THE ANALYSIS OF PRESSED PARTS DEFORMATION ON SMALL RADII

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Abstract

The article deals with the evaluation issue of deformation in the sharp radius of the pressed parts. In theory deals with the stressed states and deformation of the molded body and then with the methods of their evaluation using deformation networks and numerical simulations. The obtained results are verified by microscopic observation of the measured sites of pressed parts.

Keywords: sheet metal forming, stamping, deformation analysis, numerical simulation, deformation meshes

1. INTRODUCTION

The modern automotive industry is characteristic of tendency maximizing quality of ended body parts cars, while reducing production costs and fulfilment of capacity plans. For this reason, great emphasis is placed on efficiency, speed and minimum wastage of manufactured parts. Bodywork parts are due to the influence of current trends comprise highly complex shapes with a large number of edges with small radius of curvature, and wherein the use of high quality raw materials originate considerable complications during the entire stamping process.

The main problem in the manufacture of automobile body of sheet metal forming is the formation of considerable deformation required to achieve the desired shape of the blank. Localities with sharp radii are characteristic peaks reached magnitude of deformation and not the total strain. Objective evaluation of strain in these areas is often impossible. There are large defects, which may cause defects in stamping parts, due to the overall deformation of the material, especially this could be a material breach of the formation of cracks. Three-dimensional analysis of deformation in these areas are much more difficult, because the strain commonly used network standard size and spacing of the elements is not sufficient enough to cover the measuring point so that a correct determination of maximum deformation.

The issue of strain on small areas is well know, the area has to be described with sufficient number of elements, if the analyzed strain has to be described with sufficient accuracy. However, for small analyzed areas there is problem with creating the measurement network with relatively larger elements and afterwards to its evaluation. The object of this article is to show possibilities of the individual methods of evaluating strains and its accuracy. The analysis was realized on two experiments, on real large - format pressed part (this experiment was limited by the terms of applicable methods for determining the amount of strain) and on model of pressed cylindrical cup (the problematic of producing this pressed part is much simpler than production of large - format pressed part).

2. REALIZATION OF EXPERIMENTS

Two experiments were made for comparison. Experiment 1 was made on the extrusion of the door frame in the areas where there are frequent problems during a stamping process. Experiment 2 was realized on modelling tools cup with a diameter of 46 mm with a height of wall 15 mm. Individual cups differed inner radius R (R0, 5, R1 and R2 mm) between the bottom and the cylindrical wall of the cup.

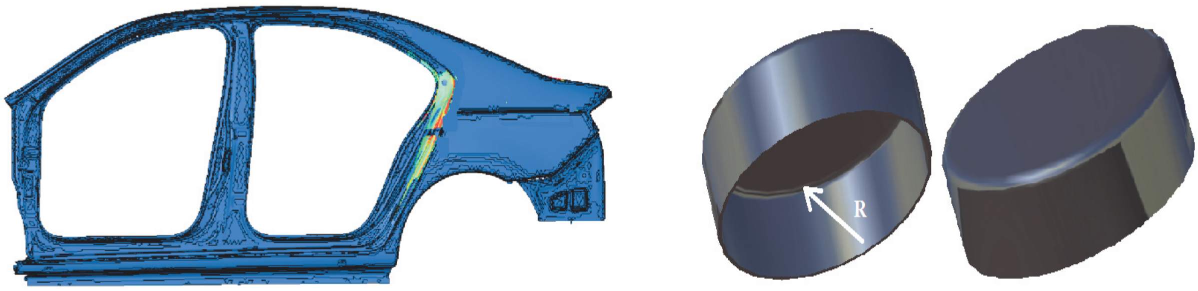


Fig. 1 The frame of car´s door for experiment 1 and test cups for experiment 2

It was used ferritic carbon steel DC06+ZE50/50-B-P-O with a nominal sheet thickness 0.7 mm in both experiments. The corrosion resistance of this material ensures double-side electrodeposited zinc layer. The plate is phosphate treated, oiled and usually comes in rolls for further processing by cutting and dragging. The properties of this material are given quality standard ČSN EN 10152:2009 (**Table1** a **Table 2**)

