SUPERVISOR DECLARTION

"I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Design & Innovation)"

Signature: .....

Supervisor: DR. HADY EFENDY

Date: 26 JAN 2013

DESIGN AND SIMULATION

OF DIE AND PUNCH FOR SHEET METAL ON BENDING

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DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged."

Signature: .....

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Date: 26 JUNE 2013

I dedicate this report to my loving mom, Madam Tan Cheok Tang, who also happens to be my best friend. She is been my main supporter all these years. She instilled in me a sense of curiosity about life and a thirst for knowledge. Besides, I would like to take this opportunity to thank all of the people whose time, efforts and help were given in order to help me complete this report on time. Furthermore, I want to thanks all the staff in UTeM especially the lecturer and technicians in FKM to make my PSM undergo smoothly and successfully. Thank you.

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ABSTRAK

Proses lembaran logam lentur adalah satu proses dimana daya tekanan dikenakan atas sekeping logam dalam usaha untuk mengubah struktur geometrinya. Daya tekanan menyebabkan kepingan logam membengkok pada sudut yang dikehendaki diantara penumbuk dan bekas. Walau bagaimanapun, kecacatan biasanya berlaku semasa proses lembaran menyebabkan kepingan logam calar, kepesongan dan perubahan dalam ciri-ciri fizikal kepingan logam. Oleh itu, bekas dan penumbuk kepingan logam direka dan dibangunkan dengan menggunakan SolidWorks untuk meminimumkan kecacatan itu berlaku. Selepas itu, analisis unsur terhingga (FEA) dengan perisian computer komersial, ANSYS digunakan untuk memberi simulasi pembengkokan kepingan logam. Selepas itu, keputusan daripada simulasi dibandingkan dengan keputusan eksperimen yang sedia ada. Ini kerana terdapat perbezaan antara simulasi dengan eksperimen hasil daripada perbezaan keadaan yang sebenar dengan keadaan yang ideal. Selain itu, kajian pembolehubah prinsip lenturan lembaran logam juga dijalankan. Pembolehubah ini termasuk perubahan mekanik seperti ketegangan, tekanan, dan penumpuan daya tekanan dalam kepingan logam.

ABSTRACT

Sheet metal bending processes is a process which force is applied on a piece of sheet metal in order to modify its geometry structure. The force causing it to bend at desired angle and shape between die and punch. However, defect during the bending process cause by die and punch such as scratching, high percentage of deflection and changes in the physical characteristic of the sheet metal usually occur. Hence, the die and punch for sheet metal bending is being designed and developed by using SolidWorks in order to minimize the defect occurs. Following by that, finite element analysis (FEA) with commercial software, ANSYS, computer based-simulation is being used to simulate the sheet metal bending. After that, the results from the simulation are compared with the existing U-bending experiment results due to the differences between real life conditions and ideal conditions. Besides, the study of the principle variables of the sheet metal bending is being carried out. These variables include mechanics of deformation such as stress, strain and force concentration in the sheet metal.

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CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

Sheet metal was a common material used in the industry to produce several of products. It was commonly undergo two groups of process which were cutting process and plastic deformation process. In the report, the bending process of sheet metal, 316L stainless steel was being concentrated. The die and punch used to bend the sheet metal was designed and the bending process was simulated in order to compare the results of simulation with existing experimental results.

1.1 SHEET METAL FORMING

The sheet metal forming can be divided into two groups which are cutting process and plastic deformation process. (Vukota Boljanovic, 2004)

i. Cutting process:

- Shearing

  The process of cutting where the flat materials are cut from sheet, strip or plate. It is classified by two types which is blade or cutter, whether rotary or straight.

- Blanking

  The process of cutting the materials by using shear stresses between die and punch in a closed contour.

- Punching

  The process of cutting where the various shaped holes are sheared in blanks during the cutting operation.

- Parting

  The process of cutting the sheet metal into pieces or remove the pieces of scrap of various shape from deep drawn pieces.

- Lancing

  The process where the work material is being cut with single line across the work piece and no material is being removed. Hence, there is no scrap.

- Shaving

  The process of cutting operation to improve the accuracy and quality of blanked part through the removing the thin strip of metal along its edges.

ii. Plastic deformation process:

- Bending

  The process of straining the flat metal sheet around its linear axis. Outer surface of the bended metal sheet is stressed in tension while inner surface of the bended metal sheet is compressed.

- Twisting

  The process of straining the flat sheet metal around the longitudinal axis.

- Deep drawing

  The process of forming the flat metal sheet into a box-shaped or cylindrical part by using the punch into a die cavity.

