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ANALYSIS OF THE COLD FORMING PROCESS

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ABSTRACT

This paper presents an investigation on the influence of the cold forming process parameters on the quality of the part to be formed. The computational model of the formation process was created in order to investigate how the quality of the part is affected by the blank holding force, matrix radius and friction coefficient. Computational simulations based on the finite element method (FEM) were performed and the most reasonable parameters values were found.

Keywords: cold forming, thinning, wrinkles, springback, blank holding force.

INTRODUCTION

Manufacturing of parts by forming is a very effective process distinctive with low material losses and very short manufacturing time as the part can be made by one press cycle. In many cases, the thinning and possible springback determine the quality of cold formed parts. The thinning is an important parameter affecting the strength of the part. Also, due to the extensive thinning, the part might crack while being formed. Therefore, it is important to determine the most suitable values of the cold forming parameters before manufacturing the die.

Padmanabhan et al. simulated the forming process of a stainless steel cylindrical cup and analysed the influence of three parameters on the part quality (Padmanabhan, 2007). The analysis showed that the matrix radius has the highest influence, the second contributor was the blank holding force and the third was the friction coefficient. The optimum process parameters were determined based on their influence on the thickness variation at different regions of the blank material by experimental study for AA6111 aluminium alloy (Reddy, 2015). It was found that in this case the blank holding force has the highest influence. A simulation of single point incremental deep drawing process for truncated pyramidal 304 stainless steel cups showed that the step depth and tool radius are highly influential in controlling the formability of the cups (Kumar, 2016).

The objective of this paper is to determine how the quality of the part is influenced by the blank holding force, matrix radius and friction coefficient.

SIMULATION AND RESULTS OF THE COLD FORMING PROCESS

A numerical model of the cold forming process of a cover made of stainless steel type 1.4301 for a beer barrel was created using AutoForm software. Formability of the part is shown in Figure 1. The red coloured areas indicate possible material splits, the blue coloured - possible wrinkles.

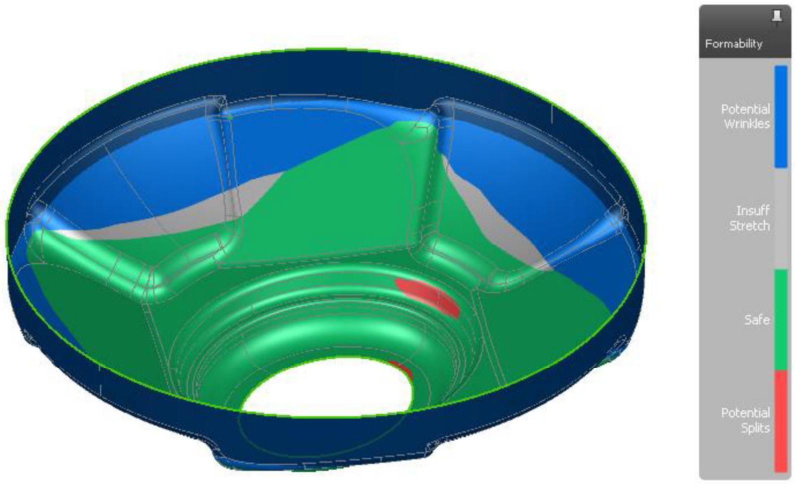

Fig. 1 - Formed part

The simulation results are shown in Figure 2. The analysis showed that the minimum parts thickness is inversely proportional to the blank holding force. The part thickness is the lowest (0.74 mm) when the blank holding force is the highest (250 kN). The holding force does not have such a significant influence on the wrinkles height. The possible form deviation has a tendency to get higher when a higher blank holding force is applied.

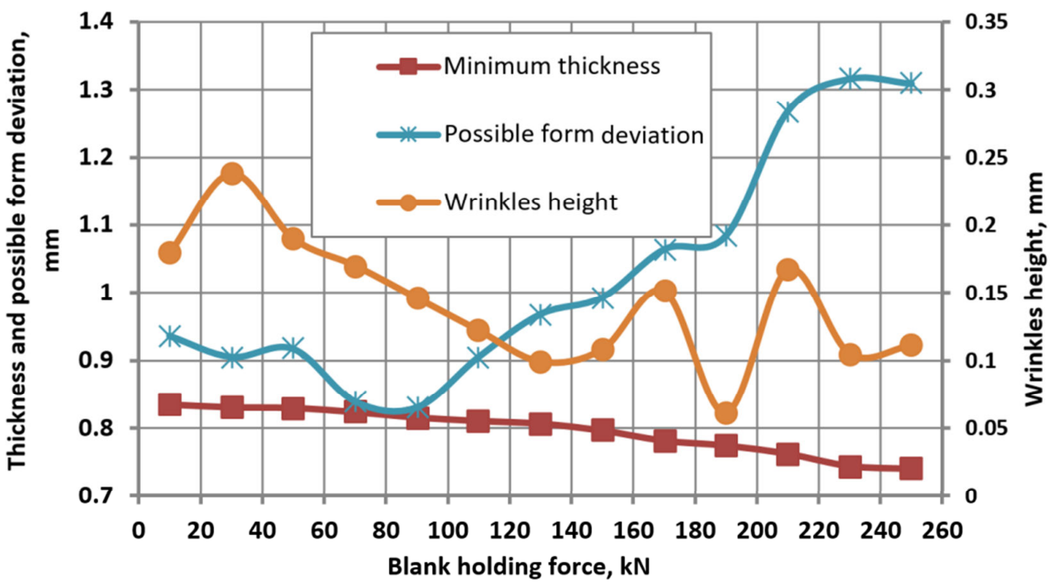

Fig. 2 - Minimum thickness, possible form deviation and wrinkles height depending on the blank holding force

The minimum thickness, possible form deviation and wrinkles depending on the matrix radius are shown in Figure 3. When the matrix radius is 18 mm, these values drastically increase. This happens because such a high matrix radius does not hold the blank properly, the wrinkles become high and the metal bends over itself. Then the forming punch goes deeper into the matrix and double sheet areas are formed. Therefore, the value of 18 mm is not suitable for further usage.

