ANALYSIS ON THIN SHEET METAL FEEDING CHARACTERISTIC BY A SERVO ROLL FEEDER

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This thesis is submitted as a partial fulfilment of the requirements for the award of the degree of Bachelor of Mechanical Engineering

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JUDUL: **ANALYSIS ON THIN SHEET METAL FEEDING CHARACTERISTIC BY A SERVO ROLL FEEDER**

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In the name of ALLAH, Most Gracious, Most Merciful

To my beloved my family also to all my friends

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ABSTRACT

This thesis was carried out to analyse thin sheet metal feeding characteristic by a servo roll feeder. Although servo roll feeding has been seen to be very successful in conventional sheet metal forming, no significant effort has been made to enable the application of this technology to micro sheet metal forming. A metal strip in micron size is very fragile, and it may be severely deformable if an inappropriate feeding facility is deployed. A model of feeder was created and simulation was further conducted to analyse the performance of servo roll feeder in term of accuracy and repeatability during feeding process of thin sheet metal. Several parameters were changed during simulation to acquire more data about servo roll feeder performance. The analysed showed that many factors affect the feed process in term of accuracy such as feed frequencies, feed distances and materials thickness.

ABSTRAK

Tesis ini dijalankan untuk menganalisis ciri-ciri suapan kepingan logam nipis oleh suapan gulungan bermotor. Walaupun suapan gulungan bermotor dilihat sangat berjaya dalam lembaran pembentukan logam konvensional, tidak ada usaha ketara telah dibuat untuk membolehkan penggunaan teknologi ini untuk pembentukan logam bersaiz mikron. Kepingan logam dalam saiz mikron sangat rapuh, dan ia boleh menjadi teruk jika perubahan suapan tidak bersesuian dilakukan. Satu model suapan telah dicipta dan simulasi dijalankan untuk dianalisis prestasi suapan gulungan bermotor dari segi ketepatan dan kebolehulangan semasa proses suapan pada kepingan logam nipis. Beberapa aturan telah diubah dalam simulasi untuk memperoleh lebih banyak data mengenai prestasi suapan gulungan bermotor. Analisis menunjukkan bahawa banyak faktor mempengaruhi proses suapan dalam ketepatan seperti kecepatan suapan, jarak suapan, dan ketebalan bahan.

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LIST OF ABBREVIATIONS

FE	Finite element
MEMS	Micro-electromechanical systems
MST	Micro-system technologies
PID	Proportional Elongated Derivative
HSS	High speed steel

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Forming is one of the most economic and mass process that contributes to nearly 80% of everyday life objects production. Examples of products made of forming process include, car, reinforced steel for constructions, wires, hand phones, coins, etc. Forming process can be many, for example, coining, stamping, rolling, extrusions, drawing etc. Stamping is one of the processes that can produce mass production within short time and is seen economics. Stamping is a process of shaping sheet metal to the designated end product.

In stamping process, sheet metal is fed into the machine (punch and dies) by a transportation system called feeder. Feeders can be of mechanical type, pneumatic as well as servo roll feeder. Servo roll feeder is seen as one of the flexible feeding mechanisms due to feeding parameters can be changed easily. Feeding large and thick sheet metal into a machine is no longer a problem since the technique used is already matured. However, the challenge arises when very thin sheet (measured around 50-100micron thick) is fed onto a forming/stamping machine. Sheet metals at this thickness are very fragile and easily deformed if not handled appropriately.

In addition to that, parts produced by thin sheet metal usually in sub millimeter size and some of it has micron range of part features. Conventional feeding accuracy of 25micron is no longer good enough for this application. This is because the achievable process accuracy is about the same size of the part features to be produced from very thin sheet metals. Moreover, only few researches were conducted to examine the feeding characteristics of thin sheet metal feeding. Lack of know-how knowledge to understand feeding characteristics is the main issue in this thin sheet metal forming. Therefore, this researches focuses on the thin sheet metal in order to understand how it’s behave during feeding process.

It is hoped that the know-how on the feeding characteristics of very thin sheet metal is usable for micro-sheet-forming applications. Micro servo roll feeder (micro version of conventional servo roll feeder) is used to study its performance when feeding thin sheet metals. The analysis is conducted by ABAQUS where the model of the feeder is created and analyzed. Then the very thin sheet behaviors or characteristics during feeding are analyzed and discussed along with the feeder performance in terms of its achievable positional accuracy and repeatability.

1.2 PROJECT BACKGROUND

The precision feeding for micro sheet forming cannot be achieved with conventional, large scale sheet metal feeder. The miniaturization concept of micro servo roll feeder still inherits the conventional inaccuracy. To achieve high operational performance, several parameters were investigated, which led to more feeding accuracy and repeatability of servo roll feeder. Therefore, FE simulations of strip feeding were conducted to do analysis (Akhtar, 2010).

The sheet metal is metal in the form of a sheet that has the thickness between foil and plate. The thickness of metal strip used in micro-sheet-forming are usually less than 100 um. It is very fragile, and it may be severely deformed if an inappropriate feeding facility is deployed. Therefore, FE simulations were conducted to quantify a servo roll feeder performance with a view to determine and analyse the feeding characteristic and strip behaviours.

There are several key factors in the characteristics of feeding were considered for analysis. The change of feed frequencies, feed distances, brake force, motion profiles, material thickness, and material types to the system was conducted to analyse the performance of servo roll feeder in term of accuracy and repeatability.

1.3 PROBLEM STATEMENT

The modernization of this era expands the demands of micro-parts especially in manufacturing industries. A lot of micro-forming machines have been designed to fulfil the industries needed. Servo roll feeder is one of micro-forming machines that serve in sheet metal feeding. These feeders perform well in speed and power required for high speed and medium gauge material stamping applications. However, these feeders usually are more vulnerable to the accuracy and repeatability problems which may decrease it performance. Thus, improvements in feeding characteristics are needed to increase the performance of servo roll feeder.

1.4 THE OBJECTIVES OF THE PROJECT

The objectives of the project are:

i. To conduct basic studies on micro-manufacturing.
ii. To analyse feeding characteristic in micro-forming application.
iii. To qualify servo roll feeder performance in terms of feeding accuracy and repeatability.

1.5 SCOPE OF STUDIES

The scope of works involve in this study will be:

i. To study the characteristic of servo roll feeder.
ii. To perform the analysis on thin sheet metal feeding characteristic by a servo roll feeder using FE simulation software, Abaqus.
iii. To investigates the best result in term of accuracy and repeatability using the parameters.

1.6 OVERVIEWS OF THE THESIS

This report is divided into five chapters. Chapter one gives the brief content and background of the project. The problem statement, objectives and scopes of the studies are also discussed in this chapter.

In chapter two, the literature review of the study is discussed. This chapter provides fundamental studies on the micro-manufacturing, micro-parts, and micro-forming. Then, this literature reviewed about the types of the feeders existed in micro-forming processes. Next, the literature reviewed about servo roll feeder. Lastly, this literature reviewed about the feeding performance and related parameters.

For chapter three, methodology of the analysis is discussed. Drawing model of the feeder by ABAQUS is generated and the data collected was analysed in Minitab software to create the histogram graph. The model then is tested and analysed. After that, the procedure of feeding performance using related parameters is discussed.

In chapter four, the result in form of histogram graph from simulation are shown for further analysis. The result from difference values or type from several parameters are shown and be discussed.

Lastly, in chapter five, the conclusions are to be made based on the objective of this thesis.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The purpose of this chapter is to provide a review of past research efforts related to thin sheet metal forming using servo roll feeder. This chapter start with the brief introduction about micro forming. Next, a review about sheet metal feeding and servo roll feeder was provided. Lastly, a review of relevant research studies about feeding performance and related parameters was provided.

2.2 MICRO-MANUFACTURING

The definition of micro-manufacturing is the manufacturing of components or devices on a micro scale. The term ‘micro-manufacturing’ in the context of a miniature factory is understood to be a micro-factory (Qin, 2006). However, the term ‘micro-factory’ is defined as a small manufacturing system conceived as a means of achieving higher throughput with less space and reduced consumption of both resources and energy via downsizing of production processes (Claessen, 2002). Therefore, all the equipment has been reduced in the scale of the micro-machines to reduce the energy consumptions, overhead costs, material requirements, reduce pollutions and create a more user friendly production environment. As the result of reducing of scales of equipment, the mass of the equipment could be reduced dramatically and this will lead to the increasing of tool speed and production rates by lowering down manufacturing cycle. The micro-forming machine was invented in micro-manufacturing system to serve a production of micro-forming products.

2.3 MICRO-PARTS

A micro-part is defined as small parts with typical part-dimensions in the range of sub-millimetres up to a few millimetres, although part-features may be in the micro-meter range. The positional of micro-part is expected to be in the range of 0.1 to 10µm. Figure 2.1 illustrates the range of part and feature size machining capability. Parts with machined features beyond 100µm are known as miniature parts, whereas a maximum size of less than 5mm usually can be found in micro-electromechanical systems (MEMS) applications.

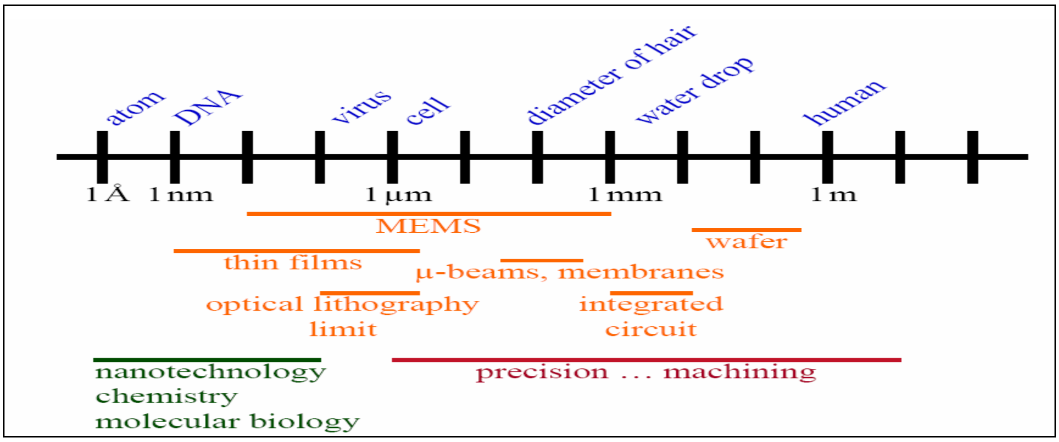

Figure 2.1: Parts scales and dimensions

Source: Qin 2006

2.4 MICRO-FORMING

The application of micro-forming in industries nowadays has grown rapidly since the demands of micro product increase. The examples of micro-forming product exist such as cell phone cases, toys, and electronic components.

