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Numerical and Experimental Investigation of the Effect of Parameters in Shear Spinning Process of a Conic Sample

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ABSTRACT: Shear forming is a kind of spinning process which is used for manufacturing of the components that have a high weight to strength ratio. In this paper, the main parameters for manufacturing of a constant thickness conic shaped specimen have been extracted, using shear spinning process. To this regard a pre designed pre-form was used to improve the efficiency of the shear spinning process of the conic sample of this study. So, the main parameters of shear spinning of this specimen are derived using experimental and numerical tries. These parameters include mandrel rotational speed, roller feed rate, tailstock pressure and friction ratio. To this regard, the optimized efficient parameters were extracted and the obtained data has been compared and validated with the experiment. Moreover, a new cup shaped preform has been used. Using of this preform can beneficially improve the quality of the final shape of the specimen. With comparison of the results of the experiments and numerical study, the optimized efficient forming parameters of the offered preform have been derived. It was observed that using of the designed preform will cause in better cone part specifications due to its close dimensional and geometrical specifications. It was shown that the proposed method can beneficially lead to better results in the shear spinning process.

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1. Introduction

The shear forming process is a special form of rotary shaping in which the cross-sectional area of the piece changes during the operation and hence can be used in making variable-thickness parts [1]. In the following, a schematic representation of this process is shown in Fig. 1.

Due to the multiplicity of parameters involved in this process, these parameters should be thoroughly investigated and optimized in order to obtain the appropriate product precision [2]. The most important parameters affecting this process are [3]:

- The shaping tool geometry
- The initial thickness of the sheet
- Material type and geometry
- The precision of installation and alignment of rollers
- The angle of attack and the angle of the shaping tool
- Preformed geometry (geometric shape preformed before shaping)
- The type of lubricant used and its temperature
- Thickness distribution in sheet or preform

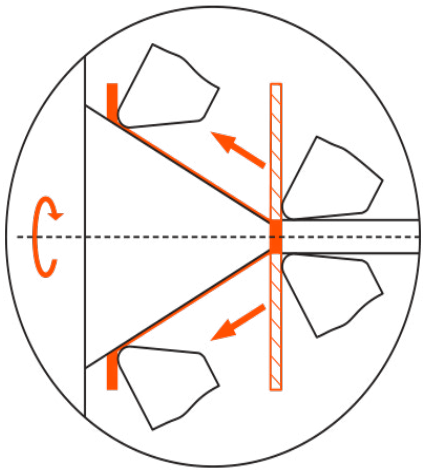

Fig. 1. Schematic of shear forming process

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The main purpose of this research is to investigate the creation of an initial preform for the production of samples to improve parameters and production conditions, as well as the final precision in terms of geometric parameters. To this regard, verified finite element model has been used to investigate some of the shear forming parameters.

2. Methodology

For the experimental design, the specimen of the cone sample was determined from a high purity copper grade. First, the raw material of the flat sheet and then the pre-designed form was used. For the experiments, required components of forming mechanism such as forming rollers and mandrel were designed perfectly. After designing and manufacturing the components, the parameters of the forming machine should be adjusted to create the desired sample. The most important parameters in this section are the mandrel rotational speed and the progression of the shaping tools.

According to the results of preliminary experiments in the production of similar components, the mandrel rotational speed was measured in three zones of 195, 340 and 420 rpm and progress rate in three ranges (0-100) , (0-150) and (0-220).

