THE SIGNIFICANCE OF THE CHANGE OF CONTACT PRESSURE IN BLANK-HOLDER ZONE IN DEEP DRAWING

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ABSTRACT
Tribological conditions in blank holder zone in deep drawing significantly influence the total forming process. The value of contact pressure in holder and die zone influences the appearance of wrinkles and tearing in the zone of forming force transfer. In standard forming processes, holder force has constant value in course of deep drawing. The paper gives results of experimental researches, realized on special researching equipment, which make possible the change of holding force. The change of blank holding force, i.e. the change of friction force on contact surfaces of holder and sheet metal, that is die, is realized according to previously determined law, as function of the position of outer flange edge, i.e. time.Standard sheet metals and sheet metals with anticorrosion coatings, as well as various lubricants, are used in experiments. The obtained results point to the influence of contact pressure onto the drawing force, strain distribution, forming limit etc.
KEYWORDS: *Sheet metal, deep drawing, variable blank holding force*

1. INTRODUCTION

Deep drawing is one of the most significant processes of thin, cold rolled sheet metals manufacture, in course of which different products are obtained, including the simple ones (cans) and most complex ones (parts of autobody). The significance of tribological conditions in the forming process is equal to the influence of other forming system factors-machines, tools and material. Standard survey of friction zones in standard deep drawing is given in fig. 1. Zone 1 is of essential importance considering complexity of stress-strain condition and tribo-conditions in that area. On one side the friction on blank holder and die significantly influences the course and results of plastic forming process, and on the other side blank holding force (BHF) is a very convinient parameter for monitoring and control. Considering the development of automation, researches in the area of the BHF control were extremely intensified in the last few years, in order to attain higher efficiency of deep drawing process /1, 2/.

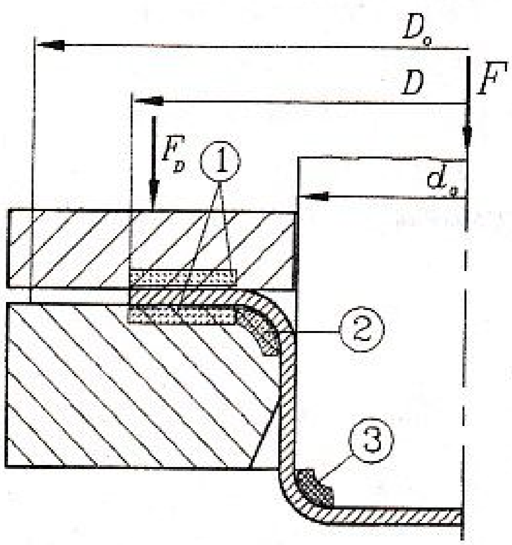


Figure 1: Friction zones

Two types of defects may appear in course of drawing: wrinkles at sheet metal surface and fracture. These appearances, so to speak, form the framework for successful continuance of the process. In classical drawing the BHF is constant. By pulling in the flange and reducing the outer diameter, the specific pressure in contact is increased, and leveling of sheet metal surface is more intensive. In course of that the sheet metal thickness on the flange perimeter is increased, because of tangential compression. The change of pressure leads to the change of lubrication regime, that is leads to the realization of boundary and mixed lubrication. With the increase of pressure, the encapsu-lating of lubricant between the roughness peaks takes place (hydrostatic pressure), but at the same time the disturbance of lubricant on the top of roughness peaks may appear (fig. 2 /3/). By convenient control it is possible to extend working area in deep drawing, to achieve higher drawing ratios etc. In course of that, tribological conditions on flange have great significance, though relatively insufficiently investigated /4/.