2.4.1 DEFINITION

The term 'micro-forming' in the context of metal forming is the production of parts or structures with at least two dimensions in the sub-millimetre range [Geiger, 2001). Parts of such size are commonly used more in extremely high numbers, in particular for electronic components in micro-system technologies (MST) and micro-electromechanical systems (MEMS) as they characterize today many products pushing forward their miniaturization. The examples of part are fasteners, micro-screws, sockets, and any kind of connecting element.

2.4.2 MICRO-FORMING PROCESSES

Nowadays, most of the micro-forming processes were tends to mimicking conventional processes. These apply toward miniaturization and some has great limitation in terms of its potential such as limited number of machining axes and capability on roughing process only compare to well-developed macro-scale processes.

Besides that, most of the micro-forming processes developed at present only capable of machining soft materials. This is due to the usage of soft tooling such high speed steel (HSS) as it was widely used in macro-processes. No harder materials can be qualified under the usage of soft tooling. The only way out to avoid the usage of micro-tools is by approaching and exploring non-contact machining process. Noncontact machining is the only promising solution available for micro-process and the potential is seen similar to the conventional manufacturing processes. The examples of micro-forming process are subtractive, additive, deforming, joining, and hybrid process. These micro-forming processes are shown in Table 2.1.

Table 2.1: Micro-forming Processes

Types of processes	**Types of machining**
Subtractive processes	Micro-Mechanical Cutting, Laser Beam Machining, Electro Beam Machining, Photo-chemical machining, etc.
Additive processes	Surface coating, Micro-casting, Micro-injection moulding, Sintering, Photo-electro-forming, Chemical deposition, Polymer deposition, etc.
Deforming processes	Micro-forming , Hot-embossing, Micro/Nano imprinting, etc.
Joining processes	Micro-Mechanical-Assembly, Laser-welding, Resistance, Laser, Vacuum Soldering, Bonding, Gluing, etc.
Hybrid processes	Micro-Laser-ECM, Micro-EDM and Laser assembly, Laser-assisted micro-forming, Micro assembly injection moulding, Combined micro-machining and casting, etc.

Source: Qin 2009

2.4.3 MICRO-FORMING MACHINES

The design of conventional, large-scale machines has been upgraded for manufacture of micro-component with enhanced precision. These machines are of much smaller size compared to the conventional, large-scale machines. The enhanced precision may be achieve through the combination of design forming tools to address concerning the size of small component and higher precision equipment. These machines may be designed primarily to manufacture components with precisions in the millimetre ranges. With specific engineering modifications implemented on these machines they could also be used for micro-forming applications. Machines of smaller size may be built with newly enhanced parts and designs that are particularly for micro-forming applications. These machines may also be of normal size but incorporated with new concepts dedicated to micro-forming (Qin, 2006).

The development of such machines has attracted a lot of interest from researchers during last 10 years. Various new concepts are being experimented upon to design and fabricate prototypes of the micro-machines.

The example of micro-stamping machines that use widely is BSTA300 series machines from BRUDERER. This machine has high precision automatic punching press with a perfected mass counterbalancing system and adjustable strokes, a press force of 300 kN, speeds of from 100 to 1400 spm (fixed stroke max. 2000 spm), with some specific considerations on the thermal and mechanical influences on the precision of the guides and the ram, and is ideal for mass production.

Other machines which could be used for micro-forming purposes include the mabu VP precision press series (speeds of up to 600 spm, with a maximum force of 250–500 kN). These machines have a press body with pre-stressed tension rods to minimise deflections, an eccentric shaft and a connecting rod fitted entirely with roller bearings, and a pre-stressed ram slide guiding with no play. These machines are environment friendly in that there is no open lubricating system, no oil, and no recycling of oil, and the machine is practically maintenance-free (Qin, 2006).

2.5 SHEET METAL FEEDING

The sheet metal feeding is used widely in micro-forming processes. Most industry use high speed feeding in their industries to produce lots of material or parts daily to fulfil market needed. The high speed feeding refers to the usage of a press driven feeding system. The feeding system is well synchronized and powered by the press. Roll feeder driven by the press through mechanical transmission system are always synchronized to the rotation of the press, Figure 2.2. Furthermore, the feeder always begins its motion at some predetermined point in the press cycle and finishes at another predetermined point, regardless of the press speed or dies engagement. Besides that, feeding system also drive by self-powered or stand-alone unit. The motion was response to a signal from the press.

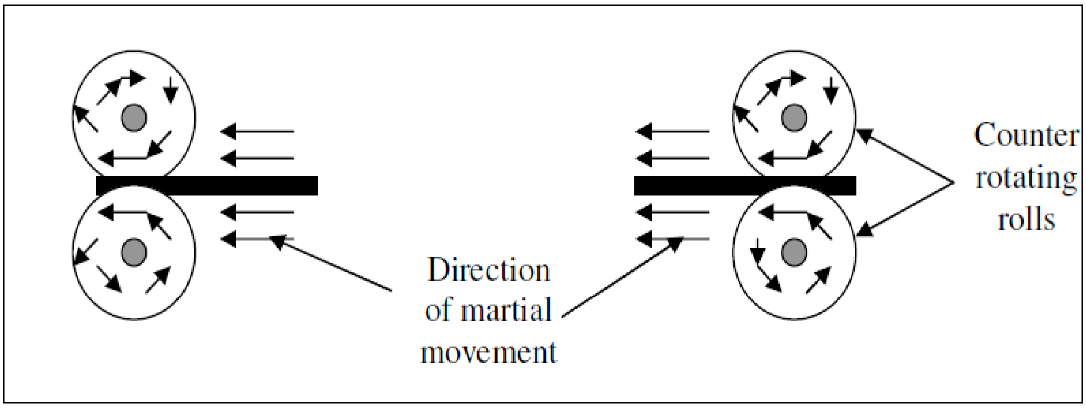

Figure 2.2: Working principle of a roll feeder

Source: Qin 2009

The ability to synchronization of press-driven feeds allows high-speed indexing on press-driven feeds, the feeding of ‘in-die’ transfers, or for use with an unloader and for other applications that require the feed motion to be well synchronized with the press rotation in order to avoid collision and tool breakage. Meanwhile, the feed motion for all dies cannot begin until it reaches a point in the stroke when the lack of timing adjustment occurs. Besides that, pneumatic and servo-powered feeds operate independently of the press and allowing adjustment to enable feeding to begin as soon as the die opens.

The press-driven feeds exhibit a very smooth motion. The motion called an ‘s-curve motion profile’ is better ‘trapezoidal-movement curve’ used by most other feeds. This s-curve motion profile enables the variation of the acceleration rate throughout the index, hence resulting in the elimination of sharp transitions or changes in velocity, which can cause slippage with other feeds. Most self-powered feeds start their motion from a stationary condition directly into a fixed rate of acceleration which results in a sharp velocity changes or transition called a ‘jerk’ point. These jerk points typically occur at the beginning, middle, and end of each move in trapezoidal motion (Akhtar, 2008).

Press-driven feeds make gradual transitions in velocity, with high-acceleration and-deceleration in the interim due to their s-curve-designed cam. This in turn leads to the elimination of these jerk points, while retaining the ability to make high-speed indexes that are within reasonably good positional precision.

There are several disadvantages to most press driven feeds. The difficulty occur when lack of adjustment, feed length/distance limitations, lack of inching capability, and the absence of a control interface. Most of the press-driven feeds require gear sets, rollers, or mechanical linkages to be changed to be able to adjust the feed length only. They are also subjected to limitation in their range of feed length/distance adjustment due to their being directly coupled to the press rotation and their lack of ability to jog the strip for threading (U. Engel, 2002). In addition, due to lack of electrical controls, mechanical feeds such as press-driven feeds cannot accept a set-up input from, or provide an output feedback to, press-control or automation systems.

The advantages of servo-driven roll-feeds include minimal space requirement due their compact size, low maintenance, and high feed frequency. However, servo feeds have some benefits that press-driven units do not have. Servo feeds utilize a microprocessor-based control that gives them an added capability. Features such as flexibility in changes of feed length/distance, programmable move patterns, self-diagnostics capability, positional auto correction, and the ability to communicate with an automation system, set them apart from other types of feeds.

Besides that, servo-driven roll feeds are also different to press-driven units in the way that they are available in a wide variety of roll-unit configurations, straighteners and unwinder. Most servo feeds manufactured at the present time utilize a trapezoidal move/motion profile with four distinct ‘jerk’ points that could result in slippage but some are also available with controls that enable the execution of s-curve move profiles to reduce the ‘jerking’ motion (Okazaki. 2004).

2.6 TYPES OF FEEDER FOR MICRO-FORMING

There are many type of feeder. The three well- known feeders are mechanical type feeder, servo roll feeder, and pneumatic feeder that still serve the metal forming industries at the present time. The mechanical type feeder use of mechanical system is good for feeding strips on medium and high speed pressure. The feeder performs in high speed in feed frequency but lack in flexibility in feed distance. The mechanical type feeder also has tendency to mechanical transmission wear. Figure 2.3 show mechanical feeder.

