PUNCHING TOOL WEAR MODELING USING FINITE ELEMENT METHOD

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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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To my Beloved Family:

JINIKOL BIN LOGIMO
ANSUNGOI BINTI AGALUK

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ABSTRACT

This paper will investigate the factor or parameter that will effect the wear that occur in the punching tool. The punching tool will be redesign by change the shear angle, do the simulation with diferrent force applied to the punching tool by using finite element method and also change the thickness of the punching tool. The purpose of this paper is to investigate the wear that will occur in the punching tool in order to increase the tool life and in the same time will increase the quantity and quality production in the factory. Using finite element method, the parameter of the cause and parameter of the wear in tool will investigate.

ABSTRAK

Kertas projek ini membincangkan atau mengenalpasti factor atau parameter yang akan mempengaruhi kerosakan yang berlaku pada mata pemotong. Mata pemotong akan direka bentuk semula dengan mengubah sudut shear, membuat simulasi dengan mengenakan daya yang berbeza kepada mata pemotong dengan menggunakan cara simulasi dan juga mengubah ketebalan pada mata pemotong. Tujuan kertas projek ini adalah mengenalpasti kerosakan yang akan berlaku pada mata pemotong dengan tujuan meningkatkat kadar hayat pada perkakas dan dalam masa yang sama meningkatkan kuantiti dan kualiti pengeluaran dalam kilang. Dengan menggunakan kaedah simulasi, parameter yang menyebabkan serta parameter kerosakan pada mata pemotong akan dikenalpasti.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS/ABBREVIATIONS

*W*ad	worn volume per unit sliding distance
V	volume of the material removed by wear from surface
k	wear coefficient
s	sliding distance
H	hardness of the sheet
F_N	normal load applied
β	part of the asperities having the ability to cut
θ	angle of the assumed cone-shaped asperities for the hardest material
γw	wear coefficient depending on sliding contact conditions
V	cutting speed
D	depth of cut
F	feed rate
x, *y*	determined experimentally
n and *C*	found by experimentation or published data
Cl	clearance
D and *d*	die and punch diameter
a_p and b_p	radial and axial wear length of punch

CAD	computer-aided design
IGES	Initial Graphics Exchange Specification

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

In manufacturing industry, tool life was the important factor that controls the quantity of the product. In order to increase the quantity of the product, we need to try maximizing or increase the tool life. There a lot of factor or parameter that will affect the tool life and in the punching tool, wear is the main factor that will decrease the tool life. Tools often show adhesive and abrasive wear in the contact zone.

In this study, we will investigate the parameter that can affect the wear like the shear angle of cutting tool, punching force, and also the type of wear that occur in the punching tool. As a result, we may design the new geometry of the punching tool that less wear occur, mean that it have the higher tool life.

1.2 PROBLEM STATEMENT

Wear are always occur in the machine tool and it will decrease tool life and in some time will affect the production in industry sector. In order to increase the product quantity, the wear that occurs in the tool should be controlled. Using finite element method, we try to investigate the factors or parameter that will lead to this wear that occurs. So, we can try to come up with something new to minimize the wear or increase the tool life. One of the way to increase the tool life is like using the lubricate and we need try to invent the new idea by studying the factors that affect the wear. In this study, we will try to design new geometry of the punching tool by change the shear angle of the punching tool. We do the simulation and find which shear angle that have less stress and strain. It means, the less the stress and strain occur in the punching tool, the wear that occur also less. The stress will affect the wear meanwhile; the strain will affect the edge quality of the punching tool surface.

1.3 OBJECTIVES

The objective of this project is to investigate the wear that occurs in punching tool. The relation between the shear angle, force applied to the punching tool and thickness of the punching tool with the wear that occur in the punching tool will be investigate. Firstly, the geometry of the punching tool will be redesign by change the shear angle. Second, the force that applied to the punching tool also will change and for the third one, the thickness of the punching tool will be change.

1.4 THESIS OUTLINE

This thesis consists of five chapters. Chapter 1 will state the background study, problem statement and objective while chapter 2 consists of literature review. Then followed by chapter 3 regarding experiment setup and design of experiment. Chapter 4 clearly explains the analysis and result obtained during experiment and finally chapter 5 will conclude the whole thesis and some recommended for future planning.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Punching operations are widely used to cut sheet or plates by a shearing process between the punch and the die. Compared with casting, forging, and machining, these processes are usually very easy, fast, and economical to obtain the desired shape, size and finish. In general, the process of shearing and the conditions of the sheared surface are influenced by the punch, the die, the speed of punching, the lubrication, the clearance between the punch and the die, and the properties of the work piece material. The performance characteristics of the punch and the die are determined by the tool geometry and materials, heat treatment, surface treatment, finishing, and the wear of the cutting edge. Singh et al. [1] had studied the design of various types of punches using a finite-element technique. The results of their analysis indicated that the radial deformations of punches with balanced convex and concave shear have a minimum value within the shear-angle range of 17–22°. This suggests that a shear angle of 20° can be proposed safely for practical purposes in order to reduce the stress on the tool or to permit the use of a lower-rated press. Furthermore, eccentricity due to asymmetric load on the press when using a punch with balanced convex shear will be smaller. The effect of high-speed blanking on the sheared edges was studied by Jana and Ong [2]. Their investigations showed that the use of high punch-speeds generally resulted in blanks being produced with an improved surface finish as compared to those obtained at low speed. This improvement is particularly marked for mild-steel blanks. Moreover, at a high punch speed, less distortion was obtained and the width of the strain-hardened region was smaller, but the distortion of the blanks increases with the increase of the radial clearance. Popat et al. [3] had studied the optimum punch–die clearance and punch penetration using a finite-element model. They stated that the optimum punch–die clearance depends on the local fracture strain of the material. The percentage of punch penetration at crack initiation for the optimum punch–die clearance does not depend greatly on parameters such as sheet thickness, work-hardening exponent, ductility, etc. and remains at a value of around 30% of the sheet thickness. Metal cutting tools are subjected to extremely arduous conditions, high surface loads, and high surface temperatures arise because the chip slides at high speed along the tool rake face while exerting very high normal pressures (and friction force) on this face. Cutting tools need strength at elevated temperature, high toughness, high wear resistance and high hardness. A key factor in the wear rate of virtually all tool materials is the temperature reached during operation, unfortunately it is difficult to establish the values of the parameters needed for such calculations, and however experimental measurements have provided the basis for empirical approaches. It is common to assume that all the energy used in cutting is converted to heat (a reasonable assumption) and that 80% of this is carried away in the chip (this will vary and depend upon several factors - particularly the cutting speed). This leaves about 20% of the heat generated going into the cutting tool. Even when cutting mild steel tool temperatures can exceed 550^{o}C, the maximum temperature high speed steel (HSS) can withstand without losing some hardness. There are many type of wear that occur during machining that will affect the product. In industry, the wear in the tool will affect the quality and quantity of the product. If we can control the wear of the tools, we can save a lot of time production and other quality. Some General effects of tool wear include increase cutting forces, increase cutting temperature, poor surface finish and decrease accuracy of finished part. Reduction in tool wear can be accomplished by using lubricants and coolants while machining. These reduce friction and temperature, thus reducing the tool wears.At high temperature zones crater wear occurs. The highest temperature of the tool can exceed 700 °C and occurs at the rake face whereas the lowest temperature can be 500 °C or lower depending on the tool. Energy comes in the form of heat from tool friction. It is a reasonable assumption that 80% of energy from cutting is carried away in the chip. If not for this the work piece and the tool would be much hotter than what is experienced. The tool and the work piece each carry approximately 10% of the energy. The percent of energy carried away in the chip increases as the speed of the cutting operation increases. This somewhat offsets the tool wears from increased cutting speeds. In fact, if not for the energy taken away in the chip increasing as cutting speed is increased; the tool would wear more quickly than is found. The mechanism of wear is very complex and the theoretical treatment without the use of rather sweeping simplifications (as below) is not possible. It should be understood that the real area of contact between two solid surfaces compared with the apparent area of contact is invariably very small, being limited to points of contact between surface asperities. The load applied to the surfaces will be transferred through these points of contact and the localized forces can be very large. The material intrinsic surface properties such as hardness, strength, ductility, work hardening etc. are very important factors for wear resistance, but other factors like surface finish, lubrication, load, speed, corrosion, temperature and properties of the opposing surface etc. are equally important.

2.2 Type of Wear

Type of wear is including the flank wear, crater wear, crater wear and many more. The flank wear is occur in the portion of the tool in contact with the finishing part erodes (relief face) and occur mostly from abrasion of the cutting edge. After an initial wearing in period corresponding to the initial rounding of the cutting edge, flank wear increase slowly at a steady rate until a critical land width is reached after which wear accelerate and become severe. The progress of the flank wear can be monitor in production by examine the tool by tracking the change in size of the tool or machining part. Flank wear can be minimizing by increasing the abrasion and deformation resistance of the tool material and by the use of hard coating on the tools. For the crater wear also known as rake face produce a wear crater on the tool face. Usually, this crater wear does not limit the tool life but will increase the effective the rake angle of the tool and reduce the cutting force. But, for the side effect, excessive crater wear weaken the cutting edge and can lead to the deformation or fracture of the tool. This should be avoiding because, it can shorten the tool life and resharpening the tool more difficult.

2.2.1 Abrasive Wear

Adhesive wear is also known as scoring, gailing, or seizing. It occurs when two solid surfaces slide over one another under pressure. The abrasive wear mechanism is basically the same as machining, grinding, polishing or lapping that we use for shaping materials. Two body abrasive wear occurs when one surface (usually harder than the second) cuts material away from the second, although this mechanism very often changes to three body abrasion as the wear debris then acts as an abrasive between the two surfaces. Abrasives can act as in grinding where the abrasive is fixed relative to one surface or as in lapping where the abrasive tumbles producing a series of indentations as opposed to a scratch. Surface projections, or asperities, are plastically deformed and eventually welded together by the high local pressure. As sliding continues, these bonds are broken, producing cavities on the surface, projections on the second surface, and frequently tiny, abrasive particles, all of which contribute to future wear of surfaces.

2.2.2 Adhesive Wear

Adhesive wear is also known as scoring, galling, or seizing. It occurs when two solid surfaces slide over one another under pressure. Surfaces which are held apart by lubricating films, oxide films etc. reduce the tendency for adhesion to occur. Surface projections, or asperities, are plastically deformed and eventually welded together by the high local pressure. As sliding continues, these bonds are broken, producing cavities on the surface, projections on the second surface, and frequently tiny, abrasive particles, all of which contribute to future wear of surfaces.

The wear resulting from adhesive wear process has been described phenomenological by the Archard equation [6]:

$$W\mathrm{ad} = \frac{V}{s} = \mathrm{K}\frac{F_N}{3H}$$

*W*ad is the worn volume per unit sliding distance; *V* is the volume of the material removed by wear from surface, *k* is a wear coefficient depending on the contacting materials and the sliding contact conditions. *s* is the sliding distance, *H* is the hardness of the sheet and F_N is the normal load applied on the tool. Inspection of Eq. (1) shows that the hardness H is the only material property appearing in the model. Typical values of the wear coefficient k are given in [7,8] for a combination of contacting materials. In the present investigation, the value k was taken in the order of 10E-05. A simplified expression for the volume of abrasive wear can be given by [8]:

$$V=\frac{\beta F N s}{\pi H}\tan(\theta)$$

Where β represents that part of the asperities having the ability to cut and θ the angle of the assumed cone-shaped asperities for the hardest material. If the parameters of the wear models are assumed to be constant through time, the above wear models can be rewritten as:

$$V=\gamma w F \mathrm{N} s$$

where γw denotes a wear coefficient depending on sliding contact conditions [8,9] and varies over the range of 10^{-2}–10^{-7} mm^2/N. In the present paper, γw is taken in the order of 1.3E-04 at the sliding interface of the work piece and the punch. This value corresponds to a hard tool steel.

2.2.3 Erosion

Erosion is caused by a gas or a liquid which may or may not carry entrained solid particles, impinging on a surface. Other explanation: erosion is the wearing away or destruction of metals and other materials by the abrasive action of water, steam or slurries that carry abrasive materials. Pump parts are subject to this type of wear. When the angle of impingement is small, the wear produced is closely analogous to abrasion. When the angle of impingement is normal to the surface, material is displaced by plastic flow or is dislodged by brittle failure.

2.2.4 Fretting wear

Fretting wear is the repeated cyclical rubbing between two surfaces, which is known as fretting, over a period of time which will remove material from one or both surfaces in contact. It occurs typically in bearings, although most bearings have their surfaces hardened to resist the problem. Another problem occurs when cracks in either surface are created, known as fretting fatigue. It is the more serious of the two phenomena because it can lead to catastrophic failure of the bearing. An associated problem occurs when the small particles removed by wear are oxidised in air. The oxides are usually harder than the underlying metal, so wear accelerates as the harder particles abrade the metal surfaces further. Fretting corrosion acts in the same way, especially when water is present. Unprotected bearings on large structures like bridges can suffer serious degradation in behavior, especially when salt is used during winter to deice the highways carried by the bridges.

2.3 Wear resistance

Surface hardness is often regarded as the basis for good wear resistance. The wear resistance improvement of the nanostructured coatings obtained from nanostructured powder could be ascribed to both the decrease of the defects size and the grains size. Furthermore, the higher fracture resistance of nanostructured coatings is due to a unique microstructure generated under appropriate plasma spray conditions and composed of a mixture of fully melted splats and partially melted particles. The partially melted regions can provide a variety of cracks arrest and deflection mechanisms, thereby increasing the crack growth resistance of the coating[4].