Table 1 Comparison of mechanical properties of material DC06 specific by standard and measured

Mechanical properties of material DC06+ZE50/50-B-P-O					
	R_e [MPa]	R_m [MPa]	A_{80mm} [%]	$r_{90°}$ [-]	$n_{90°}$ [-]
EN 10152	max 180	270-350	min 41	min 2,1	min 0,21
Measured	136.33	284.67	44.47	2.12	0.238

Table 2 Specified content of the other elements in the material quality DC06

The chemical composition of material DC06+ZE50/50-B-P-O					
C	P	S	Mn	Ti	Fe
max 0.02 %	max 0.02 %	max 0.02 %	max 0.025 %	max 0.3 %	up to 100 %

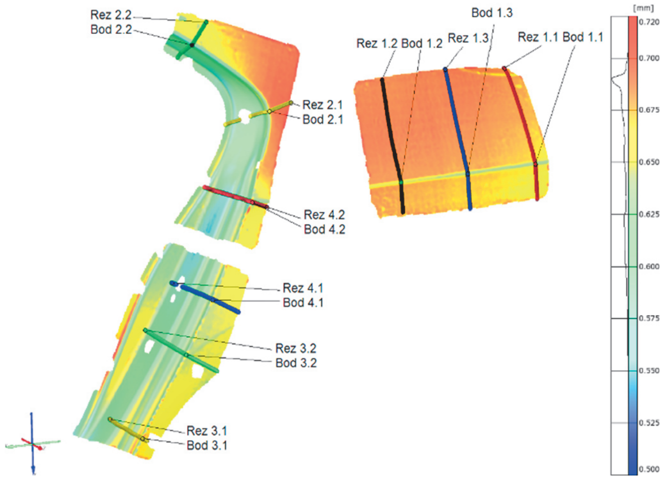
2.1 Description of the experiment 1

It was applied point deformation meshes to degreased surface of sheet with element of diameter of 1 mm and spacing between elements 2 mm. This parameter of electrolytic meshes is commonly used in automotive industry.

With the system TRITOP was created coordinate system for determining the position unambiguous on the deformation meshes pressed for comparison with numerical simulations. Followed standard sensing monitoring surface and determining the amount of deformation in the monitored areas by optical system for evaluating deformation ARGUS. The specified amount of deformation of the ARGUS were recalculated to change the thickness and compared with numerical simulations.

The critical points of each of cut thickness value measured through measurements the microscope metallographic sections. The thinning occurs over a large area, but most of the door lock´s area, where cuts have been selected for monitoring. It was measured the smallest value of the thickness of the material in this places, which was around 0.55 mm (**Fig. 2**). The performed numerical simulations were made out in SW Autoform [2].

The results obtained by measuring the deformation of the mold by using deformation meshes, numerical simulation and the measurement of thickness were compared.



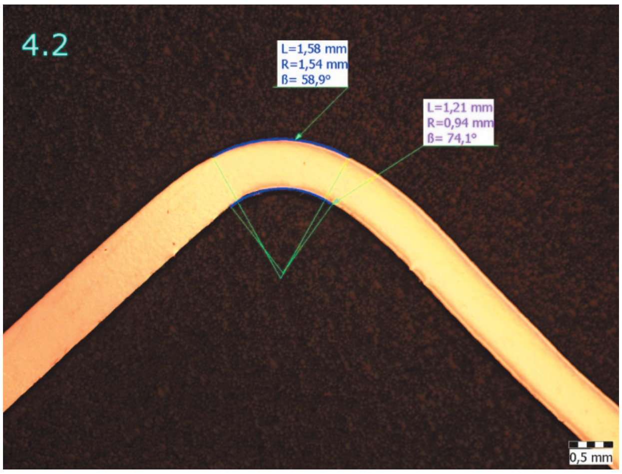


Fig. 2 Analysis of the thickness of the material by SW Autoform

Fig. 3 Size of radius in the cut 4.2

2.2 Experiment 2

The test specimens in the shape of circular blanks were applied deformation meshes by electrolytic method with the same parameters as in the first experiment. For comparison of results were also applied with a labelling laser deformation meshes element with a diameter of 0.3 mm and spacing between elements is 0.5 mm. Machining on press of test samples (**Fig. 4**) was performed on a hydraulic press machine ZM100.