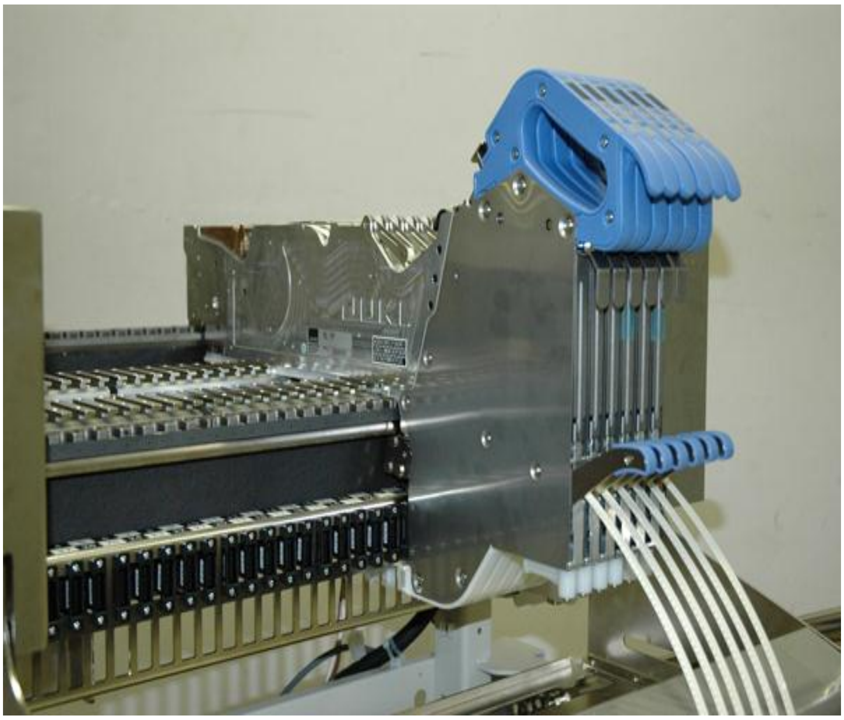

Figure 2.3: Mechanical feeder

The servo feeder uses electrical servomotor as shown in Figure 2.4. It is good in flexibility in feed distance and also can perform in high speed feeding. Servo roll feeder also better in accuracy and repeatability. Next, pneumatic feeder uses pneumatic actuation as shown in Figure 2.5. Its performance in repeatability process is very high. Pneumatic feeder also lack in accuracy when perform feeding process.

Figure 2.4: Servo roll feeder

Figure 2.5: Pneumatic feeder

2.7 SERVO ROLL FEEDER

Servo roll feeder was widely used for thin sheet feeding application. It performs well in speed, precision, and power required for high speed and medium gauge material stamping applications. The servo roll feeder is a type of feed mechanism that uses rotating rolls to intermittently feed stock into the press controlled by closed-loop operation, where a rotational incremental encoder is used for positional feedback. The feeder was controlled by its own dedicated controller, where various pitch distances can be set directly on the controller. Furthermore, the controller receives an electrical signal-pulse to generate order for the servo-motor motion. When pulsed signal is received from the press controller, the servo roll feeder will move the strip by the designated pitch distance as set on its controller (H&O Die Supply, 2008). The machine part for servo roll feeder consists of feed roll, cluster gear, AC servo motor, air pressure regulator, vertical edges, roll catenary, funnelled stock part, driven system, slotted press mount plate, and pilot pin as shown in Figure 2.6 (a) and 2.6 (b).

The cluster gear drives the upper feed roll. The transfer of motion from the bottom feed roll to the upper feed roll is accomplished through a close tolerance and low backlash cluster gear arrangement. This means of power transmission provides the highest efficiency of torque transfer. The torque loads of constant acceleration and deceleration through the life of the machine will not affect the mating shaft and gear fits and the corresponding feeding accuracy (H&O Die Supply, 2008).

The servo roll feeder is equipped with AC servo motor. This servo motor designed to meet the demands of the coil feeding application with low inertia and high torque performance capabilities. Closed loop positioning of the feed rolls is achieved by a motor-mounted, incremental encoder that provides position feedback.

Air pressure regulator for exact feed roll pressure assures that proper air pressure is applied to the upper feed roll to accommodate various material thickness, widths, and material surface sensitivity. The hardened vertical edge guide rolls allow accurate material alignment to the press and tooling. Quick released handles are provided for quick set-up and simple adjustment for varying material widths. The roll catenary supports the material by positioning rollers in a gradual arc to and from the slack loop area (H&O Die Supply, 2008).

The catenary support section prevents coil set from being re-induced to the material by assuring correct support as the stock is moved to and from the stock loop area. The rollers were lubricated and sealed bearing. The servo roll feeder also equip with funnelled stock path for the most effective means of initial strip threading and the highest level of operator safety. The entrance and exit funnels assure that the material strip is guided directly through the servo feed or straightener rolls and also provide a barrier from an operator directly accessing the pinch of the machines.

Furthermore, low inertia drive system provides more accuracy efficiency. The light weight and rugged sheaves are used as the primary means of power transmission from the AC servo motor to the lower feed roll. A non-stretch Kevlar timing belt is used to couple the lower and upper sheaves. Moreover, this low inertia type of drive system provides the highest efficiency of power transmission and accuracy compared to conventional gear driven systems. The synchronous Kevlar timing belt provides the precision and accuracy required for driving the lower roll and does not require any maintenance or lubrication (H&O Die Supply, 2008).

A pilot pin release signal is required from the stamping press to enable the automatic open and close of the feed rolls. The servo roll feeder is equipped with air operated high speed pilot pin released mechanism. Through the use of a centre mounted air cylinder, the upper roll is opened and closed for strip insertion and for pilot pin released function. The cylinder stroke length is adjusted by loosening a single jam-nut, turning the adjustment screw to increase or decrease the roll opening, and tightening the jam nut. This system eliminates time consuming adjustments to mechanical pilot pin released mechanism, or manual open and close mechanisms (H&O Die Supply, 2008).

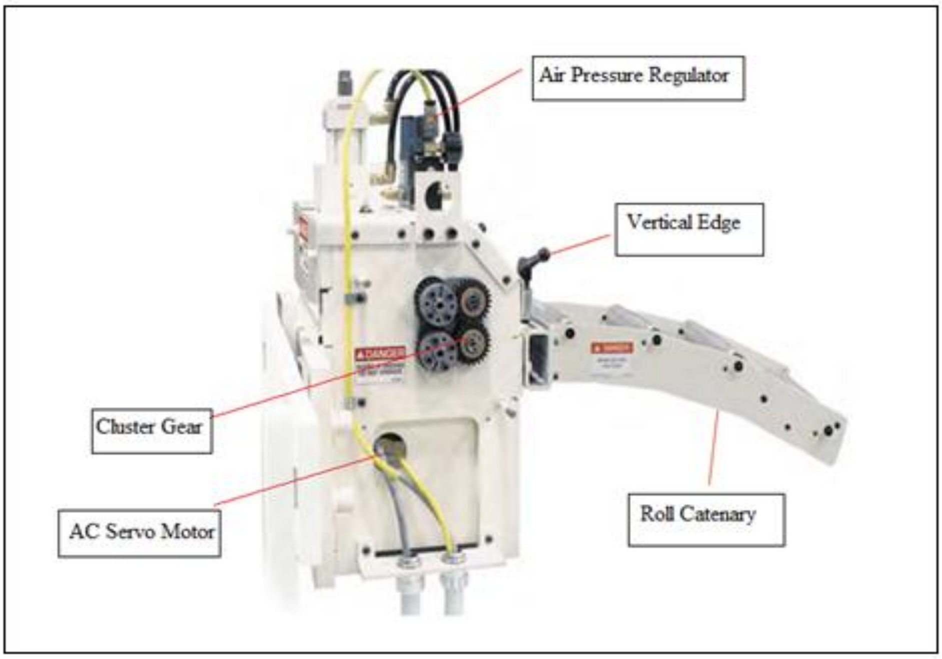

Figure 2.6 (a): Servo roll feeder

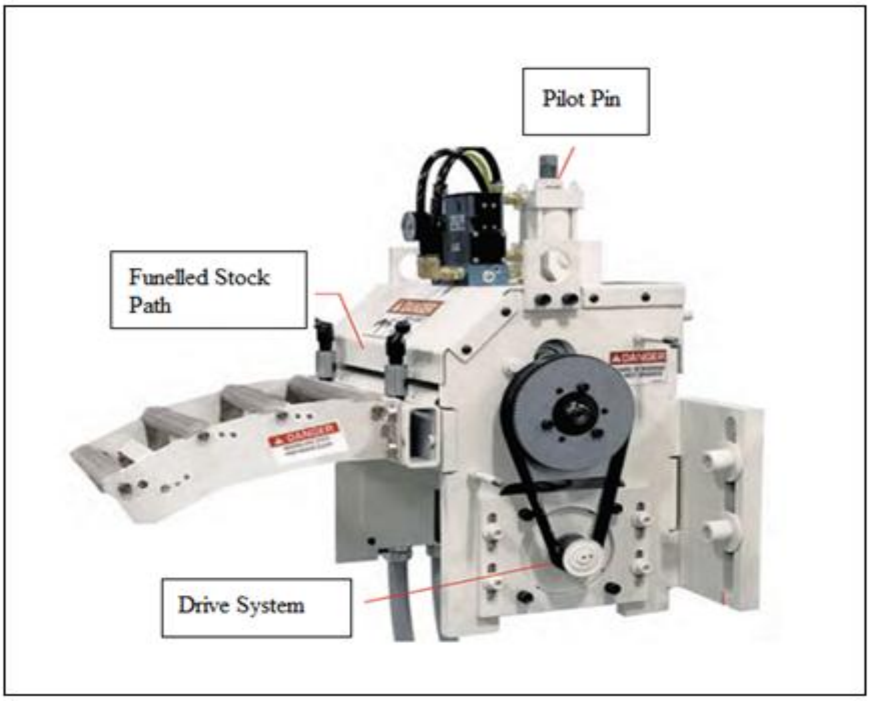

Figure 2.6 (b): Servo roll feeder

Source: H&O Die Supply

2.8 FEEDING PERFORMANCE AND RELATED PARAMETERS

The performance of sheet metal feeding was determine by it accuracy and repeatability in micro-forming processes. The term of accuracy in sheet metal feeding process is defined as the ability of a measurement to match the actual value of the quantity being measured in the product produced in manufacturing process. Meanwhile, the repeatability is defined as the ability of the feeding system to do the task or process again. The feeder for micro-stamping application is expected to achieve accuracy of 5-15% of sheet thickness used. Therefore, several parameters are used to perform test the performance of a thin sheet metal feeder. The characteristics of flexibility of servo roll feeder has allowed changes in various feeding parameters can easily improve the performance of feeding process to achieve better accuracy. Two different values of each parameter are used to the comparison for the performance test.

The first parameter is feed frequency. Feed frequency is the abilities of feeder to perform repeatability in stamping process. The high feed frequency will perform more repeatability of the feeder. Examples, 1 Hz of feed frequency, the feeder move one complete task in one second and for 2Hz of feed frequency, the feeder perform one complete task in half of second. In order for a feeder to survive commercially in the market, the feeder has to be in high feed frequency while maintaining the feeding precision (Schuler, 1998).

Second parameter is feed distance. Feed distance is the distance of sheet metal travel when the rollers move it. Due to the feeding precision, shorter feed distance is no longer being able to be treated similarly with longer feed distance. The longer feed distance requires high velocity and acceleration to accomplish the feed process within a similar given time compare to the shorter feed distance (Chern, 2006).