- Spinning

  The process of forming work pieces from a tube or circular blank.

- Stretch forming

  The process of stretching a strips, metal sheet or profile over a shaped block form to produced contoured parts.

- Necking

  The process where the top of the part are smaller than its body is being shaped.

- Bulging

  The process that expanding the split female die by placing a conical, curvilinear or tubular part in it.

- Flanging

  The process of hole-making on flat stock.

1.1.1 Bending

The force apply in the sheet metal bending is in the opposite directions resulting the plastic deformation of metal. In sheet metal bending, the stress characteristic are at the localised areas. The pressure or stress occors at the bend radius while the remaining part or flat metal part is not undergo stress during the bending. The outer surface of the sheet metal undergo tensile stress because the surface being stretched or elongated. The inner surface of the sheet metal undergo compressive stress because the surface being squeesed. Hence, the fracturing or failure will occur on the outer surface and the wrinkling will occur on the inner surface. (Lascoe, 1998)

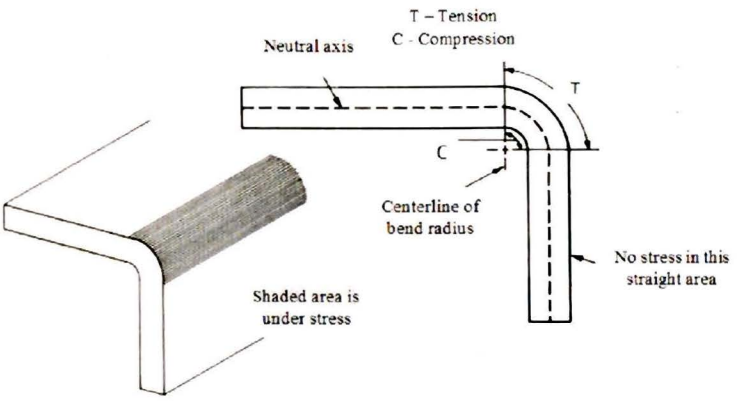


Figure 1.1: Bending Stresses

(O.D. Lascoe, 1998)

1.1.2 Die and punch

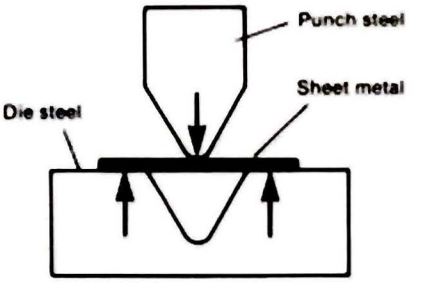


Figure 1.2: Sheet metal bending

(O.D. Lascoe, 1998)

Bending die and punch are generally classified according to their design. It is whether they are simple or complex in design and their universality of application whether they are universal of specific.

The design of bending die and punch depend on:

- Complexity of the workpiece shape
- Workpiece dimensions
- Type of material of workpiece
- The tolerances of workpiece

1.1.3 FEA Simulation

In FEA computer simulation, the effects of changing in any process parameter can be observed prior to the actual tool manufacturing. Accurate simulations and elaboration are performed during the process of tool design and manufacturing phase. Different aspect of a FEA must be considered in order to prepare an adequate numerical model. A numerical and experimental study need to be carried out for better understanding on the various numerical and physical parameters. The error can be encountered if any inappropriate criteria such as contact description, material, method of unloading and element type are used during the simulation. Therefore, the accuracy of information in FEA simulation is important for the product designers and die makers. (Burchitz, 2008)

1.2 OBJECTIVE

- To develop a design of die and punch for sheet metal bending by using engineering parameter.
- To simulate and analyse the bending of 316L stainless steel
- To compare the results of simulation with existing experimental results.

