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INSPECTION OF DRAWN PART USING PHOTOGRAMMETRICAL AND NUMERICAL METHOD

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ABSTRACT: In recent years, significant effort has been invested in improving the accuracy of the formability assessment of parts by various methods. The most significant progress in this area has been observed in the FE analysis, which can provide more and more accurately results. In recent years is also frequently used photogrammetric method in process of inspection and optimization. This paper was focused on these two methods, their application, comparison and results which can influence optimization process. For this purpose, GPS cover made of hot dipped galvanized mild steel DX 52 D was inspected. Simulation was performed in Autoform code which uses static implicit time integration scheme. Photogrammetric inspection was performed using ARGUS measuring system.
KEYWORDS: accuracy, FE analysis, photogrammetric method

INTRODUCTION

The deep drawing process has been increasingly used in recent years in variety industrial fields. This process may be optimized by various methods. These include a numerical simulation of various processes in the preproduction phase or the digital image correlation (DIC) methods in the production phase. Strains, stress states, FLD diagram, thickness reduction over the sheet thickness etc. can be determined using DIC methods. For better understanding of main principles of DIC, several publications are devoted to this issue [1-3]. In this paper, photogrammetric measuring was performed using ARGUS system. ARGUS is the contactless measuring system that on the basis of optical scanning allows predicting critic areas which are taking places during forming process. On the sheet metal is before forming applied the grid of circle points. The grid is deformed at the same time as the sheet metal is deformed. Grid of circle points is by the influence of direction and intensity of stresses deformed, and is changing his shape. Measuring consists on the photogrammetric principle where surface is scanned using CCD camera with high resolution [4]. Digital image correlation method and numerical simulation of deep drawing process is useless, if the results are not corresponding with results of experimental measuring. Therefore is necessary to investigate difficulties associated with new progressive methods of inspection. Several studies have been performed to this topic [5-8]. DIC method was compared with results of numerical simulation, where process was modeled in static implicit simulation software Autoform. Material model of blank defined in the numerical simulation was Hill 48 [9, 10] yield function and hardening curve was defined by approximation.

OBJECTIVES AND APROACH

The aim of this experiment was to investigate differences between inspection of drawn part using photogrammetric measuring system and numerical simulation. For this purpose was used ARGUS measuring system which is type 12M with 12 million pixels resolution of camera. Diameter of circles etched on the sheet was 1 mm. Measuring was possible by the increment of length 1 mm step. The accuracy of ARGUS system within strain measurement is up to 0.2% [4]. Mechanical properties of mild steel DX 52 D are in the Tab. 1.

Tab. 1: Mechanical properties of DX 52 D

Material	Rm [MPa]	Re [MPa]	A_{80} [%]
DX 52 D	360.5	285	≥26

Thickness of the blank was 0.5 mm. Initial shape of the blank, with etched grid of circle points and measuring scales are illustrated on the Figure 1.

Grid of circles was etched by electrochemical method using electrolyte which is suitable to the zinc coated surface of the sheet. Simulation was performed in the static implicit code Autoform. Shell elements were discretized by a triangular mesh, with size of 1 mm and 11 integration points through the thickness. Angle of triangular element was set to the value 22.5°. Maximum level of refinement was set to the value 4. Drawing process was performed on the hydraulic press ZD 40. In order to minimalize friction, teflon film was used. Main objective was to etch grid of circles on 7 blanks,

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measure strains by photogrammetric method on these undeformed sheets and then select the blank of best quality. It means blank with best shape and with the smallest amount of measured major strains. Selected blank was subsequently used for the drawing process and inspected with ARGUS measuring system. Thickness reduction was measured and compared with results of numerical simulation and experimental measurement.

