SPRINGBACK PREDICTION OF MILD STEEL ON V-BENDING

MOHD HIZIR ARAFAT BIN TAMBUN

A Report submitted in partial fulfillment of the requirements

for the award of Bachelor of Mechanical Engineering with Manufacturing

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

DECEMBER 2010

SUPERVISOR'S DECLARATION

"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing"

Signature	:
Name of Supervisor	: JASRI BIN MOHAMAD
Position	: LECTURER
Date	: 06 DECEMBER 2010

STUDENT'S DECLARATION

I hereby declare that this thesis entitled "Springback Prediction of Mild Steel on V-bending" 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	: MOHD HIZIR ARAFAT BIN TAMBUN
ID Number	: ME 08011
Date	: 06 DECEMBER 2010

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ABSTRACT

Bending is common process in manufacturing industry. This process is used in sheet metal deformation. Although bending is small part of sheet metal forming, but the research in bending has great intention to industry in term of material selection, production cost, productivity and quality control. So term in engineering, bending means forming of a metal part, by pressure, into a curved or angular shape, or the stretching or flanging of it along a curved path. The forming of a metal to a desired shape by pressure depends on material properties. Therefore, industry does need this bending analysis. Bending analysis also will take the spring back analysis as one of the part. Through this project, bending analysis can be made in term of knowing about spring back, and the related cause in bending process such as types of materials, types of bending, and the thickness of the material. These will give effect to the bending process in order to make an analysis to suite the material selection in industry's production lines. In addition, the companies need to reduce their cost in manufactured product but want to produce high quality product. Therefore, this analysis is important as a guide to mastering the bending analysis by analytical and numerical. This will take practicing of software which is Finite Element Analysis (FEA) software will be one of the element in this project. Methodology that used in this project, start with selection of material and type of bending. Then it goes by make the bending process at bending machine. The same specification of the bended sample will be analyzed in Abaqus version 6.7 software by simulate it. Finally, the overall analysis is done and it's achieved the objective successfully. The result of the research will be elaborate in the result and discussion chapter.

ABSTRAK

Pembengkokan adalah proses biasa dalam realiti industri. Proses ini digunakan dalam proses pembentukkan. Walaupun pembengkokan adalah sebahagian kecil dari lembaran membentuk logam, tetapi ia memberikan pengaruh besar terhadap industri dalam jangka masa kajian, pemilihan material, kos pengeluaran dan kualiti produktiviti. Jadi istilah dalam kejuruteraan, lentur bererti pembentukan bahagian logam oleh tekanan, menjadi bentuk dengan sudut melengkung, atau peregangan. Pembentukan logam ke bentuk yang dikehendaki oleh selepas tekanan atau dipengaruhi oleh sifat material itu sendiri. Oleh sebab itu, industri memang memerlukan analisis pembengkokan dan lenturan. Analisis pembengkokan juga akan mengambil analisis bangkit kembali sebagai salah satu bahagian dalam kajian ini. Melalui projek ini, analisis pembengkokan boleh dibuat untuk mengetahui kondisi bangkit kembali, dan penyebab yang berkaitan dalam proses pembengkokan seperti jenis bahan, jenis lenturan, dan ketebalan material. Ini akan memberi kesan kepada proses pembengkokan bagi proses pemilihan material dalam pengeluaran produk di industri. Selain itu, syarikat perlu mengurangkan kos mereka dalam pengeluaran produk tetapi ingin menghasilkan produk berkualiti tinggi.Jadi, analisis ini penting sebagai panduan untuk menguasai analisis lentur oleh analitik dan berangka. Ini akan membawa kepada latihan perisian iaitu perisian ‘Finite Element Analysis (FEA)’ yang akan menjadi salah satu unsur dalam projek ini. Metodologi yang digunakan dalam projek ini, bermula dengan pemilihan bahan dan jenis pembengkokan. Kemudian disusuli dengan membuat proses pembengkokan di mesin pembengkok. Spesifikasi sampel yang sama dibangunkan dan ia akan dianalisis dalam perisian ‘Abaqus’ versi 6.7. Oleh itu, keseluruhan analisis dilakukan dan simulasi akan dibuat untuk mencapai objektif dengan jayanya.Keputusan kajian akan dibincangkan dan diterangkan dalam bab keputusan dan perbincangan.