2.4 Tool life

Tool life is the most important practical consideration during selecting the cutting tools and cutting condition. Tool which wear slowly have a low per part cost and produce predicable tolerances and surface finishes. An understanding of tool life required an understanding of the ways in which tool fail. Tool failure may result from wear, plastic deformation or failure. Tools deform plastically or fracture when they are unable to support the load generated during chip formation. Research had been doing to develop method of predicting tool life from a consideration of tool failure mechanisms. Unfortunately, accurately predicting tool life in any general sense is very difficult because tool life depends strongly on part requirements. In practice, tools are removed from service when they no longer produce an acceptable part. This may occur when the parts dimensional accuracy, form accuracy, or surface finish are out of tolerance, when an unacceptable burr or other edge condition is produced or when there is an unacceptable probability of gross failure due to an increase in cutting forces or power. Tools used under the same conditions in different operations may have quite different usable lives depending on critical tolerances or requirement. Because of this fact, methods of predicting tool life are useful primarily for comparative purpose, for example in ranking expected levels of tool life for different work materials, tool materials or cutting condition [5].

2.4.1 Taylor Equation for Tool Life Expectancy

The Taylor Equation for Tool Life Expectancy provides a good approximation.

$$V_c T^n = C$$

A more general form of the equation is

$$V_c T^n \times D^x f^y = C$$

Where V_c is cutting speed, T is tool life, D is depth of cut, F is feed rate, x and y are determined experimentally, and n and C are constants found by experimentation or published data; they are properties of tool material, work piece and feed rate.

In punching processes, clearance can be expressed as a percentage of the sheet-metal thickness:

$$\text{Cl}\ (\%) = \frac{D-d}{2t} \times 100$$

Where *D* and *d* are the die and punch diameter, and *t* is sheet-metal thickness, as can be seen in Figure below.

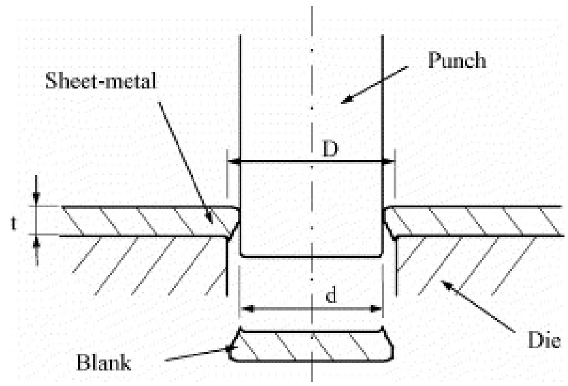


Figure 2.1: Geometrical parameters of the punching experiments.

Source: After J.J. Hern´andez, P. Franco, M. Estrems, F. Faura (2006)

2.5 Tool wear

In punching processes, the cutting tool edge is exposed to strong tribological efforts because of the high normal contact pressure and sliding distance. Cutting tools often show adhesive and abrasive wear in the contact zone.[14] Generally, the total worn area can be expressed as the addition of three terms: flank wear, face wear and tip wear (Fig.2a). . As can be seen in (Fig.2b), the worn surface of the tool presents a triangular shape [10] and the expression of the worn area is

$$S_p = \frac{a_p \, x \, b_p}{2}$$

where a_p and b_p are the radial and axial wear length of punch, respectively. The loss of cutting tool material is not uniform but strongly irregular along the cutting edge [11].

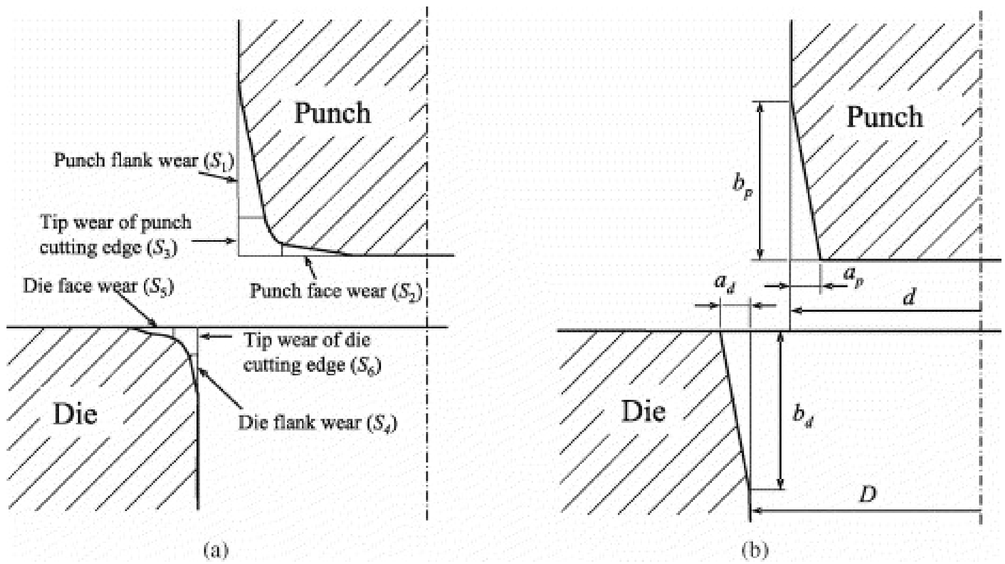


Figure 2.2: Geometry of the cutting tool worn surface: (a) generic case of tool wear and (b) tool wear analyzed

Source: After J.J. Hern´andez, P. Franco, M. Estrems, F. Faura (2006)

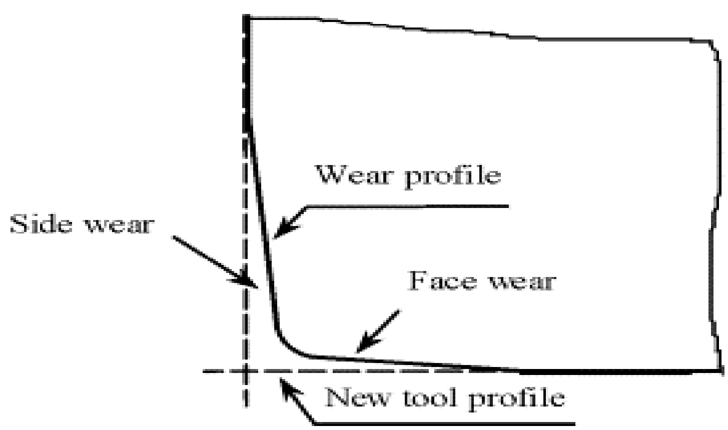


Figure 2.3: Wear profile

Source: After R. Hambli / International Journal of Machine Tools & Manufacture

This figure shows the wear profile that will occur in the punching tool after we do the simulation. The punch wear radius (Rusp) will occur between the face and the side wear, mean that most wear occur in the side of the punching tool. The more value of the punch wear radius (Rusp) or the bigger the punch wear radius, the more wear had occur in that punching tool.

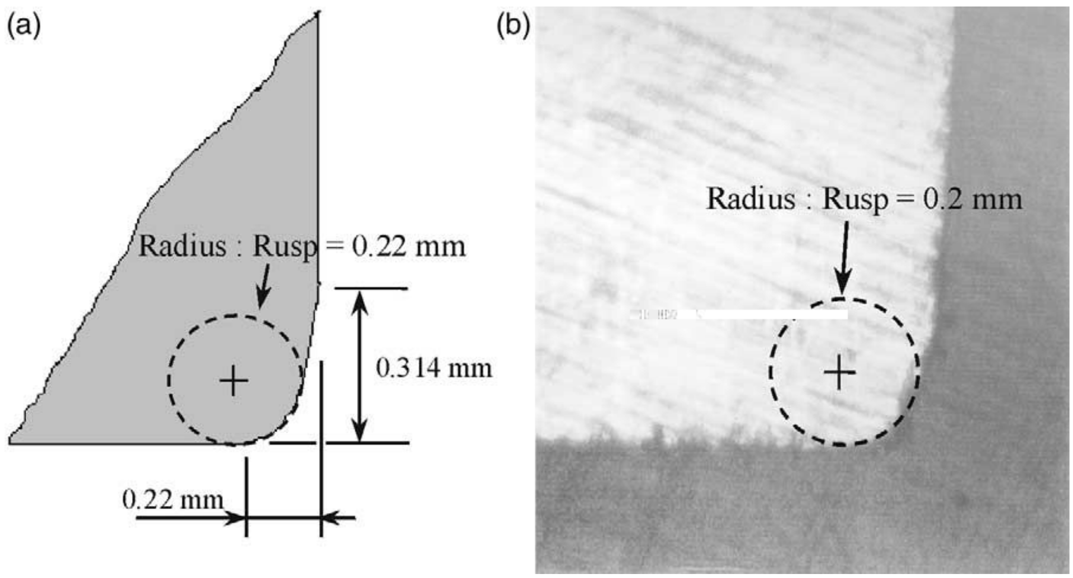


Figure 2.4: Punch wear radius: (a) by calculation and (b) by experiment

Source: After R. Hambli / International Journal of Machine Tools & Manufacture

The figure show the punch wear radius in the simulation or calculation and the punch wear radius that occur in the experiment.

2.6 Modeling of tool wear effects

In punching processes involving fresh tools, the distance between punch and die at the cutting edges is given by clearance, the extent of which has a great influence on the shearing mechanism and form errors [12]. As cutting tool becomes worn, the cutting tool surface shape is strongly modified (Fig. 2) and the distance between the cutting edge of the punch and the die increases as a consequence of the variation in punch and die diameter [13]. This change in the cutting geometry has an important effect on the shearing mechanism and, therefore, on the defects that may arise in the punched part profile. For this reason, a theoretical modeling of the distance between die and punch cutting edge with increasing tool wear will be very useful for the analysis of form errors. In this work a new parameter called "***effective clearance***" is proposed to model the increase in this distance between punch and die cutting edges as a function of tool wear, as well as to predict the effects of clearance and tool wear on form errors.

2.7 Effective Clearance

Effective clearance (Cl_e) can be defined as the sum of clearance (Cl) and a term denoted by ΔCl, which represents the increase in the distance between punch and die cutting edges due to tool wear during the process:

$$Cl_e = Cl + \Delta Cl$$

where Cl_e, Cl and ΔCl are expressed as percentages.

The increase in the distance between the punch and die cutting edges is defined mainly by the radial wear length of the punch (a_p) and die (a_d) [13]. Nevertheless, as can be seen in Fig.3, the distance between the punch and die cutting edges as the tool wears down will not be constant along the penetration depth of the punch into the die, while any effect of that increase on the shearing mechanism will depend on the cone-shape that the tool adopts with wear. This punch and die cone-shape will be determined by axial wear length (b_p and b_d, respectively). As axial wear length increases, the distance between punch and die cutting edges becomes more similar to the increase in clearance. For this reason, an exponential equation is assumed to estimate the increase in the punch and die cutting edge distance:

$$\Delta Cl = \frac{a_d + a_p}{t}(1 - e^{-b/t}) \times 100$$

where b is the average between the axial wear length of punch and die.

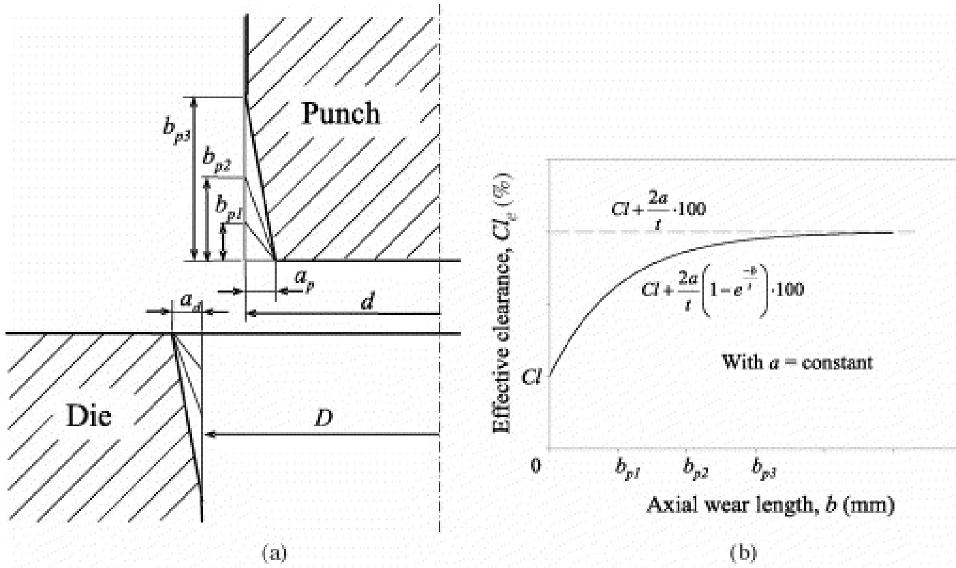


Figure 2.5: Influence of axial wear length on distance between punch and die cutting edges.

