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Modelling and Design of Deep Drawing Tools Using Logopress

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Abstract

This work will present the analysing of the deep drawing process. For the design of the part, we used Solidwork package software. The design of part for deep drawing is described step by step. Material of part is getting for this case DC03, which will be going into the deep drawing process. All required dimensions of the part are given to analyse the problem step by step. The theoretical calculation for deep drawing it is presented for centre of gravity, tolerances for up and down tools, working space of deep drawing, and percentage for a variety of materials. Also, analysing of strain, mesh, stamping force as well as stripper force for deep drawing and will be treated into Logopress software which is compatible with Solidwork.

Disciplinary: Mechanical Engineering (Modelling & Drawing)

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1 Introduction

Forming processing represents the oldest metalworking method. This is the method of processing where the workpiece is given the desired shape without chip removal, the material is loaded on the limit of elasticity and deformation will be sustained, polystyrene (non-elastic). By deformation, we understand the size and shape of the body or part. The material of part for our investigation is DC03, which includes design, theoretical calculation and simulation into the software Logopress.

At the end of the 19th century, forming processing had great development and for this reason, became a research topic. Some of the ancestors who were taken in this field were Besmer, Parkers, Adamson and Erichsen. Wrinkles, crevices and poor quality in the picture set a boundary in which the deformation process can be realized.

Özdilli, et al. (2018) have made the comparison of four different steel sheet materials that are mostly used by deep-drawing such as DC01, DC04 and for cold forming they have used DD13, DD14 to analyze the coefficient of friction, using the finite element method, to see which material is more significant.

Focused of their paper is by hydraulics press with double action is an article, a deep-drawing process using a double-action hydraulic press to examine the ability of machine for the shape deformation of a fuel-filter cup from sheet metal SPCC steel (The-Thanh et al., 2019), also they have made a comparison with theoretical and practical experiments, and have achieved that the die shoulder radius is one the more important parameter to realize the cup of the deep drawing process.

This work showed the evaluation of forming process for different kinds of sheet materials regarding the deep drawing process. And to see the effects for different sheets and die/blank holder angle on deep drawing process, for analyzing sheet metal with thickness 0.8mm of SS304 and Brass and 0.9 mm thickness for aluminum material. Where the experiments are presented step by step from designing the deep drawing tools such as die, blank holder, and punch (Reddy et al., 2016).

Amir M. et al. (2013) explained and investigated the effect of a new pulsating blank holder system to improve the forming process of aluminium alloy material 1050. Where simulation of deep drawing have make into environments of ABAQUS6.7 software.

Informing the process of Deep Drawing is very important due to the complexity of the part and the parameters of sheet materials of aluminium alloys (Dwivedi, R. D., et al. 2017).

Zaid (2016) explained the effect of geometry parameters, the radius of punch, which indicates directly the maximum deep drawing force.

The authors have presented an experimental Deep drawing process where a metal blank for radially drawn into a deformation process. Also, their focus was to analyze and control the spring back by deep drawing process, due to some parameters such as speed of punch, lubrication, nose radius of die, and blank holding force where are achieved some results of their studies (Said et al., 2020).

2 Materials and Methods

The problem of designing and manufacturing the tool for forming process is quite complicated. This requires the commitment of the staff with superior qualifications and material resources. With the continued growth of production volume with deformation processing, manufacturers of these types of tools are added to numerous requests, such as dependence on quality, the productivity of the economy, and time of production.

Designing new details or existing details where minor modifications are required are made on the basis of the technology experience and with the help of trial and error experiments. This way the design engineers enable a solution but in most cases far from optimal. Costs that are carried out during the design and testing of the tool are relatively high.

In order to reduce the possibility of working the tool without errors and in this case also decrease the possibility of lowering the tool constructing expenditure is used different strategies based on computer programs where the product of this case and tools followed during all design stages (CAD, CAM, CAP, CAE).

The process of deep drawing enters the group of sheet metal deformation operations, during which the acquired pieces of flat cylindrical details (or non-cylindrical) at the end, which may be crowned or without. Part of deep drawing earned details with walls of flatforms, which generally do not require additional processing.

Depending on the form and the technological qualities of empty walled parts, the deep drawing is divided into:

- Deep drawing for symmetrical rotating bodies.
- Deep drawing Capturing bodies in tin form.
- Deep drawing of bodies in an irregular geometric shape.

Depending on the deformation character, the deep drawing can be divided into:

- Deep drawing without reducing the thickness of the walls.
- Deep drawing with reducing the thickness of the material, ie with the dilution of the walls.

The scheme of Deep drawing process without and with sheet metal clamps (holder) is presented in Figure 1. The section without sheet metal clamping is used for the production - the cutting of details with low height (shallow) and with large thickness (Lange K. 1985).

