SPRINGBACK PREDICTION OF MILD STEEL SHEET ON L-BENDING

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We certify that the project entitled "*Springback Prediction of Mild Steel on L-Bending*" is written by *Che Amir Rajhan bin Che Jaffar*. We have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. We herewith recommend that it be accepted in partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering.

Examiner Signature

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

This report deals with deformation analysis of springback in L-bending of sheet metal. Nowadays, many softwares is produced to investigate about the springback in sheet metal bending. These softwares is getting applicable and useful from time to time. Mastering this software will make the industry especially manufacturing industry know the element and condition of materials and appropriate bending process for such material in order to manage the company production cost. This report is done with simulation of springback using a material of Mild Steel on L-bending process and also an experiment of L-bending is conducted using a 1 mm thickness. The springback of Mild Steel sheet was investigated using finite element analysis. Abaqus software is used in this project to simulate the springback of sheet metal in L-bending. The value of 0.5 mm mesh is used for the simulation. In this simulation the die and pressure pad is declared as contact with the workpiece and friction was defined with 0.1. Punch is also declared as contact with the workpiece and it was defined as frictionless. Then the nodes were taken and import to Auto Cad software to measure the angle of springback from the simulation. An experiment of ten specimens of Mild Steel sheet were conducted in this experiment and the result were taken. Thickness of 1 mm was used for the experiment for all specimens. Profile Projector machine is used to measure the angle of the ten specimens. The result from the experiment will be compared to the result of simulation. The result of this report show the springback in simulation 2^{o} and the result of experiment is 2.3^{o}.

ABSTRAK

Laporan ini berurusan dengan analisis pembentukan tentang bangkit kembali dalam L-bengkok dari lembaran logam. Pada masa ini, banyak perisian yang dihasilkan untuk menyiasat tentang lenturan dalam lembaran logam bengkokkan. Perisian ini semakin boleh di gunakan dan berguna dari semasa ke semasa. Menguasai perisian ini akan membuat industri terutama industri perkilangan mengetahui unsur dan keadaan bahan dan proses bengkokkan yang sesuai untuk bahan tersebut untuk menguruskan kos pengeluaran syarikat. Laporan ini disiapkan dengan simulasi tentang bangkit kembali menggunakan bahan Keluli Lembut dalam proses L-bengkok dan juga sebuah eksperimen L-bengkok dilakukan dengan menggunakan ketebalan 1 mm. Bangkit kembali kepingan Keluli Lembut diteliti menggunakan Analisis Unsur Terhingga. Perisian "ABAQUS" digunakan dalam projek ini untuk mensimulasikan lentur dari kepingan logam dalam L-bengkok. Nilai mesh 0.5mm digunakan untuk simulasi ini. Dalam simulasi ini pemati dan tekanan pad dinyatakan sebagai hubungan dengan benda kerja dan ditakrifkan gesekan dengan 0.1. Penekan juga dinyatakan sebagai hubungan dengan benda kerja dan ia ditakrifkan sebagai tiada geseran. Kemudian titik diambil dan dipindahkan ke perisian "Auto Cad" untuk mengukur sudut bangkit kembali dari simulasi. Sepuluh kepingan Mild Steel dilakukan dalam eksperimen ini dan hasilnya diambil. Ketebalan 1 mm digunakan dalam eksperimen ini untuk semua spesimen. "Profile Projector" mesin digunakan untuk mengukur sudut dari sepuluh spesimen itu. Hasil daripada eksperimen akan dibandingkan dengan hasil simulasi. Keputusan laporan ini menunjukkan 2° lentur daripada simulasi dan 2.3° lentur daripada eksperimen.

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LIST OF SYMBOLS

σ^2	Variance
F_{max}	Bending Force
μ	Mean

LIST OF ABBREAVIATION

FEA	Finite Element Analysis
UTS	Ultimate Tensile Strength
TS	Tensile Strength
AISI	American Iron and Steel Institute
CRES	Called-Corrosion-Resistant
FYP	Final Year Project

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter provides a brief overview of the entire project consists of project background, problem statement, objectives, scopes of the works and organization of the thesis.