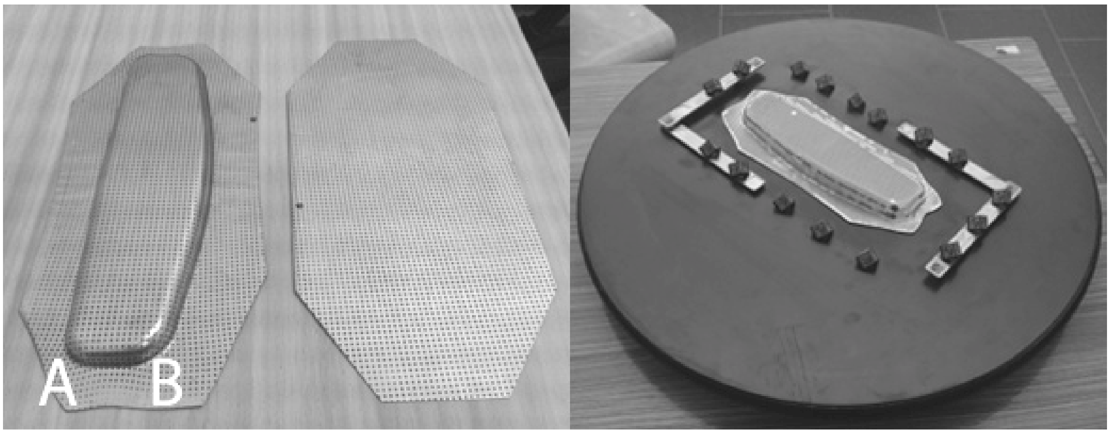

Figure 1. Final shape and blank on the left, measuring in Argus on the right.

RESULTS AND DISSCUSION

Results of strain measurement using photogrammetric method on undeformed blanks are illustrated on the Figure 2. Shape of a blank and distribution of major strain is considered.

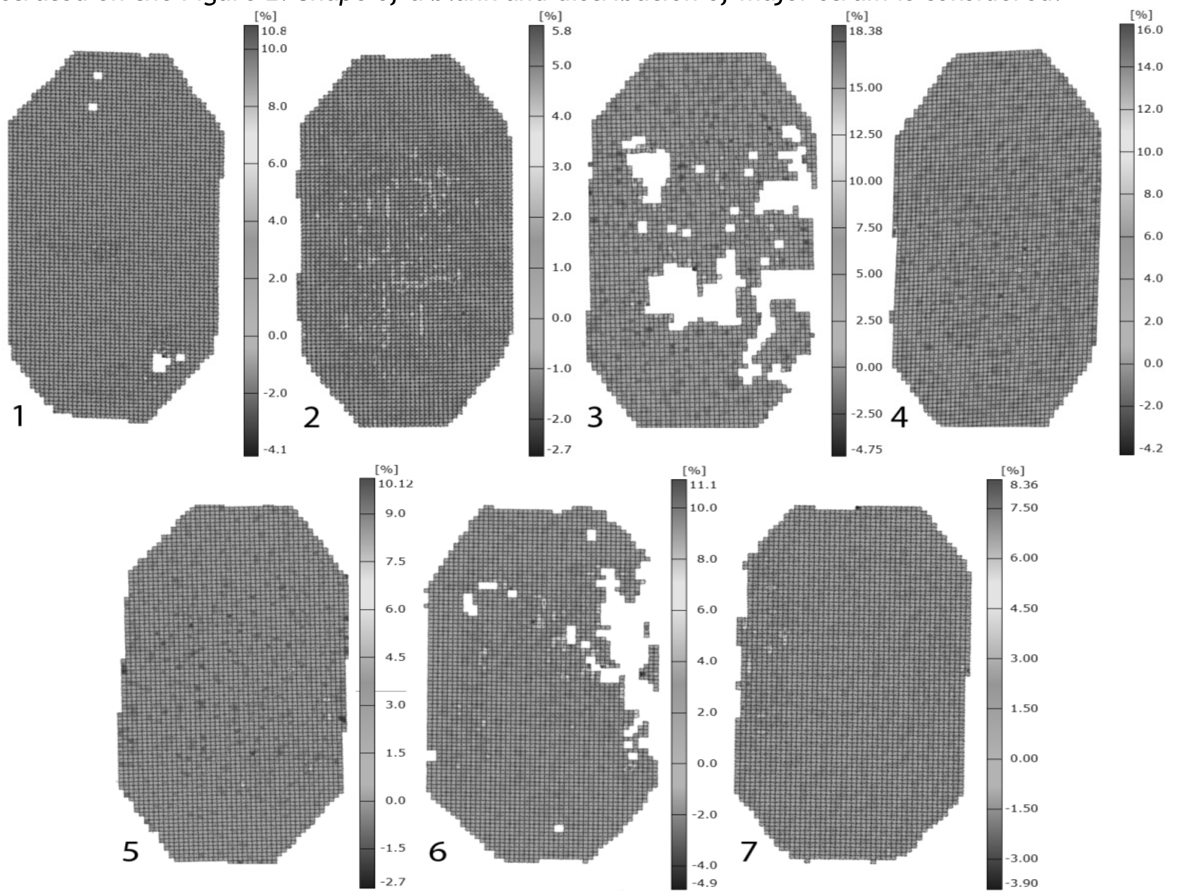

Figure 2. Shape of a blanks and distribution of major strains

From results illustrated on the Figure 2 implies, that not all blanks were scanned sufficiently enough. Especially on samples marked as 3 and 6 are visible empty places, where were dots of circle grid not recognized. On all of these blanks were measured major strains and thickness reduction in longitudinal section. Despite the small empty places, the best results were measured on the blank number 1 where was measured average major strain 0.55 % and 0.26 % of thickness reduction. Worst result was measured in the case of blank number 3 and 6. Average of major strain measured in longitudinal section in blank number 3 was 1.86 % and 0.66 % of thickness reduction.

