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THE CHANGE OF CONTACT PRESSURE IN BLANK HOLDER ZONE AND TRIBOLOGICAL INFLUENCES ON DEEP DRAWING

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ABSTRACT

Tribological conditions in deep drawing process are as important as other factors (material, work piece geometry, machine and tool). Tribological activities on work piece flange should be especially emphasized because of activity of holding force which is very convenient parameter for monitoring and control. The paper gives results of experimental researches, realized on special researching equipment. Standard sheet metal and sheet metal with anticorrosion coatings, and various lubricants, are used in experiment. The obtained results point to the influence of contact pressure onto the drawing force, strain distribution, forming limit etc.

1. INTRODUCTION

Deep drawing is one of the most important technologies in the sheet metal forming industry. It is applied in obtaining of simple geometry pieces (of cylindrical shape, for example), as well as for complex geometry pieces (parts of autobody). The significance of tribological conditions in the forming process is equal to the influence of other factors: materials, tools and machines. Friction on holder (zone 1 in fig.l) is extremely significant for two reasons: a)influence on the course and result of the process and b)possibilities of monitoring and control of holding force which represents the normal friction force on flange. Due to the development of computer systems for measurement and control, researches in the area of the BHF control in deep drawing were extremely intensified in the last few years [1,2].

Two types of defects form the framework for successful continuance of deep drawing process: wrinkles at sheet metal surface and fracture. In classical deep drawing the BHF is constant during the process. Because of continuous decrease of flange surface, the specific contact pressure is increased from initial value to the final, maximal value.

The change of holding force, that is contact pressure, significantly influences the flange friction regime. By convenient holding force dependencies on travel it is possible to improve the process efficiency (extended working area considering the wrinkles and fracture, higher drawing ratios, forming of badly formable materials etc). The main purpose in this insufficiently investigated area is to fmd the optimal functions of holding force change in course of process.

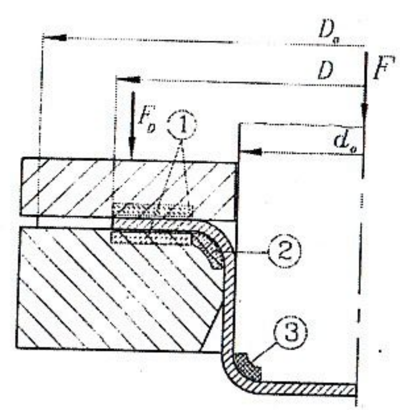


Fig. 1: Friction zones

2.EXPERIMENTAL RESEARCHES

The experimental researches, some results of which are given in this paper, are carried out at the Faculty of Mechanical Engineering in Kragujevac, where special laboratory device for researching the variable blank holding force (VBF) influence on the deep drawing process has been made. Hydraulic triple action laboratory press ERICHSEN 142/12 is the basis of this device, with maximal force of 130 Kn and forming speed range of 0-200 mm/min. Maximal piece diameter is 50 mm, and maximal drawing ratio is 2,4.

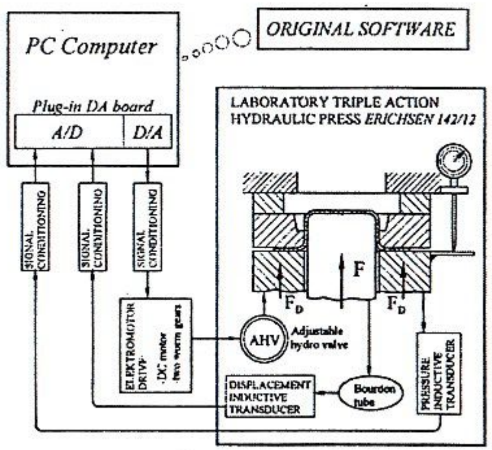


Fig. 2: Scheme of experimental equipment

In part for monitoring of holding force a modification has been carried out by building-in a computer system for measurement and control (fig.2). Holding force is continually measured and, on the feedback principle, control of electromotor drive of hydro-valve is carried out. 12-bit AD/DA card is the central part of the system. The desired VBF function is provided through software. Measured real holding force is continually compared to the given one and, if necessary, the DA converter sends the control signal to electromotor drive. In that way it is possible to realize any given VBF function in dependence on punch travel, that is time. Also, on the closed loop principle, by changing the holding force it is possible to control the drawing force. The moment of wrinkles appearance and measuring of their height can be recorded on this device (fig.2).