Source: After J.J. Hern´andez, P. Franco, M. Estrems, F. Faura (2006)

The first factor in this equation, $(a_d + a_p)/t$, corresponds to the maximum increase in the distance between punch and die cutting edges, while the second factor, $(1 - \exp(-b/t))$, represents the influence of axial wear length on the cutting tool geometry and the shearing mechanism. When axial wear length (b) is low, this second factor is approximately equal to zero and so ΔCl is negligible. Nevertheless, as b increases, $(1 - \exp(-b/t))$ tends to 1 and so ΔCl can be considered equal to $100(a_d + a_p)/t$. The sheet-metal thickness is introduced in this equation to obtain a value independent of this dimension in the workpiece material, the same as in the definition of clearance. From this definition of the increase in the punch and die cutting edge distance, effective clearance can be expressed as

$$Cl_e = \text{Cl} + \Delta\text{Cl} = \text{Cl} + \frac{ad+ap}{t}\,(1-e^{-b/t}) \times 100$$

If the radial wear length of the punch and die are assumed to be similar, an average value of radial wear length (*a*) can be considered. With this simplification, the following expression can be finally deduced for effective clearance:

$$Cl_e = \text{Cl} + \Delta\text{Cl} = \text{Cl} + \frac{2a}{t}(1-e^{-b/t}) \text{ x } 100$$

CHAPTER 3

EXPERIMENT SETUP

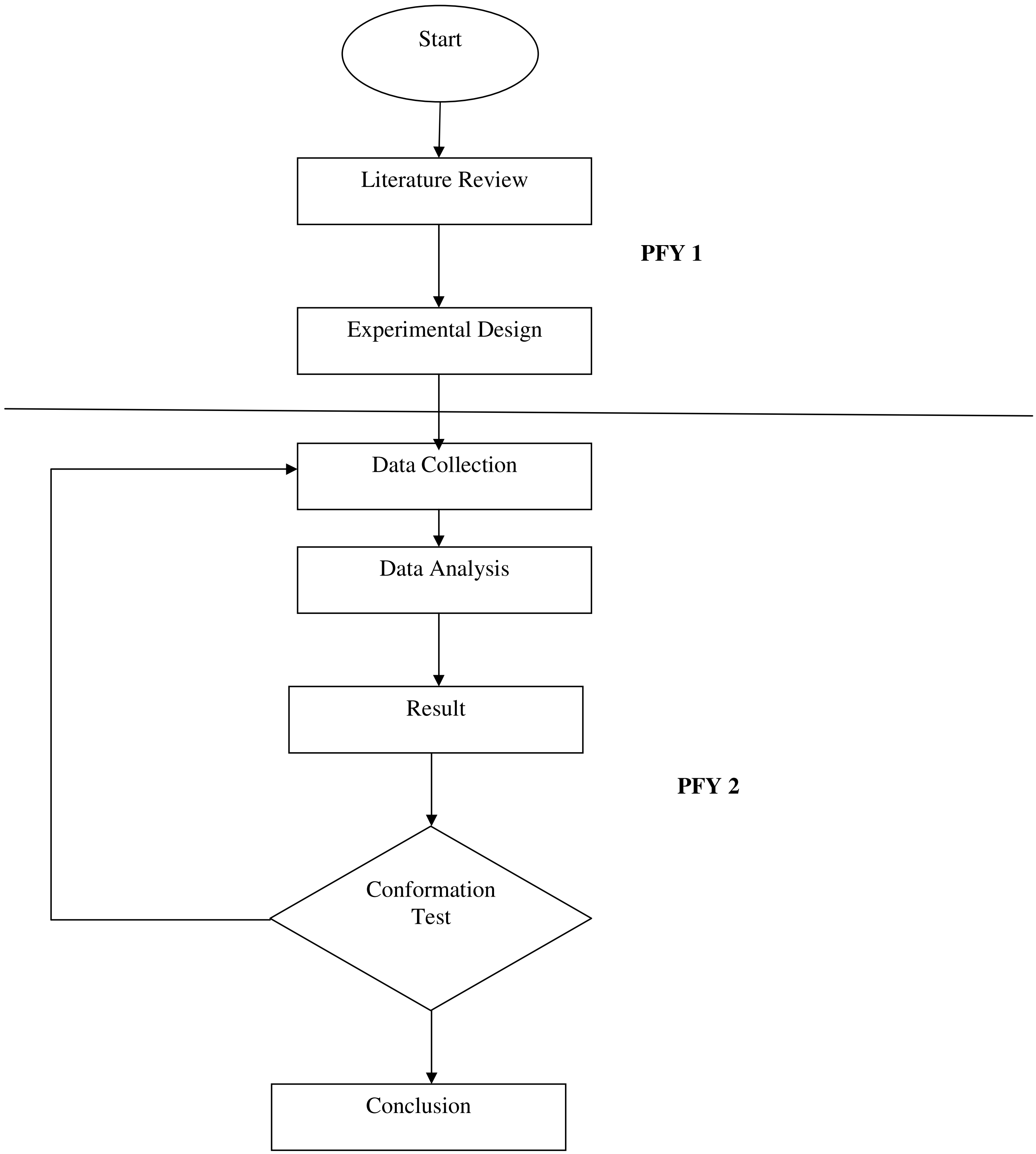
3.1 INTRODUCTION

This chapter consists of the experiment research, method from the beginning until the end of the project. In this chapter, it will tell more detail about the experiment design and analysis the data. It will tell more detail in every step taken.

3.2 Flow Chart for the Final Year Project

This flow chart will show the step that will be applied in this project from the beginning. It also shows what is parameter that included in order getting the wear that will occur in the tool. In finite element experiment, it also shows the step taken from the effect of the shear angle, the force or stress that applied to the tool and also the effect of the thickness of the punching tool.

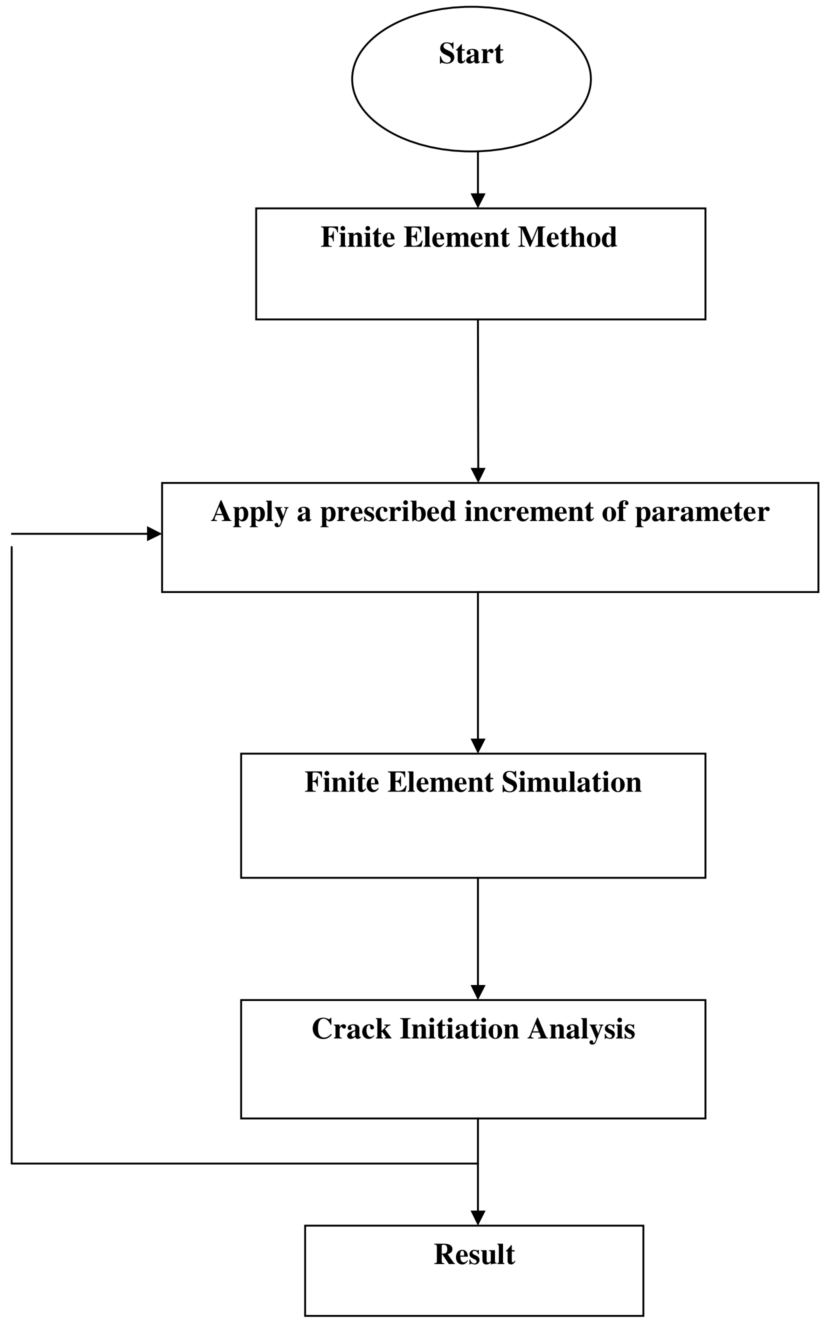
Flow chart for final year project



During the final year project 1, the work done more about searching the related research that done before that related to the project. It more on topic related and the literature review that will help and give more information about the case that should be considered. During the final year project 1, the design already planning 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.

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 before it 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. The simulation will be done in much time again and again in order to get the more accurate result. Then the conclusion will be done according to the result that had been collect and after the comparison or after we analyze the data from the simulation.

3.3 Flow chart for experiment



3.3.1 Start

The experiment step taken by preparing all the parameter that will be used to do the experiment such like the amount of force that will be added to the punching tool, geometry of the punching tool that will change by the shear angle, stress, strain and other parameter. In this step, clarify the objective of this experiment is the important rule. This is the important step were the objective of this final year project has to clarify and give earlier inspection or prediction base on the aim or the objective. Each objective has to have the prediction based on the previous research and in the end of the experiment, the result will show either the prediction is true or not.

3.3.2 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, five type of punching tool will be design and have different shear angle for each one of them. The shear angle is from 4.5º, 6.5º, 8.5º, 10.5º and 12º. The minimum shear angle is taken from the actual turret punching tool and the other taken from the previous experiment. 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.

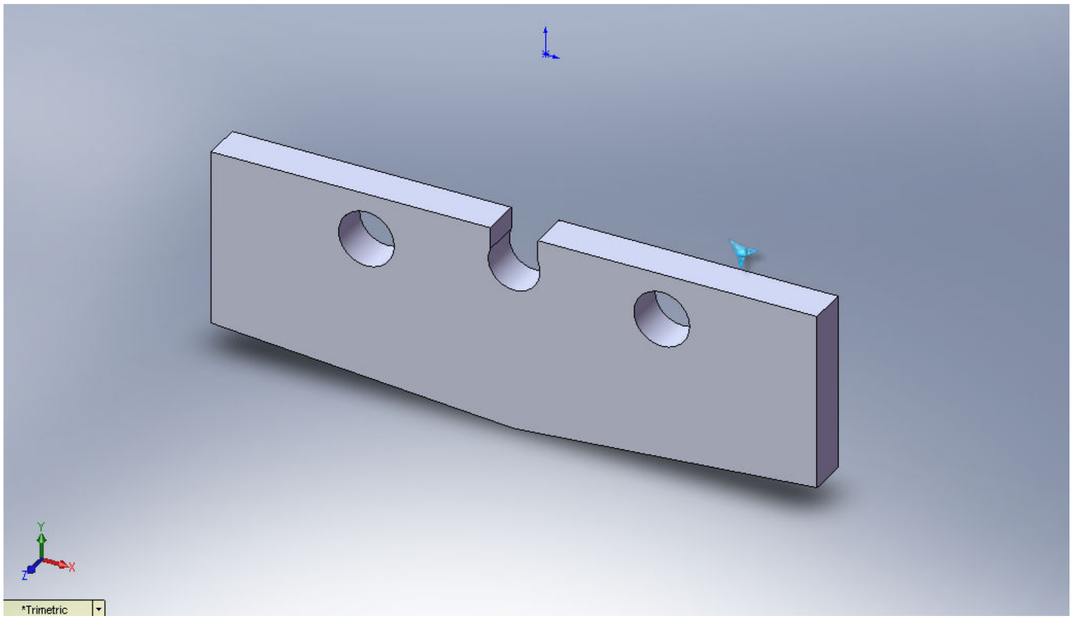


Figure 3.1: Geometry of punching tool design using the SolidWork Software

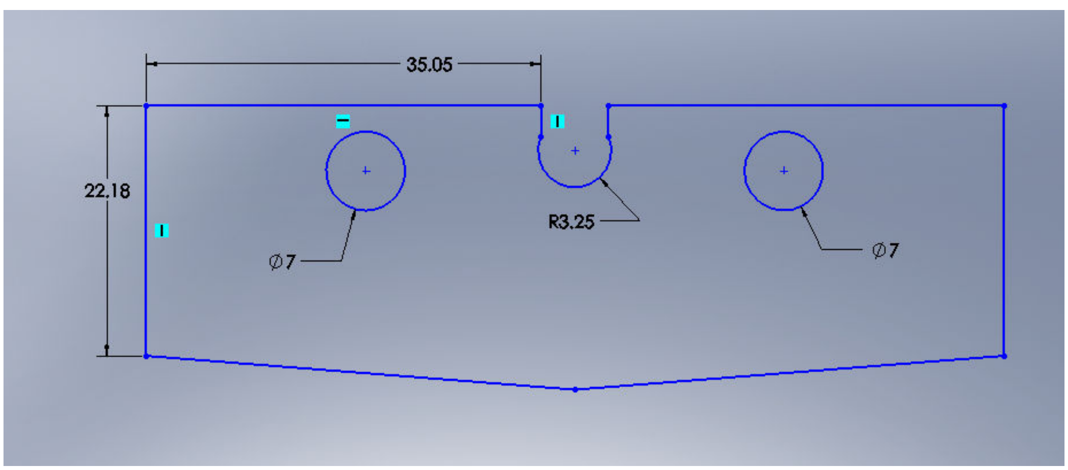


Figure 3.2: Diameter of the punching tool

3.3.3 Apply the prescribed increment of the parameter

This is the most important step that will affect the result or the wear that occur in the tool. The wear will be change if we change the value of the parameter. This is the step where all the parameter that involve in the experiment need to be control in order to get the prediction of the wear more accurate. The parameter that need to control or change in this step will be the force that be applied in the punching tool and also the shear angle of the tool. Both of this parameter will affect the stress and strain in the punching tool in this simulation. For the simulation where the affect of the shear angle to the stress and strain, the same force will be used and applied to each of the punching tool and then compare the stress and strain that occur in that punching tool. The first prediction is, when the shear angle increase, the stress and strain also increase.