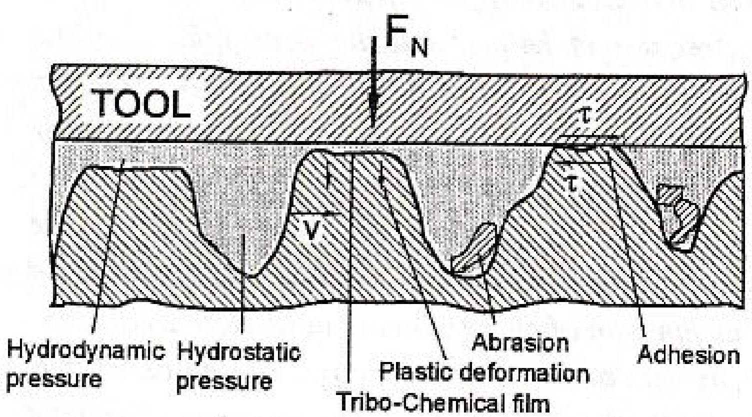
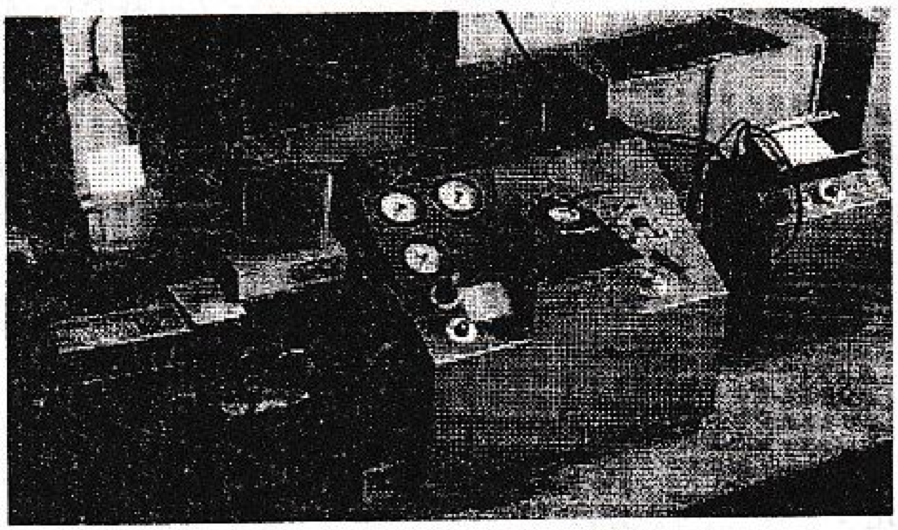


Figure 2: Rough contact between die and sheet

2. EXPERIMENTAL RESEARCHES

The experiments, the results of which are given in this paper, are carried out at Faculty of Mechanical Engineering in Kragujevac, where laboratory device for researching the variable blank holding force (VBF) influence in deep drawing has been made. Hydraulic triple action laboratory press-ERICHSEN 142/12 is the basis of this device. Maximal measuring range of the main action force is 0-130 kN and forming speed is 0-200 mm/min. Maximal punch diameter is 50 mm and maximal drawing ratio is 2.4. Originally the press was equipped with inductive transducers of force and travel for main action with Bourdon's tubes manometers for all working actions. It is possible to control BHF continually by hand regulated hydro valve. For the purposes of this research the modification in the system for BHF realization and control was carried out. Modification includes: 1) built-in electromotor drive with DC motor and two conducted worm gears applied on hydro valve for regulation of BHF axle; 2) built-in inductive transducer for BHF measuring. Considering the relatively small process speed the control of electromotor drive is integrated in computer system for data acquisition and control (phot. 1). Control of electromotor drive is performed in closed loop (by feedback) on the basis of given functional dependence of BHF and continually measured, realized BHF. PC computer with plugged-in 12-bit AD/DA card is the central part of the system. On the basis of given and momentary measured BHF value, valve axle position dependence on time during drawing process is determined, as well as BHF. By switchi- ng electromotor drive in desired moments with use of specially developed electronic unit, VBF to programme defined intensity may be obtained, and is measured directly through blank holding force transducer. The choice of any kind of force dependence type either as analitically given function or as a set of discrete values was provided through software. Developed software can also serve for other needs of experiment (deep drawing force measuring, visual proces monitoring, saving of all necessary variable values etc). Because of the limited space, it is not possible to give all details about this system.



Phot. 1: Experimental instrumentation

Materials used for this investigation are two low-carbon autobody steel sheet metals – one of a domestic manufacturer (marked C0148P5) and the other of a foreign manufacturer with one sided anti-corrosive electrolytic zinc coating (here marked TyZnI). Basic mechanical properties are given in table 1. The table contains medium values considering the plane anisotropy of the sheet metal. Because of limited space strengthening curves are not given and forming limit diagrams are visible in fig. (7) and fig. (8).

In the course of experiment planning, the application of pure deep drawing (cylindrical part with flat bottom) was chosen in conditions of constant blank holding force (CBF) on one side and in conditions of VBF on the other side. CBF intensity was defined by three values (one value was recommended in literature and other two were obtained in special investigation). VBF was defined as monotonously falling function of time, i.e. punch travel in conditions: q=const. (q is specific blank holder pressure).

Table 1 Mechanical characteristics

Material	R_P MPa	R_M MPa	A_{80} %	n -	r -	s mm
C0148P5	210	301.7	33.8	0.212	1.33	0.8
TyZnI	203.3	317.1	33.1	0.221	1.18	0.8

The influence of contact conditions was investigated by application of dry contact surfaces degreased by acetone (marked as dry or D), oil for deep drawing (oil or O) and by combination of oil and polyethylene foil (O+F).