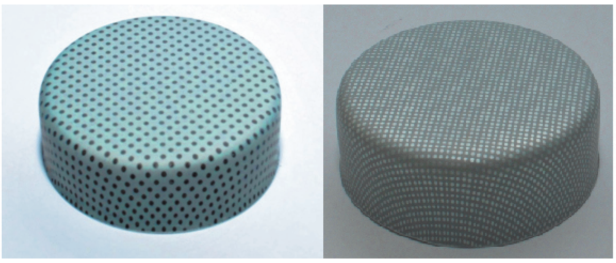


Fig. 4 Test specimens of the cylinder shape with an electrolytic deformation meshes - to the left and laser deformation meshes - in the right

In the evaluation deformation analysis system ARGUS is evident inhomogeneity of meshes caused by a large element of meshes or meshes location relative to the radius (**Fig. 5** left). In contrast, the laser-applied meshes are analyzed deformation finer. The histogram of frequency distribution of deformation is showing in the right part of record, where the largest deformation occurs in the radius between the bottom and the wall.

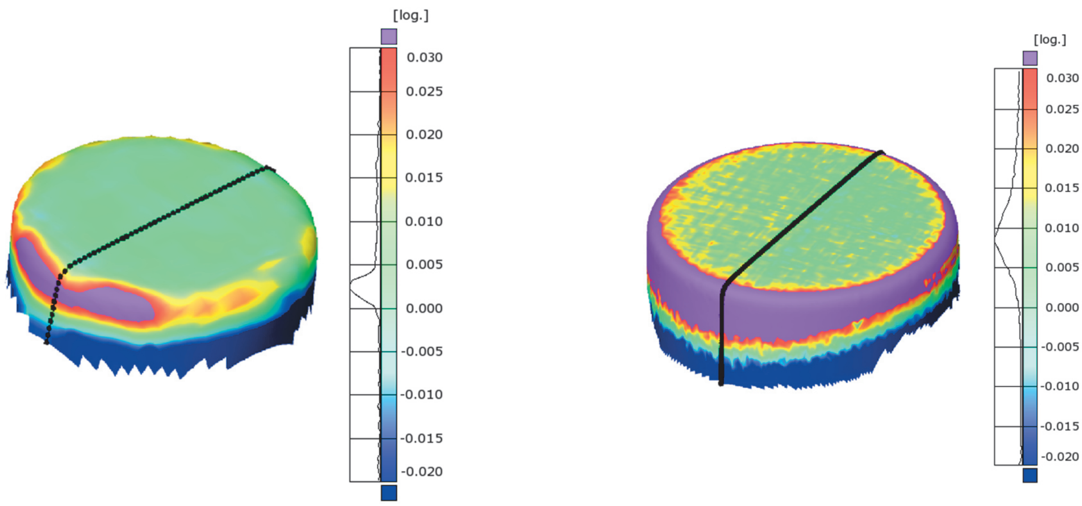


Fig. 5 Comparison of values deformation on laser meshes and electrolytically meshes (R0.5)

For increase the accuracy of numerical simulations were done by scanning drawing tools mobile contactless optical 3D scanner Atos Compact Scan with two cameras. The tools were coated by fine powder of oxide titanium for eliminate glare before scanning.

Fig. 6 shows a colour map representing a comparison of the scanned meshes real draw tool with a CAD model meshes. Both meshes are compiled by method best-fit. The results show that, in some localities the tool was in production tools to shape deviations, which may cause differences in the accuracy of the calculation of numerical simulation.

