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# Flat Die Sliding Model with Variable Contact Pressure in Deep Drawing Process

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**Abstract**

The influence of contact pressure in deep drawing processes is the current research subject related to sheet processing technology. Within this research, a tribological model was developed based on the flat die sliding process between contact surfaces under variable pressure during the process, and an original experimental computerized device was made for this purpose. A complex multi-factor experiment was performed, using an Al alloy and contact elements of varying roughness, various lubricants and variable contact pressure during the process. In addition to the description of the machinery, this paper also presents the way in which theoretical variable contact pressure dependencies were determined. Based on the predefined, theoretical pressure variations for each of the conditions mentioned here, real contact pressure was obtained. Based on this, it was possible to determine the effect of tribological factors on real pressure. Obtained real contact pressure shows the reliability of the experimental machinery, i.e. the degree of present deviations of theoretical pressure dependencies from the real ones.

**Keywords**: flat-die test, deep drawing, tribological model, variable contact pressure

## 1. INTRODUCTION

The possibilities of affecting the process of deep drawing during its duration are limited. They are reduced to the effects on the sheet edge, typically through contact pressure (holding force) and due to effects from tensile anchors of the support. Typically, in today's research, values of the holding force or support pressure were adopted as constant in the case of deep drawing tools. Continuous defining of variable pressure using predefined functions, during the sliding process and the development of the corresponding physical model represents the subject of this study, with the aim to include the influence of variable contact pressure during the deep drawing process, in addition to other corresponding effects (tool, contact conditions, material, etc.). The influence of variable contact pressure during the deep drawing process represents a current topic in the field of discovering the possibilities of management of this process. For this purpose, physical-tribological models are developed, wherein sheet strip sliding between two flat contact surfaces is typically applied, as can be seen from various relevant [1-5] papers. In the aforementioned papers, the issue of modelling a deep drawing process for sheet edges between flat contact surfaces of the support and the matrix was discussed. Tribological models were formed in a totally realistic environment, in terms of materials, tools, machinery, contact conditions, etc. Most of the research monitors the change in the friction coefficient and deformation (pulling) force by varying the above mentioned real conditions under which the process takes place. The contact conditions are, along with the state of tool contact surfaces, achieved by using multiple types of lubricants for deep drawing, as well as by using sheets with various coating (Al and steel sheets). In addition, it is possible to vary the sheet siding speed [6, 7]. The goal of these researches is to manage the output parameters of the deep drawing process with a tendency to obtain deformation force and friction coefficient values that are as low as possible. On the other hand, desired geometry without edge defects (ripples) should be achieved as well [8-10].

## 2. TRIBOLOGICAL MODEL AND EXPERIMENTAL SETUP

### 2.1 Tribological model

Deep drawing of parts with complex geometry is followed by a number of relevant parameters. Thus, this process is one of the most complex and demanding in plastic shaping technology. For better understanding of this process, the principle of physical modelling of characteristic zones of a complex part is applied (fig. 1a), which represents the basis for complete tribological modelling [11]. Sheet sliding (drawing) between flat support and matrix surfaces (model "A", fig. 1a) corresponds to zones which are not subjected to tangential compression, but only to radial tension.