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MATERIAL SAVINGS IN THE DEEP DRAWING PROCESS OF LPG CYLINDER MANUFACTURING

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Abstract - *The Deep drawing process is a metal forming process. In the LPG cylinder manufacturing, the upper dome and bottom dome of the LPG cylinders are making using this deep drawing process. The formability of the blanks depends on the process parameters such as clamping pressure, drawing pressure, lubrication, punch and die radii, die punch clearance, in addition to thickness of the sheet material. The one of the main loss of deep drawing is overconsumption of the raw material. in this project focus on the how to reduce the raw material consumption in the deep drawing process. The 3D geometry of the deep drawing process is drawn by using CREO software and the ANSYS software is used to conduct the analysis of the deep drawing process. Based on the analysis then suggest a suitable values for the parameters. Finally reduce the raw material consumption in the deep drawing process.*

***Key Words*: Deep drawing, Metal forming process, Friction coefficient, blank holding pressure, CREO , Ansys workbench**

1.INTRODUCTION

The Deep drawing (DD) process is a significant metal forming process used in the sheet metal forming operations. In the LPG cylinder manufacturing, the upper dome and bottom dome of the LPG cylinders are making using this deep drawing process. The formability of the blanks depends on the process parameters such as clamping pressure, drawing pressure, lubrication, punch and die radii, die punch clearance, in addition to thickness of the sheet metal.

In the deep drawing process the material is cut into required dimensions and moves to the deep drawing process. And using lubrications for the required friction condition. The scrap material is used for the making of protection ring, foot ring, connecting plates etc. The types of defects occured in the deep drawing process are wrinkles, pitmark, lines, halve crack, low draw etc.

1.1 Problem Definition

The LPG cylinder manufacturing industry is concerned their one of the main loss is the over consumption of the raw material in the deep drawing process. The overconsumption of the material is due to variation of the thickness from the bottom to top portion of the dome. So in this project select the parameters and find the suitable values by using analysis in the deep drawing process.

2. LITERATURE REVIEW

V.Sravani, M.Alekya [1], Simulation and optimization of deep drawing process parameters for cylindrical cup by using FEM and taguchi. In this paper analyses the parameters using finite element analysis and optimal combination of the parameters and to suggest optimal values based on ANOVA. Based on the selected parameters simulate the results.

Chandra Pal Singh, Geeta Agnihotri [2], Finite element analysis of deep drawing process to investigate effect of friction. This research article represents deep drawing Simulation of steel sheet to investigate influence of friction on product quality. In this create the 3D geometry of the model and analysis is done in the hyperworks software. Based on the result taguchi technique is used to estimate the percentage of contribution of each parameters.

R. Padmanabhan, M.C. Oliveira, J.L. Alves , L.F. Menezes [3], Numerical simulation and analysis on the deep drawing of LPG bottles. This paper presents a numerical simulation carried out and reduces the blank thinning of the dome. The major parameters selected are blank holder force and friction coefficient. Based on these parameters analysis are carried out. The best solution is obtained in the application of variable blank holder force in the analysis.

P Venkateshwar Reddy, Perumalla Janaki Ramulu, G Sandhya Madhuri, Dasari Govardhan, P V S Ram Prasad [4], Design and Analysis of Deep Drawing Process on angular Deep Drawing Dies for Different Anisotropic Materials. In this paper the formability for different metal sheets is observed for angular geometries of deep drawing tools.

3. RESEARCH FRAMEWORK

First of all collect the data from the industry. Then The geometry of the deep drawing process is drawn by using modeling software CREO. The 3D geometry imported into the ansys software. For the analysis and simulation process using Ansys software. Then suggest the suitable values for the parameters.The research methodology used for the work is shown in the figure below.

