SPRING-BACK PREDICTION OF MILD STEEL SHEET ON 60º AIR BENDING

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Bachelor of Mechanical Engineering

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I certify that the project entitled “Spring-back prediction of mild steel sheet on 60º air bending “is written by Mohd Zuhairi Bin Md Zohir. I 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. I herewith recommend that it be accepted in partial fulfilment 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 concurently submitted for award of other degree.

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ABSTRACT

This report deals with the deformation of a spring-back on 60° air bending. Now days, many research and study have been done on a spring-back. In sheet metal bending, a flat part is bent using a set of punches and dies. In this thesis, punches and die are referred to as tools. The punch and the dies are mounted on a press brake, which control the relative motion between the punch and die and provides the necessary bending pressure. In this thesis, the spring-back is done by using both experimental and simulation using FEA software which is ABAQUS 6.7. The material use in this project is mild steel with 1 mm thickness. The size of the specimen is 100 mm x 100 mm. The experimental is done fist follow by the simulation. The specimen required in this project is 10 specimens. The Profile Projector machine is use to measure the angle of the sheet metal in the experiment. In the simulation, 2D drawing of the model have been made using ABAQUS 6.7. The punch, die and the sheet metal is main part in the drawing. The sheet metal then is defined as a rigid body in the software. The meshing has been done to sheet metal with 0.5 mm of the mesh size. After all the simulation is done, several node has been taken to measure the angle by using AutoCAD software. 8 nodes is taken an then transfer it to the AutoCAD software. The result from both experimental and simulation then be compared. The spring-back value in experimental is 62.3° while in the simulation the value is 62°.

ABSTRAK

Laporan ini berkaitan fenomena “spring-back” yang berlaku pada 60° pembengkokkan secara tergantung. Dewasa ini, banyak kajian telah dilakukan pada “spring-back”. Dalam lembaran logam membengkok, bahagian datar akan di bengkokkan menggunakan satu set pemukul dan acuan. Dalam tesis ini, pemukul dan acuan disebut sebagai alat. Pemukul dan acuan sudah dipasang pada mesin, yang mengendalikan gerakan relatif antara pemukul dan acuan dan memberikan tekanan membengkokkan diperlukan. Dalam tesis ini, fenomena “spring-back” dilakukan dengan menggunakan perisian FEA dan eksperimen. Perisian yang digunakan adalah ABAQUS 6,7. Bahan yang digunakan dalam projek ini adalah kepingan besi dengan ketebalan 1 mm. Saiz spesimen adalah 100 mm x 100 mm. Spesimen yang diperlukan dalam projek ini adalah 10 spesimen. Mesin“Profile Projector” digunakan untuk mengukur sudut lembaran logam. Dalam simulasi, 2D gambar model telah dibuat dengan menggunakan ABAQUS 6.7. Pemukul, acuan dan lembaran logam adalah bahagian utama dalam gambar. Logam lembaran kemudian ditakrifkan sebagai benda tegar dalam perisian. “Meshing” telah dilakukan untuk kepingan logam dengan 0,5 mm saiz mesh. Setelah semua simulasi dilakukan, beberapa node telah diambil untuk mengukur sudut dengan menggunakan perisian AutoCAD. 8 node telah diambil kemudian dipindah ke perisian AutoCAD. Keputusan daripada kedua-dua percubaan dan simulasi kemudian akan dibandingkan. Nilai “spring-back” dalam eksperimen adalah 62,3 ° manakal pada simulasi pula nilai adalah 62 °.

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R_i	Actual radius
R_f	Radius after spring-back
Y	Yield strength
E	Elastic modulus
α	Angular
L_t	Total Flat Length
ν	Poisson Ratio
ε	Plastic Strain
σ	Yield Stress

LIST OF ABBREVIATIONS

FEA	Finite Element Analysis
CAD	Computer-aided Design
BD	Bend Deduction
BA	Bend Allowance
2D	2 Dimension

CHAPTER 1

INTRODUCTION

1.1 INRODUCTION

This chapter will discuss about the project background, problem state, project objective and the scope of the project.