For the second simulation, the amount of force will be change in order to investigate the affect of the force to the stress and strain in the five different geometry of the punching tool. The prediction for this simulation is when the force applied to the punching tool increase; the stress and strain also increase.

For the overall experiment, prediction of the type of wear that will occur in the punching tool will be made such as the punch wear radius (Rusp) and the area that wear will occur in that punching tool.

3.3.4 Finite Element Simulation

In this step, the experiment simulation in the finite element method will be run after we apply all the parameter needed like shear angle and forces that applied to the punching tool.

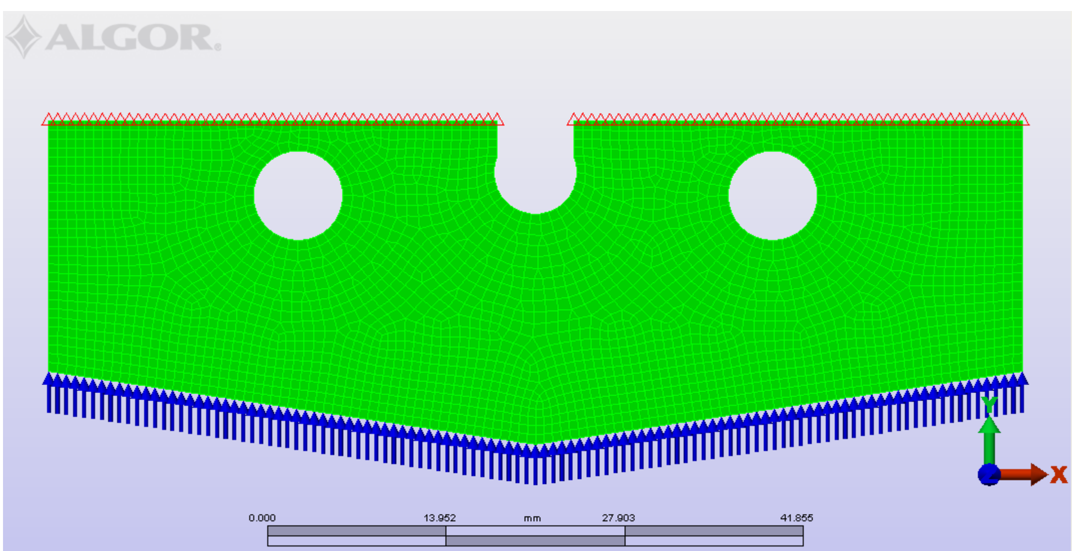


Figure 3.3: Simulation using finite element method

3.3.5 Crack Initiation Analysis

After finish the simulation, the crack that occurs on the tool will be analyze. In this stage, the wear profile in the tool will be observed. The result will be recorded and the simulation needs to run again but in different shear angle. For the next experiment, the force value will be change and the change of the wear profile due to the change of the force will be recorded. The result will be compared and the effect of the wear profile to the other parameter such as the forces or the stress that applied in the tool will be studied.

3.4 SolidWork Software

SolidWork is one of designing software that used in this project. SolidWorks is a 3D mechanical CAD (computer-aided design) program and a parasolid-based solid modeler and utilizes a parametric feature-based approach to create models and assemblies. The drawings can be created either from parts or assemblies. Views are automatically generated from the solid model, and notes, dimensions and tolerances can then be easily added to the drawing as needed. The drawing module includes most paper sizes and standards. In an assembly, the analog to sketch relations are mates. Just as sketch relations define conditions such as tangency, parallelism, and concentricity with respect to sketch geometry, assembly mates define equivalent relations with respect to the individual parts or components, allowing the easy construction of assemblies. SolidWorks also includes additional advanced mating features such as gear and cam follower mates, which allow modeled gear assemblies to accurately reproduce the rotational movement of an actual gear train. Features refer to the building blocks of the part. They are the shapes and operations that construct the part. Shape-based features typically begin with a 2D or 3D sketch of shapes such as bosses, holes, slots, etc. This shape is then extruded or cut to add or remove material from the part. Operation-based features are not sketch-based, and include features such fillets, chamfers, shells, applying draft to the faces of a part, etc. By using this software CAD drawing will be easier because this software is easy to draw. The punching tool insert will be draw using this software before we transfer the design into the ALGOR software. A part from that, this software more practical then AutoCAD software because it can safe the file in IGES. The ALGOR can read and import the IGES file.

3.5 IGES File

IGES is the common file type to use in model analysis, and other manufacturing function. IGES is actually **Initial Graphics Exchange Specification (IGES)** defines a neutral data format that allows the digital exchange of information among CAD (computer-aided design) systems. Using IGES, we can exchange product data models in the form of circuit diagrams, wireframe, freeform surface or solid modeling representations. Applications supported by IGES include traditional engineering drawings, models for analysis, and other manufacturing functions. So the CAD data can exchange product data models in the form of solid modeling that have been used in this drawing to IGES for analysis method. A part from that, IGES file format standard allows efficient and accurate exchange of product definition data.

3.6 ALGOR FEMPRO

ALGOR is a general-purpose multiphysics finite element analysis software package. It is distributed in a number of different core packages to cater to specifics applications, such as mechanical event simulation and computational fluid dynamics. ALGOR is used by many scientists and engineers worldwide. It has found application in aerospace, and it has received many favorable reviews. ALGOR's library of material models includes metals and alloys, plastics, glass, foams, fabrics, elastomers, Concrete (with rebar), soils and User-defined materials. ALGOR's element library depends on the geometry and the type of analysis performed. It includes 8 and 4 node bricks, 8 and 4 node shells, and Beam and trusses. We use the ALGOR software to predict the critical part. From the critical part so we can define the tool wear will occur. From the previous literature review, it is said that when the stress is increase, it mean that the probability of wear that will occur in that part also higher. The most important analysis must be conduct in this project because tool wear cannot measure directly during the process. An online tool wear can reduce the cost production cost. As we all know, ALGOR is one of the analysis software which is conduct for finite element method. This software is available at here and this software has expertise to use ALGOR. SO ALGOR software is practical to use.

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

From the simulation that had been done before, the data had been collect and analyze. For the first objective, the shear angle of the punching tool will act as a parameter where the shear eagle will be increase from 4.5º until 12º. The data that taken from the simulation is the maximum von mises stress and maximum von mises strain. The data were compiling in a table and the graph was plotted. From the table below, the graph were plotted with the maximum von mises stress against shear angle of the punching tool and the second one is with the maximum von mises strain against shear angle of the punching tool. The maximum von mises stress will indicate the wear that will occur in that punching tool and the maximum von mises strain will indicate the edge quality in the punching tool. When the maximum von mises stress increase it also means that the wear that occurs in that same area also will increase.

4.2 RESULT FROM THE SIMULATION

From the simulation, we collect the data and try to make it more simple by arrange it using table and show in graph in order make it more simple and easy to read. The table and graph below show all the data from the simulation that had been run.

