# EFFECT OF PUNCHING FORCE ON CUTTING TOOL IN FORMING PROCESS USING FEA APPROACH

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A report submitted in partial fulfillment of The requirements for the award of the degree of Bachelor of Mechanical Engineering With Manufacturing 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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To my beloved parents

# WAHAB BIN MAMAT ROKIAH BINTI ABDUL MANAF

To my supervisor Madam Mas Ayu binti Hassan

> To my Academic Advisor Mr. Rosdi bin Daud

To all FKM's staffs and lecturers

To all my classmates

And all my friends out there

Thank you for your supporting and teaching.

Thank you for everything that you gave during studies and the knowledge that we shared.

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#### ABSTRACT

This thesis deals with sheet metal forming process. There are two main objectives of this research, firstly, to analysis the cutting tool wear in different force of punching and clearance and the second objective is to predict the critical part or part that will wear first on the cutting tool. In sheet metal forming process, quality of product and minimize the production cost is very important. The tool wear will affect the quality of product and increase the production cost of manufacturing. In the ALGOR simulation, the tool wear will determined by analyse stress on cutting tool. In addition, the wear tool would be high as stress at the cutting edge was extremely high. This project will considered punch force and clearance between punch and die to analysis the tool wear. The punching force used for this project are 100kN, 140kN and 180kN. The range of percentage used for clearance between punch and die used in this project are between 1.70% to 3.3%. These two parameters which are the punch force and clearance is very important for tool life and the final product.

#### ABSTRAK

Tesis ini membentangkan tentang proses pembentukan kepingan besi. Terdapat dua tujuan utama dalam kajian ini,pertama,untuk menyelidik kehausan alat pemotong dalam tekanan pukulan dan tempat lapang yang berbeza dan tujuan kedua adalah untuk meramalkan bahagian yang genting atau bahagian yang akan mula-mula haus pada alat pemotong. Dalam proses pembentukan kepingan besi, hasil yang berkualiti dan meminimumkan kos penghasilan adalah sangat penting. Kehausan alat akan memberi kesan pada kualiti hasil dan meningkatkan kos penghasilan pembuatan. Dalam simulasi ALGOR, kehausan alat akan dikaji dengan menganalisis tekanan pada alat pemotong. Dalam tambahan, kehausan alat akan tinggi apabila tekanan pada tepi pemotong terlampau tinggi. Dalam projek ini hanya menimbangkan tekanan pukulan dan tempat lapang antara pemukul dan blok logam untuk menyelidik kehausan alat. Tekanan pemukul yang digunakan untuk projek ini adalah 100kN, 140kN dan 180kN. Jarak peratusan yang digunakan untuk tempat lapang antara pemukul dan blok logam adalah sangat penting untuk adalah sangat penting antara pemukul dan blok lapang antara pemukul dan blok logam antara pemukul dan blok logam antara pemukul dan blok logam atara pemukul dan blok logam adalah 100kN, 140kN dan 180kN. Jarak peratusan yang digunakan untuk tempat lapang antara pemukul dan blok logam antara pemukul dan blok logam antara pemukul dan blok logam adalah sangat penting untuk jangka hayat alat dan hasil terakhir.

# TABLE OF CONTENTS

	Page
EXAMINER'S DECLARATION	ii
SUPERVISOR'S DECLARATION	iii
STUDENT'S DECLARATION	iv
ACKNOWLEDGEMENTS	vi
ABSTRACT	vii
ABSTRAK	viii
TABLE OF CONTENTS	ix
LIST OF TABLES	xii
LIST OF FIGURES	xiii
LIST OF SYMBOLS/ABREVIATION	XV

# CHAPTER 1 INTRODUCTION

1.1	Project Background	1
1.3	Objectives	2
1.3	Scopes	3
1.4	Problem Statement	3

# CHAPTER 2 LITERATURE REVIEW

2.1	Introduction	4
2.2	Press Traumatic 2020 Rotation FMC	4
2.3	Sheet Metal Forming Process	6
2.4	Shearing	8
2.5	Shearing Process	10
2.6	Sheet Metal Characteristics	11
2.7	Punching Tool and Tool Wear	12
2.8	Material Salection and Materials in Design	14
2.9	Finite Element Analysis	15
2.10	Algor Simulation	16

# CHAPTER 3 METHODOLOGY

3.1	Introduction	18
3.2	Flow Chart for the FYP I	19
3.3	Flow Chart for the FYP II	21
3.4	Methodology of Experiment	22
3.5	Measurement on Actual Tool using CMM	23
3.6	Finite Element Method	24
3.7	Design via SolidWorks Software	25
3.8	Analysis via FEA Software (ALGOR)	25
3.9	Conclusion	26

# CHAPTER 4 RESULTS AND DISCUSSION

4.1	Introduction	27
4.2	Result from the Simulation	27
	4.2.1 Result for punching force 180kN	28
	4.2.2 Result for punching force 140kN	30
	4.2.3 Result for punching force 100kN	33
4.3	Summary	40

# CHAPTER 5 CONCLUSION AND RECOMMENDATION

5.1	Conclusions	41
5.2	5.2 Recommendations	
REF	ERENCES	43
APP	ENDICES	
А	Gantt chart FYP I / FYP II	45
В	Aluminum 1100-H18	46
С	ALGOR simulation result	48
D	Result of stress value versus punch force	52
E	Result of stress value versus percentage of clearance	54

# LIST OF TABLES

Table No	D. Title	Page
2.1	Technical data of TruPunch 2020R	6
2.2	Forming process categories	7
2.3	Punching Speed Table	8
2.4	Clearance preside percentage of stock thickness	9
4.1	Result of stress value	36

