THE STUDY OF THE EFFECT OF THE MOULD PARAMETERS ON THE MOULDING FORCE IN THE DEEP DRAWING PROCESS OF DP600 MATERIAL

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ABSTRACT: The goal of this study is to determine the suitable die parameters which are used to shape the high strength sheet metal before die production, and to design and produce proper dies using these parameters and get cups with desired production quality economically.
In this study, the parameters affecting the deep drawing process were experimentally investigated. The experiments were carried out by using samples drawn from high-strenght DP600 quality of 0,9 mm thick. All the experiemnts were realized by using Hounsfield tension-compression test device. The effects of the die radius (2,3,4 and 6 mm) punch curve radius (2,3,4 and 6 mm), punch velocity (60, 150, 250 and 350 mm/min) and lubrication (without lubricant, stretch film and mineral oil) parameters on the moulding force were investigated. It was observed that the sheet material was wrecked in small die radius. Furthermore, it was observed that molding force decreased when the punch velocity and die radius increased. The same relationship was determined when the present lubricant is replaced with other oil. The smallest molding force was obtained when strech film was used.

Key words: Deep drawing, metal forming, plate materials, radius of punch.

INTRODUCTION

The drawing process has an important place for cold shaping of plate material. According to the statistical studies, drawing die (60%) and drawing punch (18,8%) are the most effective parameters on the drawing process of the radius (Colgan, 2003).

In drawing dies, various drawing methods are applied according to the process type, size and material. These methods are basically as follows (Güneş, 2005; Simith, 1990);

At the beginning of the drawing process with hold-down force, a certain force is applied to the lamella by the compression plate and the plate which will be drawn is jammed between the drawing die and the compression plate. The aim of this compression is to prevent wrinkles formed during the drawing process. This kind of drawing process is necessary to prevent the wrinkles formed when the thickness of the sheet material is low or the height of pull is high. The elements used for the drawingl with hold-down force are indicated in the figure 1 (Güneş, 2005; Simith, 1990).

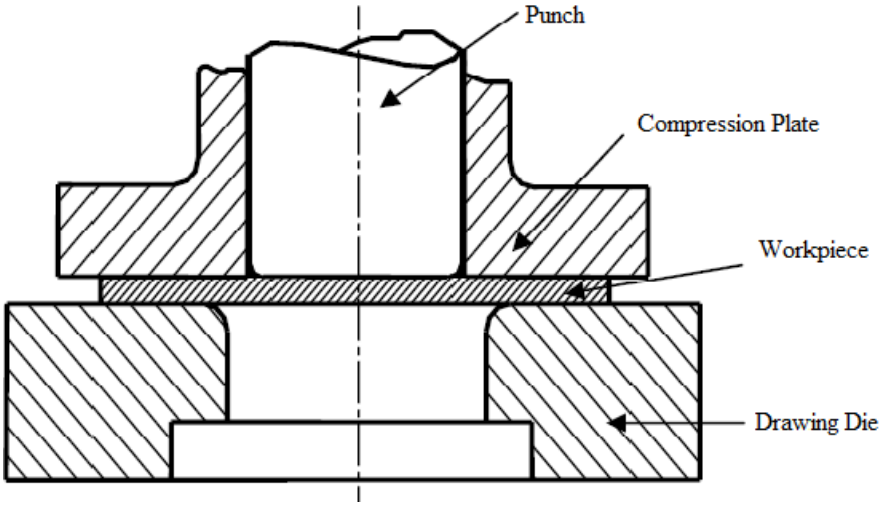

Figure 1. The Basic Elements Used For The Drawing Process With Hold-Down Force (Simith, 1990).

The operation order of the drawing with compression plate is indicated in Figure 2.

