Simulation Study on Influence of Blank Offset in Deep Drawing of Circular Cup

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Abstract. The correct alignment of the blank in deep drawing process is very much essential for quality production. The use of FE simulation software predicts the quality of sheet metal forming processes such as deep drawing to enhance the efficiency, to lower the development time and tool cost. The deep drawing tests were conducted using numerical simulation. The deep drawing tests were conducted using FE code PAM-STAMP for aluminum while keeping the blank offset values of 0 mm, 2.5 mm, 5 mm, 7.5 mm and 10 mm. It was observed that various induced stresses increases drastically with blank offset values more than 5mm for punch size of 40.

Keywords: Deep drawing, Blank alignment error, FE simulation, PAM-STAMP.

1 Introduction

The deep-drawing process is extensively used in various industrial applications such as beverages, automobile and household applications. The experience gained in the past years has been used for design of new and complex parts. The optimization of the process using finite element method and good understanding of different parameters involved in it leads to considerable saving of time and money during the initial stages of the product design. [1,2].

The stresses and strains induced in different zones of the blank during the forming are the main reasons for failure of the component. The stress state in deep drawing process is really a complex phenomenon, involving compression in the circumferential direction and tension in longitudinal direction as shown in Fig. 1. The wrong design results with defective parts and deflections of the tool set. Mark Vrolijk et al [3] discussed a detailed procedure on prediction of deformations in tool setup using standard forming simulation using PAM-STAMP.

The modeling of deep drawing setup was done using the computer aided design tool, CATIA V5. The functional surfaces of the tool were created and saved in *.igs format and it was imported into PAM-STAMP 2G software for numerical simulation.

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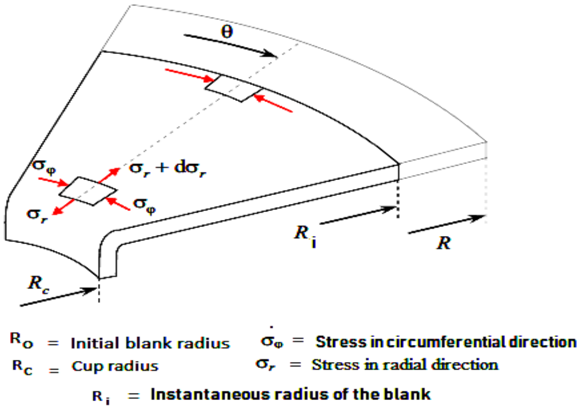
The material considered was AA6111 aluminum alloy with 0.9 mm of thickness. The tool setup modeled is shown in Figure.1 and tool measurements used are shown in Table.1. The mesh was created by choosing 2mm size of element that mainly influences on time of computation and quality [4]. The size of the blank considered was 120 mm blank and the tests were conducted with intentional misalignment balk with toolset by 0 mm, 2.5 mm, 5 mm, 7.5 mm and 10 mm to know the effect of alignment error on physical and mechanical properties of the component generated.



1. Stress state in flange portion during deep drawing

Table 1. Font sizes of headings. Table captions should always be positioned *above* the tables.

Tool	***Parameter***	***Qty***
Punch	Diameter	80.0 mm
	Nose radius	5.50 mm
Die	Diameter	81.50 mm
	Shoulder radius	5.50 mm
Blank holder	Inner diameter	85.0 mm
	Outer diameter	250.0 mm
Blank	Diameter	120 mm
	Thickness	0.9 mm
	Young’s modulus	70 Gpa
	Poison’s ratio	0.3
	Plasticity law	Hill
	Material type	isotropic
	Hardening law	Hollomon

2 Simulation Tests

The simulation process consists of pre-processing, simulation and post-processing. The processing consists of defining the model of the physical problem. The simulation, which normally is run as a background process, is the stage in which PAM-STAMP solves the numerical problem.