# **LIST OF FIGURES**

Figure N	No. Title	Page
2.1	CNC punching machine TruPunch 2020R	5
2.2	<ul><li>(a) Punching (piercing) and blanking.</li><li>(b) Examples of various shearing operations on sheet metal.</li></ul>	10
2.3	<ul><li>(a) Schematic illustration of shearing with a punch and die, indicating some of the process variables.</li><li>(b) Characteristic features of a punched hole and</li></ul>	
	(c) Characteristic features of the slug.	11
2.4	The cutting tool of punching machine TruPunch 2020R	13
3.1	Project flow chart FYP 1	19
3.2	Project flow chart FYP 2	21
3.3	Design of cutting tool, sheet metal and dies	24
4.1	Result of Stress von Misses for clearance 3.3% at 180kN	28
4.2	Result of Stress von Misses for clearance 2.8% at 180kN	29
4.3	Result of Stress von Misses for clearance 2.3% at 180kN	29
4.4	Result of Stress von Misses for clearance 1.8% at 180kN	30
4.5	Result of Stress von Misses for clearance 3.3% at 140kN	31
4.6	Result of Stress von Misses for clearance 2.8% at 140kN	31
4.7	Result of Stress von Misses for clearance 2.3% at 140kN	32
4.8	Result of Stress von Misses for clearance 1.8% at 140kN	32

xiii

4.9	Result of Stress von Misses for clearance 3.3% at 100kN	33
4.10	Result of Stress von Misses for clearance 2.8% at 100kN	34
4.11	Result of Stress von Misses for clearance 2.3% at 100kN	34
4.12	Result of Stress von Misses for clearance 1.8% at 100kN	35
4.13	Result of stress value versus punch force for clearance at 1.8%	37
4.14	Result of stress value versus clearance percentage for punch force at 180kN	38
4.15	Maximum shear stress distribution as clearance and punching force	39
6.1	Result of stress value versus punch force for clearance at 2.3%	52
6.2	Result of stress value versus punch force for clearance at 2.8%	53
6.3	Result of stress value versus punch force for clearance at 3.3%	53
6.4	Result of stress value versus clearance percentage for punch force at 140kN	54
6.5	Result of stress value versus clearance percentage for punch force at 140kN	55

# LIST OF SYMBOLS/ABBREVIATIONS

- CNC Computer Numerical Control
- CAD Computer Aided Design
- FEA Finite Element Analysis
- FYP Final Year Project
- CMM Coordinate Measure Machine
- IGES Initial Graphics Exchange Specification

### **CHAPTER 1**

#### **INTRODUCTION**

### 1.1 PROJECT BACKGROUND

This thesis involves an experimental and theoretical to predict effect of punching force on cutting tool in sheet metal forming process. The sheet metal forming is a major process in many sectors of industry. Many sheet metal forming processes are used to produce parts and shapes and there is usually more than one method of manufacturing a sheet metal from a given material.

Low carbon steel is the most commonly used sheet metal because of its low cost and generally good strength and formability characteristics (S. Kalpakjian, 1991). This material is becoming one of the main materials to take the place of steel components to reduce the vehicle weight due to advantage of low special weight, high strength and corrosion resistance. Sheet metal forming processes have been divided into two groups. First cutting processes which are include shearing, blanking, punching, notching piercing and etc. while the other one is plastic deformation processes which are bending, stretch forming, deep drawing and various other forming processes (Vukota Buljanovic, 2004). This project will focus on cutting processes.

CNC punching machine have been used to fabricate the product from sheet metal where the process is fully under computer controlled with preparing NC program. The technology in cutting process improve day by day rapidly which have plasma cutting, laser cutting, and turret punch. The cutting punch to develop in this project is for turret punch machine 2020R. Tool system is very important in machining process. Complete tool set contain punch, alignment ring, stripper, and die. Complete tool set is important to make sure the product is high quality and the process of manufacturing can conduct safely. Punch is come in three designs which are flat punch, punch with roof shear and angled punch.

Finite element method (FEM) has been a major programming tool to solve for engineering problems. It can provide today's industry maximum flexibility of no matter industry types, business goals, financial pressure, customer demand or market objectives. Finite element method (FEM) has been a major programming tool to solve for engineering problems. It can provide today's industry maximum flexibility of no matter industry types, business goals, financial pressure, customer demand or market objectives.

### **1.2 OBJECTIVE**

This project can teach the student to practice the knowledge and used the skill to apply it in problem solving. This project also important to train and increase the student capability when to answering, researching, data gathering, decision making and to solve the problem occurs to apply it in working life. The objectives of the project are;

- 1) To analysis the cutting tool wear in different force of punching and clearance.
- 2) To predict the critical part on the cutting tool.

#### 1.3 SCOPES

This project considers on investigating effect of punching force in forming process. It will start with literature review and understands the statement of problem. After that, designing with CAD software by Solid Work. Lastly, analysis with ALGOR simulation software to observe the tool wear. Punching operation of a sheet metal with dimension:

- i. The sheet metal is aluminum 1100 H-18
- ii. Thickness, t: 3.0 mm
- iii. Punching force = 100kN 180kN
- iv. Clearance percentage of stock thickness = 1.70 3.40 %

# **1.4 PROBLEM STATEMENT**

In sheet metal forming process, quality of product and minimize the production cost is very important. If tool wear, it will affect the quality of product and increase the production cost of manufacturing. Analysis of tool wear cannot be measured directly during the process but analysis by using finite element method. In this project will just consider punch force and clearance to analysis the tool wear. By changing the punch force and clearance is very important for tool life and the final product. In this project also to predict the critical part on cutting tool that will wear first. Improvement of tool life is very important because tool will often facing adhesive and abrasive wear in contact zone (Ridha Hambli, 2001).

#### **CHAPTER 2**

#### LITERATURE REVIEW

#### 2.1 INTRODUCTION

A critical literature review within a specific field or interest of research is one of the most essential activities in the process of research. In order to produce a productive literature review, it is recommendable to include whole process of selecting resources, reading and writing about previous research studies chosen which includes the discussion about the drawing methods or techniques which are applied to the modal to achieve maximum efficiency and save time. The information is transferred from source such as from internet, reference book, and scientific journals. Hence, this section acts as a platform for the whole research to support and define each action performed during analysis and experiment.

#### 2.2 PRESS TRUMATIC 2020 ROTATION FMC

Press Trumatic 2020 Rotation FMC (Figure 2.1), is an elevated precision coordinate holding sheet processing midpoint with numerical program control. The advantages of this machine because high speed of cutting, 360° hydraulic cutting head and easy to use linear tool buffer. So this machine can save time product development, minimal cost and efficient production both large and small product.



