

CERTIFICATE



DELHI COLLEGE OF ENGINEERING
UNIVERSITY OF DELHI
(Govt. of National Capital Territory of Delhi)
BAWANA ROAD, DELHI - 110042

Date:- _____

This is certified that the work contained in this dissertation entitled “**Finite Element Analysis of Deep Drawing of a Fuel Tank Exterior for a Motorbike**” by **Mr. GURVEEN SINGH** is the requirement of the partial fulfilment for the award of Degree of **Master of Engineering (M.E.) in Production Engineering** at **Delhi College of Engineering**. This work was completed under my supervision and guidance. He has completed his work with utmost sincerity and diligence. The work embodied in this major project has not been submitted for the award of any other degree to the best of my knowledge.

Sh. Vijay Gautam
Department of Mechanical Engineering
Delhi College of Engineering, Delhi

ACKNOWLEDGEMENT

I am thankful to the Almighty because without his blessings this work was not possible. It is a great pleasure to have the opportunity to extend my heartfelt gratitude to everybody who helped me throughout the course of this project.

It is distinct pleasure to express my deep sense of gratitude and indebtedness to my guide **Sh. Vijay Gautam**, Mechanical Engineering Department for his invaluable guidance, patient reviews and continuous encouragement during all stages of thesis. His help in the form of valuable information and research papers at proper time has brought life in this thesis. I feel lucky to get an opportunity to work with him. I am thankful to the kindness and generosity shown by him towards me, as it helped me morally complete the project before actually starting it. I would like to thank **Dr. B.D Pathak, HME** for their cooperation. Without their support it would have been almost impossible to complete my thesis work in time.

I would also like to extend my sincere thanks to **Shri Rajendra Tandon, Head Quality Assurance, Satyam Auto Ltd., Manesar** for the most valuable support and encouragement during the entire project.

Last, but not the least, I would like to thank my family members for their help, encouragement and prayers through all these months. I dedicate my work to them.

(GURVEEN SINGH)

Roll No. 14/pro/08

ABSTRACT

Despite the fact that sheet metal forming techniques are extensively used in the modern industry, the use of new manufacturing concepts and advanced materials is of major interest to manufacturers of automobile sector. In this connection, the use of computer applications for the effective & precise analysis of sheet metal forming is quite important in the light of large number of variables which are influencing the process. The recent development of more reliable and flexible numerical and analytical methods provides economically sound solutions to many sheet metal forming problems.

In sheet metal forming operations CRDQ steel has gained a lot of importance (because of its extreme good deep drawing capabilities) among most of the major motorbike manufacturers and steel companies worldwide. Therefore CRDQ steel sheet of 0.8mm thick was selected and characterized for various mechanical properties.

For theoretical analysis in this work finite element analysis software (HyperMesh & Dynaform), is used to perform the numerical simulation of the deep drawing of a fuel tank exterior for a new generation motorbike. Simulations were carried out for varying blank holding force during the draw for the analysis of strain distributions and drawbead.

Deep drawing operations were performed at m/s Satyam Auto components Ltd., for CRDQ steel for different blank holding forces during the deep draw. The blank holding force with and without draw bead and strain distributions have been analysed experimentally and results were compared with the FE simulation.

INDEX

Contents	Page no.
Certificate	i
Acknowledgement	ii
Abstract	iii
Index	iv
List of figures	viii
Chapter 1	
INTRODUCTION	1
1.1 DEEP DRAWING PROCESS	2
1.1.1 General description of the process	2
1.1.2 Friction conditions at deep drawing	4
1.1.3 Drawbeads	6
1.1.4 Punch force	7
1.2 DESCRIPTION OF PROCESS VARIABLES	9
1.2.1 Punch nose radius	9
1.2.2 Die nose radius	10
1.2.3 Blank holder	10
1.2.4 Clearance	12
1.2.5 Material variables	13
1.2.6 Tooling and equipment	14