Basic geometry was defined by: punch diameter (d=50 mm), bottom radius (r=6.5 mm) and die radius (3.5 mm). Drawing ratio was chosen in a way to be close to the limit value. At such ratio, and by the application of oil and foil the flawless workpiece is obtained, and by application of oil or dry contact surfaces the process cannot be succesfully carried out. For this example that is the ratio 2.2, i.e. blank diameter D_0=110 mm. Forming speed is fixed at 20 mm/min.

2.1 THE CHOICE OF CONSTANT BLANK HOLDING FORCE (CBF) AND VARIABLE BLANK HOLDING FORCE (VBF)

It is common practice (and very often the only possible solution) to determine the intensity of CBF on the basis of literature recommendations. Those recommendations usually contain particular values of the specific pressure q or formulae for the calculation of the pressure. It is always possible to discuss the universality of the application of such approach. Neverthless, we have also adopted the recommended value as one of the CBF values. Eight well-known prepositions were taken into considerations /5/, and adequate medium value was chosen. For C0148P5 it is 13.41 kN, and for TyZnI it is 13.83 kN.

More accurate approach implies creating of dependence of blank holding force and drawing depth (h-F_D) for each particular case in order to identify correctly the area in which wrinkles and fracture appear and in which a successful piece is obtained. Naturally, that is preceded by blank defining. The procedure is relatively complex, but that is the only correct way for determining the correct value of CBF. Diagrams h-F_D for both investigated

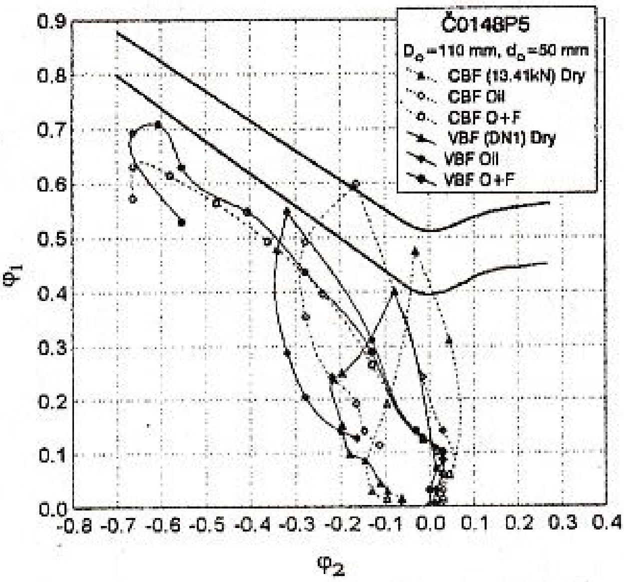


Figure 7: Strain distributions

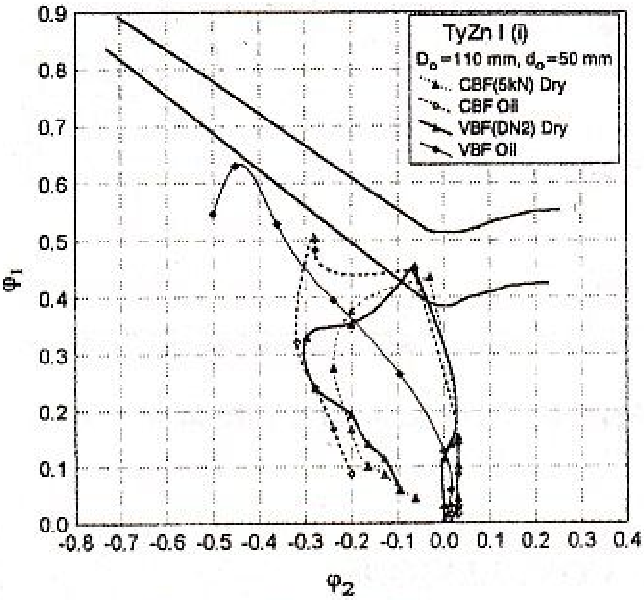


Figure 8: Strain distributions

That results in certain unloading of material and finally, in larger work piece depth (increase 13.5% for lubrication by oil and 30.5% for dry surfaces relate to CBF).

As it has been expected, in the conditions of extremely small friction (hydrodynamic lubrication –oil and foil application) there are no special effects except of increased tendency to wrinkles so, practically, there is no need to apply VBF, but only sufficiently large CBF for the elimination of wrinkles.