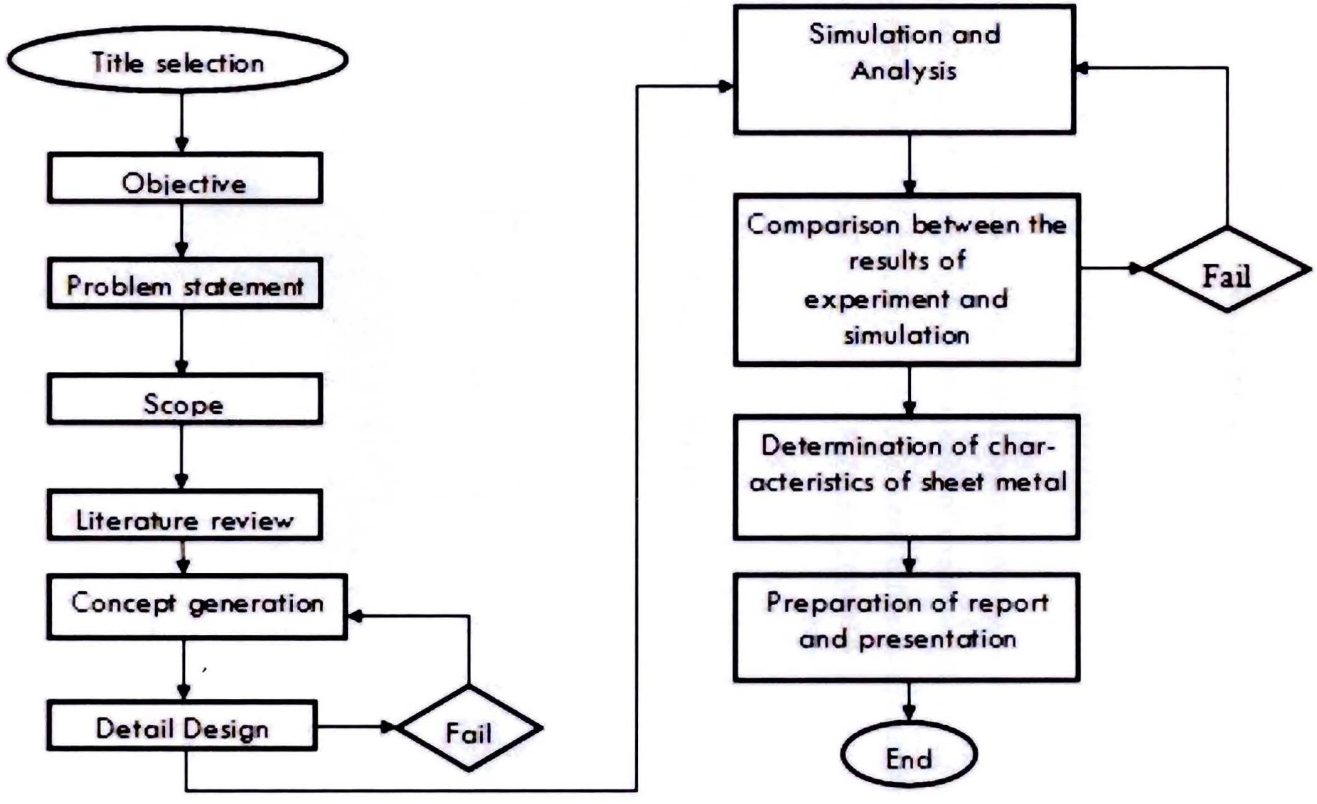
1.3 SCOPE

- Developments of design on die and punch by using SolidWorks and simulate the results by using ANSYS.
- Comparison between the results of simulation with experimental results by applying force to the 316L stainless steel.
- Characteristics of 316L stainless steel are observed during the simulation analysis.

1.4 PROBLEM STATEMENT

Simulations and experiments are often used to engineering and science to test and verify concepts. In bending process, the design of the die and punch are critical in order to get the accurate results of sheet metal bending. The results of bending are highly relied on the die and punch. Hence, the criteria in design the die and punch must be strictly followed to decrease or minimise the defect occurred during bending process. Besides, in simulation, the computer assumes the condition is ideal. For example, the distribution of temperature is well distributed. Meanwhile, experiment being performed in order to collect data that representative our real-life condition. Hence, there will be difference between simulation results and experimental results.

1.5 FLOW CHART



CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION TO BENDING PROCESS

Bending process is a kind of sheet metal forming process where it bend at the desired angle and shape by apllying force to a piece of sheet metal. The operation causes deformation along one axis. However, the several different operations can be applied to create a complex part. (Sheet Metal Forming, 2009)

2.1 SHEET METAL BENDING PARAMETERS

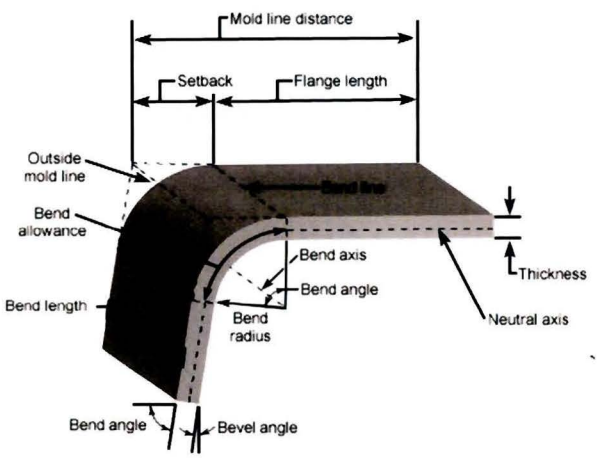


Figure 2.1: Bending diagram

(CustomPartNet, 2009)