1.2 PROJECT BACKGROUND

This report deals with deformation analysis of springback in L-bending of sheet metal. Nowadays, many softwares are produced to investigate about the springback in sheet metal bending. These softwares are getting applicable and useful from time to time. Mastering this software will make the industry especially manufacturing industry know the element and condition of materials and appropriate bending process for such material in order to manage the company production cost.

Abaqus software had been used for this project to simulate the springback of sheet metal in L-bending. The model of experiment setup is draw in Abaqus software and defined it as 2D. There have four main components in L-bending process. It is are pressure pad, die, workpiece(sheet metal), and punch. The drawing of these tools is depend on the actual geometry. After that, two nodes were taken from the simulation of sheet metal. These nodes were export to the Auto Cad and the springback will be measured.

Then, an experiment of L-bending will be conducted using bending machine. Ten specimen were be using for the specimen. Specimen is measured using Profile Projector machine to know the springback angle. The result from the experiment will be compared to the result of simulation.

1.3 PROBLEM STATEMENT

Sheet metal stamping plays a major role in many industries today. As part components get smaller and tolerances get tighter, the dimensional accuracy of a stamped part becomes a crucial factor in determining the overall quality of the part. In most, if not all, sheet metal forming processes, springback is the major problem faced. Springback often complicates the design of forming dies, and final die designs may only be accomplished after fabrication and testing of multiple prototypes. This poses significant problems to designers, who must accurately assess the amount of springback which occurs during a forming process so that a final desired part shape can be obtained.

1.4 PROJECT OBJECTIVES

The objectives of this study are:

1. To evaluate accuracy in predicting springback using Finite Element Method (FEA).
2. To apply FEA technology in sheet Mild Steel forming or bending.

1.5 PROJECT SCOPE

Basically, this analysis based on:

1. Geometrical models of 2D.
2. Numerical bending analysis based on Abaqus software.
3. To conduct experiment on sheet metal bending.
4. Analyze and compare the simulation and experiment result.

1.6 THESIS ORGANIZATION

This thesis consists of three 4 chapters:

Chapter 1 is provides a brief overview of the entire project include objective of the project, scope and problem statement.

Chapter 2 is presents the background of the system including the types of bending, parameters of bending, tolerances, springback ang the improvement of spring back. It also discuss about bend allowance and material modeling.

Chapter 3 is discussing of methodology used for the application development. It includes a flow chart of this report and the plan how to run the software to predict springback.

Chapter 4 is discussing about a result from the simulation and the experiment. It includes a how to calculates the springback by using a Auto Cad and calculation and measuring of springback from experiment using Profile Projector PJ-A3000.

Chapter 5 is discussing about a conclusion and recommendation of this report. It include a recommendation how to reduce a springback in L-bending.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will discuss about the types of bending and material. It also discuss about meaning of springback, yield point and ultimate tensile strength. Bending, springback and related equations are among the interested terms in this chapter. The source from literature review is from journals, articles and books. Literature review is done to provide information about previous research and that can help to smoothly run this project.

2.2 THEORY OF SHEET METAL BENDING

A process by which metal can be deformed by plastically deforming the material and changing its shape is called bending. The material is stressed beyond the yield strength but below the ultimate tensile strength. The surface area of the material does not change much. Bending usually refers to deformation about one axis.

Bending is a flexible process by which many different shapes can be produced. Standard die sets are used to produce a wide variety of shapes. The material is placed on the die, and positioned in place with stops and or gages. It is held in place with hold-downs. The upper part of the press, the ram with the appropriately shaped punch descends and forms the v-shaped bend.

