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ScienceDirect

Procedia Engineering 136 (2016) 137 – 142

Procedia Engineering

www.elsevier.com/locate/procedia

The 20th International Conference: Machine Modeling and Simulations, MMS 2015

Metallographic and finite element evaluation of plastic deformation during the forming process of cartridge brass casings

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Abstract

The main objective of this paper is connected with computational modeling and metallographic investigation of the production process of cartridge brass casing for various stages of its forming. Moreover, the mutual correlation of the obtained results was carried out. Forming process belongs to the most advanced technologies in mechanical engineering because it allows producing a large number of products in a short time with sufficient material utilization. Geometric and computational modeling of the individual drawing steps was performed in program MARC which is used for the calculation of cold forming process for metal materials. The given program is based on solving of nonlinear finite element analysis. The aim of the computer simulation was to determine the deformation changes in the semi-product material for individual drawing steps and it is especially connected with changes of dimensions and areas with the largest plastic deformation as well as decrease of the wall thickness. Metallographic evaluation was focused on change of the shape and size of grains after the individual technological procedures.

Peer-review under responsibility of the organizing committee of MMS 2015

Keywords: cartridge brass casings; forming process; plastic deformation; metallographic evaluation; finite element evaluation

1. Introduction

Forming process is a technology relating to the change of the shape and properties of material by application of external forces with the resulting permanent deformation of material [1, 2]. The new properties which were obtained are possible to be changed. In relation to the technological forming processes, the unique property of the material is

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Peer-review under responsibility of the organizing committee of MMS 2015
doi:10.1016/j.proeng.2016.01.187

used and this property is called plasticity. Plasticity enables to the change the material to required shape by influence of external forces. Plastic properties of metal materials can be changed from the aspect of their chemical composition and structural state and they depend on the conditions of the deformation process including temperature, stress state, strain rate [3]. Geometric and computational model of the process significantly reduces the costs relating to operating tests of forming process and allows evaluating of the influence of the forming process on change of the structure. Metallographic evaluation allows us to document the producing process of the cartridge brass casing at various stages of forming process and by this way, the mutual correlation is possible. From the first point of view, the machining process with the occurrence of chips can be understood as one of the best of the possible producing processes of cartridge brass casings considering its shape but nowadays, the mentioned machining process is very inefficient because of its many disadvantages including energy inefficiency, long processing time, high amount of waste and need of additional operations etc. [4] Furthermore, the utilization of the casting process is not a good choice because the required quality and price affordability are not able to be obtained in relation to this production process. Cold drawing is progressive forming method used for the production of cartridge brass casings [5, 6]. This process provides simplicity of tools, machines and high surface quality after drawing. The technology has to be performed by using the interstage heat treatment – recrystallization annealing. This interstage heat treatment significantly influences the final properties of the cartridge brass casing. Graphic simulation of forming process was performed with help of the computational program MARC and metallographic evaluation was focused on changes in the shape and size of grains after the technological operations. This paper describes the production of cartridge brass casing from the semi-product to the final product while the drawing method is used. Experimental part includes geometric and computational model of the forming process for individual drawing steps and Brinell hardness test for comparison of the hardness of the samples before annealing and after annealing. Metallographic evaluation of the samples after individual drawing steps was also connected with the evaluation of geometry and size of the grain.

2. Experiment

Using the shearing tool, the semi-product for the production of cartridge brass casing is produced by preparation of plate with thickness of 3.36 mm and diameter of 20.1 mm. Cartridge brass casings are commonly manufactured from materials known as cartridge brass. In terms of chemical composition, it is a binary brass and its basic chemical composition is usually based on 70% of Cu and 30% of Zn. According to STN EN 42 3210, the chemical composition of cartridge brass is shown in Table 1. The older designation of this material is MS70 [11]. Nowadays, the common or commercial designation is CuZn30. In some countries, CuZn28 brass (Ms72) is also considered as cartridge brass.

Table 1. The chemical composition of CuZn30 brass [11].

Element	Cu	Al_{max}	Fe_{max}	Ni_{max}	Pb_{max}	Sn_{max}	Others	Zn
Content (%)	69.0 – 71.0	max. 0.02	max. 0.05	max. 0.2	max. 0.05	max. 0.05	max. 0.1	residual element

2.1. Numerical simulation of drawing process for cartridge brass casing

The investigated cartridge brass casing is produced on the basis of three drawing steps. Computational modeling of the drawing steps was processed in program MARC which is used for the calculation of cold forming process for metal materials. MARC is based on solving of nonlinear analysis with usage of finite element method. Triaxial nonlinear stress occurs when metallic materials are formed. In relation to MARC, there is the processing of material elements during the calculation while mutual nodal connection is used for these material elements. Properties of forming material are assigned to elements. The material is characterized by its strength properties. The elastic deformation, plastic deformation and yield strength of areas are taken into account in relation to strength characteristics.