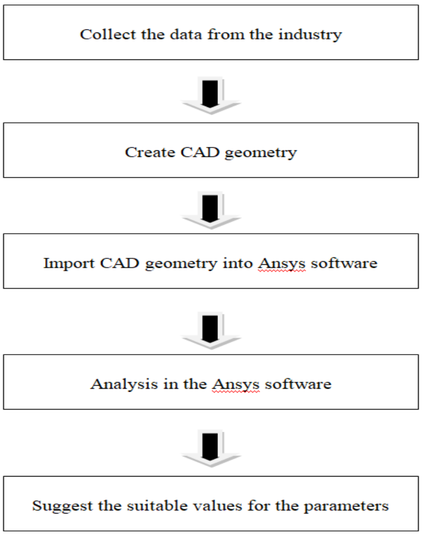

Fig-1: Research framework

4. DATA COLLECTION

Two types of cylinders are manufacturing in the industry, that is 14.2 kg cylinder and 19 kg cylinder. The width of the HR coil for both 14.2 kg cylinder and 19 kg cylinder are different. But the thickness of the raw material is same and the circle cutting diameter , halve height, halve initial diameter, bung hole diameter, the minimum thickness of the dome for the both 14.2 kg cylinders and 19 kg cylinders are mentioned in the table below.

Table-1: Measurements check list of the cylinders

	14.2 KG CYLINDER	**19 KG CYLINDER**
HR COIL (IS 6240)		
WIDTH	1680 mm	1275 mm
THICKNESS	2.8- 3 mm	2.8- 3 mm
CIRCLE CUTTING		
CIRCLE DIAMETER	610-614 mm	673- 677 mm
THICKNESS	2.8 - 3 mm	2.8- 3 mm
DEEP DRAWING		
HALVE HEIGHT	248- 250 mm	296- 298 mm
HALVE ID	314.4- 317.54 mm	330.1- 333.40 mm
BUNG HOLE DIA	52- 52.3 mm	52- 52.3 mm
MINIMUM THICKNESS	2.53 mm min	HPC- 2.53 mm min IOC, BPC- 2.50mm min

4.1 Data Analysis

From the sample measurements,

The minimum thickness of the material is 2.62, that is not uniformly distributing the thickness of dome. The 14.2 KG cylinder need minimum 6.1 KG weight and 19 KG cylinder need minimum 7.7 KG for each halves. But in the case of 14.2 kg cylinder 80 grams of raw material is overconsumed each halves production. And in the case of 19 kg cylinder 93 grams of raw material is overconsumed each halves production.

In January month 14.2 KG cylinder 29356 halves are produced and 57 rework materials are there. No rejected halves are there.

The overconsumption of the material= 29356×0.080 = 2348.48 KG

The 1kg rawmaterial rate (scrap rate)= 35 Rs

The overconsumption material cost of the 14.2 KG cylinder = 2348.48×35= 82196.8 Rs

In the case of 19 KG cylinder 24644 halves are produced and 45 reworks halves are there and no rejected halves in this month.

The over consumption of the material= 24644× 0.093 = 2291.892 KG

The over consumption material cost of the 19 KG cylinder = 2291.892× 35= 80216.22 Rs

The total cost of the overconsumption material in this month= 82196.8+80216.22=162413.02 Rs.

5. ANALYSIS IN ANSYS WORKBENCH

In the Ansys software static structural analysis is selected and assign the material. Then import the geometry and model the geometry. The parameters selected are blank holder pressure and friction coefficient. The friction coefficient 0.2 to 0.01 tested and blank holder pressure 11 Mpa to 14 Mpa are tested. Two methods are used, constant blank holder pressure method and variavble blank holder pressure method.The obtained results are compared with each other. Based on the results suggest a suitable values for the selected parameters. The different stages of the deep drawing process in the Ansys software are given below.

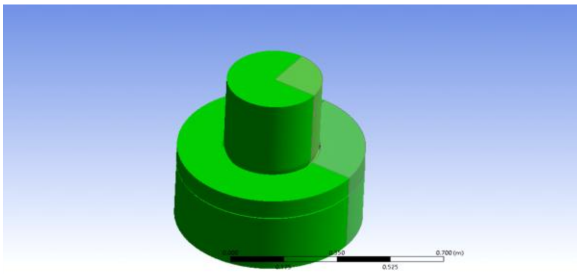

Fig-2: Imported geometry of the deep drawing process

The quarter portion of the material and model in the ansys software and given the material assign, connections, and also insert the displacement, fixed support, pressure, total deformation, stress, directional deformations etc. The figure below represent the total deformation of the dome.