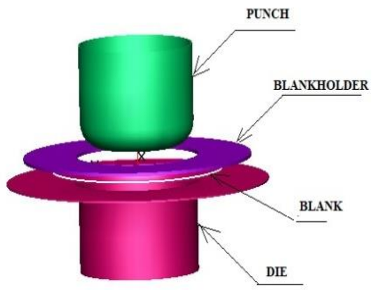


Fig. 2. Modeled tool setup for deep drawing

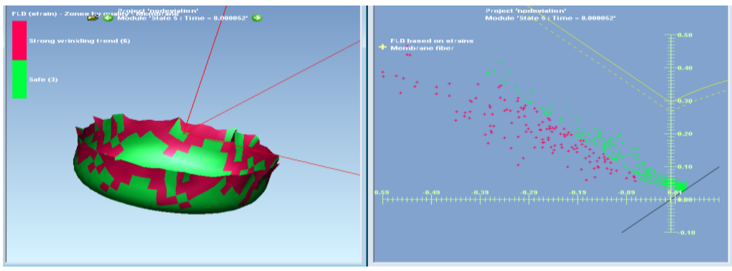


Fig. 3. FLD based strain diagram and the zones of wrinkling tendency with zero offset

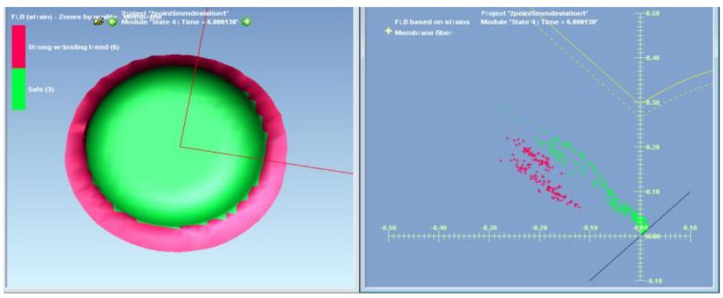


Fig. 4. FLD based strain diagram and the zones of wrinkling tendency in 2.5 mm offset

Depending on the complexity of the problem it may take few seconds to days depending upon the configuration of the computer. In post-processing we can evaluate the results of the simulation, such as stresses, strains, color contour plots, animations, deformed shape plots and X–Y plots.

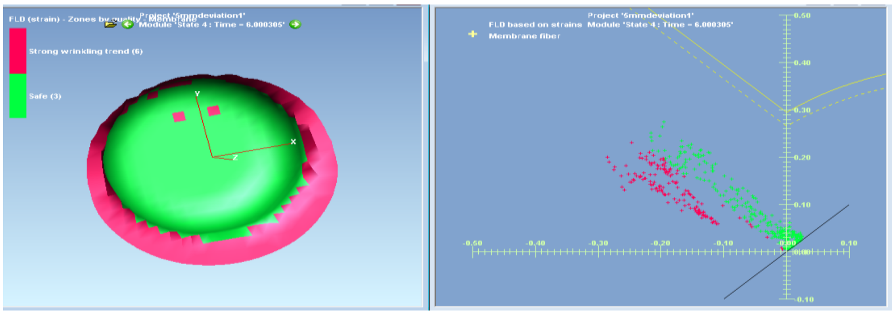


Fig.5. FLD based strain diagram and the zones of wrinkling tendency in 5 mm offset

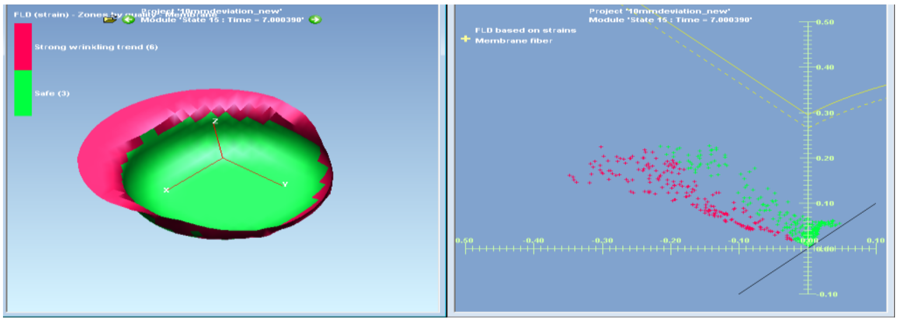


Fig. 6. FLD based strain diagram and the zones of wrinkling tendency in 7.5 mm offset