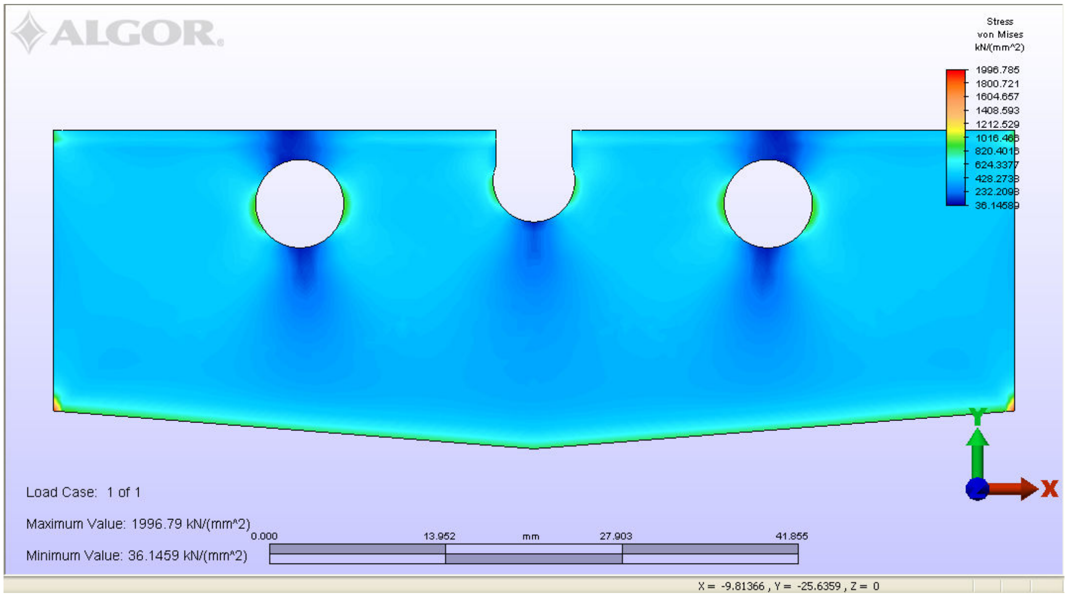


Figure 4.1: Maximum von mises stress for 4.5º shear angle

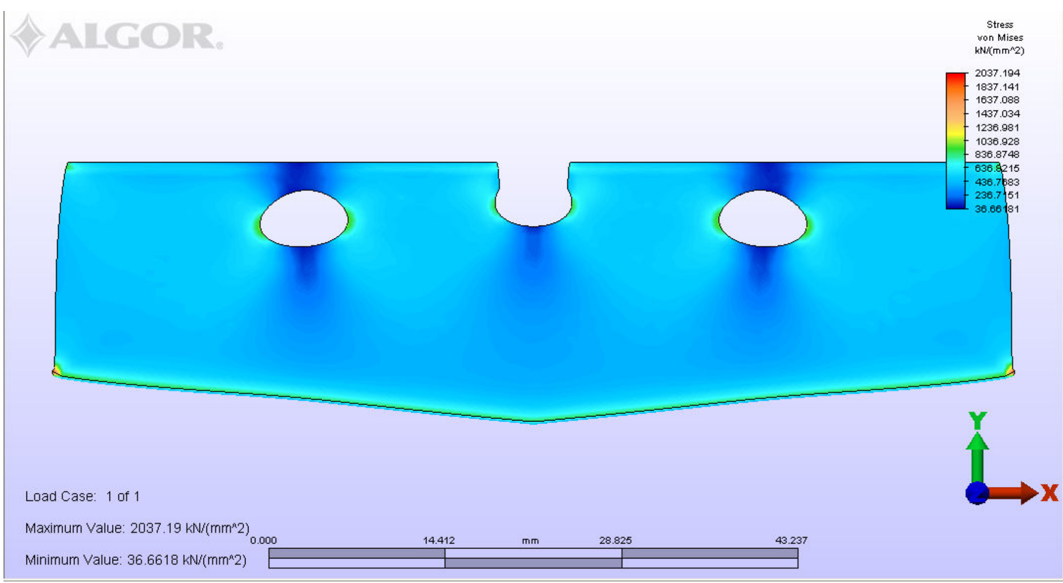


Figure 4.2: Maximum von mises stress for 6.5º shear angle

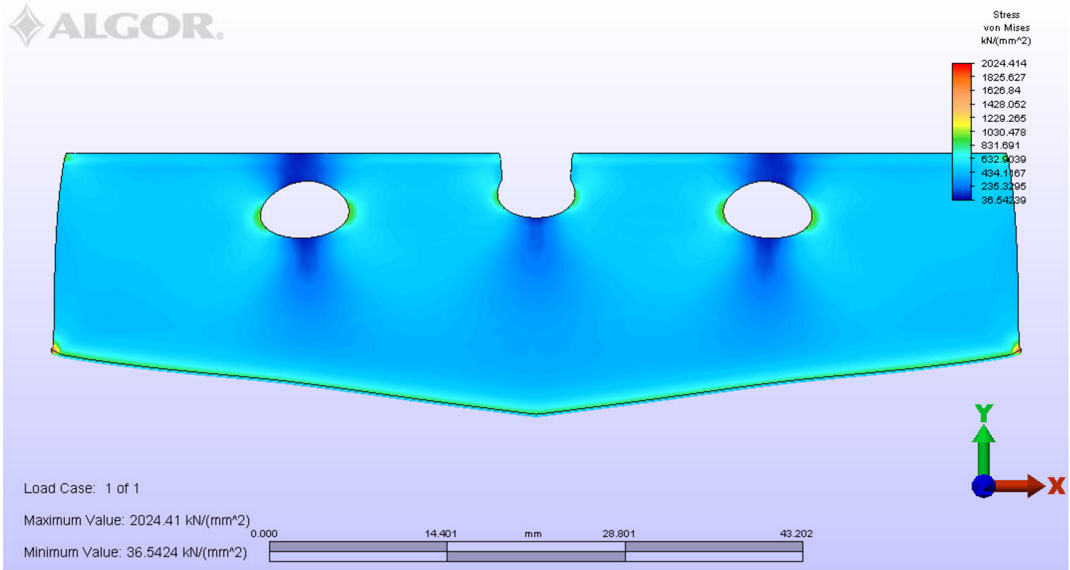


Figure 4.3: Maximum von mises stress for 8.5º shear angle

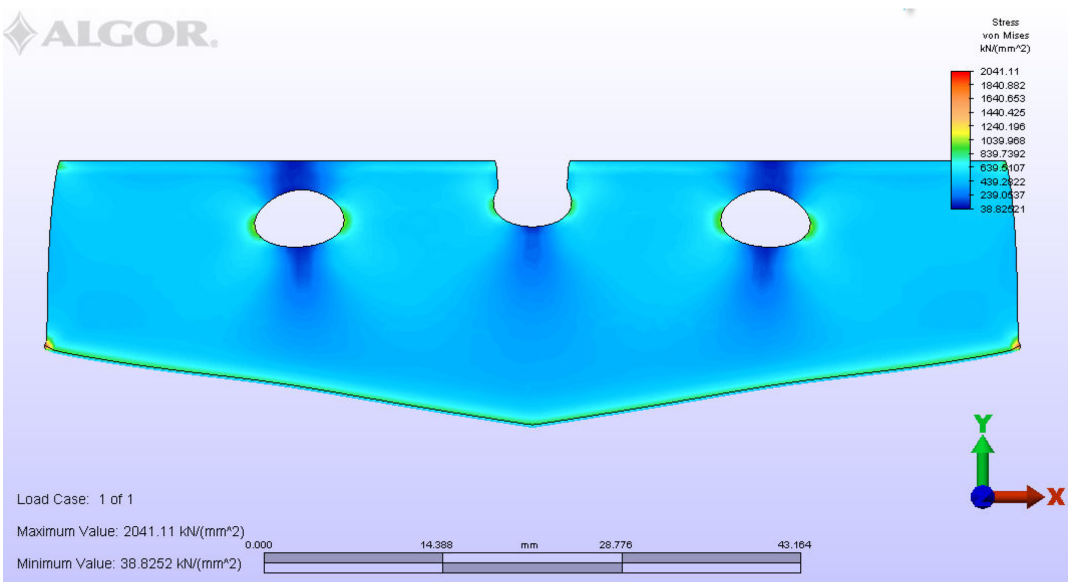


Figure 4.4: Maximum von mises stress for 10.5º shear angle

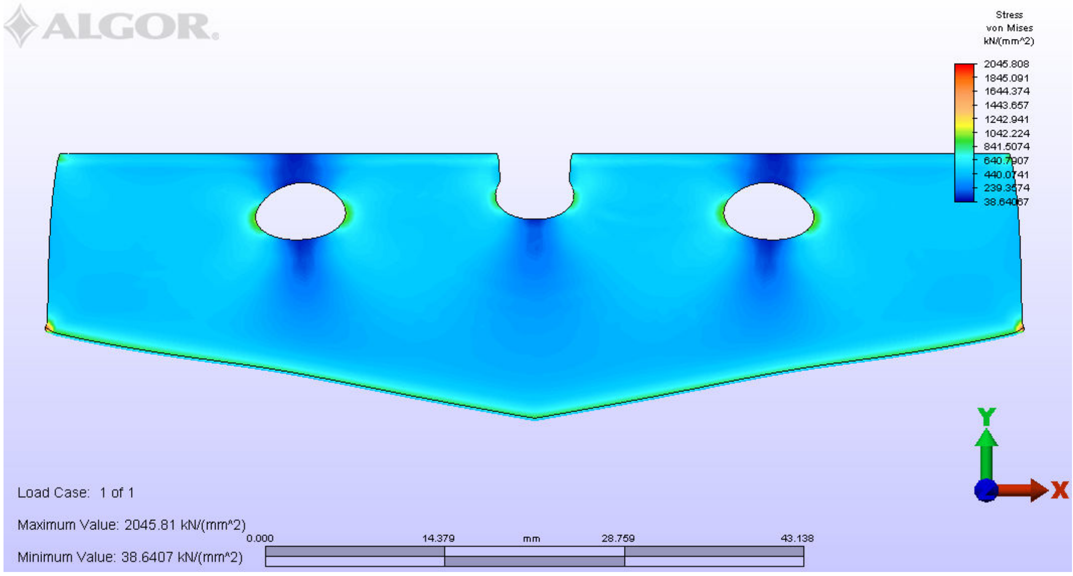


Figure 4.5: Maximum von mises stress foor 12º shear angle

Table 4.1: Effect of shear angle to the maximum von mises stress

Shear Angle (°)	Max. Stress (kN/mm²)
4.5	1996.79
6.5	2037.19
8.5	2024.41
10.5	2041.11
12.0	2045.81

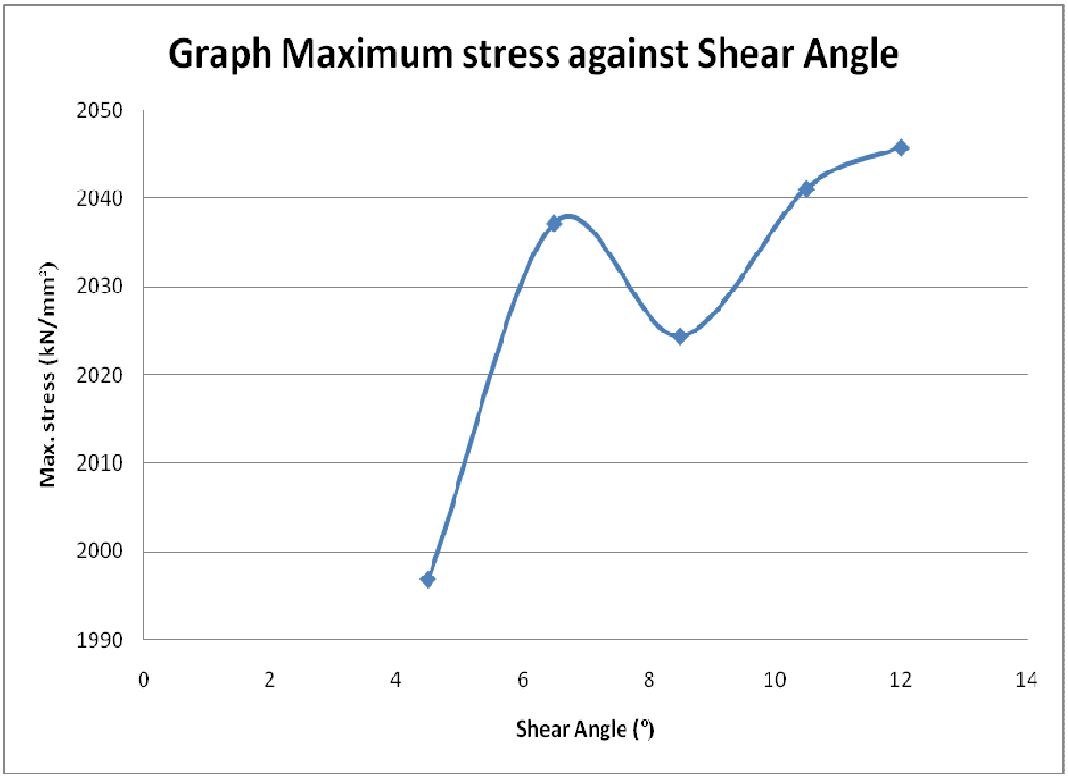


Figure 4.6: Graph maximum stress against shear angle

Table 4.2: Effect of shear angle to the maximum von mises strain

Shear Angle (°)	Max. Strain (mm/mm)
4.5	12.8825
6.5	13.1432
8.5	13.0607
10.5	13.1685
12.0	13.1988

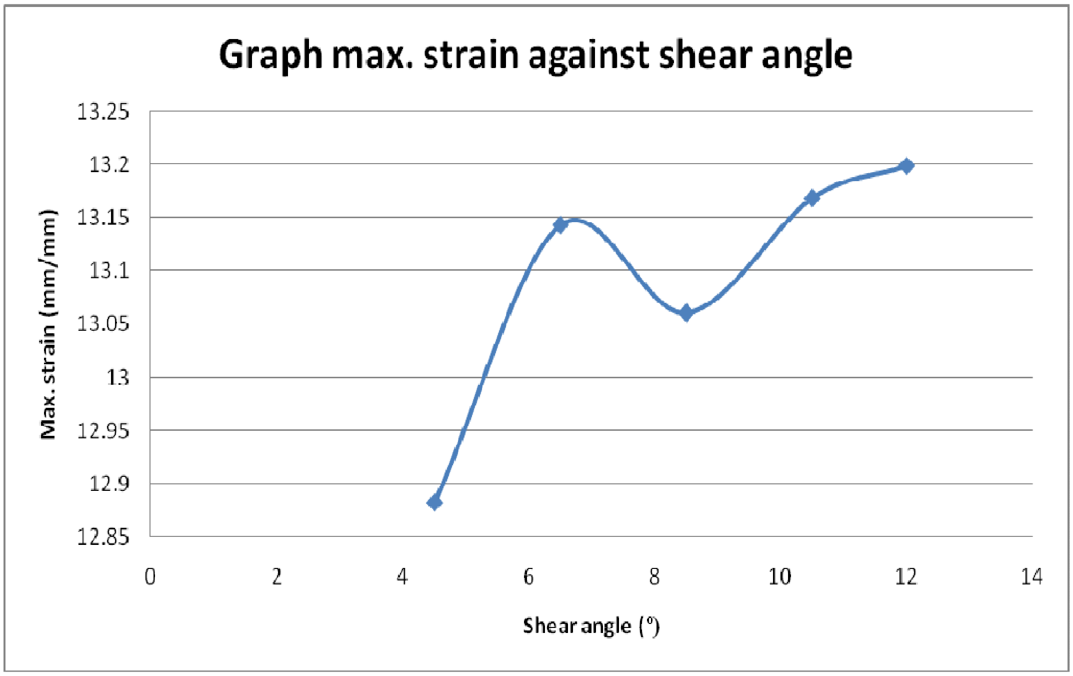


Figure 4.7: Graph maximum von mises stress against shear angle

From the graph above, we can see that the earlier prediction that we state before that when we increase the shear angle, the maximum von mises stress and strain also increase is not true. As we can see, in the earlier shear angle the maximum von mises also increase but when it reach the 6.5°, the maximum stress start to drop. When the shear angle reach at the 8.5°, the maximum stress reach the lowest maximum stress and then start to increase again. The result also shows that the maximum stress also not increases gradually with increasing the shear angle. As a conclusion for the first objective, we can conclude that the punching tool that has shear angle 8.5° is more less wear will occur than the 6.5° although its shear angles more than that that 6.5° shear angle. It means that the punching tool with 8.5° has higher tool life compare to the punching tool with 6.5° shear angle. We can conclude that we should use the punching tool with 8.5° shear angle compare to the 6.5° shear angle tool life.

The data below show second objective when we change the force applied to the punching tool and the force will be added to the all type of the punching tool. We tested the effect of the punching force for all five type of the punching tool. The data that we get from the simulation will be shown in table and then plotted in the graph.