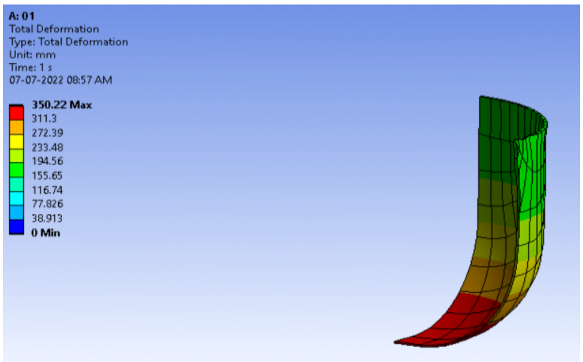

Fig-3: The total deformation of the dome

5.1 Application Of Constant Pressure In The 14.2 Kg Cylinder

In the case of the application of constant pressure in the 14.2 kg cylinder , the friction coefficient taken from 0.03 to 0.01 and the blank holder pressure taken from 11 Mpa to 13 Mpa are tested. Also calculate the thickness and weight of the dome. The table shows application of constant pressure in the 14.2 kg cylinder.

SI.No.	Friction coefficient	Blank holder pressure (MPa)	Initial coordinates (mm)				Directional deformation (mm)				Final coordinates (mm)				Thickness (mm)	Weight (kg)
			X1	Y1	X2	Y2	X1'	Y1'	X2'	Y2'	X1''	Y1''	X2''	Y2''	t	w
1	0.03	11	24.254	302.9	24.254	300	5.129	-336.5	6.65	-335.67	29.383	-33.6	30.904	-35.67	2.568723613	6.054
2	0.03	12	24.254	302.9	24.254	300	5.128	-336.65	7	-335.46	29.382	-33.75	31.254	-35.46	2.535445523	5.961
3	0.03	13	24.254	302.9	24.254	300	5.119	-336.8	7.245	-335.24	29.373	-33.9	31.499	-35.24	2.513061082	5.901
4	0.02	11	24.254	302.9	24.254	300	5.274	-335.76	7.22	-331.15	29.528	-32.86	31.474	-31.15	2.590562873	6.143
5	0.02	12	24.254	302.9	24.254	300	5.2732	-335.65	7.23	-331.06	29.5272	-32.75	31.484	-31.06	2.585568843	6.111
6	0.02	13	24.254	302.9	24.254	300	5.271	-335.52	7.25	-331	29.525	-32.62	31.504	-31	2.557506794	6.036
7	0.01	11	24.254	302.9	24.254	300	5.279	-334.12	7.27	-329.49	29.533	-31.22	31.524	-29.49	2.637608955	6.257
8	0.01	12	24.254	302.9	24.254	300	5.278	-334.08	7.28	-329.48	29.532	-31.18	31.534	-29.48	2.626405148	6.231
9	0.01	13	24.254	302.9	24.254	300	5.276	-334.01	7.3	-329.45	29.53	-31.11	31.554	-29.45	2.617666136	6.198

Table-2: Application of constant pressure in the 14.2 kg cylinder

The best solution is obtained in the blank holder pressure 12MPa and friction coefficient 0.02. The table shows the initial coordinates and directional deformation of the selected solution. Here takes the top node, middle node, and bottom node of the dome.

Table-3: Final results of 14.2 kg cylinder

SI. No.	Nodes	Initial coordinates (mm)				Directional Deformation (mm)				Final coordinates (mm)				Thickness (mm)	Height (mm)
		X1	Y1	X2	Y2	X1'	Y1'	X2'	Y2'	X1''	Y1''	X2''	Y2''	t	h
1	Top node	288.97	302.9	288.97	300	-135.36	-106.29	-131.42	-103.44	153.61	196.61	157.55	196.56	3.94031725	246.585
2	Middle node	172.93	302.9	172.93	300	-55.645	-212.41	-52.734	-209.66	117.285	90.49	120.196	90.34	2.91486209	140.415
3	Bottom node	24.254	302.9	24.254	300	5.2732	-335.65	7.23	-331.06	29.5272	-32.75	31.484	-31.06	2.58556884	18.095

The stress distribution is varied from the top to bottom portion of the dome. The maximum stress is observed at the top portion of the dome. The figure shows the stress distribution of the dome.