1.2 PROJECT BACKGROUND

In sheet metal bending, a flat part is bent using a set of punches and dies. In this thesis, punches and die are referred to as tools. The punch and the dies are mounted on a press brake, which control the relative motion between the punch and die and provides the necessary bending pressure.

1.2.1 Bending Principle

Take a beam 1m long if it starts as a straight beam then the length measured along the top face with the aid of a tape measure is one meter. Similarly the bottom face will also be one meter as shown in Figure 1.1 below.

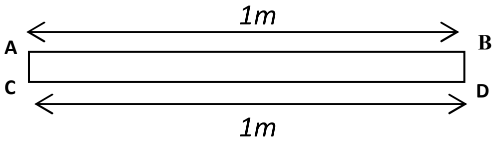

Figure 1.1: Beam

When the beam was straight, AB was equal to CD, but mow by visual inspection it is now obvious that this is not the case, once the beam is flexed. The beam as shown is said to be 'hogging' so that the upper face is longer than the bottom face as shown in Figure 1.2 below.

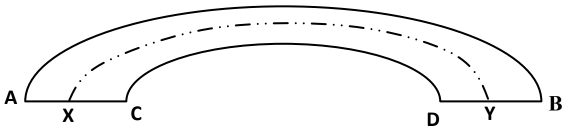

Figure 1.2: Beam is flexed

If the beam is solid then there cannot be any migration of material from the bottom to the top reaches of the beam (because solids are generally rigid or semi-rigid). The only way the hogging can occur is if AB is stretched further than CD by the bending action.

If AB remains 1m then CD must be shorter, the bottom face is therefore compressed and the fibres beneath the surface of the bottom face experience compressive stress. If however CD remains 1m then the upper face AB must have been stretched and the fibres beneath the upper surface are subject to tensile stress.

The two conditions just described represent two extremes. In most flexing situations, reality is somewhere between the two and in many cases is close to halfway between the two, such that length XY midway between AB / CD remains 1m. Therefore AB is stretched and CD is compressed.

The third situation is that assumed in the theory of simple bending generally used for analysis of bending and buckling.

1.3 PROBLEM STATEMENT

Whenever forming metals, some spring-back occurs. The cause of this spring-back is the residual stress that is an inevitable result of cold working metals. For example, in a simple bend, residual compressive stress remains on the inside of the bend, while residual tensile stress is present on the outside radius of the bend. The most common method of correcting for spring-back is to overbend the material to obtain the desired shape after forming. Simply stated, in a bend, residual compressive stress remains on the inside of the bend, while residual tensile stress is present on the outside radius of the bend.

1.4 PROJECT OBJECTIVE

The objectives of this study are:

a) To evaluate and compare the most reliable material modeling in finite element analysis (FEA) predict in spring-back.
b) To apply finite element analysis (FEA) technology in sheet metal forming of bending.

1.5 SCOPE OF THE PROJECT

The scopes of the project are limited to:

a) Develop 2D modeling of V-bending in Finite Element software
b) Analyze 2D modeling Finite Element software purpose for spring-back.
c) Conduct experiment for V-bending using bending machine (air bending).
d) Analyze the simulation and experiment result.
e) Compare the result from both tasks.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter it will discuss about theory of the sheet metal, the common types of bending bend allowance, air bending, spring-back in v-bending, material, and some previous study in v bending.

2.2 THEORY OF SHEET METAL

Sheet metal forming differs from other deformation processes such as rolling, hot extrusion and wire drawing in that it is a non-steady-state process. A deformation zone exists into which all the material enters and is subjected to a fixed deformation pattern before exiting while, in sheet metal forming, different deformation modes can operate in differ areas of the sheet or, subsequently, in the same area, initiated by the interaction between a contoured piece of sheet metal with shaped tools, which are usually installed in a power press.

In sheet metal we can use it to bend. Not all sheet metal has a correct angle when it was bending. This phenomenon calls spring-back. Spring-back occur until residual stress forces are balanced by the material’s stiffness. There is some factors that affect spring-back such as higher material strength, thinner material, lower young’s modulus, larger die radius, greater wipe steel clearance, less irregularity in part outline and flatter part surface contour.