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LIST OF SYMBOLS

ω	Natural frequency
ε	Total strain, bandwidth parameter
σ	True stress, local stress
σ_a	Local stress amplitude
σ_m	Local mean stress
σ_{max}	Local maximum stress
E, GPa	Young's modulus

LIST OF ABBREVIATIONS

CAD	Computer-aided drawing
FEA	Finite Element Analysis
AISI	American Iron and Steel Institute
ASME	American Society of Mechanical Engineers

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FACULTY OF MECHANICAL ENGINEERING

I certify that the project entitled "Springback Prediction of Mild Steel on V-Bending" is written by Mohd Hizir Arafat bin Tambun. I have examined the final copy of this project and in my 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 fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering with Manufacturing.

Examiner Signature

CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

In mechanical engineering, in the field of manufacturing engineering, study about theory of plasticity is very essential. One of the common processes used to produce sheet metal components is bending operation. This bending operation is about shaping of sheet metal by straining the metal around a straight axis. A bending operation compresses the interior side of the bend and stretches the exterior side. Bending is most common operations to change the shape of a material by plastically deforming it and depends primarily on the materials type, strength, thickness and part complexity.

Spring-back is an issue in sheet metal forming processes. The spring-back is a principle problem when precise components are produced. Elastic energy stored in sheet metal in bending operation is released during unloading and the sheet metal tends to return to its initial state. Thus the dimensions and the shape of component are changed.

1.2 PROBLEM STATEMENT

Bending is a process in which a sheet metal is plastically deformed to a curve by predicting the precision in angle which is a major concern in low carbon steel bending process. When the material has a tendency to partially return to its original shape because of the elastic recovery of the material, it is called springback. Springback is generally defined as the additional deformation of sheet metal parts after the loading is removed and the influenced factor not only by the tensile and yield strengths, but also by thickness, bend radius and bend angle**.** Springback is a phenomenon of elastic nature determined by the distribution of stress on the section of the form part. In the manufacturing industry, it is still a practical problem to predict the final geometry of the part after springback and to design the appropriate tooling in order to compensate for springback.

1.3 OBJECTIVES

i. To evaluate and compare selected material modeling accuracy in predicting springback using Finite Element Analysis (FEA).
ii. To apply FEA technology in sheet mild steel forming or bending

1.4 SCOPE OF WORKS

i. Develop 2D modeling of V-bending in Finite Element Analysis (FEA) software.
ii. Develop 2D modeling in Finite Element Analysis (FEA) software for springback prediction. (proposed: Patran, Algor, Abaqus, etc.)
iii. To conduct experiment of V-bending
iv. Analyse and compare the simulation and experimental result.

CHAPTER 2

LITERATURE REVIEW

2.1 THEORY OF SHEET METAL BENDING PROCESS

Bending is a process by which metal can be deformed by plastically deforming the material and changing its shape. 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 manufacturing process that produces a V-shape, U-shape, or channel shape along a straight axis in ductile materials, most commonly sheet metal. The behavior of the material during the bend process is reflected in the stress/strain curve. In this, a distinction is made between the elastic region and the plastic region. Within the elastic region, the material returns to its original state as soon as the force is lifted. Past a certain critical value of the forces exerted, the material will show plastic deformation. This is referred to as the yield zone. A permanent change occurs in the structure of the sheet material. When bending sheet material, under the influence of the bend force applied, strain occurs on the outer side of the bend while material is upset on the inside. In other words, there is a transition from a tensile stress to a compressive strain over the cross-section of the sheet, by which the highest values are achieved on the two surfaces. Plastic deformation therefore first occurs on the outer sides of the bend sheet, and is the greatest there during the entire bend cycle. When creating a plastic deformation, the fact must be taken into consideration that the bend force may not be so large that the tensile stress on the outside becomes so great that the ultimate stress is exceeded and cracking occurs. Naturally, thicker sheets are the most sensitive to this phenomenon. This explains why the minimum values for the bend radius to be applied for air bending and bottoming are expressed as a function of the thickness. Here only elastic deformation occurs, even with high bend forces, which is why the sheet always springs back to some degree after the bend force is lifted. This springback in thin material up to approximately 2 mm / .078" can be limited to approximately 1° by selecting the right bending parameters. With thicker sheets, especially stainless steel, this will soon increase to even 3°. Corrections can be made to compensate for the springback by modifying the bend angle of the punch.(Tekaslan et al. 2004)