Figure 2.1: CNC punching machine TruPunch 2020R

Source: Trumpf website

But this machine, it can be use to makes holes and cut of various configurations and various contour. It also can do bending, double beading, bead forming, singular or unlimited shutters, structured sheet and forming (Perfocom website). Technical information of this machine as showed in Table 2.1 (Trumpf website). From this table, the maximum punching force is 180kN. So, the force that applied for this analysis must not exceed than the force limit. So, this analysis use range 100kN to 180kN to applied for this analysis. The maximum of sheet metal thickness is 6.4mm and this analysis use sheet metal that has 3.0mm thickness.

	TruPunch 2020R
Working range (without repositioning).	2540 mm x 1270 mm
Max. sheet thickness.	6.4 mm
Max. punching force.	180 kN
Max. stroke rate punching.	900 l/min
Max. stroke rate marking.	2200 l/min
Tools, linear magazine.	19 with 2 clamps
Programmable parts chute sorted part	180 mm x 200 mm
removal, to the left and right.	
Space requirement.	Approx. 6448 mm x 7440 mm

**Table 2.1:** Technical data of TruPunch 2020R

# 2.3 SHEET METAL FORMING PROCESS

Sheet metals are very wide range of consumer and industrial products, such as beverage cans, cookware, car bodies and aircraft fuselages. Compared to those made by casting and by forging, sheet-metal parts offer the advantages of light weight and versatile shape.

Low carbon steel is the most commonly used sheet metal because of its low cost and generally good strength and formability characteristics. The most common material used in sheet metal applications is aluminum such as beverage cans, packaging and kitchen utensils (S. Kalpakjian, 1991). The common materials for aircraft and aerospace applications are aluminum and titanium, although they are being replaced increasingly with composite materials. Many sheet metal forming processes are used to produce parts and shapes and there is usually more than one method of manufacturing a sheet metal from a given material. The categories of processing methods for materials are showed as Table 2.2. There are five categories of forming process that are roll process, stretch, drawing, stamping and spinning process. Each process has different characteristics.

Forming Process	Characteristics
Roll	Long parts with constant simple or complex cross-sections, good surface
	finish, high production rates, high tooling costs.
Stretch	Large parts with shallow contours, low-quantity production, high labor
	costs, tooling and equipment costs increase with part size.
Drawing	Shallow or deep parts with relatively simple shapes, high production
	rates, high tooling and equipment costs.
Stamping	Includes a wide variety of operations, such as punching, blanking,
	embossing, bending, flanging, and coining; simple or complex shapes
	formed at high production rates; tooling and equipment costs can be
	high, but labor cost is low.
Spinning	Small or large axisymmetric parts, good surface finish, low tooling costs
	but labor costs can be high unless operations are automated.

**Table 2.2:** Forming process categories

### 2.4 SHEARING

Sheet metal is usually removed from a large sheet or coil by shearing. This sheet is cut by subjecting it to shear stresses, generally using a punch and die. Shearing generally starts with the formation of cracks on both the top and bottom edges of the workpiece (S. Kalpakjian, 1991). The major processing parameters shearing are:

a) The shape of the punch and die.

Nowadays shape of punch have three types; flat, whisper and rooftop. Whisper tools are better than flat because cutting force requirement for the same punch will reduced and reduction of noises. This statement is right because one of the study results show that if shear angle increase the appearance of punch is better. b) The speed of punching.

The different material is different the punching speed. The sample of the some material and their punching speed as showed in Table 2.3. Mostly, in sheet forming process, the material used is aluminum. This analysis also uses aluminum as material because of this material usually used in forming process.

Material	Punching Speed (m/min)
Aluminum	46- 53
Brass	53- 61
Copper	38-46
Steel	5.5-15.2
Stainless steel	9-12
Zinc	38-46

Table 2.3: Punching Speed Table

#### c) Lubrication

Important for reducing tool and die wear, thus important edge quality.

d) The clearance between the punch and the die.

The clearance is a major factor in determining the shape and the quality of the sheared edge. As the clearance increase, the zone of deformation becomes larger, and the sheared edge becomes rougher. Table 2.4 showed that clearance preside percentage of stock thickness for different type of material.

Table 2.4: Clearance preside percentage of stock thickness

	Clearance preside percentage of stock thickness						
Material	Average (%)	Range					
Aluminum Alloys	2.25	1.70-3.40					
Cold rolled steel (soft)	3.00	2.25-4.50					
Cold rolled steel (half-hard)	3.75	2.80-5.60					

Edge quality can be improved with increasing punch speed; speed may be as high as 10 to 12 m/s (30 to 40 ft/s). The extent of the deformation zone depends on the punch speed. With increasing the punch speed, the heat generated by plastic deformation is limited to a smaller and smaller zone.

The force required to punch is basically the product of the shear strength of the sheat metal and the total area being shared along the periphery. As the clearance increases, the punch force decreases, and the wear on dies and punches also reduced (Vukota Buljanovic, 2004). As discuss before, die clearances in blanking and punching is the most important to sure the final product is in high quality.

### 2.5 SHEARING OPERATIONS

Several cutting operations are based on the shearing process include punching and blanking. However, the most common shearing operations are punching. Figure 2.2(a) showed the different between punching and blanking and Figure 2.2(b) showed example of various shearing operation.



**Figure 2.2** (a) Punching (piercing) and blanking. (b) Examples of various shearing operations on sheet metal.

In shearing operation, the punch moves down and presses the workpiece in the opening die. The space between the die opening and the punch is the clearance. The amounts of clearance depends the type and thickness of material.

By this pressure, the workpiece is deformed plastically. The metal is highly stressed because this plastic deformation in small area between the cuttings edges of punch and die. When the stress exceeds the ultimate strength of material, fracture is occurred. The cutting edge of die starts the fracture in the metal from the bottom, but the cutting edge of the punch starts the fracture form top. These fractures meet at the centre of the plate. As the punch continues to moves down, the metal is completely cut off from the sheet metal. Punching is the operation of producing a circular hole in a sheet metal using a punch and die. Figure 2.3 showed schematic illustration of shearing with a punch and die.