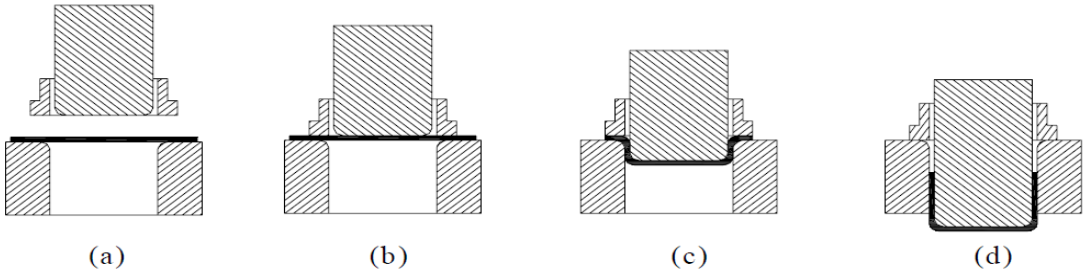

Figure 2. The Pull Operation With Compression Plate (Güneş, 2005).

The position of the sheet material
The apply of compression force
The beginning of drawing
The end of drawing
Various experimental studies were done to determine the effects of the mould parameters (drawing die curve, punch curve, feed rate and lubrication) affecting the forming of during the deep drawing process of high-strenght plates used more in

our day. At the end of the experiments, the suitable mould parameters are determined fort he moulding of high-strength plates.

The sheet Material

In this study, the DP600 quality plate of 0.9 mm, which has been used on new generation automotive parts and parts which require high-strenght (security and safety) was used . The characteristics of the sheet material used in this study are indicated in table 1.

Table 1. The Characteristics Of DP600 Quality Plate Material

Element	%	Element	%
Carbon (C)	0.086	Silicium (Si)	0.356
Mangan (Mn)	1.455	Aluminium (Al)	0.028
Phosphorus (P)	0.023	Copper (Cu)	0.018
Sulphur (S)	0.007	Niobium (Nb)	0.001
Mechanical Properties			
Tensile Strength		620 MPa	
Yield Strength		400 MPa	

METHODS

For the deep drawing methods, round plate material of 32 mm, 35 mm and 40 mm diameter were used. Thedrawing rates for the primitive lamella diameters are indicated in table 2. The compression plate, drawing die mould and surface roughness of drawing punch are indicated in table 3.

Table 2. Experimental Sample Diameters Depending On Draw Ratio (B)

Plate Diameter (mm)	Draw Ratio (β)
32	2
35	2,18
40	2,5

Table 3. Compression Plate, Drawing Die And Surface Roughness Of Drawing Punch

	Ra, µm	Rz, µm	Rt, µm
Compression Plate	0,3595	2,2725	3,3335
Drawing Die	1,7391	7,9981	8,4045
Punch	1,7439	10,5855	12,3372

Test Conditions

They were negative for all the mould parameters in the pull operations carried out for the 35 mm and 40 mm lamella diameters and all the drawed vessels were torn. The limit draw ratios of the high-strenght plates were not above 2 (Bozdok, 2008).

Therefore, the plate material of which lamella diameter was 32 mm was used in the tests. The test samples were prepared on eccentric press machine by using cut mould. The hold-down force (see figüre 3.) was 4378 N. The pulling force was counted as 29462 N. The single sided contraction cavity was counted as 1,11 mm and it was 1,15 on the mould manufacturing. The drawing die cavity was counted as 2,08 mm and the drawing die cavities were 2, 3, 4 and 6 mm. The feed-rate for these four punches were 60, 150, 250 and 350 mm/mn.