Bending is done using Press Brakes. Press Brakes normally have a capacity of 20 to 200 tons to accommodate stock from 1m to 4.5m (3 feet to 15 feet). Larger and smaller presses are used for specialized applications. Programmable back gages, and multiple die sets available currently can make for a very economical process. (Boljanovic, 2004)

2.3 TYPES OF BENDING

A bending tool must be decided depending on the shape and severity of bend. Following are the different types of bending commonly used for precision sheet metal bending. (Boljanovic, 2004)

(a) "V" Bending
(b) "L" Bending
(c) "U" Bending

2.4 L-BENDING

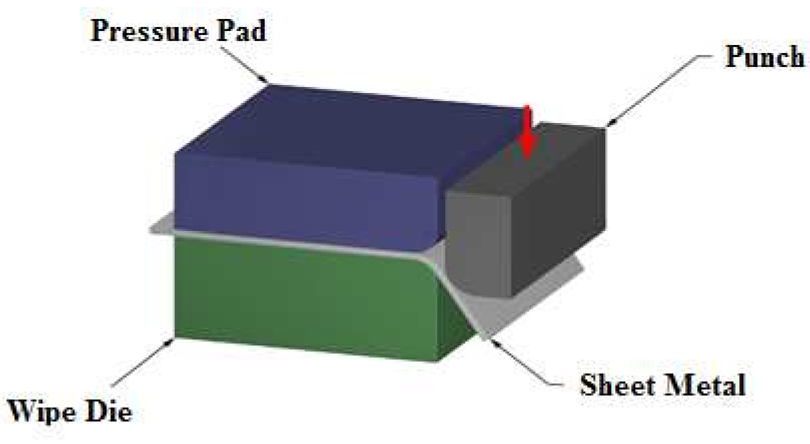

Figure 2.1: L-bending illustration
Source:

L-Bending dies are used for 90° bending. L-bending dies can produce more accurate and consistent parts compared to V-bending. This is due to the presence of spring loaded clamping pads which will hold sheet metal closer to the bending line and then the bending punch pushes the sheet metal into the bending die along the bending line. L bending dies can also be used for bending angles smaller than 90° by providing suitable punch profiles and by controlling the travel of the punch. We may need a series of L-bending operations to be done in a progressive metal stamping die to produce complex parts. Figure 2.2 shows L-bending illustration. (Boljanovic, 2004)