### 2.6 SHEET METAL CHARACTERISTICS

Basically, the sheet metal forming uses various dies and tools to stretch and bend the sheet. However, certain characteristics of sheet metals must be checked before considering the processes. Among the important effects of the characteristics are as follows: a) Elongation

To determine the capability of the sheet metal to stretch without failure and necking.

b) Yield-point elongation

Low carbon steel exhibit a behavior called yield-point elongation – having both upper and lower yield point. Yield-point elongation also called Lueder's band (also called stretcher-strain marks or worm).

c) Grain size

To determine the surface roughness of the stretched sheet.

d) Springback

Due to the elastic recovery of the plastically deformed sheet after unloading, causes distortion of part and effect the dimensional accuracy of the sheet.

e) Wrinkling

Caused by compressive stresses in the plane of the sheet.

f) Surface condition of sheet

Depend on sheet rolling practice; important in sheet forming as it can cause tearing and poor surface quality.

#### 2.7 PUNCHING TOOL AND TOOL WEAR

A punching tool consists of:

i. Punch

Punch made from high speed steel; sometimes it will be coated with TiCN. Figure 2.4 showed the punch cutting tool that used in TruPunch 2020R machine. For design of punch, although the die opening is exactly the same as that of the blank size, the punch size will be smaller than die sizes by twice the clearance assume per side. If a clearance 3% of stock thickness is assumed preside.



Figure 2.4: The cutting tool of punching machine TruPunch 2020R

ii. Die

Function as shearing tools which move away from each other in opposite directions and cut the sheet.

iii. Stripper

The stripper strips the sheet on its upstroke from the punch. This prevents the sheet from being pulled up by the punch. Besides that, it holding the work piece from for repositioning oversized sheet, the stripper is lowered directly onto the sheet and clamps it while the coordinate guidance travels with opened clamps for repositioning.

iv. Alignment ring

The alignment ring is a clamping ring which holds the shape punch in zero position. It transfer punching capacity on the punch, allocating the relative position of the punch and retaining, adapting different punch sizes, and holding punch in cartridge.

Tool wear in punching process will affect the quality of final product and increase the production cost of manufacturing. Tool will wear because in the sheet metal element has impurities, where the ultimate tensile strength of the sheet metal changes. In other addition, tool life can affect by burr after punch where it can scratch the surface of tool. Actually the tooling can be regrinding if the tool wear, but cost of sharpening is expensive and it need operator to change the tool. So, it will waste time and not economic. In manufacturing processes, if the budget can reduce to minimal cost, the production is high rate and quality is very good is more useful. The most common wear that occurs during the punch process is abrasive wear and adhesive wear.

Wear is defined as a slow degradation of the punching tool caused by friction involved between tool and metal sheet. Abrasive wear occurs when the surface of the working material contains hard particles such as carbides or oxides. Adhesive wear occurs when two solid surfaces slide over one another under pressure. Surface projections are plastically deformed and eventually welded together by the high local pressure (Chattopadhyay, 2001).

#### 2.8 MATERIALS SELECTION AND MATERIALS IN DESIGN

The selection of the suitable material for a design is a crucial step in manufacturing. The recognition of the importance of materials selection in design can be seen in the present day product design which supports the fact that materials and manufacturing are closely linked in determining the product performance (Charles et al., 1999).

A wrong selection of material can lead to failure of part and also to unnecessary life-cycle cost. However, selecting the best material for a part involves more than just selecting the suitable material with the properties to provide the wanted performance. Besides that, it also connected with the processing methods of transforming the material to the final part. In addition, the wrong material will increase manufacturing cost and increase the cost of the part. The solution is to perform simplification and systemization (Ashby,1992).

In this project, the workpiece of sheet metal chosen is Aluminium 1100-H18. This is a common commercial grade sold when 'aluminum' is specified. As with other unalloyed aluminum grades, it is used where the intrinsic formability and corrosion resistance of aluminum is needed while high strength is not. Example applications include chemical and food handling, sheet metal, hollowware, heat exchangers, and lighting (MATWEB website).

#### 2.9 FINITE ELEMENT ANALYSIS

Finite Element Analysis (FEA) is a powerful technique used for solving complicated mathematical problem of engineering and physics such as structural analysis, heat transfer, fluid flow, mass transport and electromagnetic potential. FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. Modern FEA allows engineer to subject a computer model of structure to various loads to determine how it will react. It also enables designs to be quickly modeled, analyzed, changed, checked for feasibility and structural integrity, redesigned or discarded if they do not work.

There are generally two types of analysis that are used in industry : 2-D modeling and 3-D modeling. 2-D modeling allows the analysis to be run on a normal computer because it tends to yield less accurate results. However, 3-D modeling produces more accurate results but must run on the fastest computers. 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 for plastic deformation, and many also are capable of testing a material all the way to fracture.

#### 2.10 ALGOR'S SIMULATION

When performing finite element analysis (FEA), a virtual model of a real-world situation is set up to see how a product will react in its environment. The environment is defined through a combination of loads and constraints and the decisions or assumptions that about those loads and constraints are very important to the overall accuracy of the simulation. The complicating factors related to defining loads and constraints such as:

- i. Difficult placing of loads and constraints particularly for situation involving motion, impact, time-dependent changes or multiphysics phenomena. Historically, engineering experience and judgement was relied upon to determine loads and constraints and how to best apply them. However, even experienced engineers can have difficulty determining accurate values for these critical inputs.
- ii. Artificial loads and constraints complicate results evaluation by introducing "hot spots" in the model. For example, if the user constrain a point, the nearby results will be artificially spiked. There is no way around this modeling effect and it is part of the traditional FEA process. However, it complicates looking at results (Raman, 2007).

ALGOR'S MES combines large-scale motion with stress analysis and uses nonlinear time-dependent FEA to properly account for the changing inertia, shape and material behavior of the model as it undergoes motion or experiences impact. With MES, there is no need to calculate or approximate loads because the forces and moments are automatically balanced according to Newton's Law of Motion (Nelson and Schneider, 2001).

For example, assemblies in contact which the area of possible contact or the area of contact may be changing over time. In this scenario, it is nearly impossible to figure out approximate loads or constraints that accurately represent the effect of touching parts. However with MES, just simply model the actual parts and let the software automatically calculate the contract loads.