If a flanged part has a lot of irregularity in the flanged area and the part surface contour contributes to stiffness, the spring-back will be less. Large wiping-steel clearances can result in spring-back of several degrees or more.

2.3 COMMON TYPES OF BENDING

There is several type of bending process used in industry. The common use is V-bending, U-bending and wiping dies bending (L-bending).

2.3.1 V-bending

In V-bending, the clearance between punch and die is constant (equal to the thickness of sheet blank). It is used widely. The thickness of the sheet ranges from approximately 0.5 mm to 25 mm.

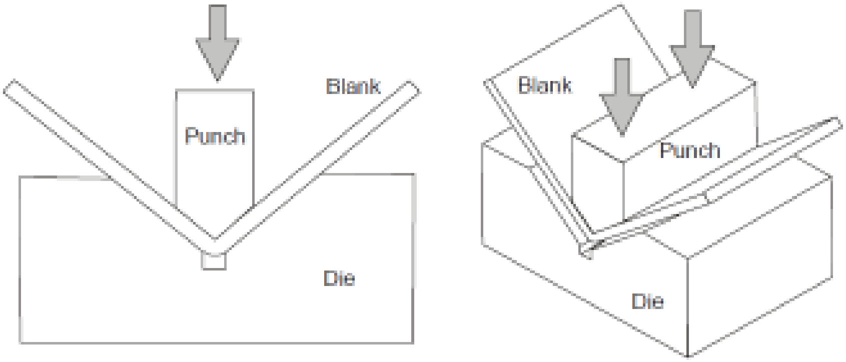

Figure 2.1: Diagram of V-bending process

Source: Diegel, 2002

2.3.2 U-bending

U-bending is performed when two parallel bending axes are produced in the same operation. A backing pad is used to force the sheet contacting with the punch bottom. It requires about 30% of the bending force for the pad to press the sheet contacting the punch.

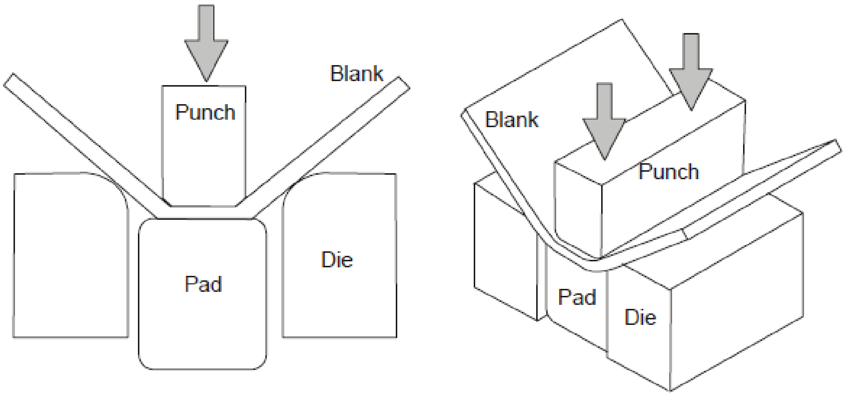

Figure 2.2: Diagram of U-bending process

Source: Diegel, 2002

2.3.3 Wiping die bending (L-bending)

Wiping die bending is also known as flanging. One edge of the sheet is bent to 90° while the other end is restrained by the material itself and by the force of blank-holder and pad. The flange length can be easily changed and the bend angle can be controlled by the stroke position of the punch.