Figure 2.1: Maxform press brake machine

Figure 2.2: Bending sample

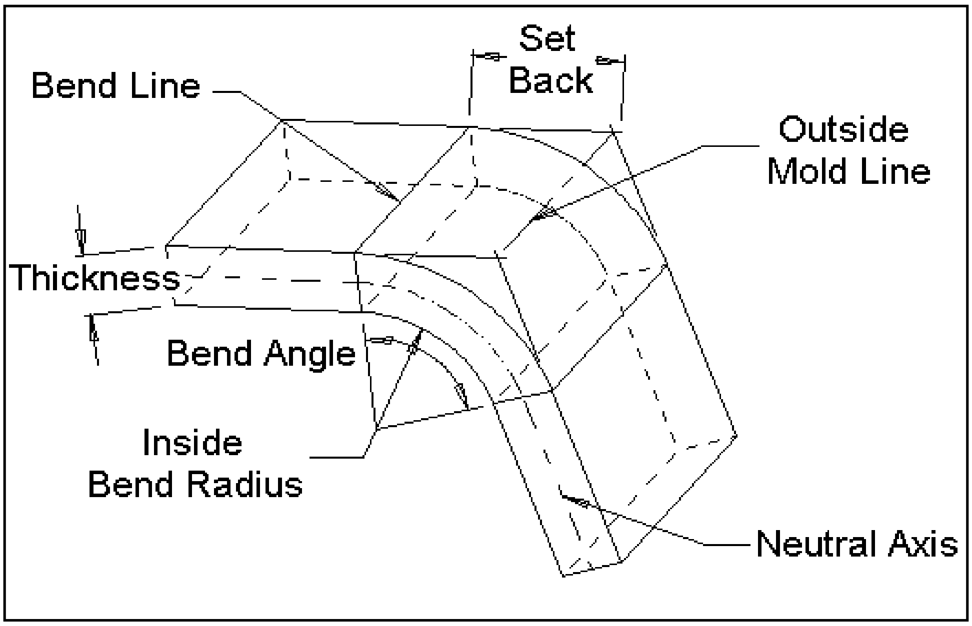

Figure 2.3: Bending process description

Source: Scribd, 2010.

Bend Allowance – The length of the arc through the bend area at the neutral axis.

Bend Angle – The included angle of the arc formed by the bending operation,

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.

Bend Lines – The straight lines on the inside and outside surfaces of the material where the flange boundary meets the bend area.

Inside Bend Radius – The radius of the arc on the inside surface of the bend area.

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.

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.

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.

Set Back - For bends of less than 180 degrees, the set back is the distance from the bend lines to the mold line.

2.2 TYPES OF BENDING

There are three basic types of bending on a press brake, each is defined by the relationship of the end tool position to the thickness of the material. These three are Air Bending, Bottoming and Coining.