The next parameter to be varied is the sheet thickness and types of material. The high quality feeder has ability to cope with various sheet thickness and types of material. Not only restricted to softer material, the feeding of harder and exotic materials is seen to be more useful to the manufacturing industry (Aronson, 2004). The changes of sheet thickness and material type affect the feed performance.

Next, the effect of brake force can be a parameter to analyse. The brake force is a force applied at sheet metal when undergoes feeding process. The effect of gravitational force to a long and thin sheet-metal strip when it is not constrained can cause the strip to bend downwards and may be easily vibrated and cause excessive waviness. To overcome this problem, the brake force is applied to the system. The brake force was conducted to studying its effect on the uniformity of the strip tension throughout the feeding process (Qin, 2010).

The last parameter to be varied is the motion profile-curve. The change of motion profile curve affects the positional stability in respect of the occurrence of a ‘jerk’ (Qin, 2010). To determine the influence on the positional accuracy, several of motion profile curves were introduced in the analysis such as 45-45 and 50-50 motion profile curves.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter discusses about process of modelling the feeder using ABAQUS software. Then, this chapter discussed about the characteristics of several parameters that been used to conduct the simulation. The work flow of work progress is shown in Figure 3.1. The modelling the thin sheet metal from the shell and appropriate meshing of the scheme produced a better approximation of thin sheet behaviour and characteristic during the feeding process.

3.2 PROCEDURE

The simulation can be running after the modelling of feeder was finish and has zero error. Then the data was collected and be analysed in Minitab to produce graph of accuracy percentage.

3.2.1 MODELLING THE FEEDER

The process starts with model the feeder by ABAQUS software based on the actual size. The first step was created the feeder part. Three parts of model such as die, roller, and strip was created. The die was 70 mm width and 10mm height, roller was 25 mm diameter, and the strip was 200 mm length. Next, the properties of materials of each part were determined. The sheet metal was assumed deformable while die and roller was assumed undeformable. The upper roller was made by polyurethane rubber and steel strip was set at 0.5 while the bottom steel roller and the steel strip were set at 0.15. The steel strip tooling was set at 0.15, rollers were set at 0.6, and the value between the roller and the sheet was set at 0.3. The material behaviour for density and elastic such as mass density, Poisson ratio, and Young's Modulus was determined.

There are four step used in this simulation such as initial, gripping force, rolling, and stop. Then, the interaction for every part was determined. After that the load was applied. The upper synthetic rubber roller was applied to 200 N clamping forces while the bottom roller was constrained in all direction. Next, the value of mesh, 0.0025 for each part was created. The completed model of feeder was shown in Figure 3.1.

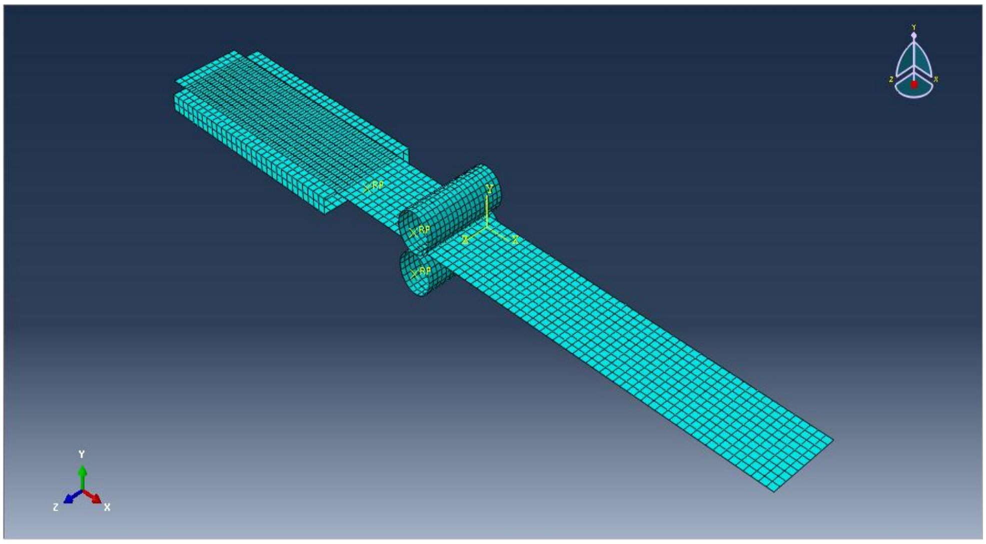

Figure 3.1: Model of feeder

3.2.2 THE CHANGE OF PARAMETER

The analysis was conducted to simulate the characteristic of the feeder using several parameters. Different values of each parameter for carbon steel and stainless steel strip are used to the comparison for the performance analysis .For the first parameter, the feed distance was set to 1mm and 5mm. Secondly, the feed frequency was set to 1 Hz and 3 Hz. For the material types, carbon steel and stainless steel were used. Next, materials thickness used were 50 µm and 100 µm. Two profiles motion curve, 45-45 and 50-50 were used to define different acceleration-deceleration phases. Lastly, the application of brake force was applied to the free end of the strip.

3.2.3 COLLECTING THE DATA

The data was collected for each parameters changed. The data was plotted using Minitab statistical software as shown in Figure 3.2. Based on the graph, the analysis can be conduct by referring to graph pattern. The accuracy and repeatability performance for feeder can be analyses.

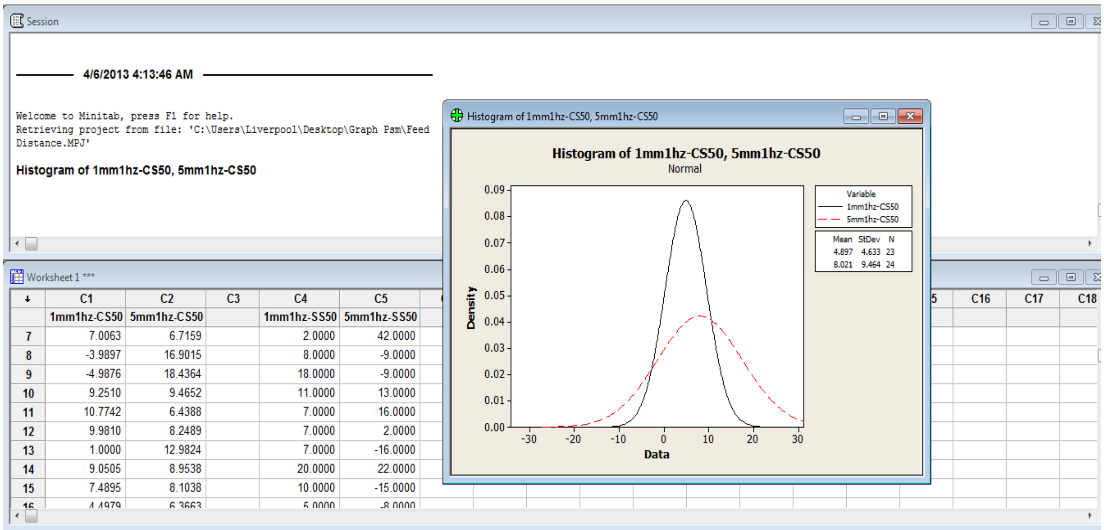

Figure 3.2: Data and graph

3.4 FLOW CHART

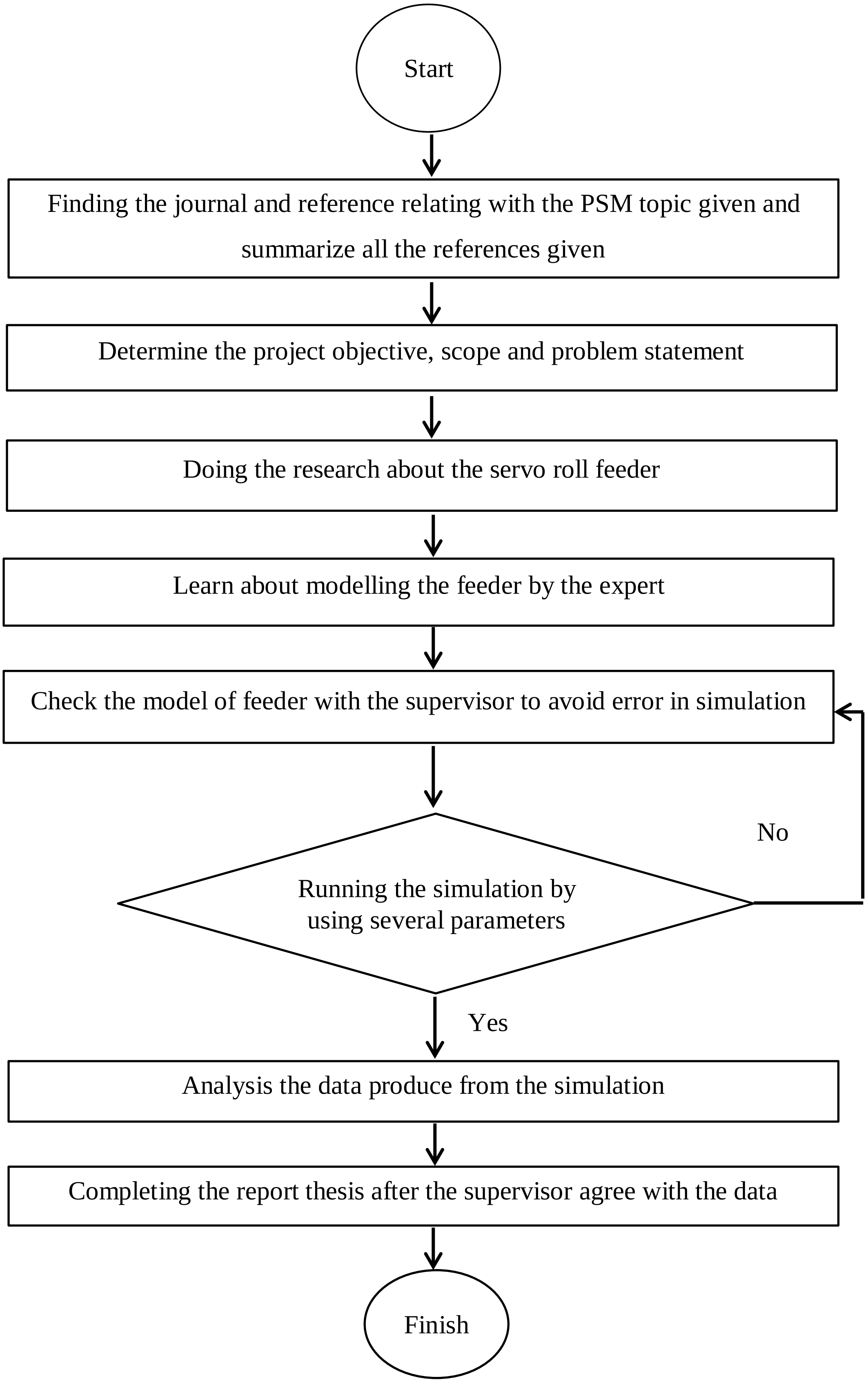

Figure 3.3: Flow Chart

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

The simulation was conducted to analyse on thin sheet metal feeding characteristic by a servo roll feeder using several parameters. According to the previous chapter, feed distances, feed frequencies, materials types, material thickness, brake force, and motion profiles are the parameters those have significant contribution towards feeding accuracy. This topic shows the results and discussions of strip behaviour using ABAQUS.