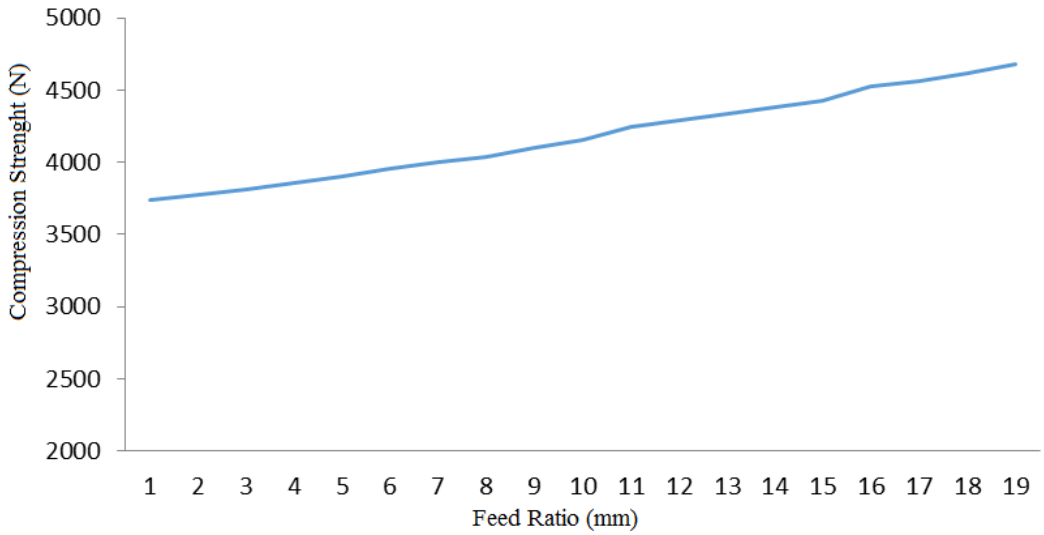

Figure 3. The Change Of Compression Strenght According The Pinch.

RESULTS AND FINDINGS

During the experimental studies, the control movement of the drawing punch and the forces taken place during the tests were recorded and saved on computer. The obtained forces were determined as moulding forces. The products obtained at the end of the tests are indicated in Figure 4.

Figure 4. The Products Obtained From The Experimental Studies

The results obtained from the tests done with cylindrical drawing dies, on DP600 steel plate material, by using different drawing die, punch cavities, lubricants and press speeds were interpreted.

The Effect Of The Feed Rate Of The Punch On The Moulding Force

The effects of the feed rate of the punch on the moulding force for DP600 plate material on the drawing die are indicated in Figure 5.

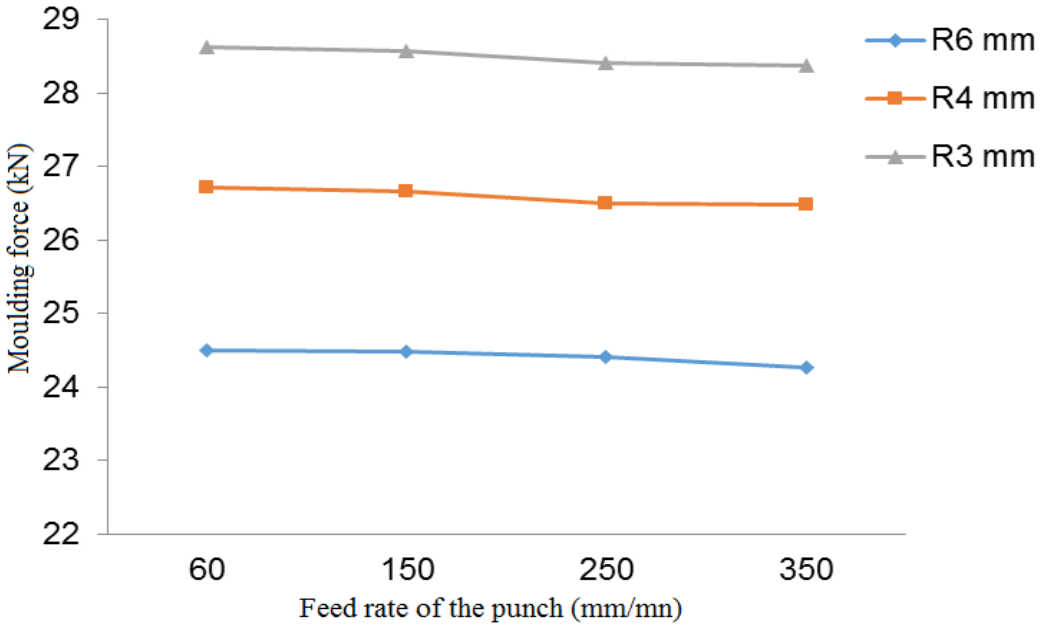

Figure 5. The Effect Of The Feed Rate Of The Punch On The Moulding Force For DP600 Plate