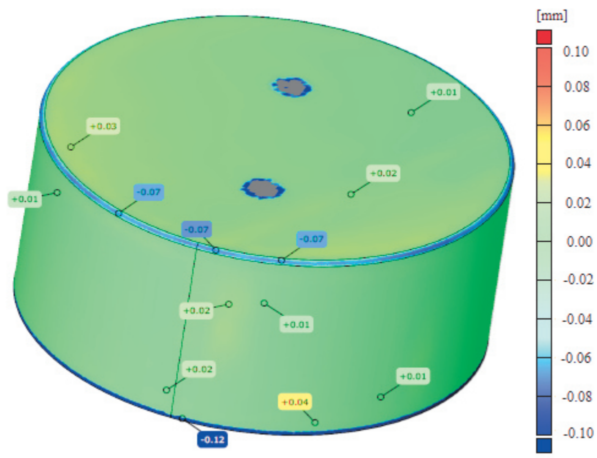


Fig. 6 Dimensional analysis of the punch. The colour map corresponds to the deviation between the CAD model and a real scan tool

The comparison of the deformation results of numerical simulation and CAD data and scanned tools are on **Fig. 7**. This experiment was realized by using software PAM-STAMP 2G. From the acquired data shows, that the influence of manufacturing drawing tools occurs dimensional inaccuracies versus the desired dimensions. Inaccuracies production in all analyzed instruments versus CAD date differs up to 0.1 mm. These inaccuracies may result in unequal of deformation in the circuit the blank.

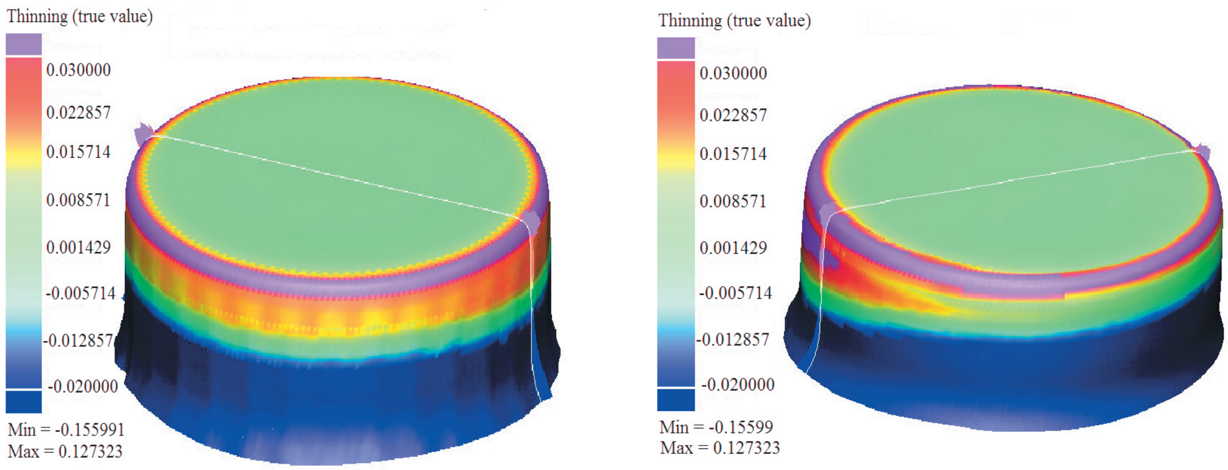


Fig. 7 Comparison of size deformation numerical simulation and CAD data and scanned tools

The deformations for individual radii are plotted in **Fig. 8**. Electrolytically applied meshes on the sample with radius R2 shows the greatest deviation from reality. Both simulation and laser-generated meshes have values close to the real situation. Development of deformation designated by numerical simulation with CAD data is closer to the deformations the designated by microscope. In contrast, the tool scans show differences in the deformation of both sides, which can be caused by manufacturing inaccuracies of tool.

Also at the radius R1 electrolytically applied meshes exhibits the greatest deviation from the reality found by observation on the microscope. It is caused by excessive elements of meshes that fail to adequately quality (a sufficient extent) to describe monitored radius. The difference between the two sides can be caused by the position of deformation meshes toward the radius of curvature. Appears to be the most accurate are numerical simulations.