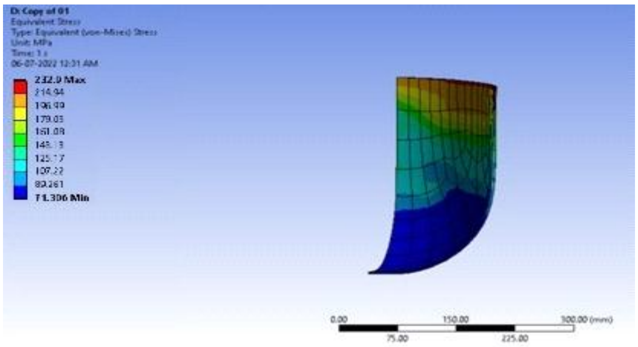

Fig-4: Stress distribution of 14.2 kg cylinder dome

The dome is cut into required length and The volume of the dome is calculated by using the fluid flow fluent. The figure shows the volume calculation by using the fluid flow fluent.

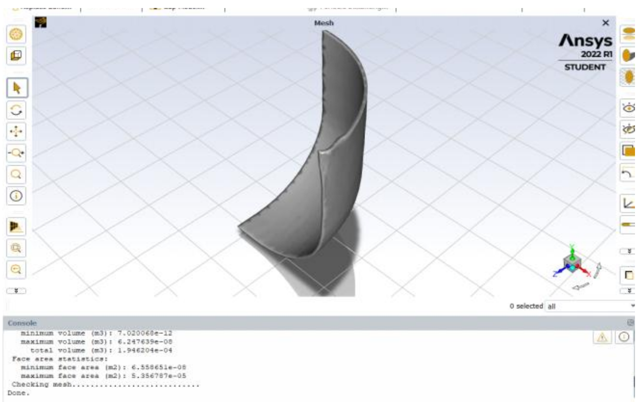

Fig-5: Weight calculation by using fluid flow fluent

The weight of the dome is calculated by using the equation,

$$Volume = 1.946204 \times 10^{-4} m^3$$
$$density = 7850 kg/m^3$$
$$Mass = volume \times density$$
$$Mass = 1.946204 \times 10^{-4} \times 7850 \times 4 = 6.111 kg$$

5.2 Application Of Variable Pressure In The 14.2 Kg Cylinder

In the case of the application of variable pressure in the 14.2 kg cylinder , the friction coefficient taken from 0.03 to 0.01 and the blank holder pressure taken from 11 Mpa to 13 Mpa are tested. The only difference is applying the variable pressure as two stages. That is applying variable pressure is devided into initial stage and final stage. Also calculate the thickness and weight of the dome. The table 6.5 shows application of variable pressure in the 14.2 kg cylinder.

The best solution is obtained in the initial pressure at 10 Mpa and final pressure at12MPa and friction coefficient is 0.02. Here takes the top node, middle node, and bottom node of the dome. To solve the problem by using Microsoft excel sheet. The table below shows, the calculated final results are,

Table-4: Final results of 14.2 kg cylinder

SI. No.	Nodes	Initial coordinates (mm)				Directional Deformation (mm)				Final coordinates (mm)				Thickness (mm)	Height (mm)
		X1	Y1	X2	Y2	X1'	Y1'	X2'	Y2'	X1''	Y1''	X2''	Y2''	t	h
1	Top node	288.97	302.9	288.97	300	-131.57	-105.58	-128.07	-102.72	157.4	197.32	160.9	197.28	3.50022856	247.3
2	Middle node	172.93	302.9	172.93	300	-55.824	-212.06	-52.905	-209.32	117.106	90.84	120.025	90.68	2.92338177	140.76
3	Bottom node	24.254	302.9	24.254	300	5.043	-334.48	7.3096	-330.29	29.297	-31.58	31.5636	-30.29	2.60798304	19.065

5.3 Thickness Vs Height Graph Of 14.2 Kg Cylinder

The figure shows the thickness vs height graph of the both constant pressure and variable pressure . In horizontal axis represent the height and vertical axis represent the thickness of the dome.

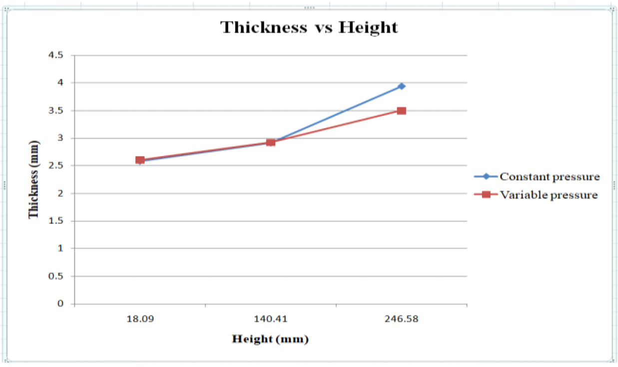

Chart -1: Thickness vs height graph of 14.2 kg cylinder

5.4 Application Of Constant Pressure In The 19 Kg Cylinder

Similarly in the case of the application of constant pressure in the 19 kg cylinder , the friction coefficient taken from 0.03 to 0.01 and the blank holder pressure taken from 12 Mpa to 14 Mpa are tested. Also calculate the thickness and weight of the dome. The table 6.7 shows application of constant pressure in the 19 kg cylinder.