4.2 RESULT

The result obtain for the effect of each parameter changes have improvement in positional accuracy and repeatability.

4.2.1 EFFECT OF CHANGE FEED DISTANCE

The change of feed distance generally was observed to have significant improvement in positional accuracy as shown in both Figures 4.1 and 4.2. Figure 4.1 show carbon steel with 1 mm and 5 mm feed distance and Figure 4.2 show stainless steel with 1 mm and 5 mm feed distance. The feed frequency was set 1 Hz, no brake force was applied, and the material thickness for both materials is 50 µm. The results showed that a shorter feed distance inhibits better positional accuracy compared to when using a longer feed distance for both figure. The longer feed distance requires high velocity and acceleration to accomplish the feed process within a similar given time to that for a shorter feed distance.

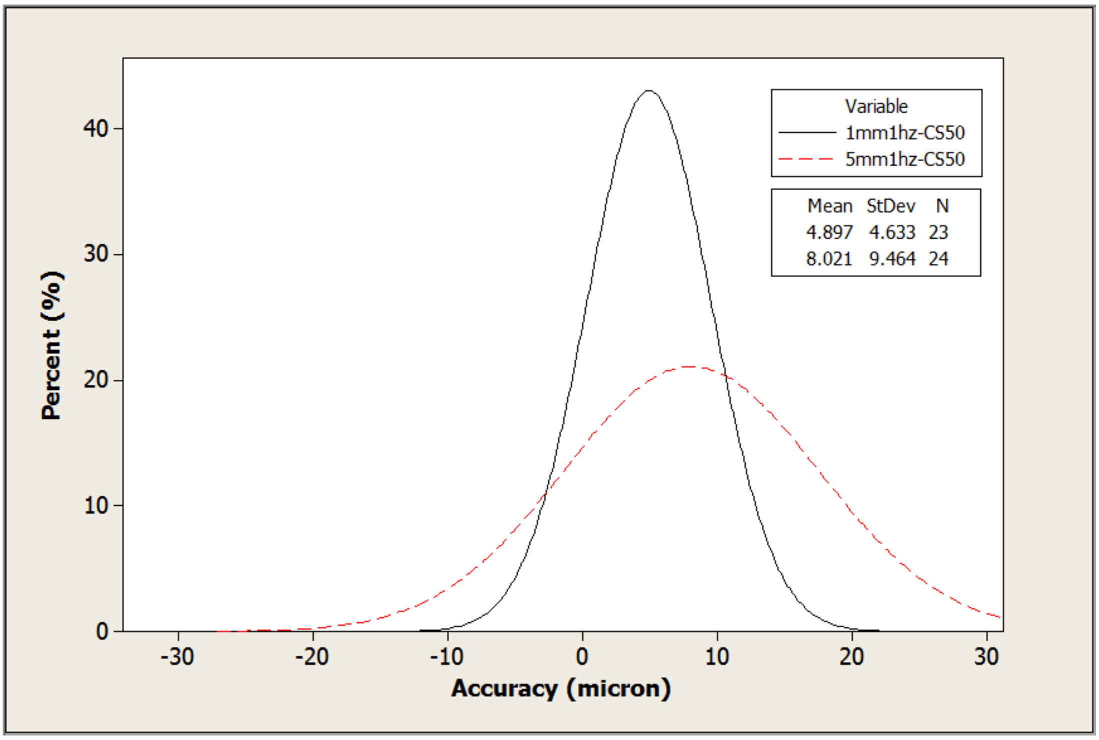

Figure 4.1 Percentage vs accuracy of 1 mm and 5 mm feed distance of carbon steel

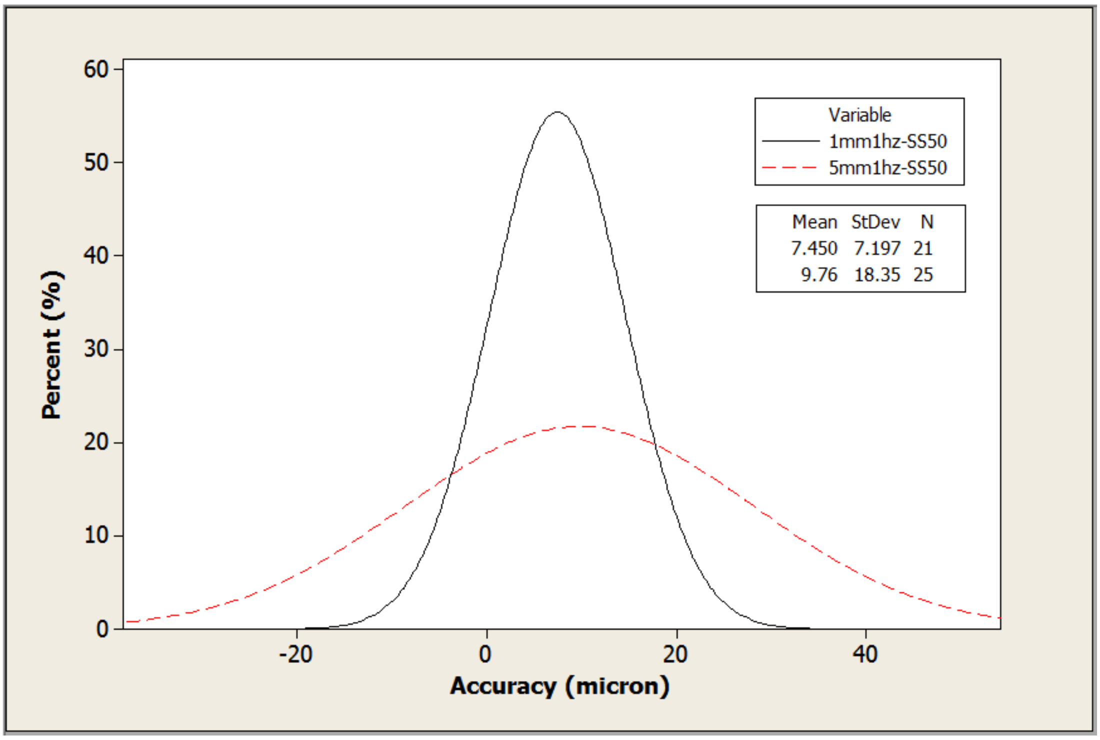

Figure 4.2: Percentage vs accuracy of 1 mm and 5 mm feed distance of stainless steel

4.2.2 EFFECT OF CHANGE FEED FREQUENCY

The change of feed frequency generally was observed to have improvement in positional accuracy as shown in both Figures 4.3 and 4.4. Figure 4.3 show carbon steel with 1 Hz and 3 Hz feed frequency and Figure 4.4 show stainless steel with 1 Hz and 3 Hz feed frequency. The feed distance was set 1mm, no brake force was applied, and material thickness for both materials was 50 µm. The result showed that a smaller feed frequency inhibits better positional accuracy compared to bigger feed frequency.