Table 4.3: Effect the force to the maximum von mises stress

	Shear angle				
Force(kN)	4.5	6.5	8.5	10.5	12
100	1109.33	1131.77	1124.67	1133.95	1136.56
120	1331.19	1358.13	1349.61	1360.74	1363.87
140	1553.06	1584.48	1574.54	1587.53	1591.18
160	1774.92	1810.84	1799.48	1814.32	1818.50
180	1996.79	2037.19	2024.41	2041.11	2045.81

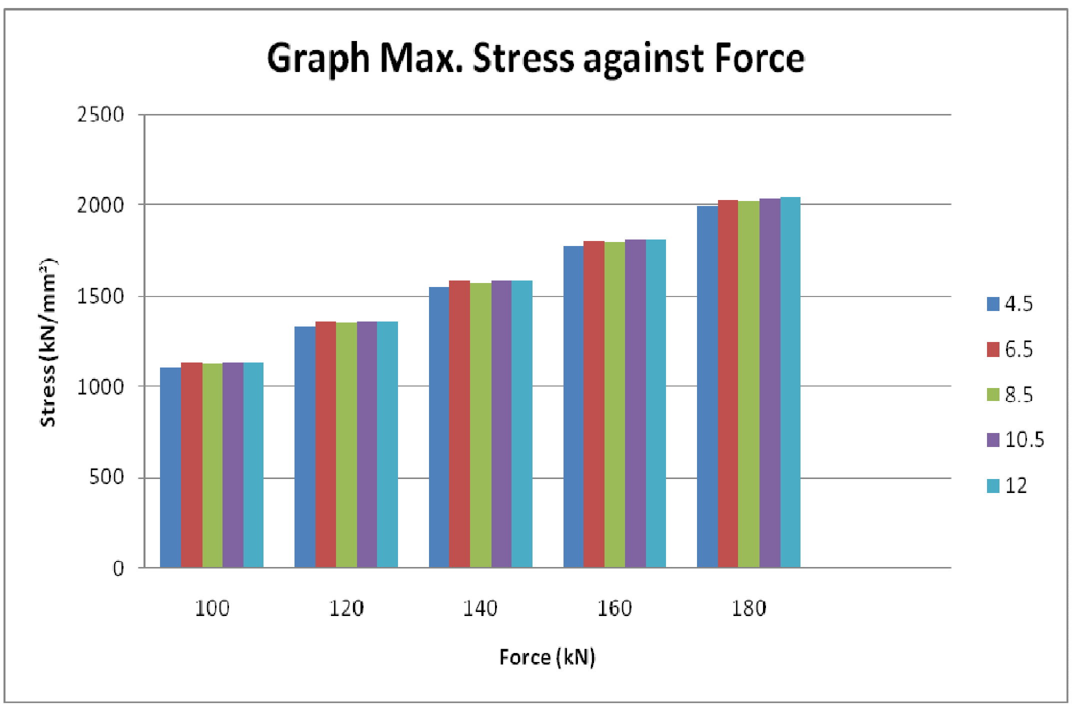


Figure 4.8: Graph Maximim von mises against force applied to punching tool

Table 4.4: Effect the force to the maximum von mises strain

	Shear angle				
Force(kN)	4.5	6.5	8.5	10.5	12
100	7.15694	7.30177	7.25596	7.31581	7.33264
120	8.58832	8.76213	8.70716	8.77897	8.79917
140	10.0197	10.2225	10.1583	10.2421	10.2657
160	11.4511	11.6828	11.6095	11.7053	11.7322
180	12.8825	13.1432	13.0607	13.1685	13.1988

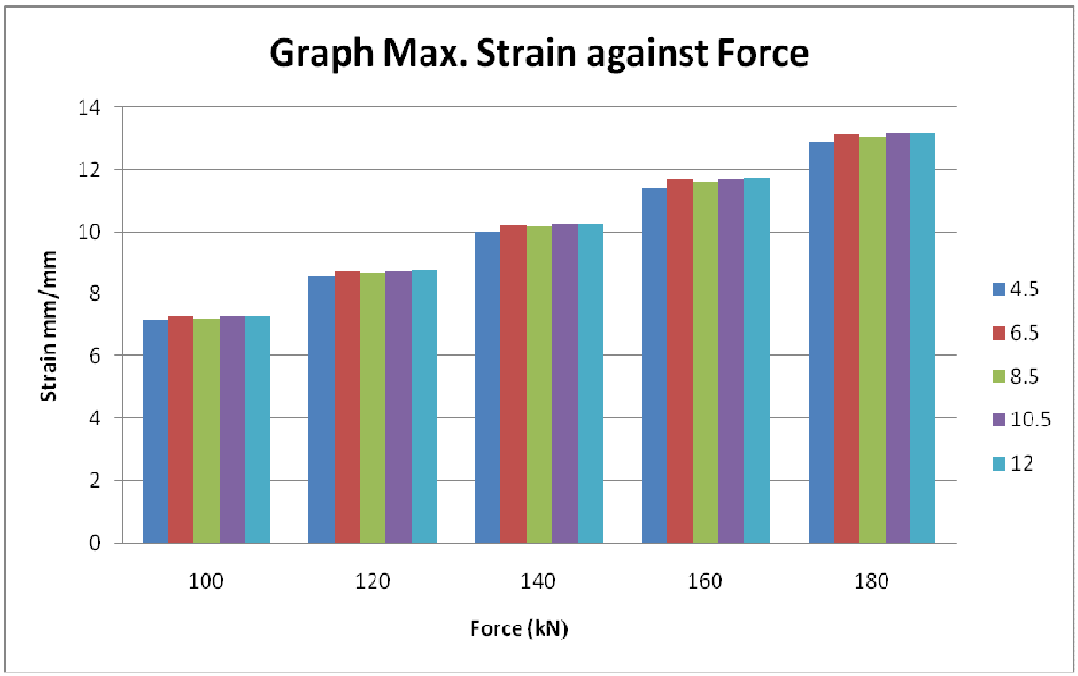


Figure 4.9: Graph Maximum von mises strain against force applied to punching tool

From the data and graph above, we can conclude that when we increase the force, the maximum von mises stress and strain also increase. The first objective also can be shown in this graph where the 8.5º have less maximum von mises stress and strain along with the increasing of the force applied. The force 180kN is the maximum force applied in the punching tool according the actual maximum force that can be applied in the actual machine in the laboratory.

For the third objective, the parameter that will be change is the thickness of the punching tool from the 5mm until it reaches 10mm thickness. The force applied to the punching tool will be constant with the 180kN.