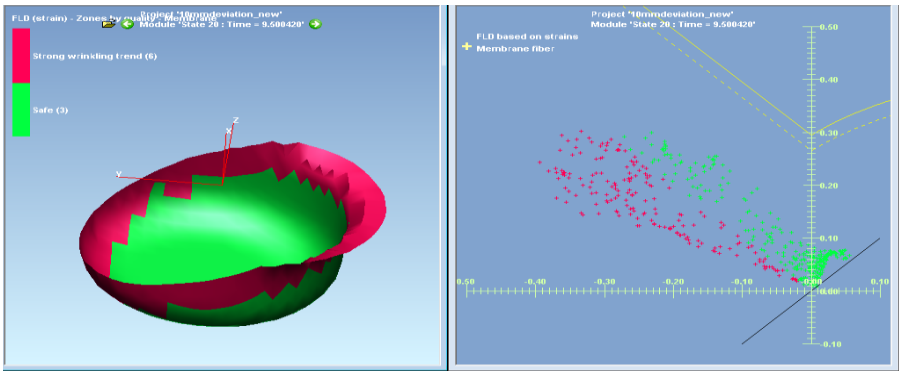


Fig.74. FLD based strain diagram and the zones of wrinkling tendency in 10 mm offset

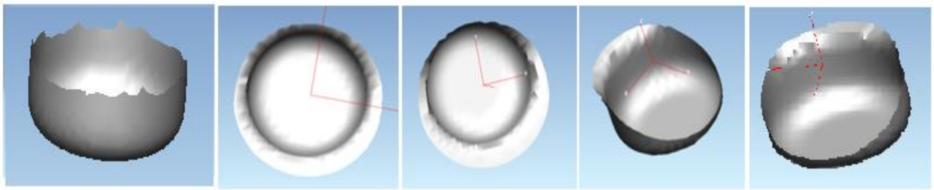


Fig. 8. Simulated cups in with different offset values: a). 0 mm, b). 2.5 mm, c) 5 mm, d) 7.5 mm, and e) 10 mm

Table 2. The Maximum and minimum stress and strains recorded in simulation tests.

Blank deviation		**0 mm**	**2.5 mm**	5.0 mm	7.5 mm	10.0 mm
Minor stress GP	Min.	0.240	0.143	0.085	-0.201	-0.478
	Max.	0.195	0.188	0.210	0.3520	0.450
Major stress GPa	Min.	-0.039	-0.02	-0.020	-0.184	-0.332
	Max.	0.311	0.314	0.367	0.4698	0.724
Vonmises stress GPa	Min	0.001	0.004	0.036	0.032	0.060
	Max.	0.377	0.364	0.354	0.3827	0.423
Equivalent strain	Min.	0.443	0.138	0.028	-0.051	-0.425
	Max.	0.849	0.721	0.677	0.657	0.605

It was observed that the cup formed is not uniform and the strain diagram shows the strain at bottom of the cup is less at the top of the cup in comparison to the punch nose region of the cup. The cup has tendency to fail in further deformation at punch nose region. As the cup is fully drawn in this case found that the strains at the top of the cup is comparatively less than at the punch nose region. The FLD diagram shows that the top region of the cup was subjected to more negative strain i.e., compressive strain. At the bottom region the minor and major strains are equal as the blank at the canter can be subjected to equal bi-axial strains. Figure 8 shows the simulated cups produced in different error tests. The table 2 and fig. 9 to 12 gives the various forming properties found in simulation tests.