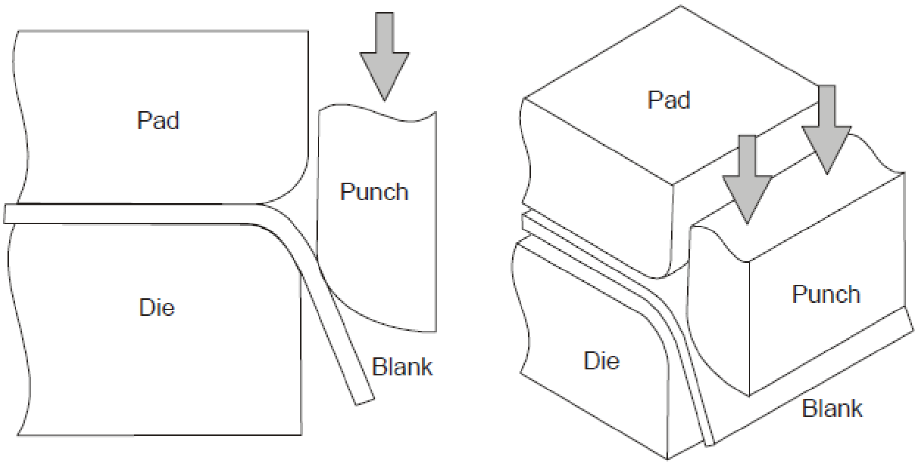

Figure 2.3: Diagram of L-Bending

Source: Diegel, 2002

2.4 BEND ALLOWANCE

When sheet metal is bent, the inside surface of the bend is compressed and the outer surface of the bend is stretched. Somewhere within the thickness of the metal lies its natural axis, which is a line in the metal that is neither compressed nor stretched.

What this means in practical terms is that if we want a work piece with a 90º bend in which one leg measures A and other measures B, then the total length of the flat piece is not A+B. to work out what length of the flat piece of metal needs to be, we need to calculate the Bend Allowance or Bend Deduction that tells us how much we need to add or subtracts to our leg length to get exactly what we want.

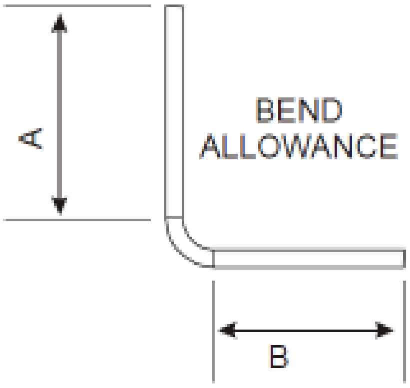

Figure 2.4: Bend allowance

$$L_t = A + B + BA \tag{2.1}$$

Where:

L_t = total flat length

BA = bend allowance value

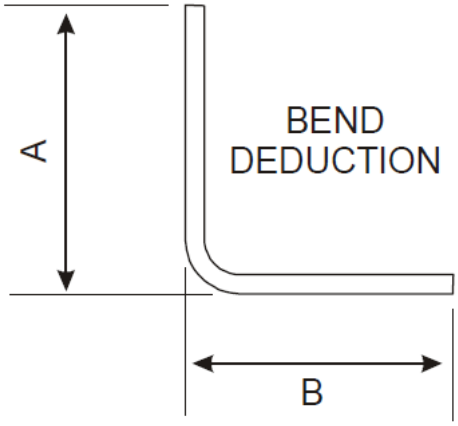

Figure 2.5: Bend deduction

$$L_t = A + B - BD \tag{2.2}$$

Where:

L_t = total flat length

BD = bend deduction value

The location of the neutral line varies depending on the material itself, the radius of the bend, the ambient temperature, direction on the material grain, and the method by which it is being bent, etc. the location of this line is often referred to as the K-factor.

K-factor is a ratio that represents the location of the neutral sheet with respect to the thickness of the sheet metal part.

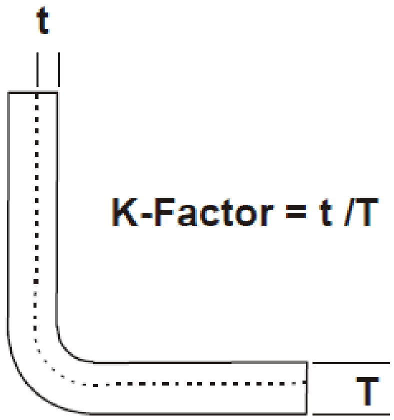

Figure 2.6: Diagram of K-factor

Source: Diegel, 2002

The only truly effective way of working out the correct bend allowance is to reverse engineer it by taking a measured strip of material, bending it and measuring it to calculate the bend allowance. These bend allowance can be measured for many materials and scenarios and then tabulated so that the table can be used by CAD programs to produce accurate sheet metal work.

Many CAD programs however also work out bend allowances automatically by using K-factor calculations.