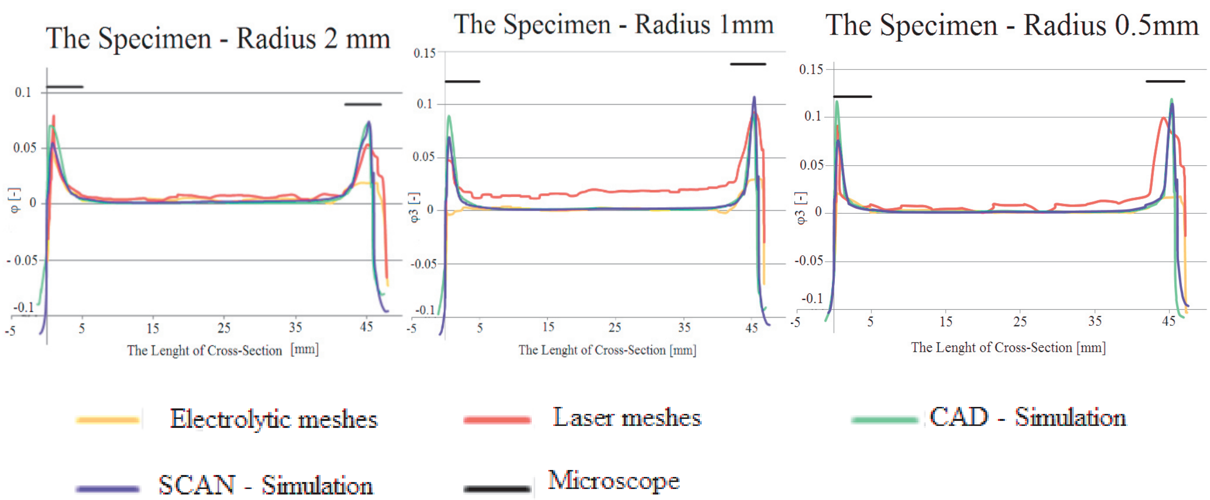


Fig. 8 Size the thinning for radiuses (R2, R1, R0,5)

The electrolytic deformation meshes again showed, that is least precise for samples with smallest radius R0,5, where the deformation meshes didn´t describe radius of drawing tools. The laser deformation meshes may reach precision indicating by numerical simulations.

CONCLUSION

In Experiment 1 made measuring of deformation in selected areas of radius at a selected point using a microscope. The smallest radius of curvature was 0.29 mm. For the comparison was used a standard electrolytic point deformation meshes with element of a diameter of 1 mm and a spacing between elements of 2 mm. It found that this method is difficult to apply the finer deformation meshes elements from previous experiments. [1]. Numerical simulations made by AutoForm software. For comparing the two methods was performed of microscopic thickness measurements on prearranged metallographic sections for the individual cuts observed. They made curves of material thicknesses from results of numerical simulation and true strain for each researched cuts. It is apparent that the numerical simulation versus deformation meshes allows much finer deformation meshes and therefore the curve is more fluent, at the critical point is closer to the reality observed by using a microscope. The measured values of analyzed cuts of material were not close to real values. It made laser deformation meshes with parameter of element - diameter 0.3mm and spacing between elements 0.5 mm. Analysis was performed with tools which has different radius of the tools (0.5, 1 and 2 mm).

On the measured results are clearly visible precision of laser applied deformation meshes compared with electrolytic meshes. Also numerical simulations scans drawing tools appear to be more accurate values and more closer to the real values measured using a microscope. On the contrary, the values obtained from applied electrolytic deformation meshes are inaccurate to real values, as expected.

It appears as a promising solution for precise evaluation of the deformation not only in areas of sharp radii, but also in the areas and negative shapes portable the engraving systems based on the principle of laser marking. These allow the applied deformation meshes not only on the small experimental sample, but is it possible to continuously and with time saving to apply the all surface completely of cut and large parts. The analysis also showed that the numerical simulation can also be used to describe the deformation on small radii, the accuracy of the simulation results are considerably affected by the accuracy of data entered in the calculation, which correspond with the actual stamping process.

ANKNOWLEDGMENTS

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