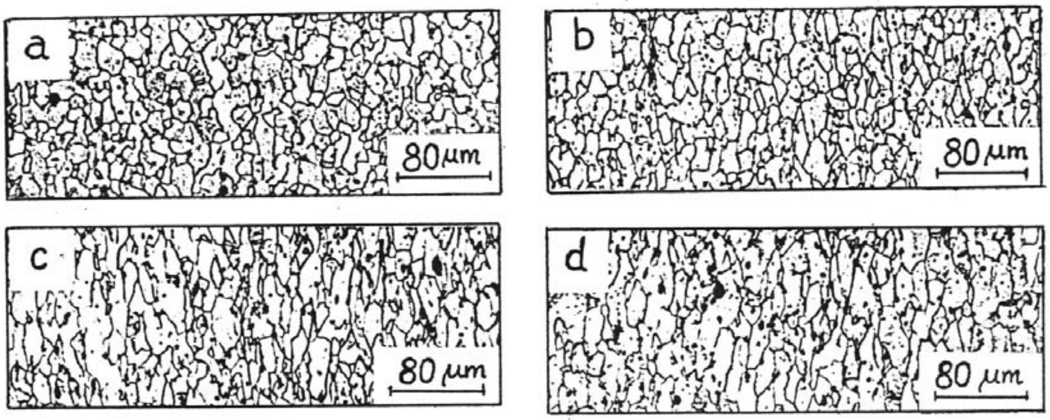


Fig. 1 The structure of the samples from the material ČSN 11 305. 1 mm thick ofa conic drawn shell (D = 80 mm, taper ratio ⊲ 1 : 5)

a) the initial state, Nital, magn. 250 times
b) the transition from the bottom to the shell wall, Nital, magn. 250 times
c) the lateral wall of the shell, Nital, magn. 250 times
d) the transition of the shell wall to the flange, Nital, magn. 250 times

From the point of view of the shell structure research the area of the transition between the bottom and the lateral wall appears to be very interesting and important (fig. 2).
I subjected this critical area – as it is called in the classical drawing, because it is the place where the shell wall disruption occurs frequently – to a special analysis. The reason for this was also the fact that the shells produced by hydromechanical drawing did not display the disruption of the material in this area.

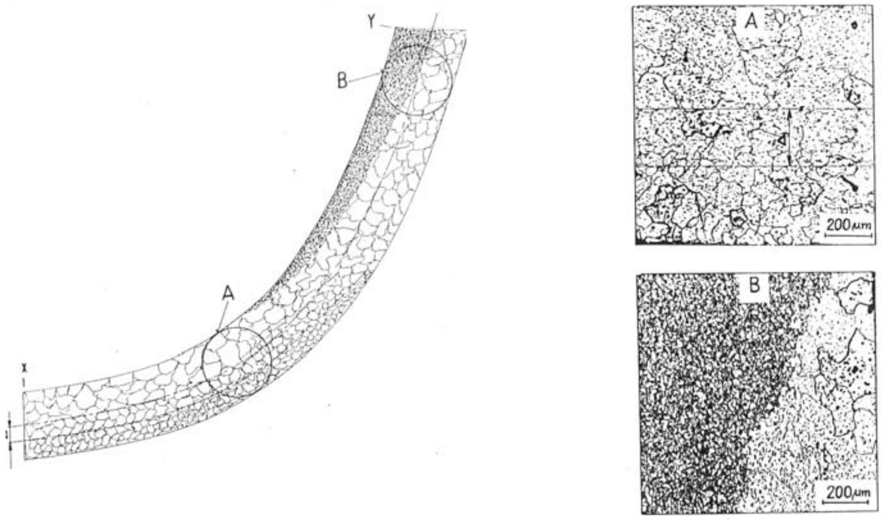
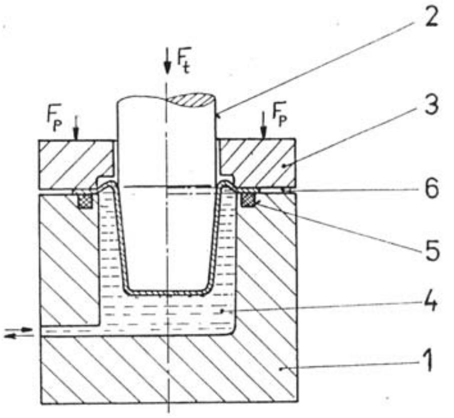


Fig. 2 Coarsening of the 11 305. 1 material, 1 mm thick, in the area of the transition of the bottom to the lateral wall of the conic drawn shell (XY), Nital, magn. 30 times.

It was established that in the area of the transition between the bottom and the lateral wall conic shell the coarsening of the grain of examined material ČSN 11 305. 1 appeared, as documented in fig. 2). Between the neutral axis and the outer fibres must be areas where the deformation reached the critical stage. At the temperature of 680 °C the grain crystals in these areas coarsened much more than the grain crystals in the areas where the deformation was subcritical or above critical.

The fig. 2) also conveys that when bending the metal sheet the neutral axis (Δ) is shifted in the initial phase of its collaring onto the drawer and the neutral axis moves in the opposite direction than established in the classical theory of beam bending. A number of structure pictures proves that the neutral axis is shifted toward to outer edge fibre in the examined critical area of the drawn shell. It was established that this shift in the drawn shells produced by the method of hydromechanical drawing makes roughly one quarter of the initial metal sheet thickness. The appearing shift might be explained by different degree of deformation on the inner and outer surface and the space state of stress brought forth by the tool face against the inner rounding area of the produced conic drawn shell.

