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Designing, manufacturing and processing of Tailored Blanks in a sheet-bulk metal forming process

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Abstract

Sheet-bulk metal forming is an innovative method for the manufacturing of functional components by applying bulk metal forming processes or combined sheet and bulk metal forming processes to sheet metal. The investigated process combines deep drawing and upsetting. Occurring 2D and 3D stress and strain states lead to challenges regarding the material flow control during the forming process to ensure a high die filling and accurate part geometry. Regarding these challenges, the application of conventional semi-finished products is not expedient wherefore Tailored Blanks with a process adapted sheet thickness distribution are applied to the forming process. The Tailored Blank geometry is designed by a numerical analysis and manufactured by an orbital forming process considering the resulting geometric part properties during deep drawing and upsetting. Therefore, the whole process chain from the conventional circular blank to the finished functional component is linked and modelled. This enables a realistic description of the part properties as the effective plastic strain caused in the manufacturing of semi-finished products is taken into account in the processing of the material. Subsequently the results are verified by experimental tests.

Keywords: Deep drawing, Finite element method (FEM), Sheet metal, Forming

1. Introduction

Due to legal and social changes pushed by the society, reducing carbon dioxide emissions and resource consumption play a decisive role in industrial research and development. Focusing on more efficient products and

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processes recently is seen as a key capability recently. Particular the automotive industry was affected by these radical changings. Road Traffic causes 26 % of all carbon dioxide emissions in the European Union [1]. Hence the EU adapted regulations to limit carbon dioxide emissions for cars in 2009. By 2020 the average of the fleet of cars of every carmaker has to be lower than 95 g/km [1]. This leads to intensive research in several sectors. A way to reach the mandatory regulations is downsizing the car engines, which combines lightweight construction and reduction of gas consumption. Downsizing increases the loads on power train components what makes their production even more complex. This development makes complex and thin-walled elements, such as synchronizer rings necessary. Realizing that producing more efficient components with conventional forming processes turns out to be complicated, innovative forming processes need to be developed to reach its requirements. [2] To enhance process boundaries a combination of sheet and bulk forming, so-called sheet-bulk metal forming (SBMF) can be deployed. SMBF combines the advantages of both forming classes [3]. During forming with SMBF a 3-dimensional tension appears inside the parts and sheets with thickness between 1 – 5 mm can be formed [4]. Using SBMF enables new paths in realizing novel component geometries and further has several advantages, such as increasing the number of integrated functional elements, reducing the length and increasing the robustness of process chains. For example the production of a synchronizer ring can be realized with SMBF in a single forming step and long process chains are not necessary any more. A SMBF process can consist out of sheet forming process deep drawing and bulk forming process. This technique makes it possible to form cups in a single step with several functional elements. [5] Caused by lacks of know-how further investigations, especially to inquire material flow during the forming process, are necessary as these processes have proofed its potential in proceeding investigations.

2. Part properties and forming concept

In this section an overview of the part geometry, the forming process, the modelling and methodology is given to provide the necessary information for the investigation and discussion.

Geometric dimensions of the functional component, set-up and modelling of the forming process

The investigated demo part is a cup with a circumferential external gearing. Figure 1-a) shows the part geometry with the geometric dimensions. The gearing has 80 teeth with a flange angle of $\alpha = 90°$ each. The outer diameter of the cup amounts to $d_o = 82.72$ mm and the inner diameter amounts to $d_i = 75.5$ mm. The height of the cups depends on the geometry of the semi-finished product and on the forming force applied to the modular tool concept. The tool concept consists of an upper tool with internal geared drawing die and upsetting punch and a lower tool with upsetting plate and drawing punch as presented in Figure 1-b).

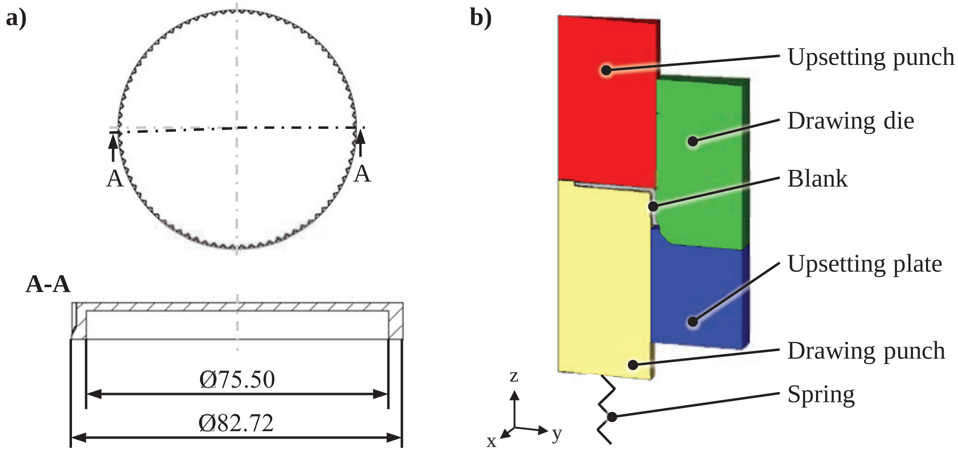

Figure 1: Part geometry (a) and process set-up (b)