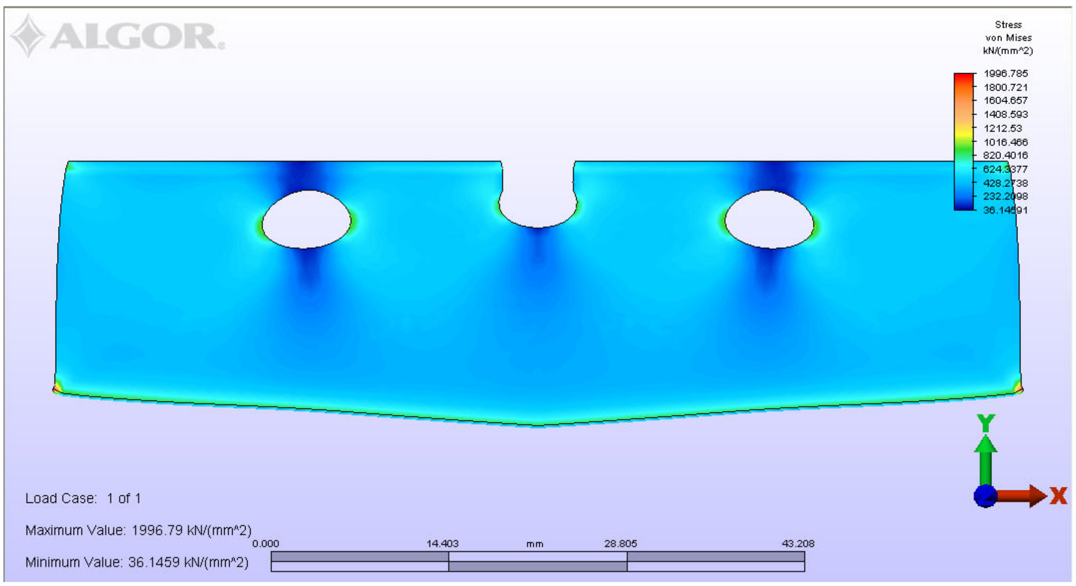


Figure 4.10: Punching tool 4.5º shear angle with 5mm thickness

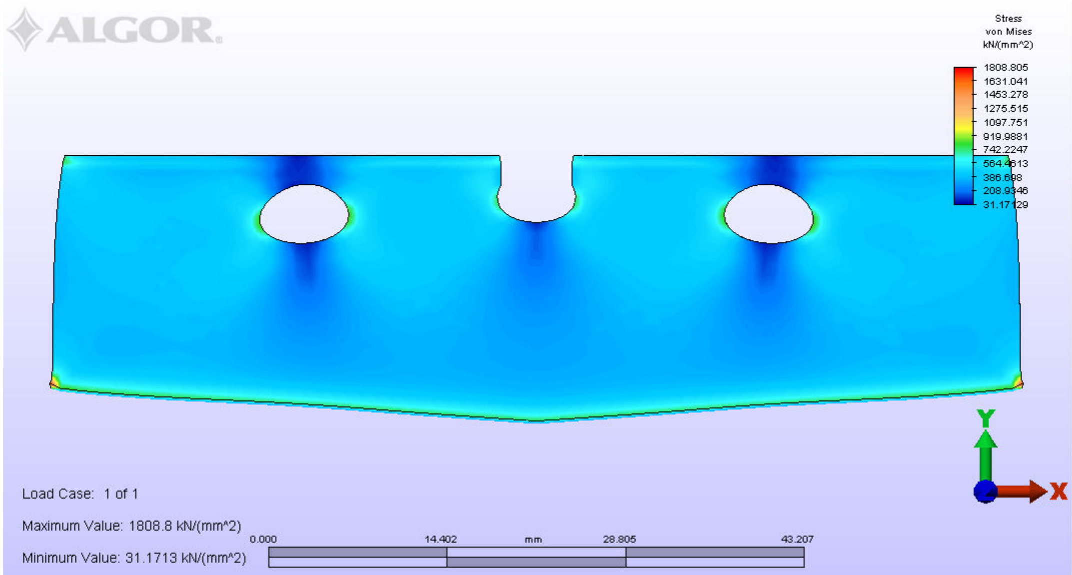


Figure 4.11: Punching tool 6.5º shear angle with 6mm thickness

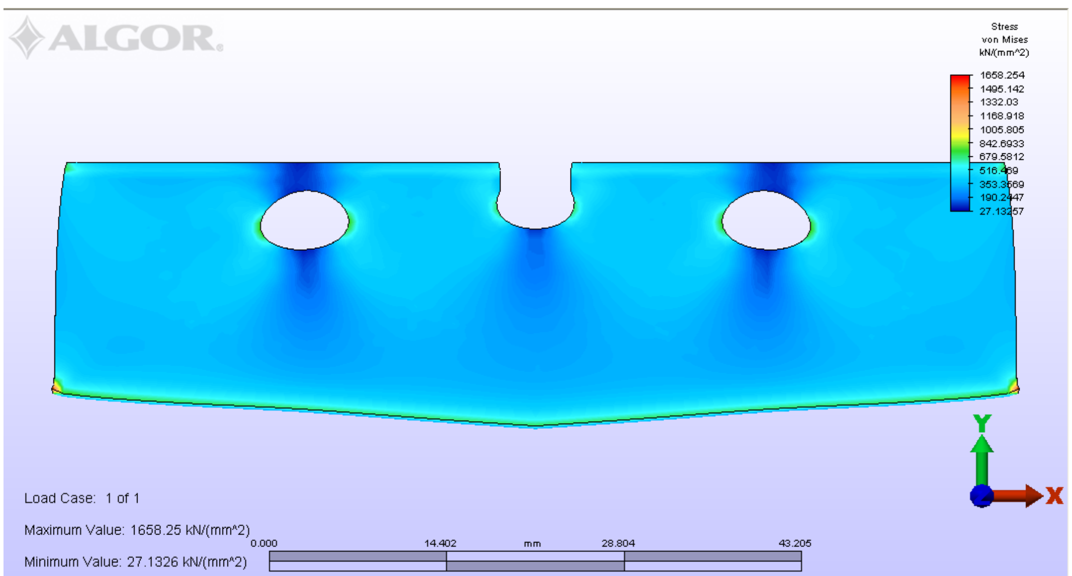


Figure 4.12: Punching tool 4.5º shear angle with 7mm thickness

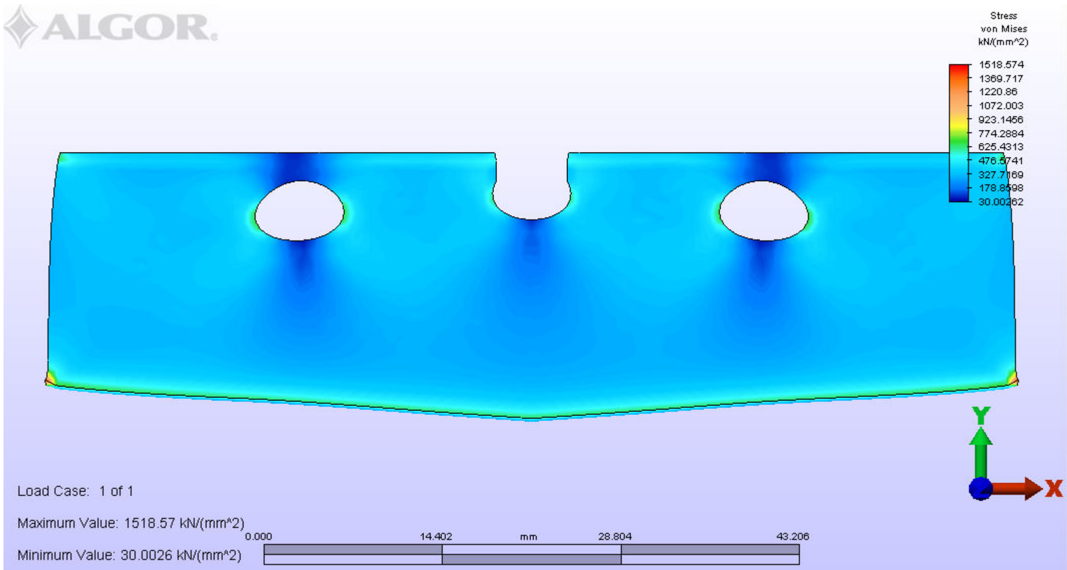


Figure 4.13: Punching tool 4.5º shear angle with 8mm thickness

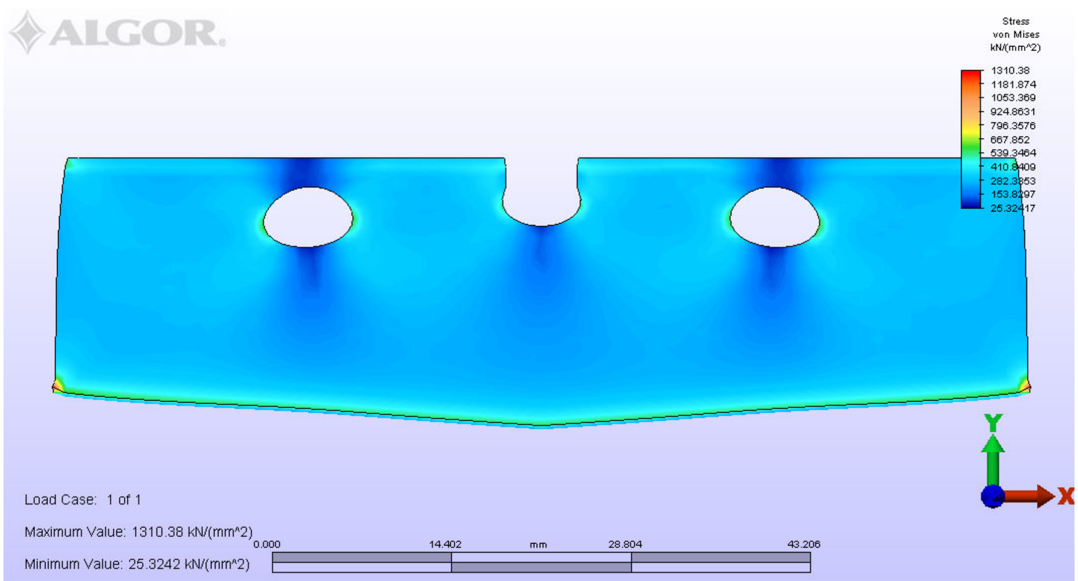


Figure 4.14: Punching tool 4.5º shear angle with 9mm thickness

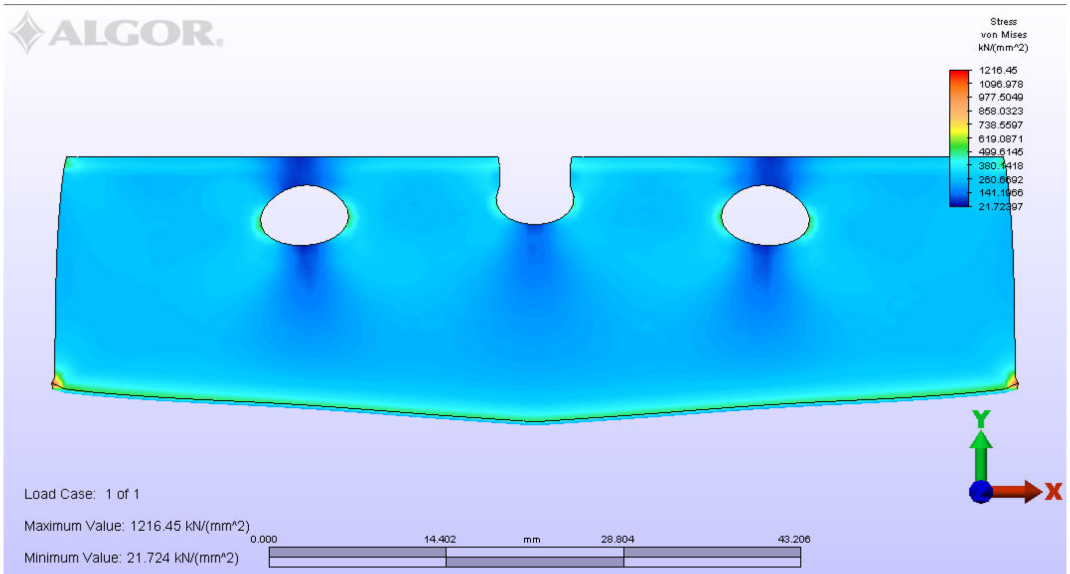


Figure 4.15: Punching tool 4.5º shear angle with 10mm thickness

Table 4.5: Effect of thickness of punching tool to the maximum von mises stress

Thickness (mm)	Maximum stress (kN/mm²)
5	1996.79
6	1808.80
7	1658.25
8	1518.57
9	1310.38
10	1216.45

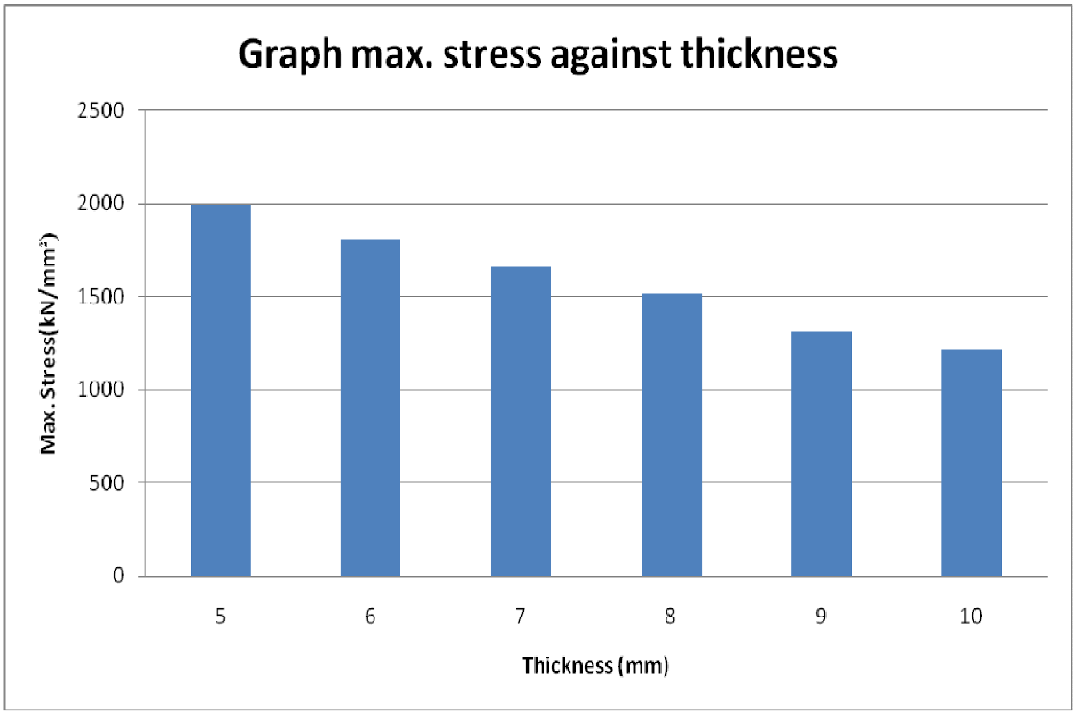


Figure 4.16: Graph maximum von mises stress against thickness of the punching tool

From the data that we get from the simulation we can see that when we increase the thickness of the punching tool, the maximum von mises stress will decrease gradually. It mean that when the thickness in increasing, the contact area between the punching tool and the sheet metal also increase. This theory can explain the situation why the maximum stress will decrease when we increase the thickness of the punching tool. When we increase the thickness of the punching tool, the maximum stress will decrease and we can conclude that the wear also decreases. We can say that during the punching process, we better use the higher thickness of the punching tool.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSIONS

From the simulation that had done, we do the relation between the maximum von mises stress and the wear that will occur in the actual punching tool. For the first objective where the shear angle act as a parameter, the shear angle change from 4.5º until 12º and from the simulation the result show that when the shear angle increase, the stress not really increase gradually with the stress. The maximum stress for 8.5º is less than 6.5º although from 4.5º it is increase. When it reach 6.5º, the stress start to decrease until 8.5º and then start to increase again. It is show that the tool life for punching tool with shear angle 8.5º is better than 6.5º and above itself.

For the second objective, there force are change from 100kN until 180kN and the result show that the maximum stress are increase when the force applied to the punching tool also increasing. The result also shows the same for all punching tool with different shear angle.

When the thickness of the punching tool changing, the result show the opposite from the previous result. When we change the thickness of the punching tool from 5mm until it reach 10mm, the result show that the maximum stress will decrease. The simple explanation for this result is when the thickness of the punching tool is increase, the contact area between the punching tool and the sheet metal also increasing. We can use the punching tool that has higher thickness because it has higher tool life.
As a conclusion, the punching tool with shear angle 8.5º has higher tool life compare with 6.5º and above itself. The thickness of the punching tool also has important rule

and the higher the thickness, the wear that occur in that punching tool is less and it mean that the punching tool has higher tool life. In the future, the right punching tool will affect the wear in the punching tool.

5.2 Recommendation

For the future research about the study of the punching tool life, I would like to recommend that the experiment also can be done in the real machine. The result from the simulation need to be compare with the actual punching tool so we can conclude either the result from the simulation is same with the real experiment.

The simulation also has to be run by using finer mesh design and enhanced mesh geometry so the result that we get is more accurate. We also can use the advance software where we can do the simulation in many time using the same punching tool. It means that when we do the simulation with the same punching tool, we can predict how many time the punching tool can be punch or use.

The other parameter that we can change during the simulation is the material that we use to fabricate the punching tool. We can choose the type of material that will have higher tool life when it is operate in the machining.

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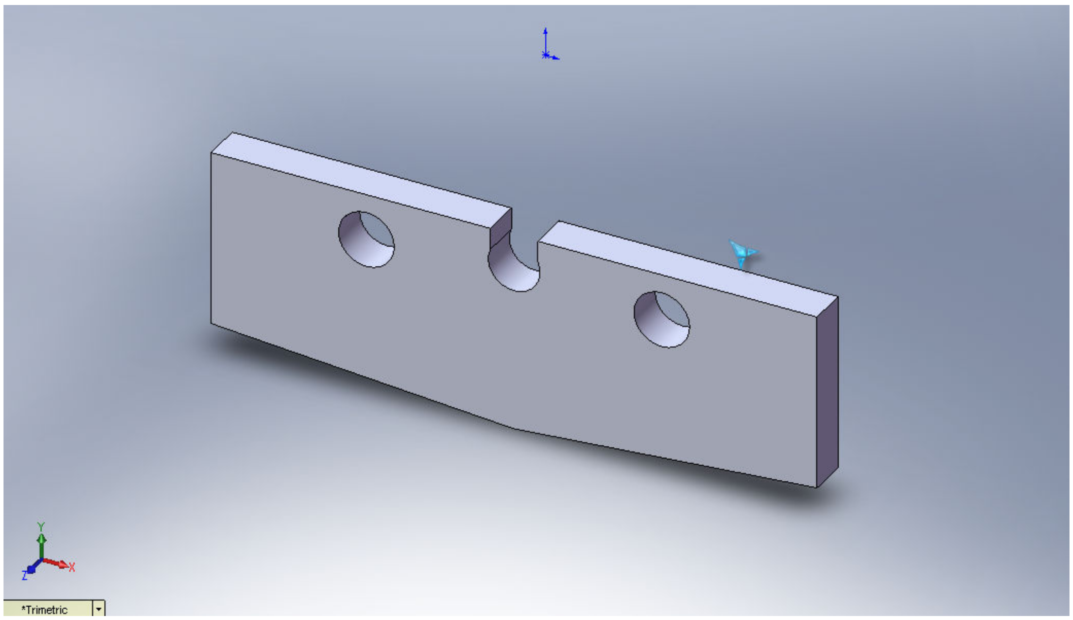
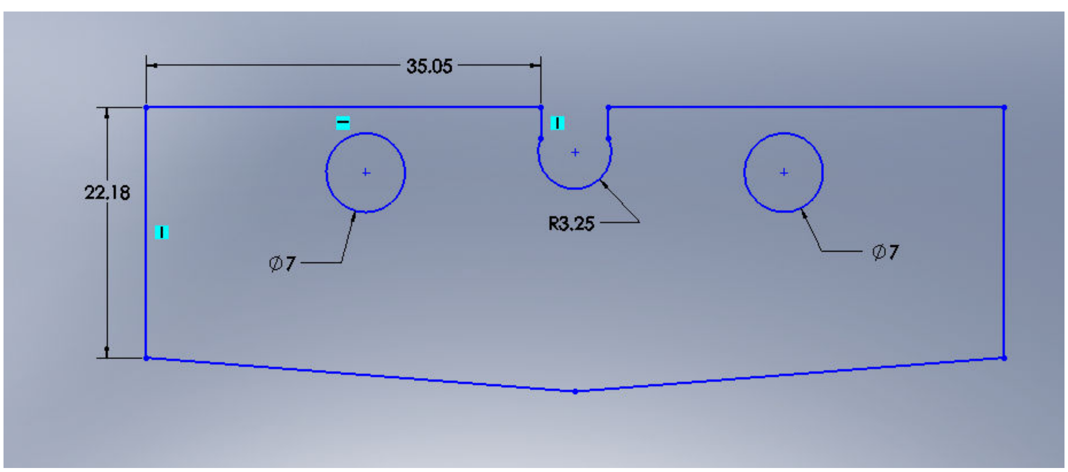
APPENDIX A