In order to examine the structure changes in the conic drawn shell more thoroughly, that is not only after it was pressed, but also after the thermal treatment, i. e. after the working heat load, it was necessary to set up a recrystallizing diagram[1]. For this purpose a diagram for 580 °C and 680 °C was set up for the given material of the soft carbon steel of ČSN 11 305. 1, 1 mm thick, which was done on the basic of experimental results. Tensile test was carried out on the Instron TT - DM – L with the GLM type of head for the purpose of the established deformed structure of the examined material in the extent of 4 %. The test bar 1, ČSN 42 0321, the dimensions of which were 1 x 50 mm had the initial section of1 x 125 mm [5]. The speed of the cross beam shift was 2 mm x min^{-1}. The experiments were carried out at the temperature of 20 °C. The deformed test bars were annealed immediately on to the recrystallizing temperatures of 580 °C, 630 °C and 680 °C for the period of 1 hour in an electric furnace. Protective coating of "Kalsen" prevented oxidation and decarburization. It is basically an organo – metallic coating modified by organobetonit of approximate thickness of 0.11 mm.



1 – drawing die
2 – conic drawing punch
3 – blankholder
4 – pressure fluid
5 – circular packing
6 – semi – product (circular metal sheet shave)

F_P = blankholder
F_t = drawing punch force

Fig. 3 Simple hydromechanical drawing of the cones

Even thought the structure changes are somewhat different when only tensile stress is in question compared to the tensile stress employing versatile action of the pressure component from the working fluid in the hydromechanical drawing, yet we should not ignore analogous connections in the grain shape affter the plastic deformation brough about drawing.

The most conspicuous changes in the grain size of the annealed structure appeared at the temperature of 680 º C. The critical area appears in the deformation of 6-10 % . In the real conic drawn shell produced by hydromechanical drawing under optimal conditions there was a critical area when the shells were often disrupted in the upper part of the lateral wall of the conic shell[1]. This is the place where to focus the attention in the production aiming at improving the quality of the drawn shells.

3. CONLUSION

The above mentioned knowledge about the issues concerning the material in conic drawn shells produced by hydromechanical drawing contribute to new ideas about the sectional non – homogeneity of the material sumbited to drawing. This problem has not been commonly observed yet and it remained outside the specialistś attention in practice. In the lterature, e. g. [3], the autors, above all, deal with the technological questions and problems of drawing. This article shows that it is necessary to observe and respect the structural changes in the material as well, and that not only after pressing but also following the possible heat load leading to changes in the structure. This information was revealed by the experiments with conic drawn shells made by the method of hydromechanical drawing of soft carbon steel ČSN 11 305. 1, 1 mm thick. The mentioned material has a variety of possible utilization in practice.

4. REFERENCES

1. Dvořák, M. : Optimalize of forming parameters by hydromechanical drawing. Thesis dissertation. VA Brno, 1989, 157 pp.
2. Píšek, F. and all.: Teaching about material I, bunch 2, Prague, Academica ,1001 pp.
3. Blaščík, F. – Polák, K. :Theory of plasticity. Prague,SNTL 1985,374 pp.
4. ČSN 42 0462 : Determination of grain size of steels and non-ferous metals, ÚNM 1983
5. ČSN 42 0321 : Experimental tensile test flat of pieces thickness from 0,1 mm below 4 mm.Prague , ÚNM 1983

PRILOG ISTRAŽIVANJU STRUKTURE KONIČNIH DELOVA OD LIMA DOBIJENIH HIDROMEHANIČKIM DUBOKIM IZVLAČENJEM

Milan Dvořák

REZIME

Za proizvodnju koničnih delova od lima pomoću tradicionalne (klasične) tehnologije dubokog izvlačenja sa krutim alatima neophodno je više operacija. Pri tome je često potrebno i međuoperaciono žarenje. Sve to u značajnoj meri povećava troškove izrade takvih radnih komada. Primenom hidromehaničkog dubokog izvlačenja moguće je prevazići gore navedene teškoće, čime se mogu postići ne samo tehnički već i ekonomski efekti. Neki od različitih sistema hidromehaničkog dubokog izvlačenja u svetu su: Hydroform and ARMCO (USA), Fluid-Form and Zagan (Švedska), Hydro-Mec und Krupp (Nemačka), Hydromechanical Drawing (Češka Republika). Češki sistem hidromehaničkog dubokog izvlačenja izvodi se na hidrauličnoj presi CTM 250A u kompaniji Ždarske strojirny a slevarny. Ovaj sistem je još u fazi razvoja. Jedan od problema koji se analizira je i strukturno stanje materijala nakon hidrodinamičke obrade. Ovaj rad je posvećen toj temi. Ispitivana je struktura lima ČSN 11305.1 debljine 1mm na konično izvučenom obratku, sa nagibom 1:5, većim prečnikom D = 80mm, ukupnom visinom h = 72mm. Parametri procesa su: pritisak u alatu P_N = 25Mpa, sila držača F_P = 0,5 MN, koeficijent vučenja m = 0,464.

Autor na osnovu ovih istraživanja zaključuje da je potrebno da se proces hidromehaničkog dubokog izvlačenja dalje istražuje sa tog specifičnog aspekta (mikrostrukture) obzirom da u literaturi postoji određena praznina na tom planu.