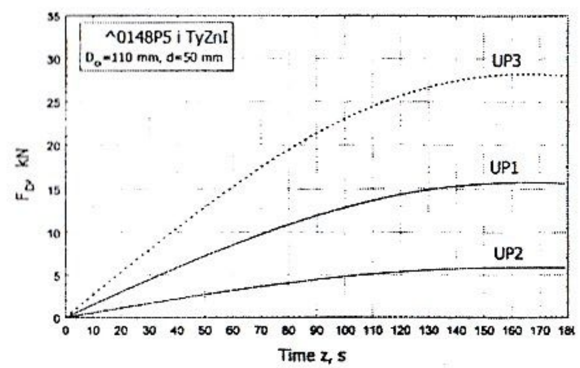


Fig.3: Increasing blank holding forces

A part of results of two materials investigation is given in this paper; those materials are; low-carbon autobody steel sheet metal of a domestic manufacturer (marked C0148P5) and galvanic autobody sheet metal with one sided zinc coating (marked TyZnI). The details about characteristics are given in [3]. The plan of experiment suggests the usage of cylindrical piece (pure deep drawing) in conditions of constant blank holding force (CBF) on one side, and variable blank holding force (VBF) on the other side.

The CBF intensity was defined as a medium value of 8 well-known empiric formulas results [4] and results of author's particular researches. Also, the CBF was defined by limit diagrams of wrinkles and fractures which give dependency of drawing depth and holding force [3]. The VBF was defined as monotonously increasing function in line with the idea

given in the paper [5]. The details are given in [4].

The influence of contact conditions was included by application of dry surfaces cleaned by acetone (marked D), by application of oil for deep drawing (O) and by application of oil and polyethylene foil (O +F).

The basic geometry was defined by the following values: punch diameter 50 mm, piece bottom radius 6,5 mm, die radius 3,5 mm, drawing ratio 2,2 (close to the limit one). Forming speed is 20 mm/min.

Three VBF dependencies, determined for the particular research conditions, with main purpose being the prevention of wrinkles appearance on flange, are given in fig.3. By the increase of holding force, contact pressure additionally increases (besides increase due to flange surface decrease) which makes the conditions for the wrinkles appearance unfavourable. The danger exists at the very beginning of the process when contact pressure is small, but it appeared that they possible wrinkles were mostly small and easy to smooth in course of drawing. Small initial holding force acts very conveniently from the aspect of sheet metal thinning in critical zone (punch radius zone).

3.RESULTS

Effects of increasing VBF were monitored in comparison to CBF by following indicators: a)strain distributions in coordinate system of main strains of sheet plane (φ_1, φ_2), fig. 4 and 5; b)distribution of thinning strain (φ_3) in dependence on location on piece; c)piece depth and d)drawing force, fig. 6 and 7. Because of limited space only a small part of results is given.