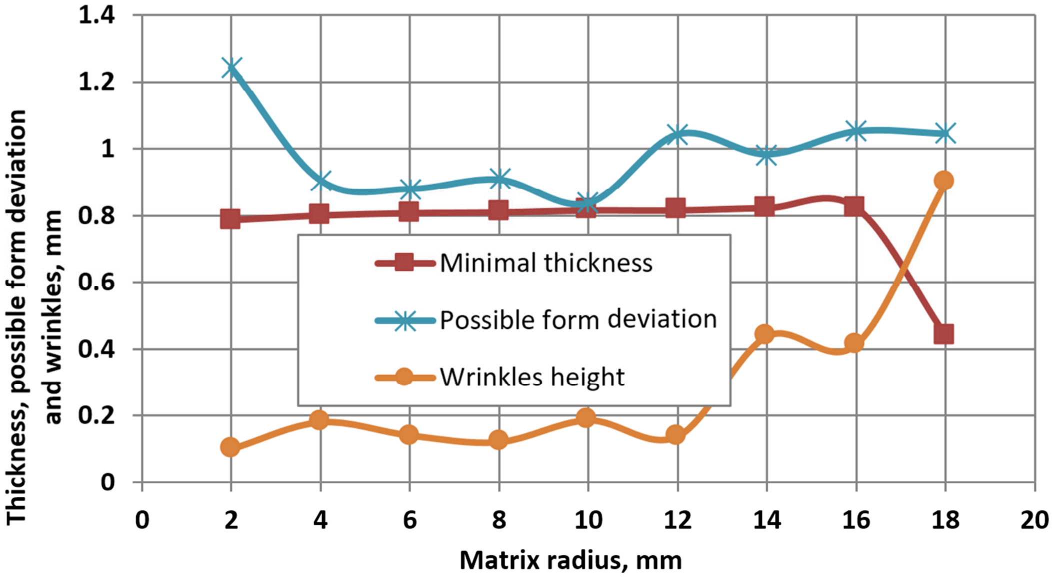

Fig. 3 - Minimum thickness, possible form deviation and wrinkles height depending on the matrix radius

The analysis showed that both the minimum part thickness and the wrinkles height are directly proportional to the matrix radius The possible form deviation has the lowest value (0.84) when the matrix radius is 10 mm. The minimum thickness, possible form deviation and wrinkles height depending on the friction coefficient are shown in Figure 4.

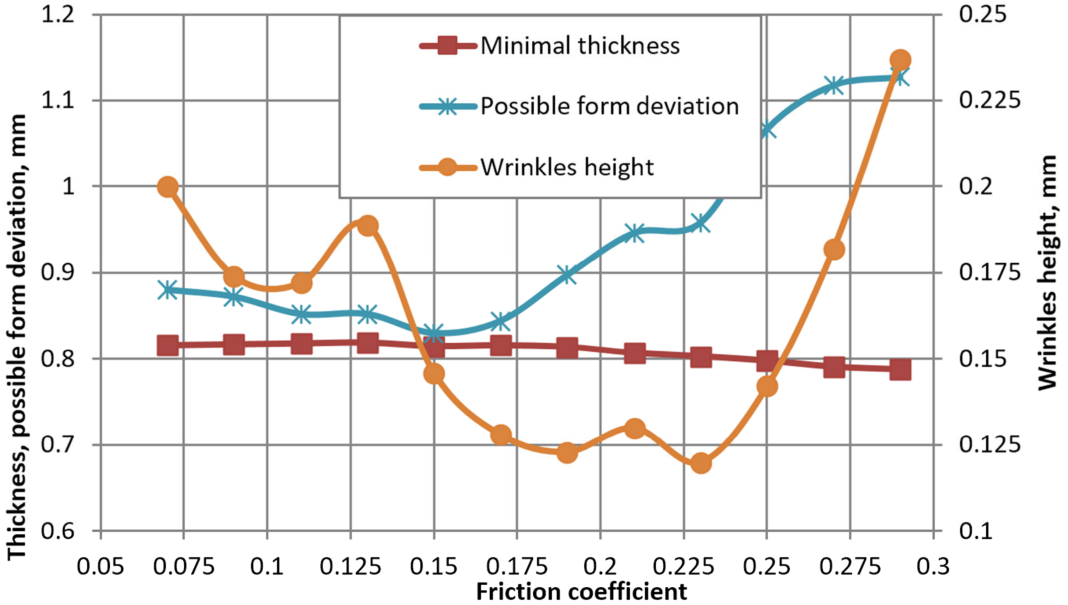

Fig. 4 - Minimum thickness, possible form deviation and wrinkles height depending on the friction coefficient

The analysis showed that the minimum parts thickness is inversely proportional to the friction coefficient. The part thickness is the lowest (0.79 mm) when the friction coefficient is the highest (0.29). The blank holding force does not have such a significant influence on the wrinkle height. The lowest values of the wrinkles height are when the friction coefficient is between 0.17-0.23. The possible form deviation has a tendency to get higher when a higher friction coefficient is used.

CONCLUSIONS

It was found that the minimum part thickness decreases when the blank holding force is increasing. The results suggest that the most suitable blank holding force is 90 kN as the possible form deviation is the lowest and the minimum thickness is over 0.8 mm. The part with the best quality parameters is produced with these parameters: the matrix radius of 10 mm; the blank holding force of 90 kN and the friction coefficient of 0.17.

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