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EXPERIMENTAL-NUMERICAL ANALYSIS OF CONTACT CONDITIONS INFLUENCE ON THE IRONING STRIP DRAWING PROCESS

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Results of experimental investigations and physical model were used as the input variables for numerical analysis of the ironing strip drawing process by application of lubricants. The numerical simulation was realized in the specialized applicative software Simufact.forming. By applying the software for the 3D modeling, a model of the tool element assembly was made, which served as the starting basis for numerical simulation by application of the Finite Element Method. Experimental values of the friction coefficient for each type of lubricants and the contact pressures were used for defining the contact conditions. Numerical simulation of the drawing process was done for each type of the contact conditions between the tool's elements and the thin sheet sample. The work was based on comparison of experimental values of the drawing forces to numerical values in different contact conditions, with taking into account the appearance of galling because of difficult drawing process conditions. By comparing results of the previously conducted experiment and the numerical simulation, it is possible to interpret what types of simplifications were adopted in creating the experimental physical-tribological model.

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1. INTRODUCTION

Simultaneous modeling of a product and virtual manufacturing, i.e., simulation of the production processes, is applied in early design phases of both the new products and tools for their manufacturing [1]. Significant financial savings are realized and delays in products placing on the market are avoided by application of the physical and numerical modeling [2].

Software, based on the Finite Element Method is used widely for optimization of the process parameters, eliminating the flaws during the material flowing, determination and minimizing the stresses in the tool, etc [3]. Material's behavior during the forming process can be completely predicted by application of the corresponding software in the stress-strain analysis [4, 5]. Analysis and simulation of the real processes can be done on cold and hot, by correction of tolerances between the die and the drawing tool, what directly influences the thin sheet thickness during the forming [6]. In that way, the higher degrees of drawing can be achieved without the appearance of destruction. Similarly, simulation results should lead to optimization of the process, so that the fast and efficient reaction to market needs would be achieved. Thus, for instance, authors of paper [7] have shown that conceiving and design of products can be done in the virtual CA-x environment, without large investments and longtime consumption. After several iterations, by analysis of all the parameters, varying the geometry of the product and the tool, one reaches the optimal procedure, which then can be optimized further. Authors in paper [8] have studied the ironing of austenitic stainless steel cups by the real experiment and FEM analysis. Aim of paper was to quantify the discrepancy (due to tool deformation) between nominal die–punch gap and real final wall thickness. As a result, the states of stress in the cup's wall, during and after the drawing, obtained by the FEM, were compared to results obtained by the analytical model. Since in processes of this kind the friction has the strong influence, in paper [9] is presented in details the procedure for determination of the friction coefficient between the tool and the thin sheet during the strip drawing process, while in papers [10, 11, 12] is presented the experimental results of tribological investigations of specified materials' properties at sliding tests. Since the objective is to achieve resistance as least as possible, and by that the deformation forces in the ironing process, in papers [13, 14] is presented an analysis of lubricants that are used in the multi-phase ironing process. It was concluded that the new group of ecological lubricants possesses somewhat better lubricating properties with respect to conventional lubricants (the zinc-phosphate layer, oil for deep drawing, etc.) [15, 16].

This paper consists of experimental investigations report and numerical analysis of the strip drawing with change of thickness (ironing), with application of the physical and numerical modeling concepts. The experimental part, where the original physical model was developed, had, as an objective, the analysis of application of various lubricants in the ironing process. The purpose of experiment was to test the influence of four types of lubricants on the forming process and to identify the optimal lubricant for the adopted physical-tribological model, in order for the process to be brought to an end