Moreover, basic FEA, MES provides flexibility to help users apply known loads and constraints in ways that make sense. For example, user can apply point, surface, edge and body loads. Still with MES, the user no longer needs to make guesses when defining FEA input.

Many engineering scenarios also involve multiphysics phenomena where the model must include not only structural effects but also fluid characteristics, thermal behavior, voltage effects and more. Because of this, MES supports taking temperature and voltage data as input for multiphysics analysis so users can better simulate the real-world environment. The deflection calculated by Algor's software was very close to the test measurement, with less than 10 percent difference. The simulation results verified an acceptable margin of error and the product is confirmed.

### **CHAPTER 3**

#### METHODOLOGY

### **3.1 INTRODUCTION**

This chapter will be discussed about the method that have been selected and also draft the flow chart to ensure this project going smoothly. Methodology is defined as the analysis of the principles of method, rules, and postulates employed by decipline or the development of methods to be applied within discipline. Actually, methodology is very important to describe the project analysis, planning, design, construction and procedures necessary. So selection of methodology and types of manufacturing process in very important to ensure that this project is successful. There are five main methods that have been applied in this project together with sketching, modeling and analysis simulation. The knowledge in sheet metal forming process is very important to success this project. In sheet metal forming process, the tool or sheet metal ware will be identify when use the different force of punching and difference clearance.



Figure 3.1: Project flow chart FYP I

Figure 3.1 showed the project flow chart for Final Year Project 1(FYP 1). First, the FYP title will receive from the supervisor. After that, gather and study the information of turret punching cutting tool from books and journals. Then, construct the definition for determine dependent and independent variable. Define the objective, scope and problem statement. Planning the design according the parameter that should be considers. The parameter or the design of the punching tool had been considered according the previous published work as references. The design were took from the previous report and will be compare to the result that will be get after the simulation on the finite element method done. After that, finish the summary report and slide for presentation and prepare for presentation FYP1. The project and presentation is evaluated from panel either the project was accepted or not. If the project was accepted, the project will continue and submit full report for FYP1 to supervisor. But if the panels do not accept the project, the FYP will start from beginning.

### 3.3 FLOW CHART / PROJECT FLOW CHART FYP II



Figure 3.2: Project flow chart FYP II

For the final year project 2, the parameter that had been consider or design in final year one will be applied. The design of the punching tool will be done using Solid work software. Then, the design will import and simulate using Algor software. After, the simulation done, the result will be collect and then analyze. The data will be recorded in table or in graph in order to make us easier to analyze it and in same time make the comparison. Then the conclusion will be done according to the result that had been collect and after the comparison or after analyze the data from the simulation. After finish the analysis, the report and slide presentation will make and prepare to presentation. Panels will evaluate the project and presentation either this project either accepted or not. If the project is accepted by panels, the project will continue and submit final report to supervisor. But if the panels do not accept the project, the report must be edited before submit final report.

#### **3.4 METHODOLOGY OF EXPERIMENT**

i. Setting the force of punching

Sample	1	2	3
Punching Force (kN)	180	140	100

ii. Setting clearance percentage of stoke of thickness

Sample	1	2	3	4
Clearance (%)	1.8	2.3	2.8	3.3

iii. Compare the maximum shear stress for every sample. Then compare with the previous researcher statement "as the clearance increases, the punch force decreases, and the wear on dies and punches also reduced" (Vukota Buljanovic, 2004).

# 3.5 MEASUREMENT ON ACTUAL TOOL USING COORDINATE MEASURE MACHINE (CMM)

Coordinate Measure Machine, CMM is one of the latest technologies in measuring equipment to measure the dimension of equipment. CMM consist of machine itself, probing s system and computer software. This machine is one of persist machine when taking the dimension.

In this project to measure need precisely measurement part dimension. By using CMM it will make practical more easier and precise measurement. The measuring instrument consist of in CMM is calipers, micrometer, height gages and other graduate devices. So CMM is the most capable to measured and used in this project.

Besides, CMM will more capable to use in this project because the actual dimension is very important to compare with actual tool. So, CMM is a good choice for measured because it can measure the cutting tool precisely. In other addition, by using CMM it wills safe time for measured and not use many instrument. But the most important CMM used is available in UMP lab to measure part dimension. Step of using CMM is as below:

- i. CMM was switched on as in the procedure provided in a lab.
- ii. Before using CMM, folder Calypso at the computer screen was clicked.
- iii. Base start element was defined.
- iv. Clearance plane was defined in the range of joystick only.
- v. A button feature was clicked. Types of feature must applicable to the place to measure.

In other addition, CMM is applicable to use because it can measured at critical part accurately. This is because accurate dimension is needed to draw that tool in CAD software. By using CMM, the dimension can take at the time and CMM also provide drawing.

#### **3.6 FINITE ELEMENT METHOD**

As a first step, Solid Works software will used to design the punching tool before safe it as an IGES file. Using this software, the different punching force and different clearance will be applied. The design is base on parameters that get from TruPunch 2020R punching machine where the maximum punching force is 180kN and recommendation by Vukota Buljanovic where the range clearance percentage of stock thickness for aluminum 1100 H-18 between 1.70 % – 3.40 %. So in this design, it categorized the punching force to 100kN, 140kN and 180kN and categorized the clearance to 1.8%, 2.3%, 2.8% and 3.3%.

After that, the ALGOR software will be use and the IGES file that been made before will be import to the ALGOR software and the simulation can be run. For this step, the ALGOR software is used as a finite element method to do the experiment to predict the wear that will occur on the tool. Figure 3.3 show the design of cutting tool, sheet metal and dies in ALGOR that import from SolidWorks software.



Figure 3.3: Design of cutting tool, sheet metal and dies

#### 3.7 DESIGN VIA SOLIDWORKS SOFTWARE

SolidWorks is one of designing software to use in this project. By using this software CAD drawing will be easier because this software is easy to draw. A part from that, this software more practical than AutoCAD software because it can save the file in \*.IGS and \*.DFX. this is because in this project, CAD drawing is important to convert from \*.SLDPRT to \*.DXT. this is because ALGOR V16 Fempro can read fail in \*.IGS.