Table 2.1: Bending Characteristic

(Source: CustomPartNet, 2009)

Sheet Metal Bending Characteristic	**Definition**
Bend line	The straight line of bending on the sheet metal.
Outside mold line	The straight line where the outside surface of sheet metal of two flanges would meet when they continue.
Flange length	The extension between the two flanges from edge of the sheet metal to the bend line.
Mold line distance	The distance of the sheet metal from end to the outside mold line.
Setback	The distance from either bends line to the outside mold line.
Bend axis	The sheet metal bends on the straight line that defines its center around.
Bend length	The measured length along the axis of bend.
Bend radius	The distance between the bend lines from axis of bend to the surface inside of sheet.
Bend angle	The angle between the original position and bent flange.
Bevel angle	The complimentary angle to the bend angle.

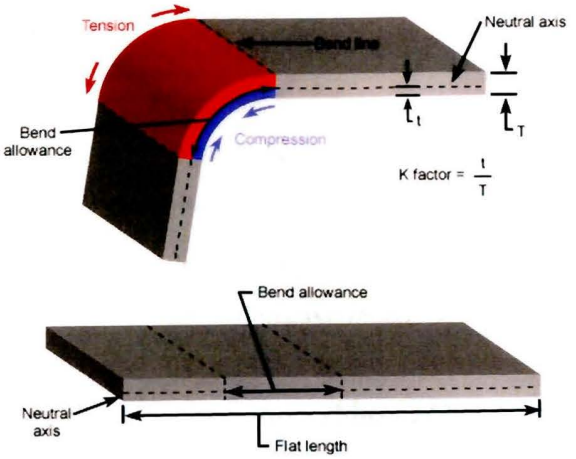


Figure 2.2: Neutral axis

(CustomPartNet, 2009)

The bending process has caused the sheet metal undergo tension and compression stress. The outer surface undergoes tension and stretch to a greater length. Meanwhile, the inner surface undergoes compression and become shortens. The neutral axis occurred between the inner and outer surface which no forces are present. Hence, the length remains constant. The changes in length of the inner and outer surface of two original flat lengths with two different parameters which are bend allowance and bend deduction. (Sheet Metal Forming, 2009)

Table 2.2: Bending parameters (CustomPartNet, 2009)

Parameters	**Definition**
Neutral axis	The location in the sheet metal that is neither compressed nor stretched and remains constant length
K-factor	The neutral axis location defines as ration of neutral axis distance to the thickness of material. The K-factor typically falls between 0.25 and 0.50.
Bend allowance	The length between neutral axis and bend lines. The total of allowance bend length and flange lengths is equal to the total value of flat length.
Bend deduction	The amount of workpiece that stretched by bending. The total value is same with the difference between total flat length and mold line lengths.

2.2 SPRINGBACK

The residual stresses after the bending process will cause the sheet to springback slightly. Due to the elastic recovery of sheet metal, over-bend the sheet metal is necessary in order to achieve desired bend radius and angle. The final bend angle will be smaller than original bend angle while the radius of final bend will be greater than initial. The springback factor, Ks is the ration between final bend angle and the initial bend angle. The springback amount depends on the initial bend angle, bend radius, material and bending operation. (Sheet Metal Forming, 2009)

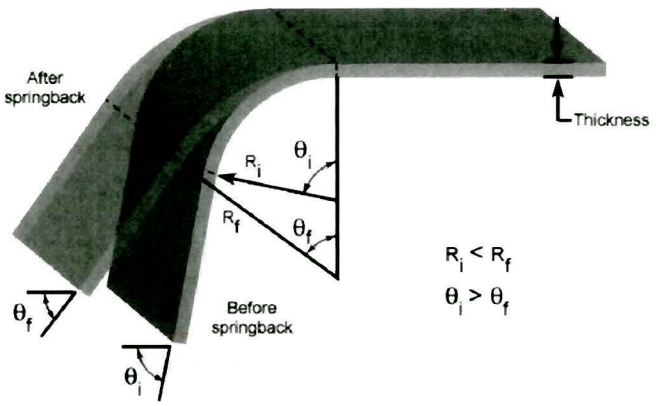


Figure 2.3: Springback

(CustomPartNet, 2009)