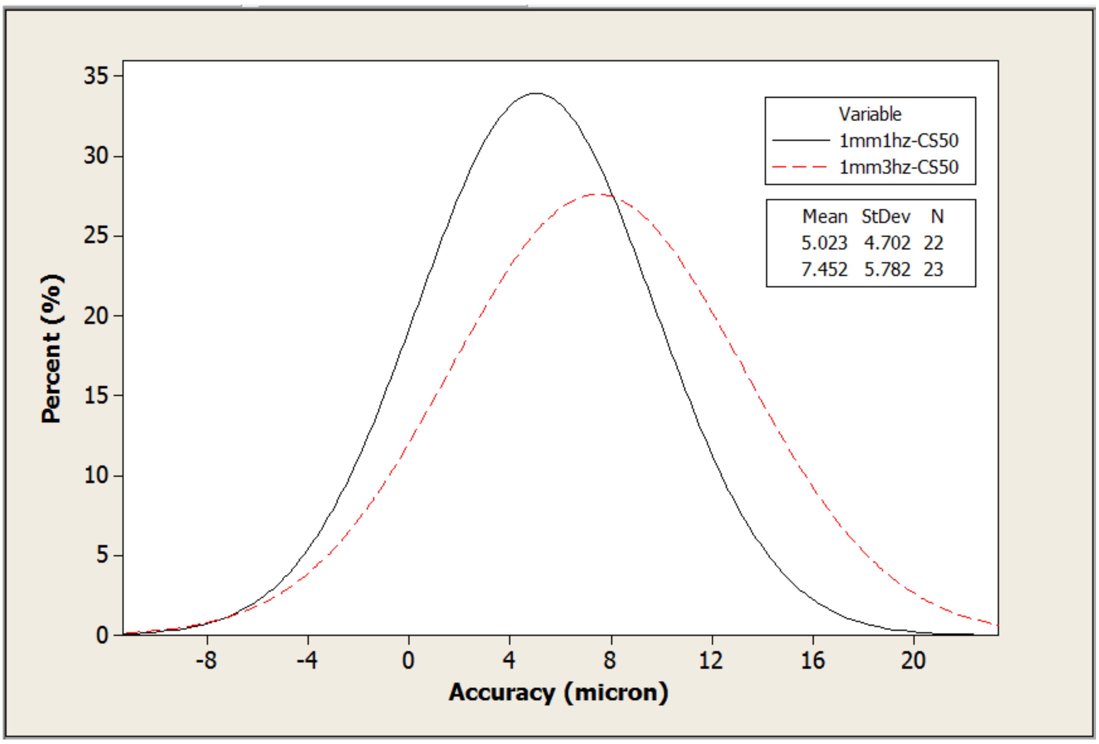

Figure 4.3 Percentage vs accuracy of 1 Hz and 3 Hz feed frequency carbon steel

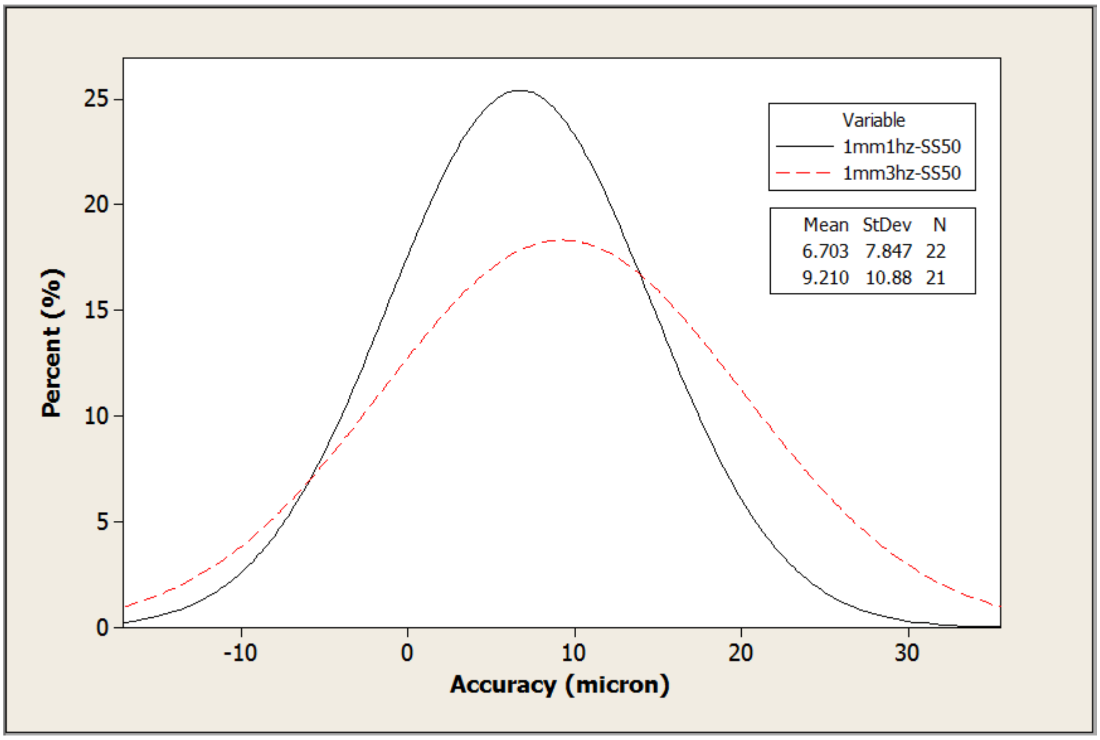

Figure 4.4: Percentage vs accuracy of 1 Hz and 3 Hz feed frequency stainless steel

4.2.3 EFFECT OF CHANGE MATERIAL THICKNESS

The effect of two different material thickness showed that have improvement in positional accuracy. Figure 4.5 and Figure 4.6 show carbon steel and stainless steel with 50 µm and 100 µm thickness. The feed distance and feed frequency was set 1 mm and 1 Hz both materials. There was no brake force was applied. The result showed that larger material thickness inhibits better positional accuracy compared to smaller material thickness.

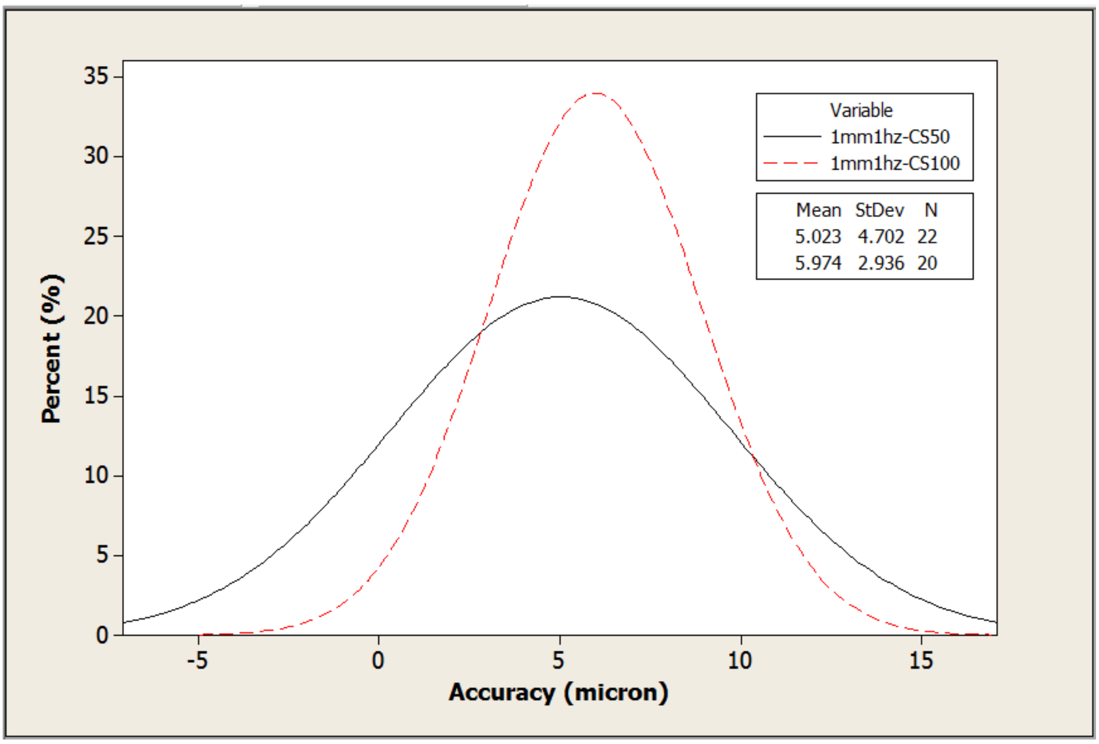

Figure 4.5: Percentage vs accuracy of 50 µm and 100 µm carbon steel thickness

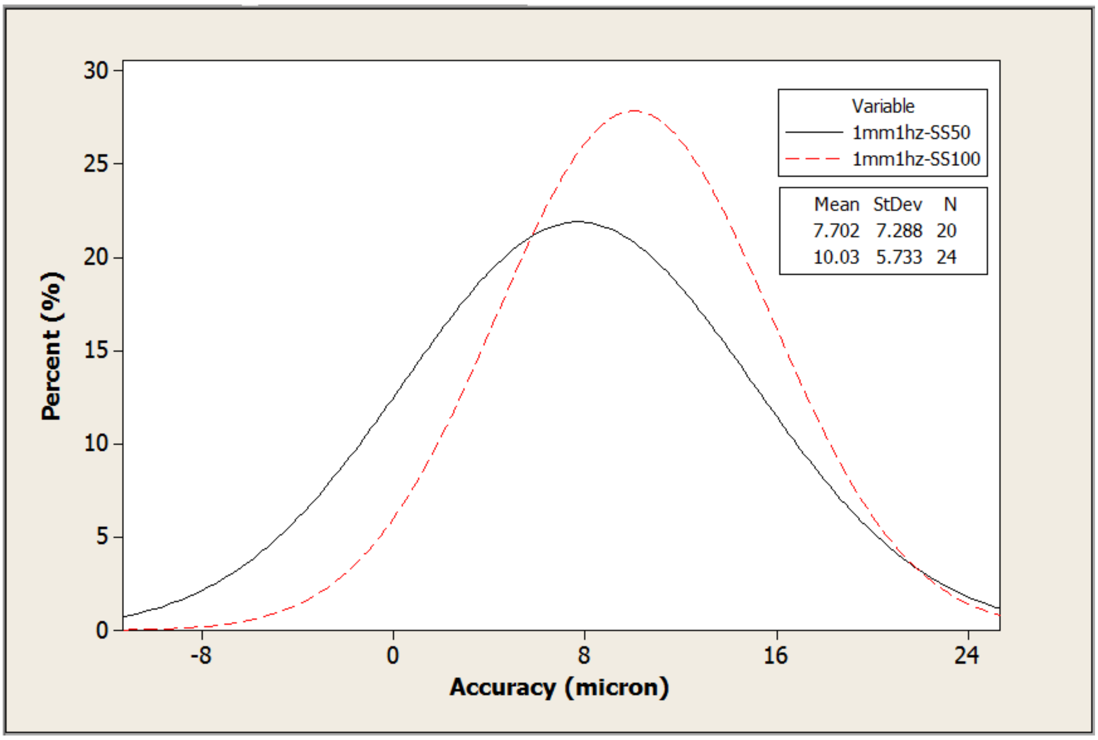

Figure 4.6: Percentage vs accuracy of 50 µm and 100 µm stainless steel thickness

4.2.4 EFFECT OF MATERIAL TYPE

The effect of two different material types showed that have significant improvement in positional accuracy. Figure 4.7 and 4.8 show the result for carbon steel and stainless steel. The feed distance and feed frequency was set 1 mm and 1 Hz bot both materials, no brake force was applied, and material thickness is 50 µm. The result showed that carbon steel inhibits better positional accuracy compared to stainless steel.