\*.IGS is the common file type to use in the model analysis, and other manufacturing function. Actually \*.IGS is Initial Graphics Exchange Specification to defines data format that allows the digital exchange of information among Computer Aided Design (CAD) systems. So the CAD data can exchange product data models in the form of solid modeling that have been used in this drawing to \*.IGS for analysis method. A part from that, Initial Graphics Exchange file format standard allows efficient and accurate exchange of product definition data.

So the fail type is important when drawing because not all software can read the file format. Sometime file format just can use for certain software or machine only. Subsequently this software is applicable to use base on useful function and easy to conduct.

#### **3.8** ANALYSIS VIA FEA SOFTWARE (ALGOR)

Analysis for this method wants to predict the critical point of the insert during punching or blanking process. To done this analysis, modal analysis method is used. The software of modal analysis is ALGOR V16 FEMPRO. The objective function was defined as minimum possible shear stress for failure and the best possible edge quality. From the ALGOR, the critical point is the area that has high shear stress.

# 3.9 CONCLUSION

Conclusions are made after analysis on process is conducted. Conclusions basically will answer all objectives' questions. In this section, a success will determine the comparison shear stress between the different the punching force and clearance. By using ALGOR simulation will determine the shear stress for each parameter and will predict critical part on punching cutting tool.

#### **CHAPTER 4**

#### **RESULTS AND DISCUSSION**

#### 4.1 INTRODUCTION

This chapter will discuss the whole of the project going on either problem or consideration during analysis. This chapter also discusses the result of analysis and comparison the maximum shear stress for different punching force and clearance. From the simulation that had been done before, the data had been collect and analyze. The analysis start by parameter of punch force 180kN and will applied for the different clearance 1.8%, 2.3%, 2.8% and 3.3%. After that, change the punch force to 140kN and applied to different clearance. The final step, the punch force will change to 100kN and applied it to different clearance. The data that taken from the simulation is the maximum von misses stress. The data were compiling in a table and the graph was plotted. The maximum von misses stress will indicate the wear that will occur in that punching tool. When the maximum von misses stress increase it also means that the wear that occurs in that same area also will increase.

# 4.2 **RESULT FROM THE SIMULATION**

Analysis of the product is very important to predict the tool wear in different punching force and clearance. By the Finite Element Analysis, we can reduce cost especially for analysis. This analysis used different of punching force and clearance as parameter. This analysis is to predict the tool wear by compare the maximum shear stress from different punching force and clearance.

#### 4.2.1 Result for punching force at 180kN

Figure 4.1 showed the result when punch force 180kN and the percentage of clearance is 3.3%. The maximum stress value is 1867020 N/(mm<sup>2</sup>). The result is lowest than maximum stress for punch force 180kN and the clearance 2.8% as showed in Figure 4.2. The stress result showed in Figure 3 at clearance 2.3% is higher than clearance at 2.8% and 3.3% but lower than stress result at clearance at 1.8%. The highest maximum shear stress for punch force 180kN is when the clearance is 1.8% as showed in Figure 4.4. The maximum stress value is 1874488 N/(mm<sup>2</sup>). So, from this analysis for punching force is 180kN, the minimum clearance will increase the stress value.



Maximum stress value: 1867020 N/(mm<sup>2</sup>) **Figure 4.1:** Result of Stress von Misses for clearance 3.3% and punch force 180kN



Maximum stress value: 1869371 N/(mm<sup>2</sup>) **Figure 4.2:** Result of Stress von Misses for clearance 2.8% and punch force 180kN



Maximum stress value: 1873029 N/(mm<sup>2</sup>) **Figure 4.3:** Result of Stress von Misses for clearance 2.3% and punch force 180kN



Maximum stress value: 1874488 N/(mm<sup>2</sup>)

Figure 4.4: Result of Stress von Misses for clearance 1.8% and punch force 180kN

### 4.2.2 Result for punching force at 140kN

Figure 4.5 showed the result when punch force 140kN and the percentage of clearance is 3.3%. The maximum stress value is 1452127 N/(mm<sup>2</sup>). This result showed that the stress value is lower than stress at punch force 180kN by using using same percentage of clearance. This high puncher force will increased the maximum stress. The highest maximum shear stress for punch force 140kN is at the clearance is 1.8% as shown in Figure 4.8. The maximum stress value is 1457935 N/(mm<sup>2</sup>). Conclusion can be made from this analysis that punching force at 140kN with the minimum clearance will increased the stress value. Meanwhile, stress result is average at clearance 2.8% and 2.3% as showed in Figure 4.6 and Figure 4.7.



Maximum stress value: 1452127 N/(mm<sup>2</sup>) **Figure 4.5:** Result of Stress von Misses for clearance 3.3% and punch force 140kN



Maximum stress value: 1453956 N/(mm<sup>2</sup>)

Figure 4.6: Result of Stress von Mises for clearance 2.8% and punch force 140kN



Maximum stress value: 1456800 N/(mm<sup>2</sup>)

Figure 4.7: Result of Stress von Mises for clearance 2.3% and punch force 140kN



Maximum stress value: 1457935 N/(mm<sup>2</sup>)

Figure 4.8: Result of Stress von Misses for clearance 1.8% and punch force 140kN

# 4.2.3 Result for punching force at 100kN

The last step is by applying for 100kN to different percentage of clearance. Figure 4.9 showed the result when punch force 100kN and the percentage of clearance is 3.3%. The maximum stress value is 1037234 N/(mm<sup>2</sup>). This result showed that the stress value is lower than stress when punch force are 180kN and 140kN by using same percentage of clearance. That mean the lowest punch force will decrease the maximum stress. So, the punch force is directly proportional to the percentage of clearance. The highest maximum shear stress for punch force 100kN is when the clearance is 1.8% as shown in Figure 4.12. The maximum stress value is 1041382 N/(mm<sup>2</sup>). Meanwhile, stress result is average at clearance 2.8% and 2.3% as showed in Figure 4.10 and Figure 4.11. So, from this analysis showed that when decreasing the percentage of clearance, the stress will increase. That mean, the clearance is inversely proportional to stress value.