Also, as seen on the Figure 2, blank number 3 is full of empty places which were not recognized. These errors which are associated with empty places, and major strains measured in undeformed *sheet have several reasons as for example insufficiently clean surface, inequality of surface, errors during etching caused by long time effects of electric current, influences of imperfect photogrammetric detecting by camera etc.*

Drawn part was inspected in two corner curvatures, highlighted on the Figure 1. Depth of housing was equal to 20 mm. Thickness reduction over the section was inspected, due to simplicity of experimental measuring. Results are illustrated on the Figure 3.

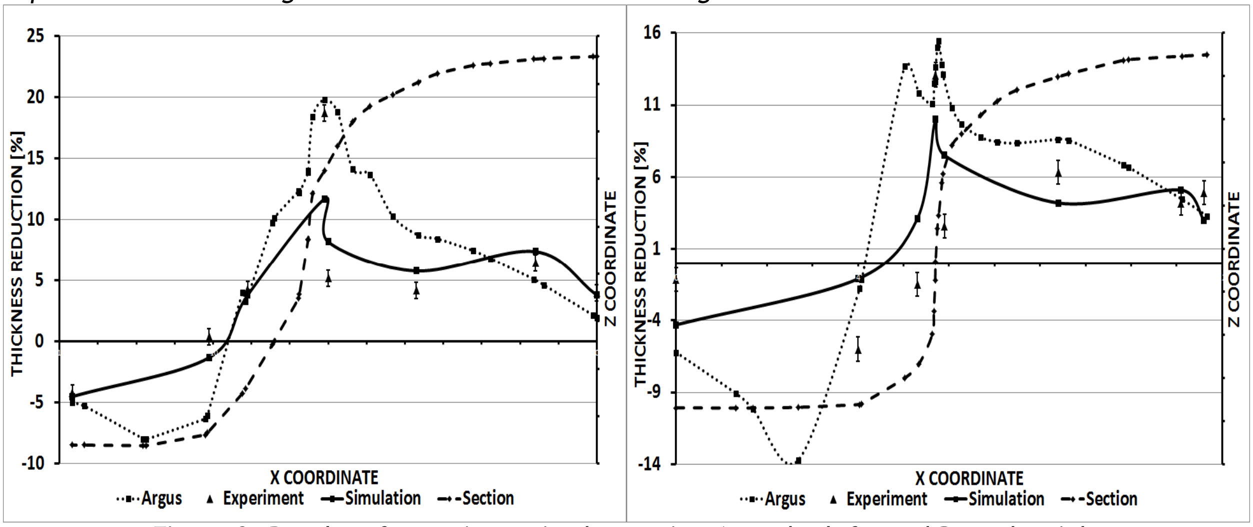

Figure 3. Results of experiment in the section A on the left, and B on the right

Result of experiment, where drawing depth was set to 20 millimetres is shown on the Figure 3. As from this graph implies, numerical simulation was more accurate in comparison to experimentally obtained values. However, numerical simulation underestimated the value of thickness reduction in the most critical area. This may cause a problems in the production, or problems with quality of final product. Eight experimental measuring were performed and in every measuring, uncertainty of measurement was computed.

CONCLUSIONS

In this experiment, two progressive methods were compared. Drawn part was inspected with photogrammetric optical system and with numerical simulation. Measuring using optical system shown several pitfalls which can by suppressed to some extent. Measuring shown that there are some inaccuracies during inspection of undeformed blank which can bring an error to the final shape measuring. Therefore the numerical simulation of process was performed, in order to determine which method is more accurate. Results were discussed, and it has been shown that inspecting with both methods varies in approximately the same amount of error. Trend of thickness reduction and critical places were recognized in the same areas. Although as is shown on the Figure 3, neither method describe course of thickness reduction absolutely precisely. There is still much room for improvement, either by better material description and material models considering Bauschinger effect or apparent Young's modulus in numerical simulation etc., or denser grid of circles, better quality of surface, etching errors etc. in the case of photogrammetric measuring.

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