2.4.1 Parameter of Bending

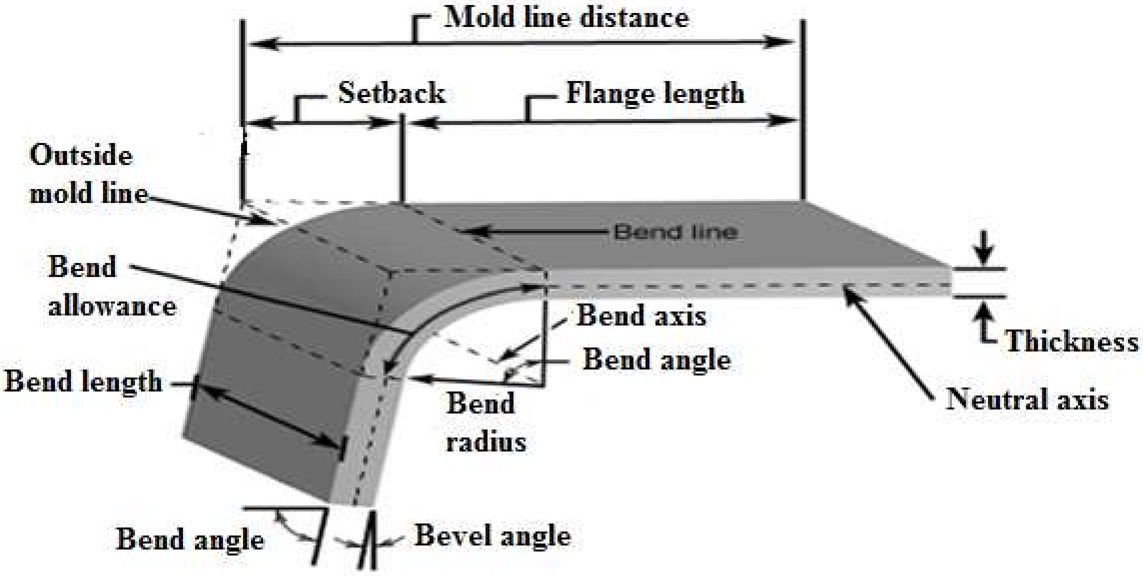

Figure 2.2: Parameters of Bending

Source: www.custompartnet.com

1. **Bend Allowance –** The length of the arc through the bend area at the neutral axis.
2. **Bend Angle –** The included angle of the arc formed by the bending operation.
3. **Bend Compensation –** The amount by which the material is stretched or compressed by the bending operation. All stretch or compression is assumed to occur in the bend area.
4. **Bend Lines –** The straight lines on the inside and outside surfaces of the material where the flange boundary meets the bend area.
5. **Inside Bend Radius –** The radius of the arc on the inside surface of the bend area.

6. **K-factor** – Defines the location of the neutral axis. It is measured as the distance from the inside of the material to the neutral axis divided by the material thickness.
7. **Mold Lines –** For bends of less than 180 degrees, the mold lines are the straight lines where the surfaces of the flange bounding the bend area intersect. This occurs on both the inside and outside surfaces of the bend.
8. **Neutral Axis –** Looking at the cross section of the bend, the neutral axis is the theoretical location at which the material is neither compressed nor stretched.
9. **Set Back** - For bends of less than 180 degrees, the set back is the distance from the bend lines to the mold line. (Boljanovic, 2004)

2.5 BASE EQUATION OF BENDING FORCE

The equation for maximum bending force is,

$$F_{\max} = k\frac{(UTS)Lt^2}{W} \tag{2.1}$$

,

where k is a factor taking into account several parameters including friction, and L and t are Length and thickness of sheet metal respectively. The variable W is opening width of a V-die or Wiping die. (Boljanovic, 2004)

2.6 STRESS-STRAIN CURVE

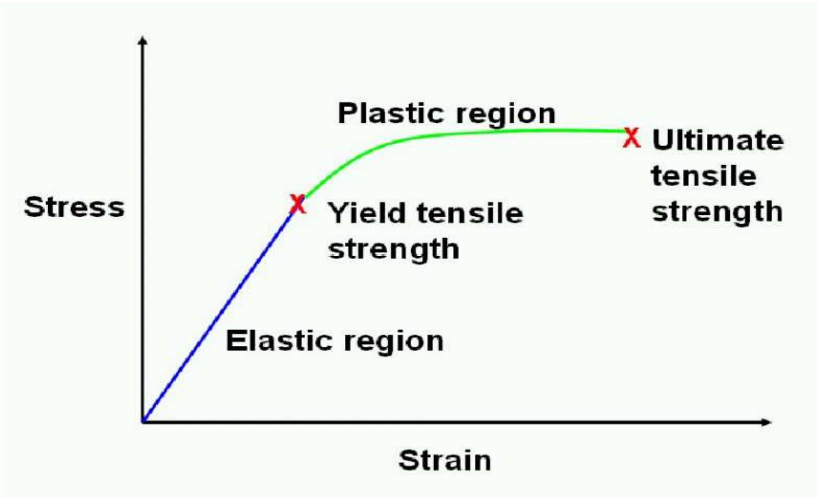

Figure 2.3: Stress-Strain Curve

Source: www.tutorvista.com

2.6.1 Yield Point

The yield point is that point when a material subjected to a load, tensile or compression gives and will no longer return to its original length or shape when the load is removed. Some materials break before reaching a yield point, for example, some glass-filled nylons or die cast aluminum. To try to further visualize this property, take a piece of wire and slightly bend it. It will return to its original shape when released. Continue to bend and release the wire further and further. Finally, the wire will bend and not return to its original shape. The point at which it stays bent is the yield point. The yield point is a very important concept because a part is usually useless after the material has reached that point. (Michael F. Ashby, 2005)