Chapter 2	BEHAVIOUR OF MATERIAL IN SHEET	15
	METAL DRAWING	
2.1	Factors influencing plastic deformation	15
	In deep drawing	
2.1.1	Anisotropy value (r) and work Hardening coefficient (n)	16
2.1.2	Friction	18
2.1.3	Forming speed	20
2.2	Failure modes in deep drawing	20
2.2.1	Wrinkling	21
2.2.2	Tearing	22
2.2.3	Earing	23
2.3	Formability	24
Chapter 3	LITERATURE REVIEW	26
3.1	Effect of work hardening and anisotropy in deep drawing	27
3.2	Effect of process variables in deep drawing	27
3.3	Effect of blank holding pressure in deep drawing	29
3.4	Effect of friction in deep drawing	30
3.5	Finite element analysis in deep drawing process	31
3.6	Experimental studies in deep drawing	32
3.7	Objective , need and scope of the study	33

Chapter 4	FINITE ELEMENT ANALYSIS OF DEEP DRAWING PROCESS	34
4.1	Introduction	34
4.2	Constitutive equations	
4.2.1	Elastic-plastic model	36
4.2.1.1	Formulation for elastic-plastic deformation	37
4.3	Yield criterion	38
4.3.1	Tresca's yield criterion	38
4.3.2	Von mises yield criterion	39
4.3.3	Hill's anisotropic yield criterion	39
4.4	Finite element analysis	40
4.4.1	Dynaform	40
4.4.2	Hypermesh	40
Chapter 5	METHODOLOGY	41
5.1	Experimental work	41
5.1.1	Selection of materials	41
5.1.2	Determination of tensile properties	42
5.1.3	Determination of average plastic strain ratio (Normal anisotropy – \bar{R} value)	44
5.2	Testing the material for biaxial stretching	47
5.2.1	Preparation of the blank	48
5.2.2	Stretch forming experiments	49
5.2.3	Strain measurement	50

5.2.4	Cup Height measurement	52
5.3	FE simulation of stretch forming	52
5.3.1	Design parameters for stretch forming simulations	53
5.3.2	Material model	55
5.3.3	Simulation Results of Biaxial Stretching	56
5.4	Experimental results of Fuel tank Exterior of Motor Bike	59
Chapter 6	RESULT AND DISCUSSION	61
6.1	Step 1 Blank Size Optimization	61
6.2	Step 2 Optimisation of Blank Holding Force	63
6.3	Step 3 Die Corner Radius	65
6.4	Step 4 Drawbead Analysis	67
6.5	Step 5 Thinning Analysis	69
6.6	Step 6 Blank Shape obtained after Re-engineering	71
Chapter 7	CONCLUSION	72
7.1	SCOPE FOR FUTURE WORK	73
References		74

List of Figures

Fig.no	Description	Page no.
1	Schematic representation of the deep drawing operation, for a cylindrical tool	3
2	Variation in thickening of flange, deformation and necking of workpiece during deep drawing process (M. Colgan, J. Monaghan, 2003)	4
3	Drawing operation with Drawbead	7
4	Different types of blank holders	12
5	Factors affecting material behavior	17
6	Areas of lubrication in Deep Drawing	19
7	Two samples of wrinkling ;(a) flange wrinkling,(b) dish wrinkling (Jamal Hematian, 2000)	21
8	Tearing	22
9	Earing	23
10	FEA in Hypermesh	34
11	Dimensions of Tensile specimen (ASTM E8)	42
12	10 Ton Instron machine used for tensile testing	43

13	True Stress-True Strain curve	47
14	Schematic of punch and die setup for LDH tests	47
15	Pattern of grid marking on the sample	48
16	Pattern of stamping on the sample for LDH test	49
17	Experimental setup on the 100-tonne hydraulic press	50
18	Specimen with Necking	51
19	Travelling Microscope used for measuring deformed circles.	51
20	Arrangement of tools and blank in FE simulation	54
21	Modelling in Dynaform	54
22	Limiting Dome Height	56
23	Thinning Strain in LDH Test	56
24	VonMises stresses in LDH Test	57
25	Thickness Strain in LDH Test	57
26	Fuel tank exterior without flange	58

27	Fuel tank Exterior with flange	58
28	Thinning Analysis	68
29	VonMises Stresses	69
30	Plastic Strain	69
31	Simulation result of original blank shape	70