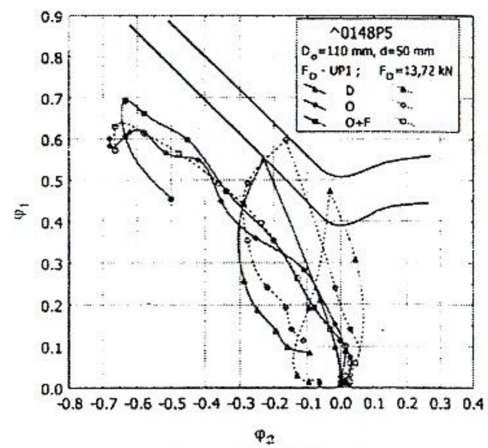


Fig. 4: Strain distributions

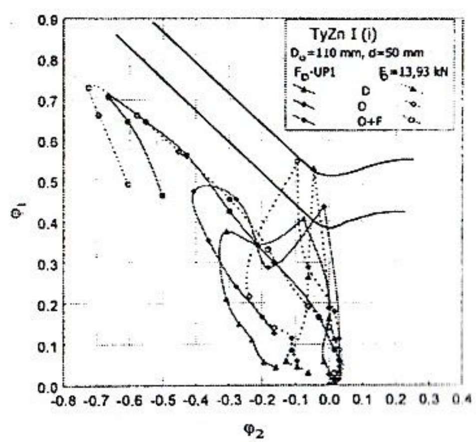
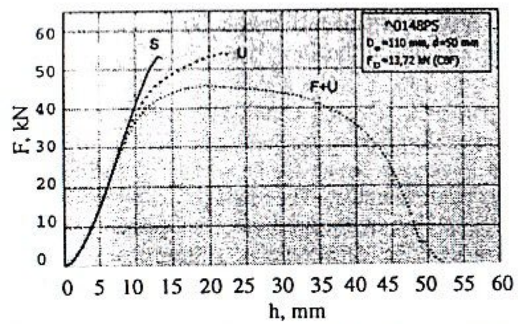


Fig. 5: Strain distributions

According to the given results (fig. 4 to 7) first we notice the known fact that in conditions of extremely small friction (application of oil and foil with the effects of hydrodynamic lubrication) there is no prominent influence of holding force, that is contact pressure. However, if the surfaces are dry (D) more favourable strain distribution is obvious if VBF marked with UP1 is applied (fig. 4 and 5). Loops were shifted on the left towards the zone of considerably higher limit strains. For sheet metal with zinc coating TyZnI the loop is considerably wider, which implies bigger and more balanced strains in the sheet metal plane. Drawing depth increases for about 25% in comparison to piece drawn with CBF. In case of lubrication by oil the effect is extremely favourable. By the application of CBF it is impossible to obtain a piece without fracture (fig. 3 and 6). By the application of increasing

VBF (UP1) a piece of total depth is obtained out of sheet metal C0148P5 (fig. 4 and 7).On the sheet meta TyZnl piece, the favourable effect of increasing VBF can be observed. The depth is larger for about 30 with more convenient strain distribution (fig.5).



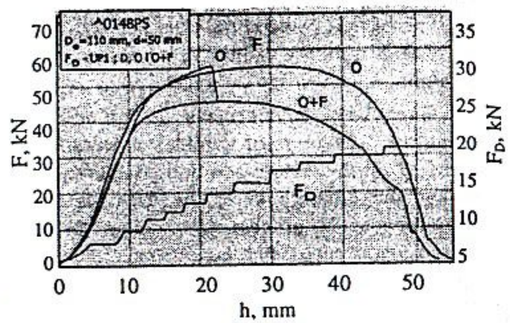


Fig. 6: Forming force dependence on drawing depth Fig. 7: Forming and holding forces dependence on drawing depth

4.CONCLUSIONS

The application of VBF leads to better technological results and more complete comprehension of the deep drawing process. The results given in this paper (in reduced form) point to the positive influence of the rising holding force, especially in conditions of mixed lubrication (application of oil for deep drawing). Much more favourable strain distribution is achieved, which postpones (or completely avoids) fracture with rather successful compensation of wrinkles.

Further researches of the author will include other variants of VBF with varying of contact conditions, materials characteristics and forming history. The final aim is to create conditions for answering the question: "Which form of VBF dependence represents the optimal solution for the particular deep drawing process and how can it be realized? "

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