2.6.2 Ultimate Tensile Strength

Ultimate tensile strength (UTS), often shortened to tensile strength (TS) or ultimate strength, is the maximum stress that a material can withstand while being stretched or pulled before necking, which is when the specimen's cross-section starts to significantly contract. Tensile strength is opposite of compressive strength and the values can be quite different. The UTS is usually found by performing a tensile test and recording the stress versus strain and the highest point of the stress-strain curve is the UTS. It is an intensive property, so its value does not depend on the size of the test specimen. However, it is dependent on other factors, such as the preparation of the specimen, the presence or otherwise of surface defects, and the temperature of the test environment and material. (Michael F. Ashby, 2005)

2.7 SPRINGBACK IN L-BENDING

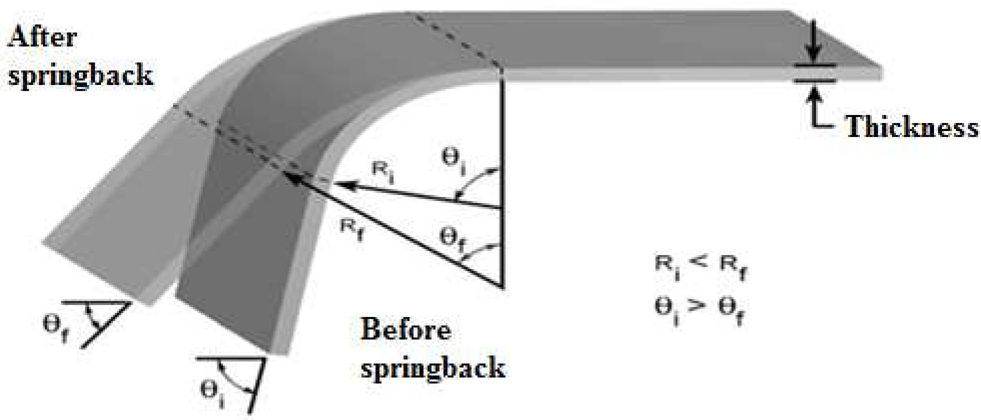

Figure 2.4: Springback

Source: www.custompartnet.com

Figure 2.5 show a angle in springback. R_i is a radius before springback and R_f radius after springback. θ_i is a angle before springback and θ_f is angle after springback. Springback is a main defect occurred in the sheet-metal forming processes and has been thoroughly studied by researchers. Among them, quite a few efforts have been made to obtain a deep understanding of the springback phenomenon. Springback can be defined as an elastically-driven change of shape of the deformed part upon removal of external loads. This phenomenon results in a deviation of the real product geometry from that defined in the design phase and can cause significant problems during assembly. To keep the product development time and manufacturing costs low, finite element analysis aims to provide reliable information necessary for the modification of tool and product geometry. Therefore, the accuracy of information obtained in a numerical simulation of springback is essential for the product designers and die makers.

Springback is generally defined as the additional deformation of a structural component, after the removal of forming loads. It is agreed in the literature that the three main variables that influence springback are the geometry, manufacturing process and blank material. Because of the extensive applications of high strength steels, the significance of springback related problems has increased (Schrader, 2000).

2.8 FINITE ELEMENT ANALYSIS

FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. It is used in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.(Lakshmi, 2009)

There are generally two types of analysis that are used in industry: 2-D modeling, and 3-D modeling. While 2-D modeling conserves simplicity and allows the analysis to be run on a relatively normal computer, it tends to yield less accurate results. 3-D modeling, however, produces more accurate results while sacrificing the ability to run on all but the fastest computers effectively. Within each of these modeling schemes, the programmer can insert numerous algorithms (functions) which may make the system behave linearly or non-linearly. Linear systems are far less complex and generally do not take into account plastic deformation. Non-linear systems do account