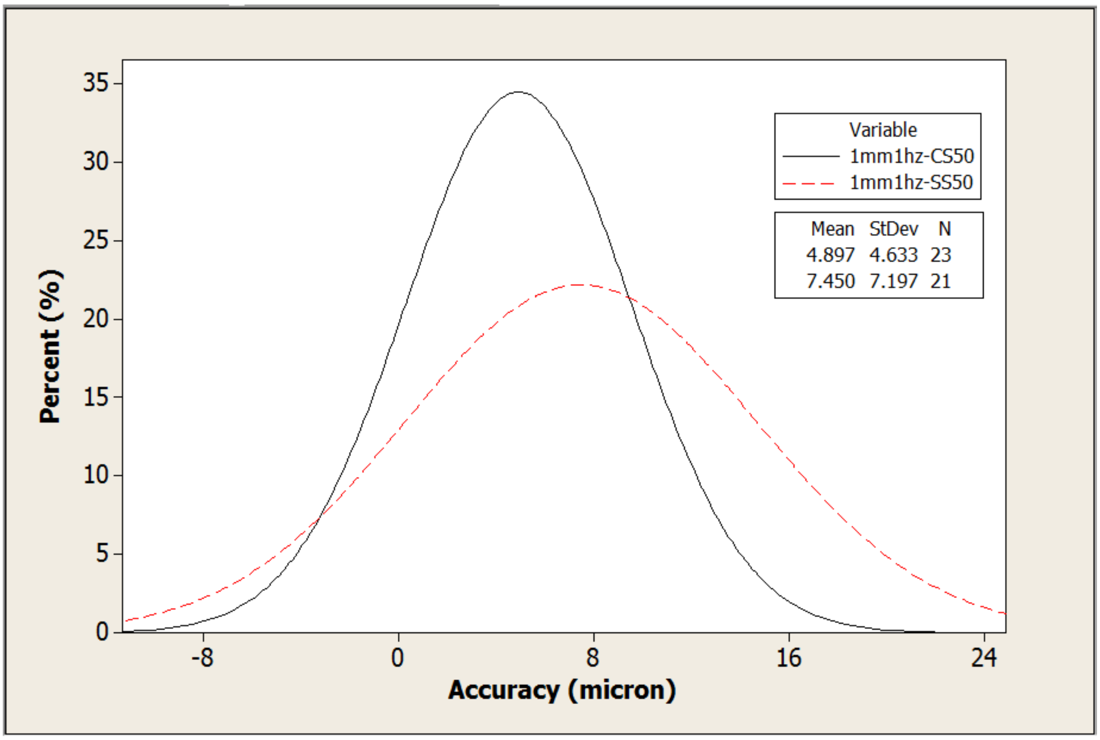

Figure 4.7: Percentage vs accuracy of different materials type

4.2.5 EFFECT OF BRAKE FORCE

The application of brake force to feeding process showed that have significant improvement in positional accuracy for both materials. Figure 4.8 show the result of positional accuracy when no brake force was applied and Figure 4.9 show the result when brake force was apply. The material thickness is 50 µm, feed distance is 1mm, and feed frequency is 1 Hz for both types of materials. The significant positional accuracy improvement was observed with presence of brake force on the materials.

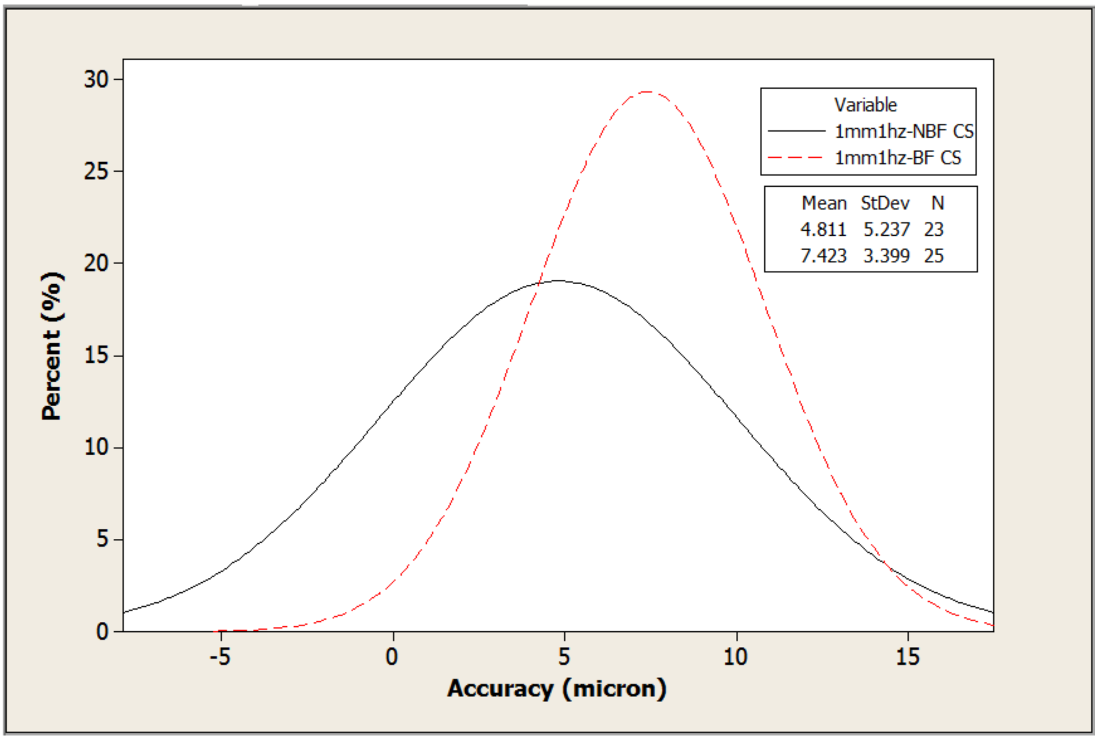

Figure 4.8: Percentage vs accuracy of the effect brake force on carbon steel

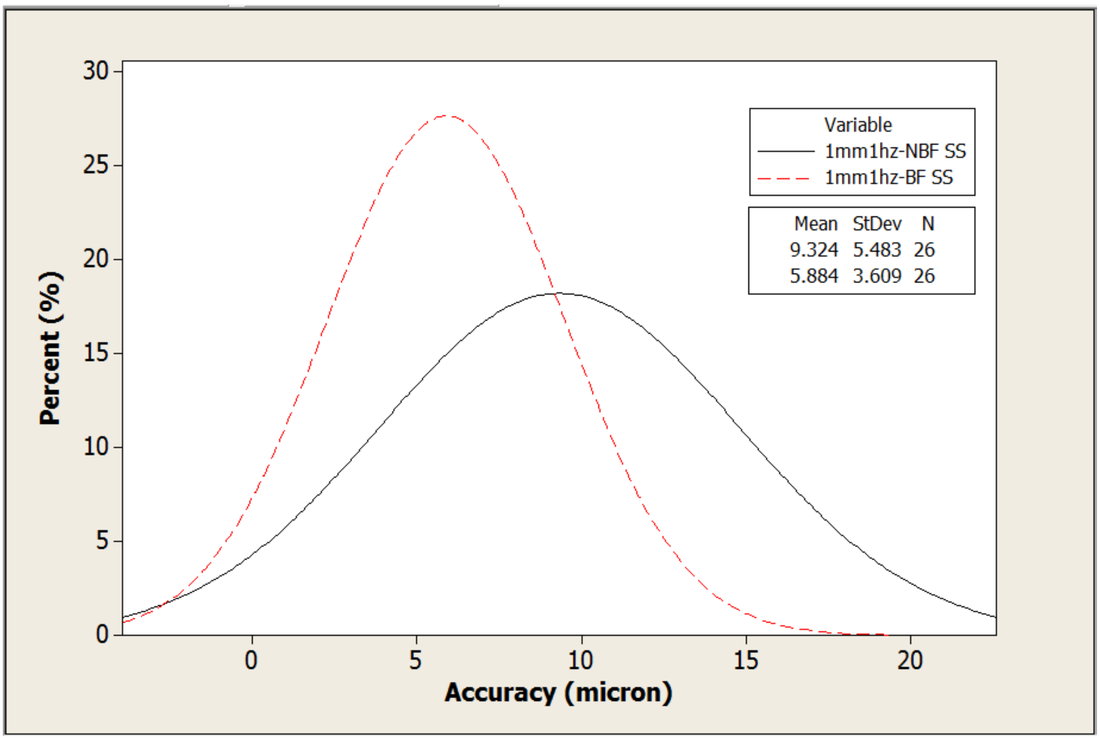

Figure 4.9: Percentage vs accuracy of the effect brake force on stainless steel

4.2.6 EFFECT OF MOTION PROFILE

The change of motion profile generally was observed to have no significant improvement in positional accuracy, as shown in both Figures 4.10 and 4.11. Figure 4.10 show the 45-45 motion profile and Figure 4.11 show 50-50 motion profile for both materials. The material thickness is 50µm, feed distance is 1mm, no brake force was applied, and feed frequency is 1 Hz for both types of materials. The change of motion profile caused severe underfeeds in the settling pattern for both materials. It is suggested that deterioration of positional accuracy may be experienced when a sharper motion- profile curve is used, which in this case is 50-50.