The drawing tests done on DP 600 material without lubricant showed that there was a decrease in the moulding forces when the feed rate of the punch increased. The highest moulding force was 28630 N for the drawing die of 3 mm and punch cavities and the lowest moulding force was 28350 N. The highest moulding force was 26710 N for the drawing die of 4 mm and punch cavities and the lowest moulding force was 26480 N. The highest moulding force was 24510 N for the drawing die of 6 mm and punch cavities and the lowest moulding force was 24270 N.

The Effect Of The Lubrication On The Moulding Force

The effects of the lubricants on the moulding force for the DP 600 sheet material at different punch feed rates on drawing dies are indicated in Figure 6.

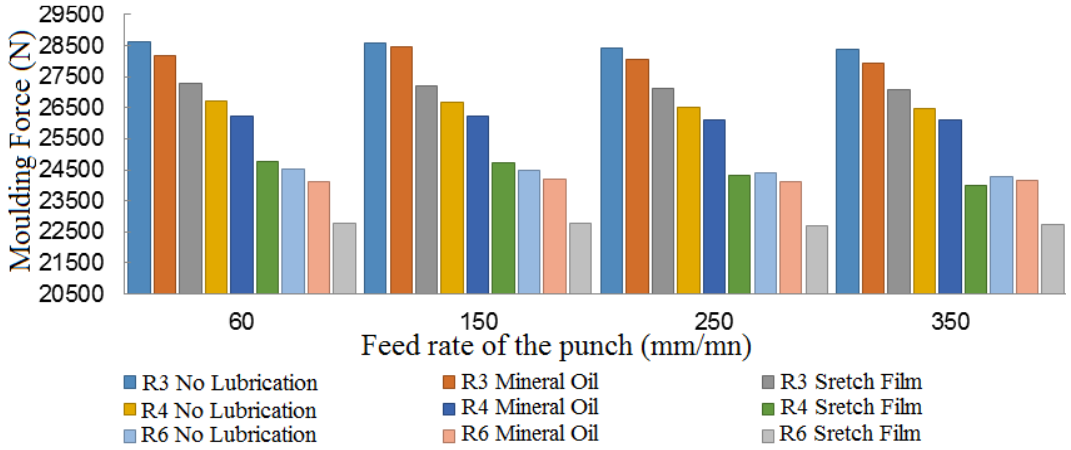

Figure 6. The Effects Of The Lubricants On The Moulding Force For the DP600 Material

When the results obtained from the tests were examined, it was seen that mineral lubricant decreased the friction between the plate material and mould cavity in proportion to the pull operation without lubricant and as a result, decreased averagely the moulding force at 1.7%. The strech film became more effective in decreasing the moulding force and it decreased the moulding force averagely 7,4% (Park and et a, 2002).

Lubrication decreases the moulding force. Dry film lubrication decreases effectively the moulding force (Allen, 2008; Kim, 2007).
The Effect Of The Feed Rate Of The Punch On The Moulding Force Depending On The Punch Speed

The 3 different die mould (3,4 and 6 mm) and punch cavity values were used in the tests. The mould cavities have important effects during the plate material's flux into the mould cavity. For a successful drawing, suitable mould cavities will be useful.

The effects of the drawing die and punch curve values on the moulding force of the punch feed rate for the DP 600 material are indicated in Figure 7.