Maximum stress value: 1037234 N/(mm<sup>2</sup>) **Figure 4.9:** Result of Stress von Misses for clearance 3.3% and punch force 100kN



Maximum stress value: 1038540 N/(mm<sup>2</sup>) Figure 4.10: Result of Stress von Mises for clearance 2.8% and punch force 100kN



Maximum stress value: 1040572 N/(mm<sup>2</sup>)

Figure 4.11: Result of Stress von Mises for clearance 2.3% and punch force 100kN



Maximum stress value: 1041382 N/(mm<sup>2</sup>)

Figure 4.12: Result of Stress von Misses for clearance 1.8% and punch force 100kN

From the analysis result, it showed that different of punch force and different of percentage of clearance will effect of the value of stress. Besides, in this analysis also will determine critical part. Critical part is the location that receives highest stress so that the location will wear first compare the other location. In this analysis, the critical part is place at the bottom of tool. The critical part at bottom tools can effect to the final product during sheet metal forming process.

Punching Force (kN)	Clearance (%)	Maximum shear stress (N/(mm <sup>2</sup> )
	1.8	1874488
180	2.3	1873029
	2.8	1869371
	3.3	1867020
	1.8	1457935
140	2.3	1456800
	2.8	1453956
	3.3	1452127
	1.8	1041382
100	2.3	1040572
	2.8	1038540
	3.3	1037234

 Table 4.1: Result of stress value

From Table 4.1, it showed that at punch force 180kN it will absorb or give high value of stress. But when 140kN it decrease. The minimum stress absorb by this tool is at 100kN. It also shown the decreasing percentage of clearance will increase the stress. The maximum stress absorb by this tool when the percentage of clearance is 1.8% and the minimum stress absorb when the clearance is 3.3%. This result also showed the maximum stress absorb by this tool is 1874488 N/(mm<sup>2</sup>) when the punch force is 180kN and the clearance is 1.8%. The minimum stress is 1037234 N/(mm<sup>2</sup>) when the punch force is 100kN and the clearance is 3.3%.



Figure 4.13: Result of stress value versus punch force for clearance at 1.8%

Figure 4.13 showed example result of stress value in different punch force. This result of graph taken from clearance at 1.8% as example and the others graph for others clearance showed in appendix V. The punch force is directly proportional to the value of stress on cutting tool. By increasing punch force, the value of stress also increase. This analysis showed that the highest stress when punch force 180kN and the minimum stress value when punch force 100kN. In addition, cutting tool tend to wear at punch force 180kN because at this force receive highest stress compare the other force. As a conclusion, this graph showed that the stress value or wear on cutting tool will increase as the punch force increase.



Figure 4.14: Result of stress value versus clearance percentage for punch force at 180kN

Figure 4.14 showed example result of stress value in different percentage of clearance. This result of graph taken from punch force at 180kN as example and the others graph for others punch force showed in appendix V. From this graph, the effect of percentage of clearance is clearly showed. The clearance is inversely proportional to the value of stress on cutting tool. By increasing punch force, the value of stress is decrease. This analysis showed that the highest stress when clearance 1.8% and the minimum stress value when clearance 3.3%. In addition, cutting tool tend to wear at clearance 1.8% because at this clearance percentage receive highest stress compare the other force. As a conclusion, this graph showed that the stress value or wear on cutting tool will increase as the clearance decrease.



Figure 4.15: Maximum shear stress distribution as clearance and punching force

Figure 4.15 showed the graph of maximum shear stress distribution as clearance and punching force. From this graph, the highest punch force is increase the maximum shear stress. In the other hand, the punch force is directly proportional to the maximum shear stress. However, the increasing the maximum shear stress occur in decreasing the percentage of clearance. That mean, the percentage of clearance is inversely proportional to the maximum shear stress is at highest punch force and lowest percentage of clearance.

#### 4.3 SUMMARY

From the analysis result, it shown that the highest shear stress is when the punching forces is 180kN and clearance is 1.8%. The lowest shear stress is when the punching force is 100kN and the clearance is 3.3%. This analysis shows that the highest punching force will increase the shear stress at the cutting tool. However, the clearance is decrease as the shear stress increase. So, as summary for this analysis, the increasing punching force and the decreasing clearance will increase the shear stress at the cutting tool of punching. The analysis also show the critical part is at end of surface edge tools. This is because at end of surface edge tool receive highest stress value compare the other area. Therefore, this area will wear first compare the other area. In the addition, tool wear would be high as the shear stress at the cutting edge was extremely high. As a conclusion, when punching force decrease and clearance is increase, the cutting tool wear is reducing. So, the analysis result same as previous researcher, Vukota Buljanovic, said as the clearance increases, the punch force decreases, and the wear on dies and punches also reduced. This analysis shows that the statement from that previous researcher is true. The increasing punching force and decreasing clearance will increase wear at cutting tool of punching. From this analysis, we can know how to reduce the cutting tool wear. Reducing the tool wear is very important because tool wear will affect the quality of final product and also production cost of manufacturing. By reducing tool wear, it will increase the quality of final product and also decrease the production cost of manufacturing. However, to get the high quality of final product, the punching force and clearance must take from the range that suitable for the material. This is because the different material is different their range of clearance. This analysis only takes aluminum 1100 H-18 as material.

### **CHAPTER 5**

# CONCLUSION AND RECOMMENDATION

#### 5.1 CONCLUSION

Base on this project, it showed that the correct method how to minimize wear on the cutting tool. Here we can conclude that, the punching force and clearance are factoring that effect tool life. Base on analysis, the punching force is directly proportional with the stress but the percentage of clearance is inversely proportional with the stress. By decrease the punching force and increase the clearance will reduce the tool wear. If tool wear, it will affect the quality of final product and also increase production cost of manufacturing.

From this project also, critical part can be predicted where it will wear first. The place is at end of surface edge tools because the simulation shown at that edge is the highest value of stress. Critical part is the location that receives highest stress so that the location will wear first compare the other location. In this analysis, the critical part is place at the bottom of tool. The critical part at bottom tools can effect to the final product during sheet metal forming process.