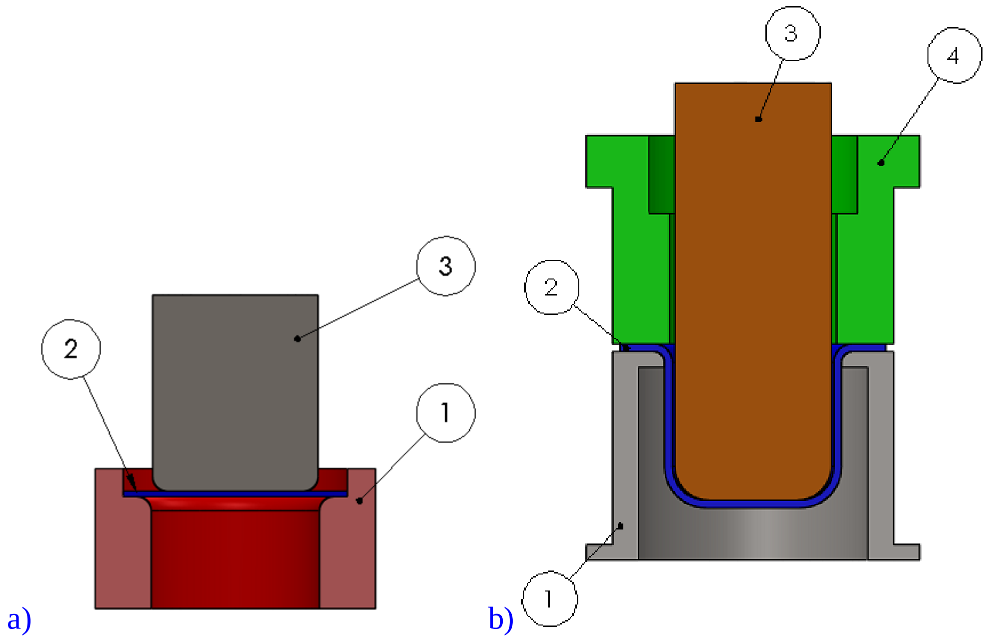


Figure 1: a) Deep drawing without the holder of the sheet, 1 – Die, 2 – Sheet metal, 3 – Punch; b) Deep drawing with the holder of the sheet, 1 –Die, 2 – Sheet metal, 3 – Punch, 4 – Holder of the sheet.

Deep drawing with a holder of sheet metal, is used for the production of parts with greater depth and for the smaller thickness of the material - sheet metal. The deep drawing operation is performed on presses, which can be ordinary (single) or double action and triple action.

The process of production of sheets is done in machines, presses with double action, respectively in hydraulic presses and presses with a single action.

In addition, presses for deep drawing based on their constructive properties are classified into:

- One positional (one phase).
- Progressive - with horizontal order of operations.

From Table 1 we can read the value of coefficient "c", for different types of sheet materials to determine working space by deep drawing.

Table 1: Value of coefficient "c" in depend of steel material.

Sheet material factor [c]	
Steel	0.07
Aluminium	0.02
Other non-ferrous metals	0.04

Calculation of working elements of deep drawing and cutting tool, as well as working space, is presented in Figure 3 (Whereas in Figure 3 left are showed working elements, in the right side is presented working space for deep drawing) (Tschaetsch, 2006).

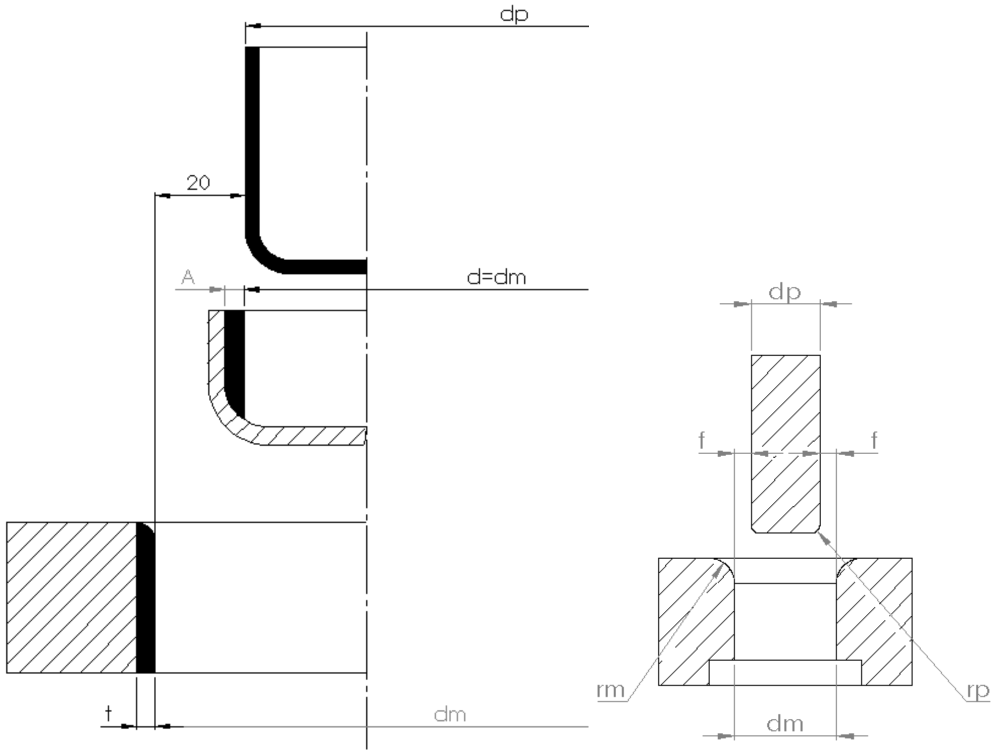


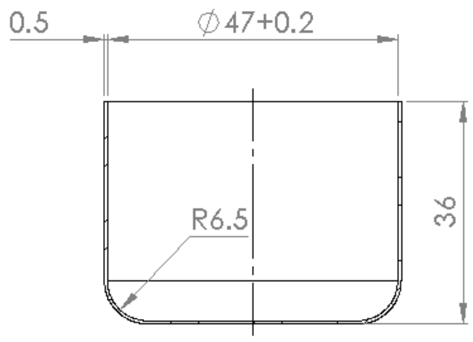
Figure 2: Working elements and working space by deep drawing.