2.2.1 Coining

Coining is a bending process in which the punch and the sheet on the die. Here, in the process compressive stress is applied to the bending region to increase the amount of plastic deformation. This reduces the amount of springback. (Diegal, 2002)

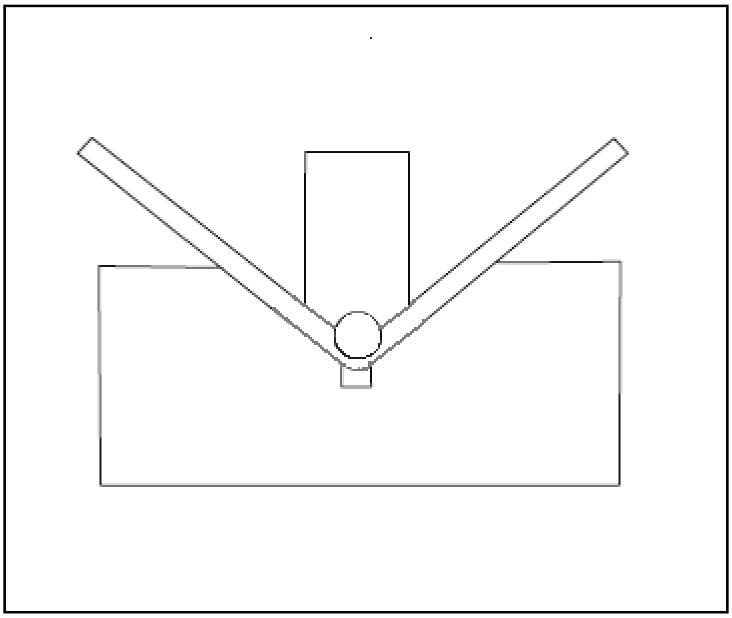

Figure 2.4: Coining Bending

Source: Diegal, 2002

2.2.2 Bottoming

Bottoming is a bending process where the punch and the work piece bottom on the die. This makes for a controlled angle with very little springback. The tonnage required on this type of press is more than air bending. The inner radius of the work piece should be a minimum of 1 material thickness. In bottom bending, springback is reduced by setting the final position of the punch such that the clearance between the punch and die surface is less than the blank thickness. As a result, the material yields slightly and reduces the springback. (Diegal, 2002)

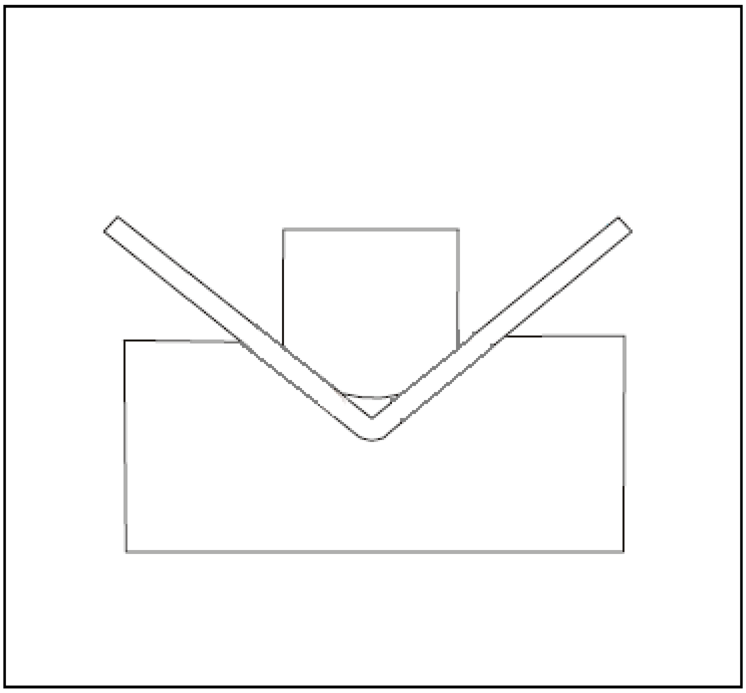

Figure 2.5: Bottoming Bending

Source: Diegal, 2002

2.2.3 Air Bending

Air bending is a bending process in which punch touches the work piece and the work piece does not bottom in the lower cavity. As the punch is released, the work piece springs back a little and ends up less bend than that on punch with greater included angle which is called springback.