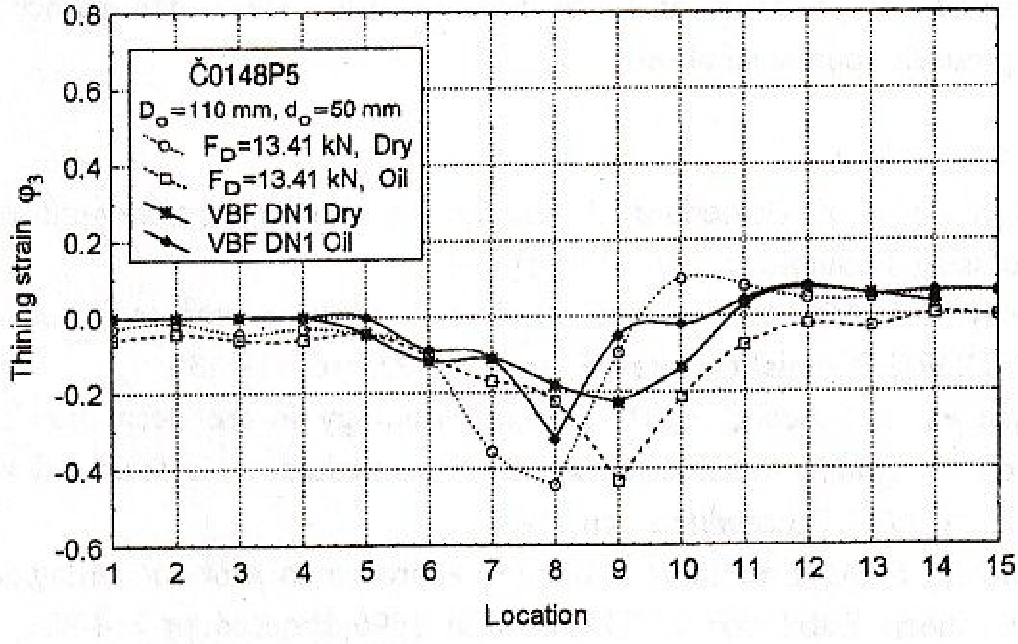


Figure 9: Thining strain distributions

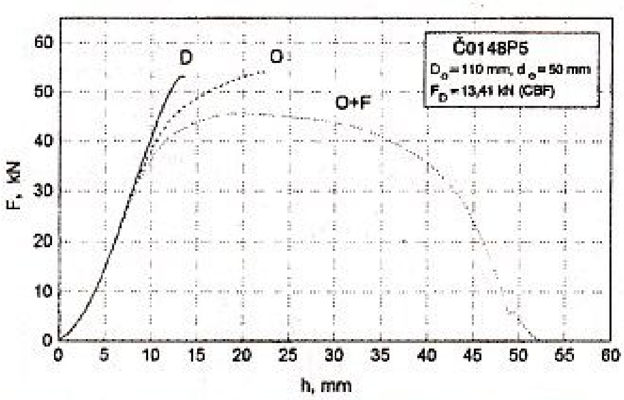


Figure 10: Forming force dependence on drawing depth

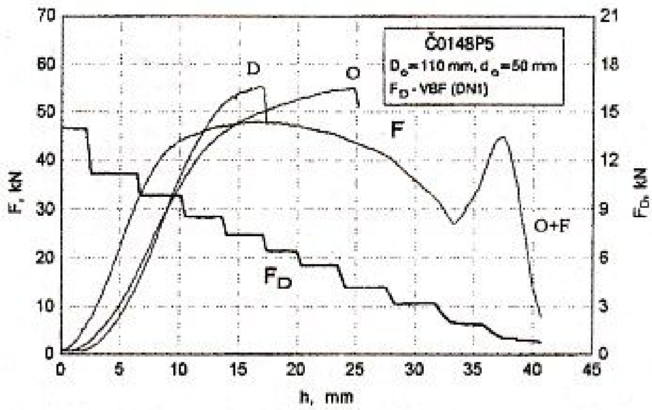


Figure 21: Forming force dependence on drawing depth

3. CONCLUSIONS

The application of VBF can be a significant means for the improvement of technological results and better knowledge of the essence of the deep drawing process. Results given in this paper (in reduced form) point to the positive influence of the falling variable blank holding force (VBF) especially in conditions of more prominent friction (boundary lubrication), which is clearly visible in the more convenient strain distribution in the sheet plane with significantly less thining. Draw depth increases even over 30% in extreme case of dry surfaces.

Further researches will include other variants of VBF (rising VBF, combination of falling and rising VBF etc) taking into consideration and monitoring mutual influences: contact conditions, materials characteristics and strain history. The final aim is to give the following answer: which form of blank holding force shape for particular process conditions represents optimal solution.

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