The working space between the upper part of the tool and the lower part is calculated with the equation as follows:

$$d_p = (d + \Delta'' \cdot h)^{-\delta M} = (d + 0.2 \cdot \Delta)^{\delta p} \quad (1),$$

$$d_M = (d + 0.2 \cdot \Delta'' + 2 \cdot f)^{+\delta M} \quad (2).$$

The material of the workpiece for our case is DC03, which has wide application for deep drawing, with thickens s = 0.5 [mm]. For our case Solidworks, it designed the part with dimension, as shown in Figures 4, the 2D and 3D design drawings. For this part will be shown the mesh and strain with software logopress and at the same time will be presented the results of the theoretical calculations.



a)

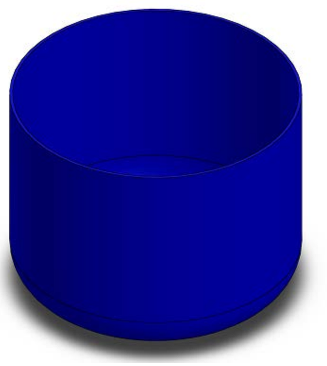

b)

Figure 3: a) Design of part into 2D sketch and b) 3D view.

Then with the command to close the sketch (Close sketch) as in Figure 3 a), we close the sketch. Detail created with the help of the Revolved Boss / Base command. Then with the Revolved Boss / Base command the 3D view of the cut part is realized as in Figure 3 b).

3 Result and Discussion

Before starting with the software Logopress, it is presented the drawing of parts for the calculation of center gravity. In this paper, research methods will be used based on the analysis and synthesis of various tools mainly from different sources, mathematical methods for calculation. Modeling and simulating the tool for specific details is accomplished with the help of SolidWorks software and is it integrated to Logopress3.

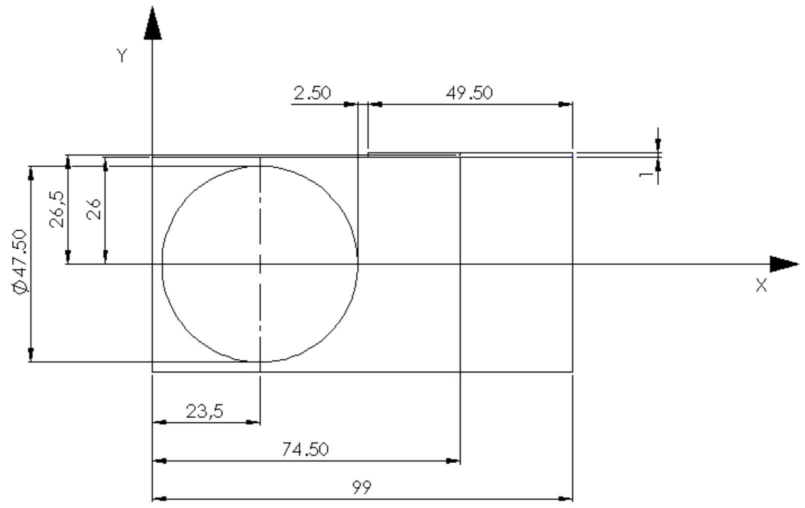


Figure 4: Dimensioning of center gravity.

Calculation of center of gravity is given through the expressions as follows:

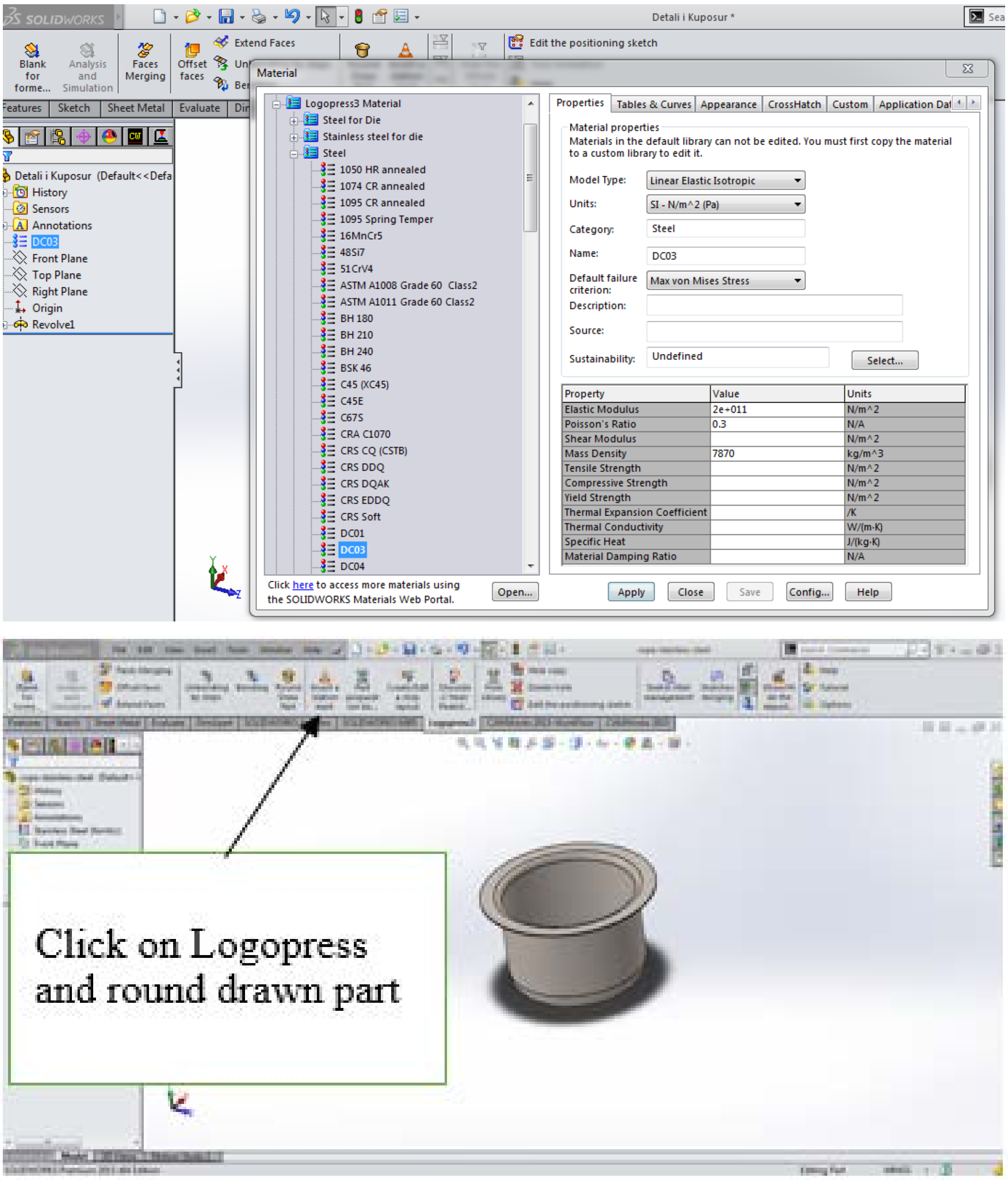
This is example 1:

$$x_c = \frac{x_1 \cdot l_1 + x_2 \cdot l_2 + x_3 \cdot l_3}{l_1 + l_2 + l_3} = \frac{23.5 \cdot \pi \cdot 47 + 74.25 \cdot 49.5 + 99 \cdot 1}{\pi \cdot 47 + 49.5 + 1} = 36.58\ [mm] \quad (3),$$

$$y_c = \frac{y_1 \cdot l_1 + y_2 \cdot l_2 + y_3 \cdot l_3}{l_1 + l_2} = \frac{26 \cdot 49.5 + 26.5 \cdot 1}{50.5} = 26\ [mm] \quad (4),$$

Based on Figure 2, expression (1) and (2) and Table 1, for steel of sheet metal DC03 working space is presented with expression as follow:

$$f = s + c\sqrt{10 \cdot s} = 0.5 + 0.07\sqrt{10 \cdot 0.5} = 0.65\ [mm] \quad (5),$$



a)

b)

Figure 5: a) Material selection (DC03) and b) Logopress round drawn part.

All versions of Logopress are well-integrated into the Solidworks program, and many engineers around the world use logopress for designing tools within the forming process. Working with the Logopress software can start from a detail designed in the SOLIDWORKS program, or from a part imported from another CAD system. For a quarter of a century, Logopress's main goal has been the development of software for designing tools in the field of forming processes. The Logopress3 software is currently used in many countries around the world.

With just five simple clicks of the cursor, you can see the workflow and then look at and define the intermediate stages during the job descriptions process. The software Logopress module also provides the ability to determine how many operations can be performed. Where through this two software, we have a shortened time in designing the buyout tool, if they were to be counted manually then they would take several hours or even a few days, and with Logopress's help, this could be done for a few minutes.

In Figure 5, we select the material DC03 which it is seen on the right side in the open window the properties of the material DC03.

After completing the 3D workflow in Solidworks, we move to Logopress, which is integrated in Solidworks with the help of this, we can see the stages of the development process from the initial dimensions of the workflow to the final, rounded, semifinal, the reduction factor for the first operation and for the subsequent operations, the type of material is assigned, the material thickness and the shrinkage ratio determined depending on the operation operations.