The best solution is obtained in the blank holder pressure 13 MPa and friction coefficient 0.02. Here takes the top node, middle node, and bottom node of the dome. Also calculate the thickness and weight of the dome. The table 6.8 shows application of constant pressure in the 19 kg cylinder.

Table-5: Final results of 19 kg cylinder

SI. No.	Nodes	Initial coordinates (mm)				Directional Deformation (mm)				Final coordinates (mm)				Thickness (mm)	Height (mm)
		X1	Y1	X2	Y2	X1'	Y1'	X2'	Y2'	X1''	Y1''	X2''	Y2''	t	h
1	Top node	303.17	352.9	303.17	350	-135.68	-106.27	-132.47	-103.43	167.49	246.63	170.7	246.57	3.2105607	271.6
2	Middle node	175.8	352.9	175.8	350	-68.16	-204.4	-65.404	-201.54	107.64	148.5	110.396	148.46	2.75629026	173.48
3	Bottom node	21.06	352.9	21.06	350	5.8	-362.85	8.2503	-359.13	26.86	-9.95	29.3103	-9.13	2.58386727	15.46

5.5 Application Of Variable Pressure In The 19 Kg Cylinder

Similarly in the case of the application of variable pressure in the 19 kg cylinder , the friction coefficient taken from 0.03 to 0.01 and the blank holder pressure taken from 12 Mpa to 14 Mpa are tested. The only difference is applying the variable pressure as two stages. That is applying variable pressure is devided into initial stage and final stage. Also calculate the thickness and weight of the dome. The table 6.9 shows application of variable pressure in the 19 kg cylinder.

The best solution is obtained in the initial pressure at 10 Mpa and final pressure at13 MPa and friction coefficient is 0.02. Here takes the top node, middle node, and bottom node of the dome. To solve the problem by using Microsoft excel sheet. The table 6.10 shows, the calculated final results are,

Table-6: Final results of 19 kg cylinder

SI. No.	Nodes	Initial coordinates (mm)				Directional Deformation (mm)				Final coordinates (mm)				Thickness (mm)	Height (mm)
		X1	Y1	X2	Y2	X1'	Y1'	X2'	Y2'	X1''	Y1''	X2''	Y2''	t	h
1	Top node	303.17	352.9	303.17	350	-135.59	-106.18	-132.48	-103.36	167.58	246.72	170.69	246.64	3.11102877	271.68
2	Middle node	175.8	352.9	175.8	350	-68.165	-204.35	-65.398	-201.49	107.635	148.55	110.402	148.51	2.7672891	173.53
3	Bottom node	21.06	352.9	21.06	350	5.798	-361.83	8.2848	-358.18	26.858	-8.93	29.3448	-8.18	2.5974361	16.445

5.6 Thickness Vs Height Graph Of 19 Kg Cylinder

The figure 6.17 shows the thickness vs height graph of the both constant pressure and variable pressure . In horizontal axis represent the height and vertical axis represent the thickness of the dome.

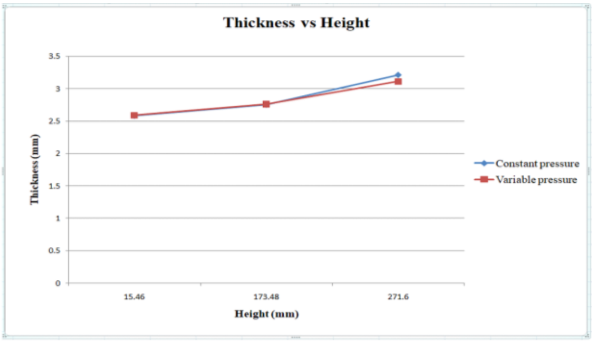

Chart -2: Thickness vs height graph of 19 kg cylinder

6. RESULTS AND FINDINGS

In the case of the application constant pressure in the 14.2 kg cylinder, the results indicates thickness variation is high. But the proposed parameter values reduce the overconsumption of the material. The best result is obtained at friction coefficient 0.02 and pressure at 12 Mpa.

