EXPERIMENTAL AND NUMERICAL STUDIES ON SPRING BACK IN U-BENDING OF TAILOR WELDED BLANKS

Submitted to **Delhi Technological University** in partial fulfilment of the requirement for the award of the degree of

Master of Technology

In

Production Engineering

By

ASHISH KUMAR SHUKLA (2K12/PIE/04)

UNDER THE SUPERVISION OF

Shri Vijay Gautam

Assistant Professor

Mechanical Engineering Department

Delhi Technological University

Bawana Road, Delhi-110042, INDIA

July-2014

Certificate

Date: - ____/___/_____

This is to certify that report entitled **"Experimental And Numerical Studies On Spring Back In U-Bending of Tailor Welded Blanks"** by **Mr. Ashish Kumar Shukla** is the requirement of the partial fulfilment for the award of Degree of **Master of Technology (M.Tech.)** in **Production Engineering** at **Delhi Technological University**. This work was completed under my supervision and guidance. He has completed his work with utmost sincerity and diligence.
The work embodied in this project has not been submitted for the award of any other degree to the best of my knowledge.

Shri Vijay Gautam

(Assistant Professor)

Department of Mechanical Engineering

Delhi Technological University, Delhi

Student's Declaration

I hereby declare that this thesis entitled "**Experimental And Numerical Studies On Spring Back In U-Bending of Tailor Welded Blanks**" is my own research except as cited references. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature :

Name : ASHISH KUMAR SHUKLA

Roll no. : 2K12/PIE/04

Date : 16 JULY 2014

Acknowledgement

There are many person who given me a reason to thank them, firstly, I am grateful to **Prof. Navin Kumar**, Head Of Department (Mechanical Engineering) for giving me an opportunity to work with **Shri Vijay Gautam**. I wish to express my deep sense of gratitude to my supervisor, **Shri Vijay Gautam** for his encouragement, guidance, advices, motivation and friendship to make this thesis become reality. Without his continuous support this thesis would not be completed.

I am also thankful to staffs of Mechanical Engineering department lab of Delhi Technological University for the guidance and support during this thesis in making. My special acknowledgement also goes to my family, and my colleagues for their full support either morale or materials in helping me to finish up this thesis. I also sincerely acknowledge the help of all people who directly or indirectly helped me in my project work and constantly encouraged me.

Ashish Kumar Shukla

(2K12/PIE/04)

Abstract

Tailor welded blank (TWB) is an advancement in the field of sheet metal forming in which multiple blanks are welded together to create a single blank prior to forming process. Springback behaviour of TWBs in bending is complex due to thickness, material combination and rolling direction of sheet metal which shows variation with different Punch corner radius. In this Thesis, the effect of punch profile radius on the springback of Parallel to length welded strips has been investigated in U-bending operation with Tool bend angle of 90° and using punches with three different punch profile radii of 7.5 mm, 10 mm and 12.5 mm. TWBs were prepared by laser welding of interstitial- free steel blanks with a thickness combination of 0.8 mm and 1.5 mm. The Tensile properties of parent materials and tailored blanks were evaluated by Tension test as per ASTM-E8M standard. The bend samples with transverse weld line were prepared to a size of 20mmX130mm to ensure plane strain bending. The different naked eye observations of tailoring Pattern with one sheet to other sheet lead to modelling of TWBs Cross-section. After Proper modelling Finite element (FE) simulations were performed for TWBs Model with and without Weldline property. Whereas in with Weldline property as per Width provided by ASTM-E8 for subsized and micro specimens used for simulation using Abaqus. All FEA Specimens in Abaqus are divided on the basis of material orientation and section assignment for Centre line TWBs cross-section Integration model, for top surface shell element analysis, with anisotropy and without anisotropy were found to be in good agreement with the experimental results

TABLE OF CONTENTS

List of Figure

List of Table

List of Symbols

α = bend angle (in radians)

R = Bend radius

t = sheet thickness

K = Strength coefficient

n = Strain hardening exponent

e_o = Strains the outer fibres

e_i = strains inner fibres

$F_{max} =$ Maximum bending force

L = length of the part

R_i = Bend radius before spring back

R_f = Bend radius after spring back

K_s = Spring-back ratio

θ_i = Bending angle before springback

θ_f = Bending angle after springback

z = The distance of an element from neutral axis in the bend region

$L_0 =$ Arc length at the mid-plane

e = Engineering strain

ε_x = True strain in x-axis

ε_y = True strain in y-axis

ε_z, = True strain in z-axis

M= Bending moment

σ_x=Stress in x direction

S = Plane strain yield stress

E' = Modulus of elasticity in plane strain

μ = coefficient of friction

ϵ_w = Strain in width direction

ϵ_t = Strain in thickness direction

ν = Poisson's ratio.

E = Young's modulus

Y= Distance from middle surface to stress at some distance

ρ = Radius of curvature of sheet of a cylindrical bent region

σ= Representative/effective or equivalent stress

r_p = Plastic strain ratio

$\bar{R}$ = Normal anisotropy (R-BAR)

r_0 = Plastic strain ratio in rolling direction

r_{45} = Plastic strain ratio in diagonal direction

r_{90} = Plastic strain ratio in transverse direction

θ_{tool}= Angle of die

List of Abbreviations

ASTM	American Standard for Testing and Materials
CAD	Computer-aided design
IF Steel	Interstitial Free Steel
FEA	Finite Element Analysis
FEM	Finite Element Method
UTM	Universal Testing Machine
UTS	Ultimate Tensile Stress
YS	Yield Stress
ST	Standard size Tensile Specimen
SS	Sub-sized tensile Specimen
SEM	Scanning Electron Microscope
SIM	Simulation
TWB	tailor Welded blanks
RD	Rolling Direction
PCR	Punch Corner Radius
SB	Spring-Back

Specimen's Nomenclature

T	Thickness
T1	Thickness of thinner Sheet Metal 0.8mm
T2	Thickness of thicker Sheet Metal 1.5mm
T1-T2	TWB of both the sheet

$$\mathbf{T1 - T2 - XX - YY} \quad (1)$$

$$\mathbf{T1 - XX - YY} \quad (2)$$

$$\mathbf{T2 - XX - YY} \quad (3)$$

XX	Rolling Direction of TWB or orientation of joined sheet w.r.t. weld line
XX	0^0 Parallel to rolling direction, 45^0 to rolling direction and 90^0 perpendicular to the rolling direction
YY	Dimension of specimen size mentioned only in case of Subsized and micro-sized specimens
YY	Subsized Specimen Width 6.0mm
YY	Micro-Sized Specimen Width 2.0mm

Note: Similar sequence Followed in parent, TWBs, bending and Simulation, With Further Property of Test incorporated