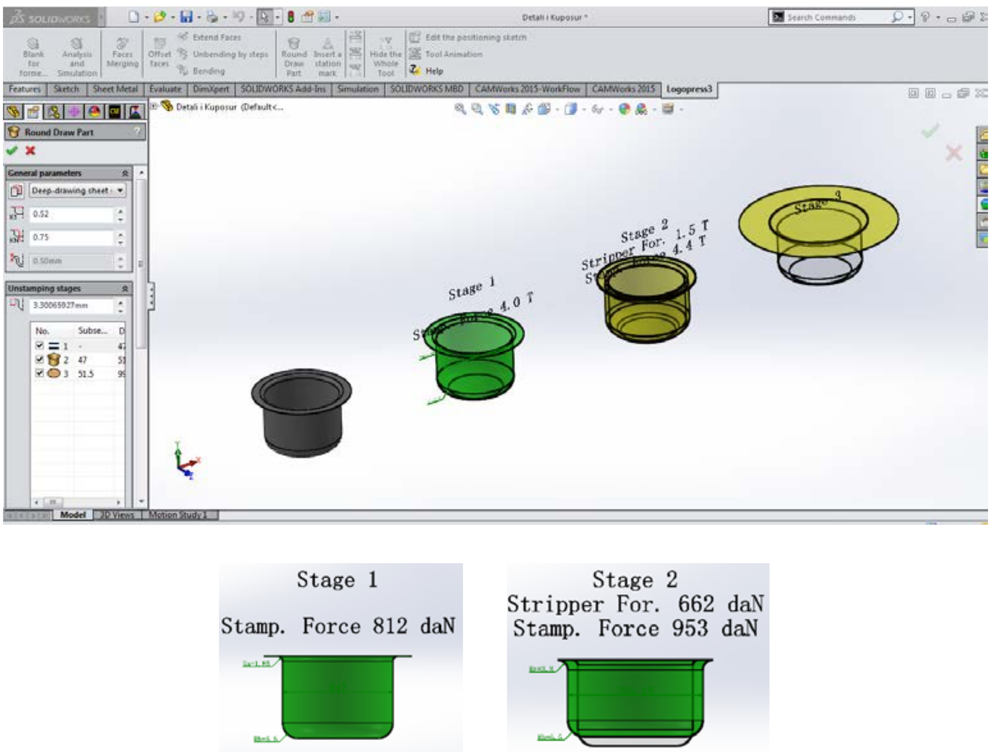


Figure 6: a) Step/stage of deep drawing, b) Stage 1 and stage 2 of deep drawing.

After clicking with the command “Round drawn part” as in Figure 6, where are presented the number of operations of deep drawing, for our case deep drawing, is done with two operations. Also, is presented the display for “Round Draw Part”, wherein this step is choosing the main parameters during deep drawing, in the beginning, it is selected ‘Deep-Drawing Sheet Steel’, at the same time in an automatic way are choice the value of factor K1 and factor KN.

Where:

- K1 – reducing factor after the first operation,

- o KN – reducing factor in a subsequent operation.

In Figure 6 rights are shown stages of deep drawing: the force for the first stage of deep drawing is achieved F = 812 [daN] and the force for the second stage during deep drawing is obtained with a value F = 953 [daN].

In Figure 7 shows the creation of the strip for cutting, where it is performed initially by clicking on the command "create / edit a strip layout".

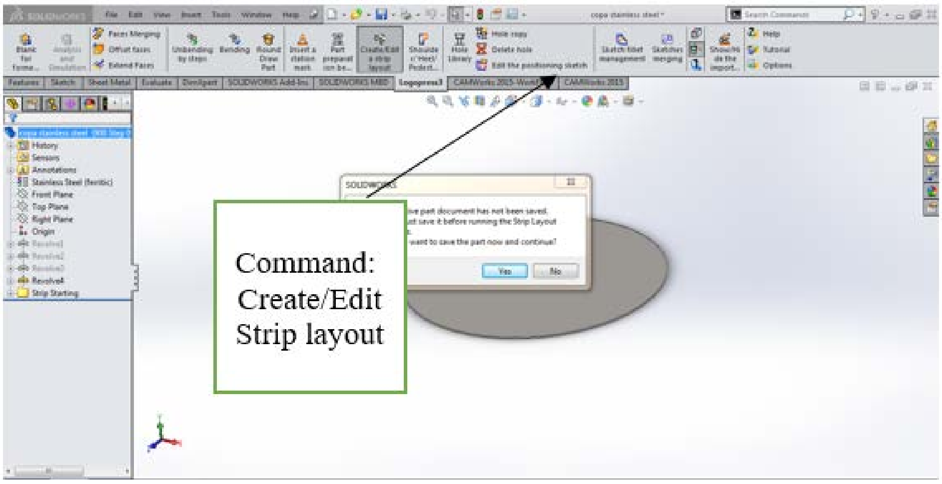


Figure 7: Creating the sheet.

Figure 8 shows the bar, where after clicking on the above commands we have the creation of the bar. During the creation of the tape we have achieved the utilization of the material with a value of 75.46%, and only 24.54% loss of the material, as seen in the Figure 8.