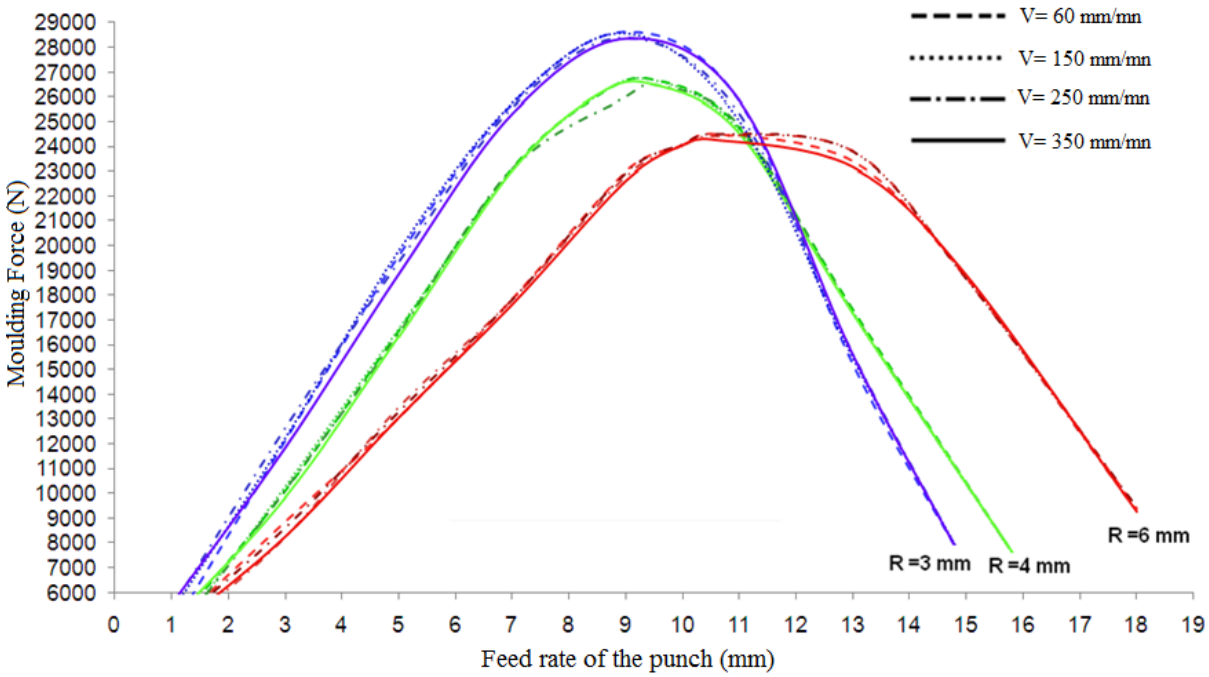

Figure 7. The Effect Of The Punch Feed Rate On The Moulding Force For The DP 600 Material

It was seen that there was a decrease in the moulding force when the drawing die cavity increased. The lowest pull force was on the mould cavities of 6 mm. It was also seen that there was a decrease when the pulling speed increased.

CONCLUSION

After having examined DP 600 sheet material experimentally, it can be inferred that its usage especially in automotive industry in a widespread manner will save up energy and fuel economy considerably since it is light and has high-strenght characteristics; as a result, since fuel consumption decreases, harmful substances will decrease in the environment.

Limit draw ratio in the shaping of high-strength sheets doesn't go beyond 2.
There has been a tearing in the drawing die of 2 mm and curve radius of drawing punch, in all the mould parameters when sheet material was used. The drawing die curve radius of 2 mm and the curve radius of the drawing punches are insufficient in shaping high-strength plates of 0,9 mm.
It was seen a decrease in the moulding force during shaping the part when the curve radius of the mould increased.
It was found that the drawing die radius was more effective than the punch radius to decrease the moulding force.
Increasing the feed rate of the punch didn't change the moulding force but it was seen a slight tendency of decrease in the moulding force.
The lubrication with strech film decreased the moulding force significantly.

RECOMMENDATIONS

The compression plate force and the effects of drawing cavity can be studied. This study was done with cold shaping. Another study can be done with warm and hot shaping. The effects of profile and rolling direction on the drawing process can be studied by using more different drawn profile. High-strenght materials of different thickness can be studied by using this method. The test results can be compared by using analyse programmes and suitable moulding parameters for different materials can be determined.

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