Similarly in the case of the application variable blank holder pressure in the 14.2 kg cylinder, the results indicates thickness variation is less compare to constant pressure application. Also the proposed parameter values reduce the overconsumption of the material. The best result is obtained at friction coefficient 0.02 and pressure in initial stage at 10 Mpa and in final stage at 12 Mpa.

In the case of the application constant pressure in the 19 kg cylinder, the results indicates thickness variation is high. But the proposed parameter values reduce the overconsumption of the material. The best result is obtained at friction coefficient 0.02 and pressure at 13 Mpa.

Similarly in the case of the application variable blank holder pressure in the 19kg cylinder, the results indicates thickness variation is less compare to constant pressure application. Also the proposed parameter values reduce the overconsumption of the material. The best result is obtained at friction coefficient 0.02 and pressure in initial stage at 10 Mpa and in final stage at 13 Mpa.

7. CONCLUSIONS

The application of constant blank holder pressure increases the variation between minimum thickness and maximum thickness and it lead to increased thinning at the bottom portion of the cup. whereas, the proposed variable blank holder pressure and friction coefficient reduces the thinning of the deep drawn part. At low constant blank holder pressure in the initial stage prevents thinning of the material. If the blank holder pressure is too small it will leads to wrinkling in the material. The magnitude of the blank holder pressure in the initial stages plays a vital role in the thickness distribution in the drawn part. Then the punch pressure remains constant, an increasing blank holder pressure restrains the wrinkling tendency and enables a smooth flow of material into the die cavity.

For applying the variable blank holder pressure extra setup are needed in the industry. Because, as far as industry is concerned only single constant pressure application is possible. There is only single input setup is possible in the industry. So additional setups are needed to the application of variable blank holder pressure in the industry.

REFERENCES

[1] V.Sravani, M.Alekya (2020), Simulation and optimization of deep drawing process parameters for cylindrical cup by using FEM and taguchi , Journal of Interdisciplinary Cycle Research, ISSN NO: 0022-1945.

[2] Chandra Pal Singh, Geeta Agnihotri (2017), Finite element analysis of deep drawing process to investigate effect of friction, ijmet, Volume 8, Issue 10, October 2017, pp. 759–767.

[3] R.Padmanabhan, M.C. Oliveira, J.L. Alves , L.F. Menezes (2008), Numerical simulation and analysis on the deep drawing of LPG bottles, journal of materials processing technology 200 (2008) 416–423.

[4] P Venkateshwar Reddy, Perumalla Janaki Ramulu, G Sandhya Madhuri, Dasari Govardhan, P V S Ram Prasad (2016), Design and Analysis of Deep Drawing Process on angular Deep Drawing Dies for Different Anisotropic Materials, IOP Conf. Series.

[5] Anubhav Singh, Shamik Basak, Lin Prakash P.S, Gour Gopal Roy, Maha Nand Jha,Martin Mascarenhas, Sushanta Kumar Panda (2018),Prediction of earing defect and deep drawing behavior of commercially pure titanium sheets using CPB06 anisotropy yield theory, Elsevier, 256-267.

[6] Sandip chaudhary, Dhaval shah (2015), A Review on Influence of the effect of process parameters in deep drawing, ijar, volume 5 ,issue 1.

[7] Adnan I.O. Zaid (2017), Effect of Different Lubricants on Deep Drawing of Galvanized Steel, International Journal of Scientific & Engineering Research, Volume 8, Issue 1, January-2017.

[8] Alok Tom, Geo Mathew Pius, George Joseph, Jacob Jose and Mathew J Joseph (2014), Design and analysis of LPG cylinder , International Journal of Engineering & Applied Sciences (IJEAS), Vol.6, Issue 2(2014)17-31.

[9] Dr. R . Venkat Reddy and V. Mounika (2017), Effect Of Various Process Parameters On Punch And Die Design In Deep Drawing Process, (IJITR) International journal of innovative technology and research, Volume No.5, Issue No.6, October - November 2017, 7684-7691.

[10] Hussein Zein and Osama M. Irfan (2021), Optimization and Mapping of the Deep Drawing Force Considering Friction Combination, MDPI, Appl. Sci. 2021, 11, 9235.