#### 5.2 **RECOMMENDATION**

This project needs to run the experiment to get the comparison between experimental result and analysis result. From the experiment also the real wear or defect of tool will be see but from the analysis, there are only know where the critical point but cannot see the wear.

Besides, by using the advance software where can do the simulation in many time using the same punching tool also very suitable for this project. It means that when do the simulation with the same punching tool, but can predict how many times the punching tool can be punch or use.

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# APPENDIX A

# Gantt Chart FYP I

Subject/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Title confirmation														
Objective and scope confirmation														
Problem statement identification														
Literature review														_
Research methodology														
PSM 1 report writing														
PSM 1 report presentation														

# Gantt Chart FYP I I

Subject/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Literature														
Design using SolidWork														
Analysis with ALGOR														
PSM 2 report writing														
PSM 2 report presentation														

Plan: —	
Actual:	

### **APPENDIX B**

#### Aluminum 1100-H18

Categories: Metal; Nonferrous Metal; Aluminum Alloy; 1000 Series Aluminum

**Material Notes:** This is a common commercial grade sold when 'aluminum' is specified. As with other unalloyed aluminum grades, it is used where the intrinsic formability and corrosion resistance of aluminum is needed while high strength is not. Example applications include chemical and food handling, sheet metal, hollowware, heat exchangers, and lighting.

**Composition Notes**: The aluminum content for unalloyed aluminum not made by a refining process is the difference between 100.00 percent and the sum of all other analyzed metallic elements present in amounts of 0.010 percent of more each, expressed to the second decimal before determining the sum. For alloys and unalloyed aluminum not made by a refining process, when the specified maximum limit is 0.XX, an observed value or a calculated value greater than 0.005 but less than 0.010% is rounded off and shown as " less than 0.01%". Composition information provided by the Aluminum Association and is not for design.

<b>Physical Properties</b>	Metric	English	Comments
Density	2.71 g/cc	0.0979 lb/in <sup>3</sup>	AA; Typical

Mechanical	Metric	English	Comments
Properties			
Ultimate Tensile	165 MPa	24.0 ksi	AA; Typical
Strength			
Tensile Yield	152 MPa	22.0 ksi	AA; Typical
Strength			
Modulus of	68.9 GPa	10000 ksi	AA; Typical;
Elasticity			Average of tension
			Compression
			modulus is about 2%
			greater than tensile
			modulus.
Poissons Ratio	0.330	0.330	
Machinability	30 %	30 %	0-100 Scale of
			Aluminum Alloys
Shear Modulus	26.0 GPa	3770 ksi	
Shear Strength	89.6 MPa	13000 psi	AA; Typical

### **APPENDIX C**

**ALGOR simulation report** 





#### Summary

#### Model Information

Analysis Type - Static Stress with Linear Material Models Units - Custom - (N, mm, s, deg C, deg C, V, ohm, A, J) Model location - C:\Documents and Settings\Sir fizi\My Documents\SolidWork PSM\Assem\Assem 1.8%.fem Design scenario description - Design Scenario # 1

# Analysis Parameters Information

#### Load Case Multipliers

Static Stress with Linear Material Models may have multiple load cases. This allows a model to be analyzed with multiple loads while solving the equations a single time. The following is a list of load case multipliers that

were analyzed with this model.

Load Case	Pressure/Surface Forces	Acceleration/Gravity	Rotation	Angular Acceleration	Displaced Boundary	Thermal	Voltage
1	1	0	0	0	0		

# Multiphysics Information

Default Nodal Temperature	0 °C
Source of Initial Nodal Temperatures	None
Time step from Heat Transfer Analysis	Last

# Part Information

Part ID	Part Name	Element Type	Material Name
1	Part2	Brick	Steel (ASTM - A572)
2	Part3	Brick	Aluminum Alloy 1100-H18
3	die 1.8%	Brick	AISI 1005 Steel
4	die 1.8%	Brick	AISI 1005 Steel

# Material Information

# Steel (ASTM - A572) -Brick

Material Model	Standard
Material Source	ALGOR Material Library
Material Source File	C:\Program Files\ALGOR\22.00\matlibs\algormat.mlb
Date Last Updated	2004/09/30-16:00:00
Material Description	High-strength low-alloy
Mass Density	0.000000078548 N·s²/mm/mm³
Modulus of Elasticity	199950 N/mm <sup>2</sup>
Poisson's Ratio	0.29
Shear Modulus of Elasticity	77221 N/mm <sup>2</sup>
Thermal Coefficient of Expansion	0.0000117 1/°C

# Aluminum Alloy 1100-H18 -Brick

Material Model	Standard
Material Source	ALGOR Material Library
Material Source File	C:\Program Files\ALGOR\22.00\matlibs\algormat.mlb
Date Last Updated	2004/09/30-16:00:00
Material Description	None
Mass Density	0.000000027104 N·s²/mm/mm³
Modulus of Elasticity	68947 N/mm²
Poisson's Ratio	.33
Shear Modulus of Elasticity	25993 N/mm <sup>2</sup>
Thermal Coefficient of Expansion	0.00002358 1/°C

# AISI 1005 Steel -Brick

Material Model	Standard
Material Source	ALGOR Material Library
Material Source File	C:\Program Files\ALGOR\22.00\matlibs\algormat.mlb
Date Last Updated	2004/09/30-16:00:00
Material Description	None
Mass Density	0.00000007872 N·s²/mm/mm³
Modulus of Elasticity	200000 N/mm <sup>2</sup>
Poisson's Ratio	0.29
Shear Modulus of Elasticity	80000 N/mm <sup>2</sup>
Thermal Coefficient of Expansion	1.260000E-005 1/°C

### **APPENDIX D**

# Result of stress value versus punch force



Figure 6.1: Result of stress value versus punch force for clearance at 2.3%



Figure 6.2: Result of stress value versus punch force for clearance at 2.8%



Figure 6.3: Result of stress value versus punch force for clearance at 3.3%

### **APPENDIX E**

# Result of stress value versus percentage of clearance



Figure 6.4: Result of stress value versus clearance percentage for punch force at 140kN



Figure 6.5: Result of stress value versus clearance percentage for punch force at 100kN