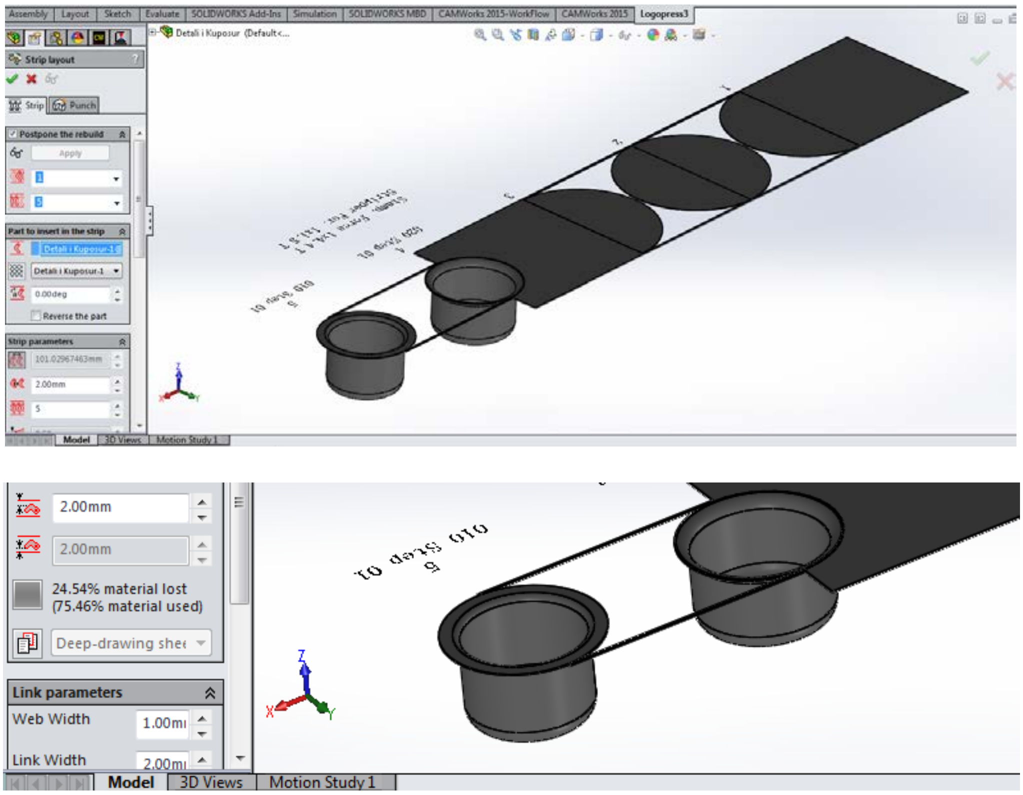


Figure 8: Bar of deep drawing.

By setting the parameter "The entire entity" the uninterrupted force of the sheet metal clamp is achieved, the surface turns red and remains fixed, and click to "The entire entity" command. Figure 9 a), is presented the determination of the size of the mesh where for the first case we took it for the number 4000. Also, are set the material of part DC03, thickness 0.5 mm, c = 0.07 mm, for 3D shape.

Show simulation of how the cut-off part is formed from the starting material in a circle. Command "2D BLANK" we have the scope of the material. Clicking on the "Play" command then begins the simulation of the duplicated part where from the initial material in the form of a circle, where the duplicated part is formed. Also, in Figure 9 b), the command "Mesh" is presented, when we select the command "Mesh" can be seen the grid formed inside the material.

a)

b)