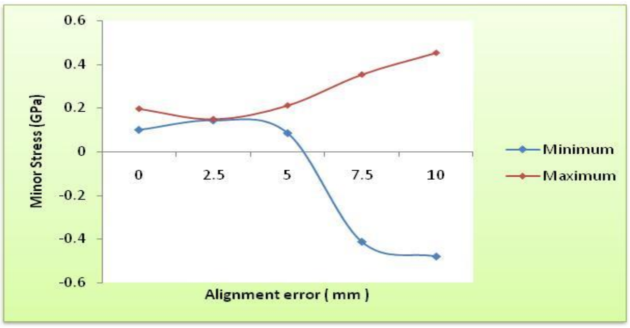


Fig. 9. Minor stresses with alignment error of nil, 2.5 mm, 5 mm, 7,5 mm and 10 mm

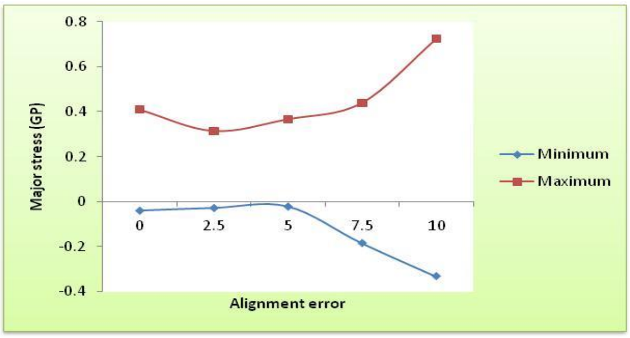


Fig. 10. Major stresses with alignment error of nil, 2.5 mm, 5 mm, 7,5 mm and 10

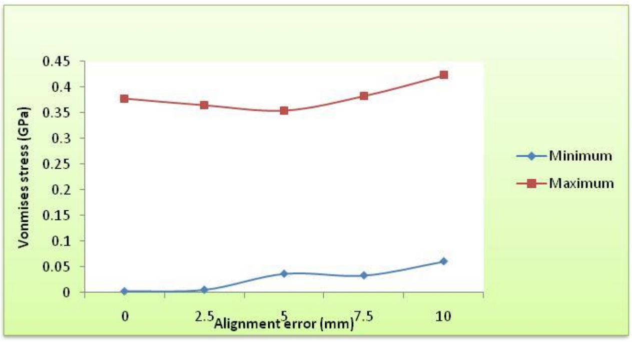


Fig. 11. Von-misses stresses with alignment error of nil, 2.5 mm, 5 mm, 7,5 mm and 10 mm

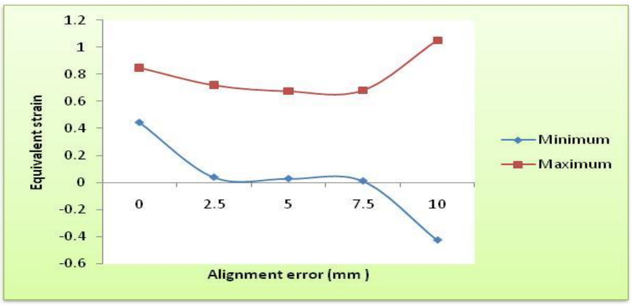


Fig. 12. Equivalent strains for alignment error of nil, 2.5 mm, 5 mm, 7,5 mm and 10 mm

2 Conclusions

Using the numerical simulation the following conclusions were made

1. The minor stresses lower value varies considerably for offset values of 5mm and above.
2. The major stress also vary considerably at 5mm and above
3. Similar observations were also found for equivalent stresses
4. The Vonmises stresses are minimum at 5 mm offset
5. The blank offset should be less than 5 mm for the given tool set for production of defect free products.

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