In air bending, there is no need to change any equipment or dies to obtain different bending angles because the bend angles are determined by the punch stroke. The forces required to form the parts are relatively small, but accurate control of the punch stroke is necessary to obtain the desired bend angle. (Diegal, 2002)

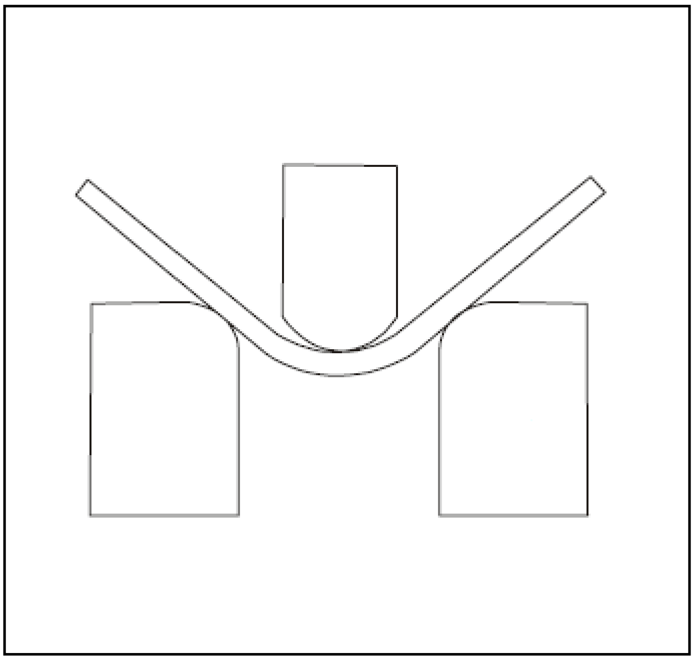

Figure 2.6: Air Bending

Source: Diegal, 2002

2.3 V- BENDING

A bending operation performed by compressing the sheet metal between a matching V-shaped punch and die.(SME, 2010). Happen when the punch touch the workpiece and the workpiece, is bottoming in the lower cavity. As the punch is released, the workpiece ends up with less bend than that on the punch with greater included angle. During V-bending, the punch slides down, coming to a contact with the unsupported sheet metal. By progressing further down, it forces the material to follow along, until finally bottoming on the V shape of the die. As may be observed, at the beginning of this process, the sheet is unsupported but as the operational cycle nears its end, the bent-up part becomes totally support while retained within the space between the punch and die. (Gowri et al. 2008)

2.3.1 SPRINGBACK IN V-BENDING

Elastic recovery of a formed part in unloading, known as springback, causes shape errors in the final product of sheet metal forming processes. Several approaches have been proposed for the analysis of springback and compensating its error. The springback occurs at the last step of process and the final geometry of the work piece can be obtained at the end of direct process modelling. In this article, an algorithm for inverse springback modelling is presented. In this approach, required conditions for the inverse movement of final product towards the end of the loading state are prepared. Having the product geometry at the end of the loading, the geometry of die parts can be designed for the production of a target shape. For this inverse movement in FEA modelling, the optimum constrained node and balanced contact forces are proposed in this algorithm. The presented approach is verified for symmetric and asymmetric bending processes. The results have shown that this approach can model symmetric and asymmetric processes inversely with tight tolerances. An optimization algorithm for compensating springback error and iterative tool design is presented based on inverse modelling. This algorithm is verified on symmetric V-bending process and its convergence rate is compared to the direct trial trend. The inverse approach shows more convergence rate in this comparison. Performing an experimental test on symmetric V-bending and asymmetric bending processes, the accuracy of the presented algorithms is investigated. The results show that the presented algorithms are efficient and accurate in both cases. Springback is a formidable problem in many of today's sheet metal bending. Correction for springback is based on "rules of thumb' and experience. Today is wide range of materials and forming processes have led to increasing trouble when attempting to compensate for springback during the design stage. Materials such as high strength steel and aluminum, with their increased tendency for springback, are now used for a wide range of autobody components. (Behrouzi et al. 2008)