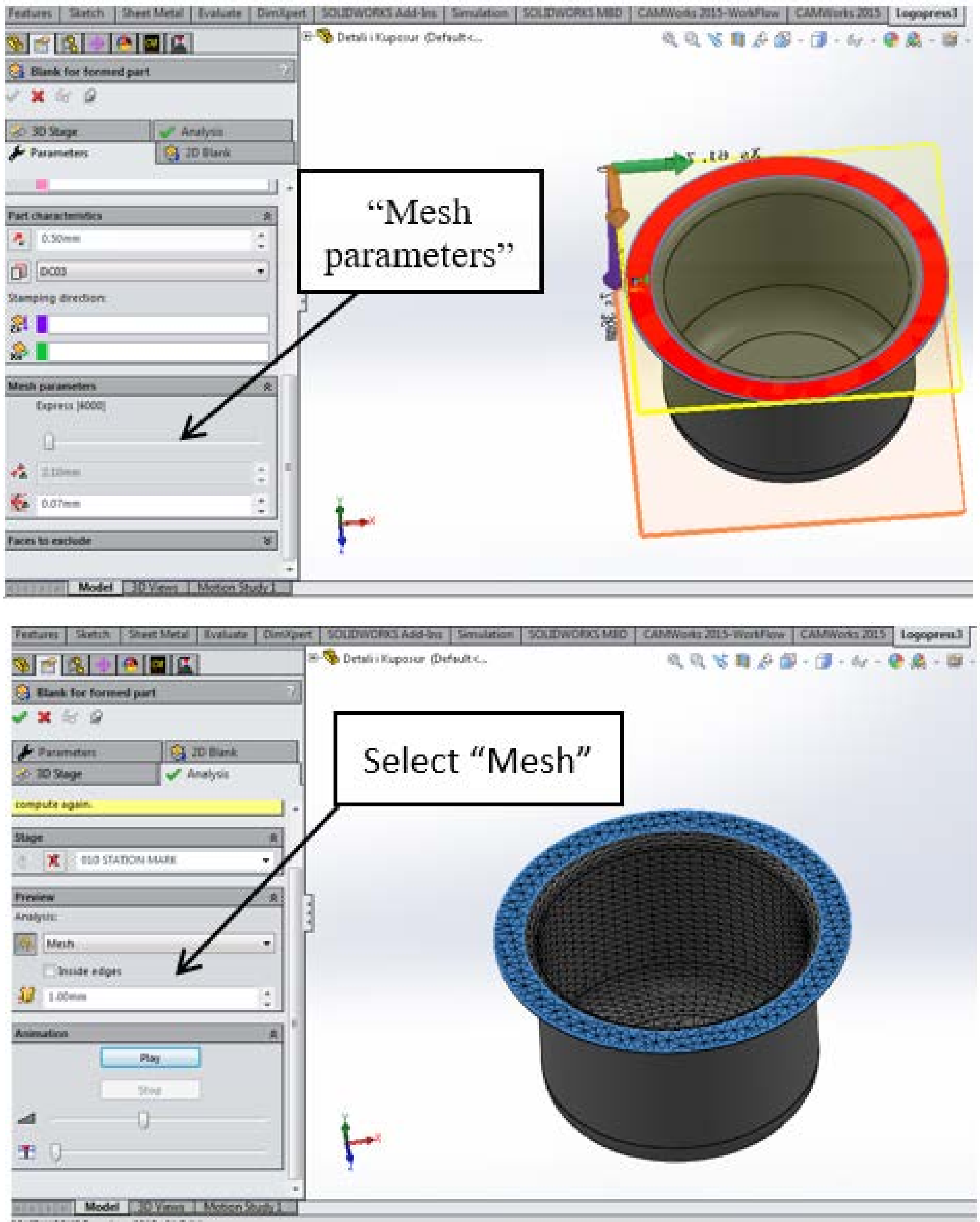


Figure 9: a) determining the mesh parameters, b) simulation of command “Mesh”.

Figure 10 shows the calculation of those parameters which were defined in the figures above by clicking on the "Compute" command. Also, we can show the simulation of how the cut-off part is formed from the initial material in a circle. Command "2D BLANK" we have the scope of the material. Clicking on the "Play" command then begins the simulation of the copied part where from the initial material in the form of a circle as seen in Figure 10, where the copied part is formed.

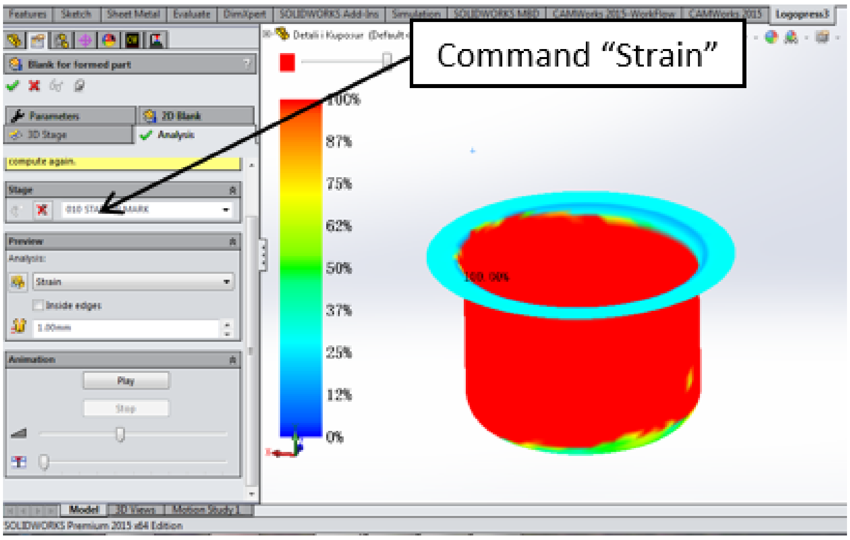


Figure 10: Calculation of strain.

In Figure 11, the largest strains in the force transmission area of the copied part are shown. Also, is obtained the stress as shown below by clicking on the "Stress" command and it can be seen that even the largest stresses are in the area of force transmission.

At the same time Figure 11 b), presented thickness variation of sheet metal parts, during the deep drawing process.

Below are performed the calculation of the variation in sheet metal depending on thickness in the percentages shown in the Figure above where we can see below the calculated values Δs.

For 80% the equation gives this form:

$$\Delta_s = 0.5mm \cdot \frac{80\%}{100\%} = 0.4 \quad (5),$$

For 60% the equation gives this form:

$$\Delta_s = 0.5mm \cdot \frac{60\%}{100\%} = 0.3 \quad (6),$$

For 40% the equation gives this form:

$$\Delta_s = 0.5mm \cdot \frac{40\%}{100\%} = 0.2 \quad (7),$$

For 20% the equation gives this form:

$$\Delta_s = 0.5mm \cdot \frac{20\%}{100\%} = 0.05 \quad (8),$$

For -19% the equation gives this form:

a) b)