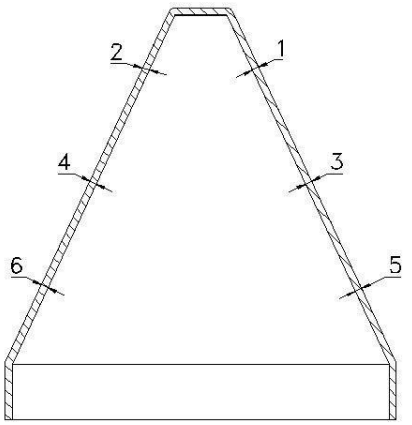

Fig. 2. Measuring points of the wall thickness in produced samples

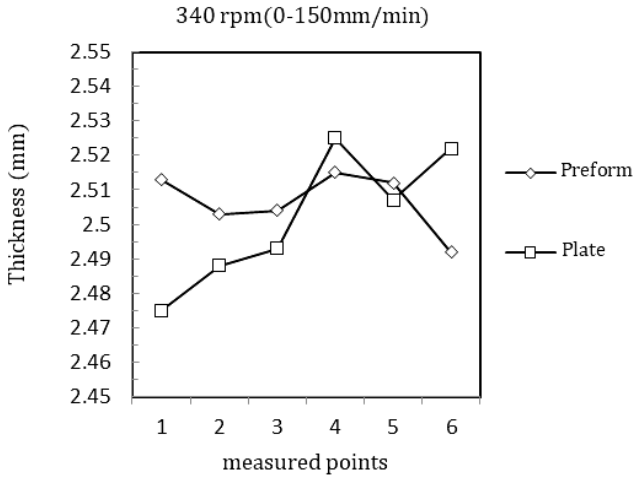

Fig. 3. Variations of the thickness in the both plate and preform shaped samples

The accuracy of the results of the experiments should be compared with the results of the simulations. So, some parameters should be considered for measurement, which can be measured in simulation software. Because of the possibility of accurate measurement of the wall thickness of the cone in different sections, measurements were performed at six points of the cone edge in accordance with Fig. 2 and the results were compared in terms of the graphs.

Due to the shape of the fragment and its high sensitivity as well as the final packet tolerances, a non-destructive ultrasonic measuring instrument is used to determine the thickness of the shell in different regions. By examining the final desired shape of the conic, optimum Rotational speed of the mandrel was selected as 340 rev /min and optimum progression of the shaping tools as 150 mm /min.

To study the effects of using a preform instead of a sample sheet, a pre-designed preform was used to form the final specimen in addition to the simple specimen.

3. Results and Discussion

To measure the uniformity of the produced parts, six points were measured. A closer look at the graphs obtained from various speeds and tool advances, shows that at three speeds with a progression of 150 mm /min, the results are almost the same. It also has been observed that due to the completion of the continuous process on a flat sheet forming, modification of the flat sheet to a pre-formed sheet can beneficially reduce the percentage of changes in the thickness of the piece.

Regarding to the final dimensions of the designed components such as preforms, plain blanks, mandrels, pins, rollers and birdies, the finite element modeling of the process was performed using ABAQUES software. In this manner, some other researchers used numerical simulation to model shear spinning process [4]. After performing simulations and according to the measurements of the thickness of the conical edging wall of the simulated piece, in both the flat panel and the preformed application, the thickness was in the acceptable area, but the wall thickness in the preform has a less dispersion relative to the flat sheet as is shown in Fig. 3.

By examining the parameters, it is shown that with increasing speed of rollers from 100 to 150 mm /min at a constant rotating speed, the internal rigidity values fall from 0.087 to 0.017 and the outer rigidity from 0.118 to 0.0.03 mm. In such a situation, the spring back values of the internal angle have dropped from -7 to zero to a maximum of +1. This reflects the fact that with the increase of the above parameter, the material is more fluid than the pinnacle and has been improved.

It also has been observed that the speed of the shaping tool has a little effect on the straightness of the cone.

4. Conclusions

In this paper, shear spinning of a conic sample was investigated. To study the effects of the main effective parameters, experimental tests and numerical analysis was performed. According to the results, the following conclusions can be pointed:

- Using a pre-formed shape sample instead of a sheet block can be beneficially improve the final quality of the conic product
- The optimal mandrel rotational speed to form the conic sample presented in this study is 340 rev /min.
- A verified finite element model can be used to predict the thickness variation in the presented sample.
- The roller bearing radius, attack and scape angle was derived as 4 mm, 47 ° and 24.5 ° respectively to reach the best production conditions.

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