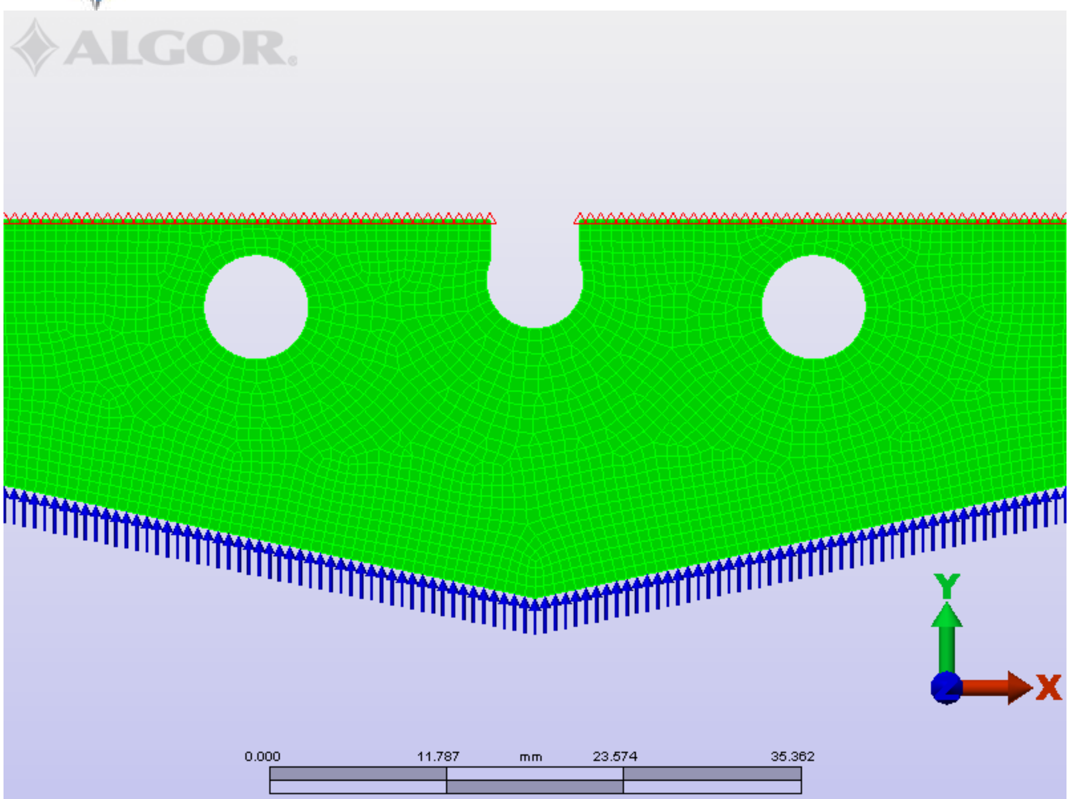
Geometry and diameter of the insert punching tool





APPENDIX B

Attach file from simulation ALGOR Software



Design Analysis
Project Title Here

Created by

Author:
Department:
Created Date: 11/2/2009

Reviewed by

Reviewer:
Department:
Model Created Date: 11/2/2009
Reviewer Comments:

Executive Summary

This is where to put your Executive summary. So, replace this text with your overall Project Description.

Summary

Model Information

Analysis Type - Static Stress with Linear Material Models
Units - Custom - (kN, mm, s, deg C, deg C, V, ohm, A, J)
Model location - C:\Documents and Settings\Surugau\Desktop\12.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	Accelerati on/Gravity	Rotati on	Angular Accelerat ion	Displac ed Bounda ry	The rma l	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

Processor Information

Type of Solver	Automatic
Disable Calculation and Output of Strains	No
Calculate Reaction Forces	Yes

Invoke Banded Solver	Yes
Avoid Bandwidth Minimization	No
Stop After Stiffness Calculations	No
Displacement Data in Output File	No
Stress Data in Output File	No
Equation Numbers Data in Output File	No
Element Input Data in Output File	No
Nodal Input Data in Output File	No
Centrifugal Load Data in Output File	No

Part Information

Part ID	Part Name	Element Type	Material Name
1	Part 1	Brick	Steel (ASTM - A572)

Element Information

Element Properties used for:

- Part 1

Element Type	Brick
Compatibility	Not Enforced
Integration Order	2nd Order
Stress Free Reference Temperature	0 °C

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	7.8548E-12 kN·s²/mm/mm³
Modulus of Elasticity	199.95 kN/mm²
Poisson's Ratio	0.29
Shear Modulus of Elasticity	77.221 kN/mm²

Thermal Coefficient of Expansion	0.0000117 1/°C

Loads

FEA Object Group 2: Nodal Forces

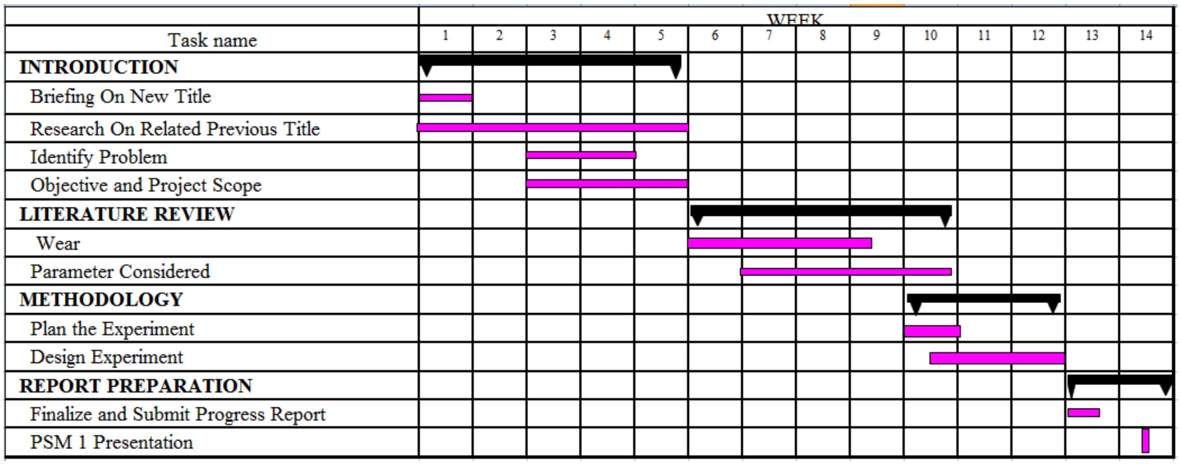
Nodal Force

ID	Description	Vertex ID	Node Number	Vx	Vy	Vz	Magnitude	Multiplier Table ID
1	Unnamed	294	294	0.000000	1.000000	0.000000	180.000000	1
2	Unnamed	295	295	0.000000	1.000000	0.000000	180.000000	1
3	Unnamed	296	296	0.000000	1.000000	0.000000	180.000000	1
4	Unnamed	297	297	0.000000	1.000000	0.000000	180.000000	1
5	Unnamed	298	298	0.000000	1.000000	0.000000	180.000000	1
6	Unnamed	273	273	0.000000	1.000000	0.000000	180.000000	1
7	Unnamed	274	274	0.000000	1.000000	0.000000	180.000000	1
8	Unnamed	275	275	0.000000	1.000000	0.000000	180.000000	1
9	Unnamed	276	276	0.000000	1.000000	0.000000	180.000000	1
10	Unnamed	277	277	0.000000	1.000000	0.000000	180.000000	1
11	Unnamed	17	17	0.000000	1.000000	0.000000	180.000000	1
12	Unnamed	19	19	0.000000	1.000000	0.000000	180.000000	1
13	Unnamed	18	18	0.000000	1.000000	0.000000	180.000000	1
14	Unnamed	278	278	0.000000	1.000000	0.000000	180.000000	1
15	Unnamed	279	279	0.000000	1.000000	0.000000	180.000000	1
16	Unnamed	280	280	0.000000	1.000000	0.000000	180.000000	1
17	Unnamed	281	281	0.000000	1.000000	0.000000	180.000000	1
18	Unnamed	282	282	0.000000	1.000000	0.000000	180.000000	1
19	Unnamed	288	288	0.000000	1.000000	0.000000	180.000000	1
20	Unnamed	289	289	0.000000	1.000000	0.000000	180.000000	1
21	Unnamed	290	290	0.000000	1.000000	0.000000	180.000000	1
22	Unnamed	291	291	0.000000	1.000000	0.000000	180.000000	1
23	Unnamed	292	292	0.000000	1.000000	0.000000	180.000000	1

24	Unnamed	293	293	0.000000	1.000000	0.000000	180.000000	1
25	Unnamed	27	27	0.000000	1.000000	0.000000	180.000000	1
26	Unnamed	26	26	0.000000	1.000000	0.000000	180.000000	1
27	Unnamed	334	334	0.000000	1.000000	0.000000	180.000000	1
28	Unnamed	335	335	0.000000	1.000000	0.000000	180.000000	1
29	Unnamed	336	336	0.000000	1.000000	0.000000	180.000000	1
30	Unnamed	337	337	0.000000	1.000000	0.000000	180.000000	1
31	Unnamed	338	338	0.000000	1.000000	0.000000	180.000000	1
32	Unnamed	339	339	0.000000	1.000000	0.000000	180.000000	1
33	Unnamed	340	340	0.000000	1.000000	0.000000	180.000000	1
34	Unnamed	341	341	0.000000	1.000000	0.000000	180.000000	1
35	Unnamed	342	342	0.000000	1.000000	0.000000	180.000000	1
36	Unnamed	343	343	0.000000	1.000000	0.000000	180.000000	1
37	Unnamed	344	344	0.000000	1.000000	0.000000	180.000000	1
38	Unnamed	345	345	0.000000	1.000000	0.000000	180.000000	1
39	Unnamed	346	346	0.000000	1.000000	0.000000	180.000000	1
40	Unnamed	347	347	0.000000	1.000000	0.000000	180.000000	1
41	Unnamed	348	348	0.000000	1.000000	0.000000	180.000000	1
42	Unnamed	349	349	0.000000	1.000000	0.000000	180.000000	1
43	Unnamed	319	319	0.000000	1.000000	0.000000	180.000000	1
44	Unnamed	320	320	0.000000	1.000000	0.000000	180.000000	1
45	Unnamed	321	321	0.000000	1.000000	0.000000	180.000000	1
46	Unnamed	322	322	0.000000	1.000000	0.000000	180.000000	1
47	Unnamed	323	323	0.000000	1.000000	0.000000	180.000000	1
48	Unnamed	324	324	0.000000	1.000000	0.000000	180.000000	1
49	Unnamed	325	325	0.000000	1.000000	0.000000	180.000000	1
50	Unnamed	263	263	0.000000	1.000000	0.000000	180.000000	1
51	Unnamed	264	264	0.000000	1.000000	0.000000	180.000000	1
52	Unnamed	265	265	0.000000	1.000000	0.000000	180.000000	1
53	Unnamed	266	266	0.000000	1.000000	0.000000	180.000000	1
54	Unnamed	267	267	0.000000	1.000000	0.000000	180.000000	1
55	Unnamed	253	253	0.000000	1.000000	0.000000	180.000000	1

56	Unnamed	254	254	0.000000	1.000000	0.000000	180.000000	1
57	Unnamed	255	255	0.000000	1.000000	0.000000	180.000000	1
58	Unnamed	256	256	0.000000	1.000000	0.000000	180.000000	1
59	Unnamed	257	257	0.000000	1.000000	0.000000	180.000000	1
60	Unnamed	25	25	0.000000	1.000000	0.000000	180.000000	1
61	Unnamed	258	258	0.000000	1.000000	0.000000	180.000000	1
62	Unnamed	259	259	0.000000	1.000000	0.000000	180.000000	1
63	Unnamed	260	260	0.000000	1.000000	0.000000	180.000000	1
64	Unnamed	261	261	0.000000	1.000000	0.000000	180.000000	1
65	Unnamed	262	262	0.000000	1.000000	0.000000	180.000000	1
66	Unnamed	248	248	0.000000	1.000000	0.000000	180.000000	1
67	Unnamed	249	249	0.000000	1.000000	0.000000	180.000000	1
68	Unnamed	250	250	0.000000	1.000000	0.000000	180.000000	1
69	Unnamed	251	251	0.000000	1.000000	0.000000	180.000000	1
70	Unnamed	252	252	0.000000	1.000000	0.000000	180.000000	1
71	Unnamed	350	350	0.000000	1.000000	0.000000	180.000000	1
72	Unnamed	351	351	0.000000	1.000000	0.000000	180.000000	1
73	Unnamed	352	352	0.000000	1.000000	0.000000	180.000000	1
74	Unnamed	353	353	0.000000	1.000000	0.000000	180.000000	1
75	Unnamed	354	354	0.000000	1.000000	0.000000	180.000000	1
76	Unnamed	355	355	0.000000	1.000000	0.000000	180.000000	1
77	Unnamed	356	356	0.000000	1.000000	0.000000	180.000000	1
78	Unnamed	555	555	0.000000	1.000000	0.000000	180.000000	1
79	Unnamed	556	556	0.000000	1.000000	0.000000	180.000000	1
80	Unnamed	557	557	0.000000	1.000000	0.000000	180.000000	1
81	Unnamed	558	558	0.000000	1.000000	0.000000	180.000000	1
82	Unnamed	559	559	0.000000	1.000000	0.000000	180.000000	1
83	Unnamed	560	560	0.000000	1.000000	0.000000	180.000000	1
84	Unnamed	561	561	0.000000	1.000000	0.000000	180.000000	1
85	Unnamed	562	562	0.000000	1.000000	0.000000	180.000000	1
86	Unnamed	563	563	0.000000	1.000000	0.000000	180.000000	1

Gant Chart for final year project 1



Gant Chart for Final Year Project 2