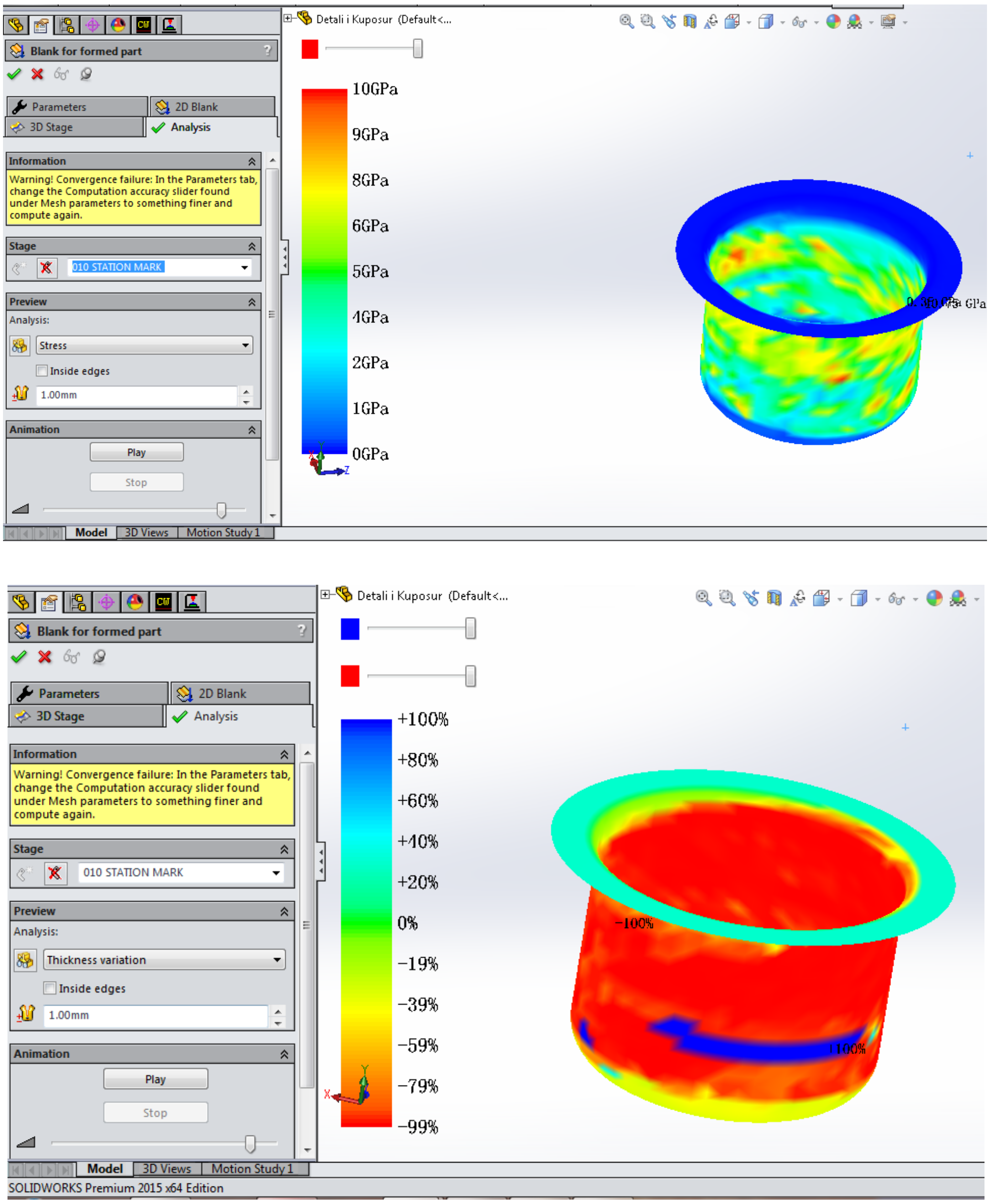


Figure 11: a) Analyzing of stress, b) variation of thickness material.

$$\Delta_s = 0.5mm \cdot \frac{-19\%}{100\%} = 0.05 \quad (9),$$

For -39% the equation give this form:

$$\Delta_s = 0.5mm \cdot \frac{-39\%}{100\%} = 0.195 \quad (10),$$

For -59% the equation give this form:

$$\Delta_s = 0.5mm \cdot \frac{-59\%}{100\%} = 0.295 \quad (11),$$

For -79% the equation give this form:

$$\Delta_s = 0.5mm \cdot \frac{-79\%}{100\%} = 0.395 \quad (12),$$

For -99% the equation give this form:

$$\Delta_s = 0.5mm \cdot \frac{-99\%}{100\%} = 0.495 \quad (9),$$

4 Conclusion

The main goal of this paper is focused on developing a model of the deep drawing process which includes modeling stages, calculations and simulations of the deep drawing tool. The calculation with expression and simulation with software (Solidwork, Logopress) for our problem has been studied and the results have been obtained.

In the framework of this paper, the process of machining by cutting without sheet metal clamps is treated, and the geometric and physical parameters of the tool are analyzed (working space f, material thickness s, coefficient for type of material c, properties of the base material, etc.). Also presented are most types of cutting such as sheet metal thickness reduction cutting, deep hydro-mechanical cutting, conical, reversible cutting where most tools for these types of processes of coupons are modelled with SolidWorks software.

With the help of Solidworks software, the design of the tool was realized step by step, starting from the geometric shapes in 2D, then the design in 3D. The advantage of the software is that it enables the integration of Loggopress, where after designing the tool and the geometry of the part to be cut, we can analyze any errors with the help of simulation. Within the Solidwork - Loggopress3 software, the real parameters of the coupling coefficients are given, then it is achieved with how many operations the detail to be coupled can be realized. Also, for the part with diameter d = 47.50 [mm], thickness s = 0.5 [mm], inside radius r = 6.5 mm and outside radius r = 2.35 mm and the type of material DC03, are obtained results for stress and forming process.

The results and the change in the thickness of the part walls during the cutting process with the help of Loggopress are also presented. At the same time the structural mesh (Mesh), is achieved as well as the progressive tool simulation.

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