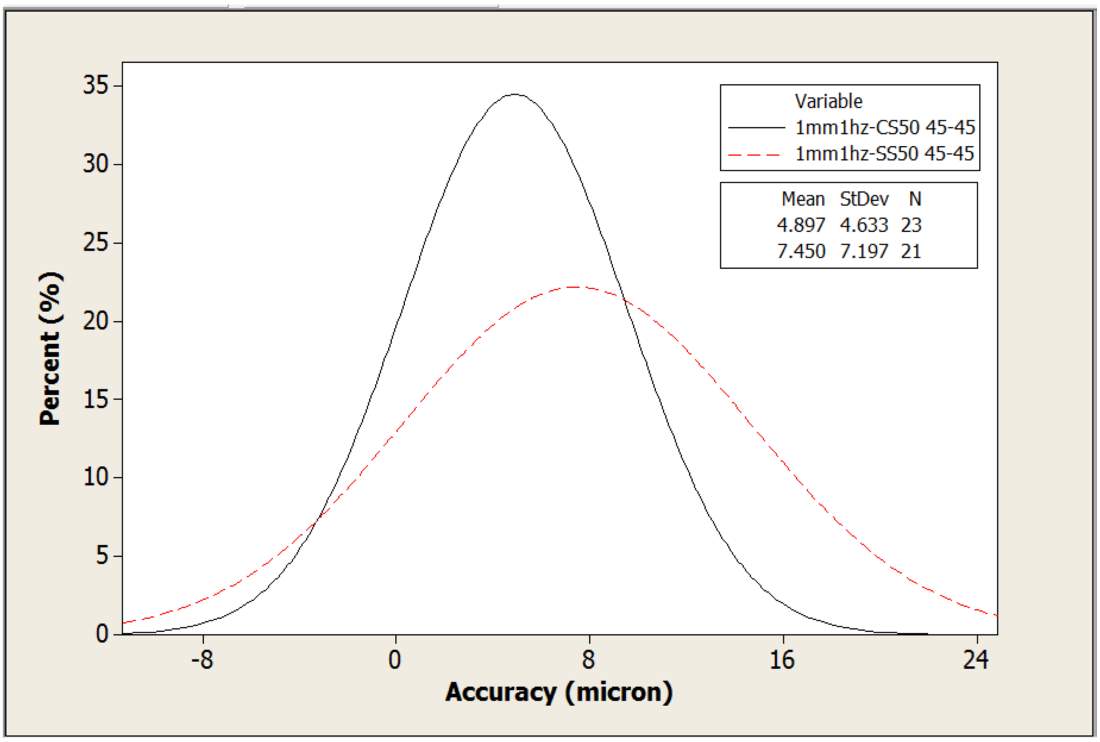

Figure 4.10: Percentage vs accuracy of 45-45 motion profile

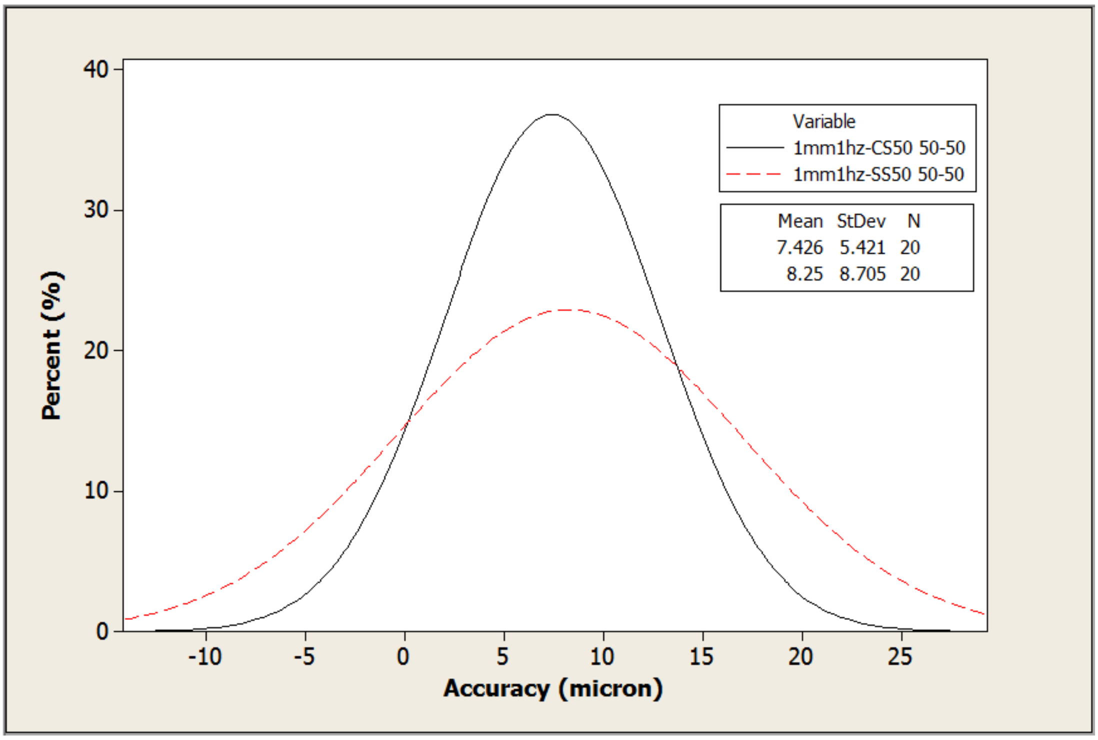

Figure 4.11: Percentage vs accuracy of 50-50 motion profile

4.3 DISCUSSION

There are many factors that influence the improvement in positional accuracy for each parameter.

4.3.1 EFFECT OF CHANGE OF FEED DISTANCE AND FEED FREQUENCY

The results for different feed distance and feed frequency show that change of feed distance and feed frequency has significant improvement in positional accuracy. The shorter feed distance and feed frequency inhibits better positional accuracy compared when using longer feed distance and greater feed frequency. The shorter feed distance requires less velocity and acceleration to accomplish the desired distance. This leads to a lower inertia value produced during the feeding process. However, longer feed distance requires high velocity and acceleration to accomplish the feed process within similar given time for shorter feed distance. The larger inertia value was produce during feeding process lead to less positional accuracy.

4.3.2 EFFECT OF MATERIAL THICKNESS

The results for different material thickness show that thicker strip inhibits better positional accuracy compared to thinner material thickness. The positional error observed with thinner strip could be explained by its mass. The thicker strip inhibits less waviness to the strip during the feeding process. The less waviness of strip results the feeding process to perform better positional accuracy.

4.3.3 EFFECT OF MATERIAL TYPE

The results show that carbon steel inhibits better positional accuracy compared to stainless steel. Different steels have different values of strength and toughness depending on the alloys made and the heat treatments used. Carbon steel is more stiffness than stainless steel based on value of Young Modulus of materials. For 50 μm carbon steel the Young's Modulus was about 210 GPa and stainless steel was about 200 GPa.The stiffer the strip, the less waviness occurs to strip during the feed process.

4.3.4 EFFECT OF BRAKE FORCE

The results show that the applications of brake force to feeding process have significant improvement in positional accuracy for both materials. The brake fore was applied to the ends of strip edge to represent the decoiler-brake-force effect on feed process reduce error and increasing the stability. The application of brake force also reduced the waviness of the strip during feed process. Without brake force applied to the system, the free end of the strip more vulnerable to disturbance that lead to greater waviness.

4.3.5 EFFECT OF MOTION PROFILE

The change of motion profile caused severe underfeeds in the settling pattern for both materials. The 45-45 motion profile show better positional accuracy compare to 50-50 motion profile because the ‘jerk’ occur during the feed process. A high ‘jerk’ occurs usually associated with high speed motion as shown in 50-50 motion profile.. A high ‘jerk’ affects the settled pattern and the positional error of the least-stiff material through increasing the waviness of the strip. Based on Newton’s Law of Motion, increase in acceleration result in increasing in force. The tendency of high ‘jerk’ was reduced by introducing a constant-velocity phase, hence reducing any sharp transition during change of acceleration and deceleration.

CHAPTER 5

CONCLUSION

5.1 INTRODUCTION

This chapter will discuss about the conclusion of this research. The conclusion is made from the objective and also problem statement. The result collect show the objective is achieved.

5.2 CONCLUSION

i. Better positional accuracy can be achieved at shorter feed distance and smaller feed frequency.
ii. The thicker and stiffer the material inhibits better positional accuracy and repeatability.
iii. The application of brake force is useful in improving positional accuracy and repeatability.
iv. A low 'jerk' motion profile provides better positional accuracy (45-45 motion profile).

5.3 RECOMMENDATION

For the better result of feeder simulation, the type of materials use should be added since many industries use many types of metal strip when perform sheet metal forming process such as aluminium, copper, brass, and others. Besides that, the application of PID feedback on servo drive to incorporate the effect on the feeding characteristic can be used.

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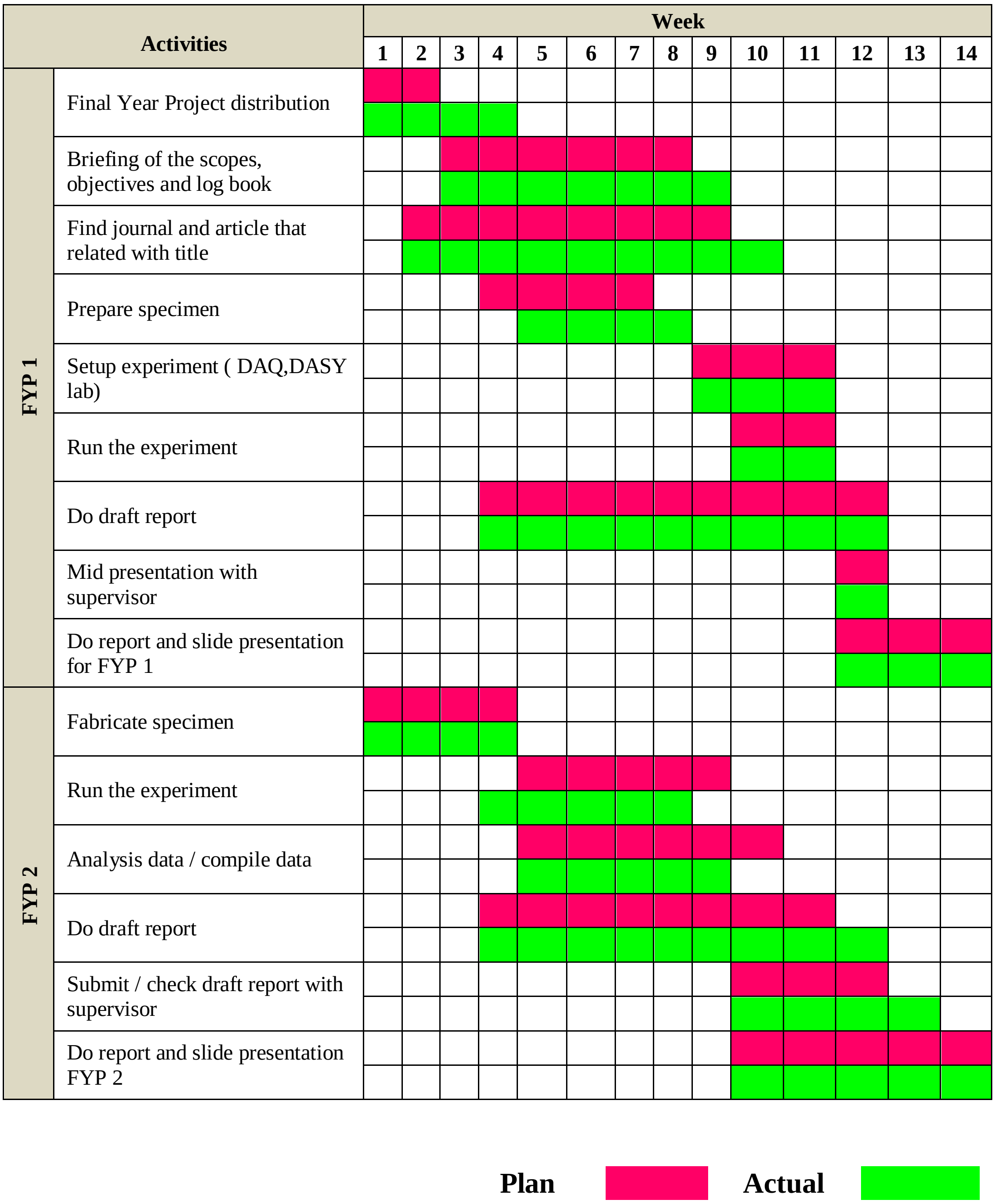
APPENDIX A1

PROJECT GANTT CHART



APPENDIX B1

Types Of Material	Carbon Steel		Stainless Steel	
Feed distance	1mm	5mm	1mm	5mm
	1.955769	-27.9318	8.96933	-31
	15.04312	9.947271	-6	2
	5.00616	16.17356	1	1
	1.851374	12.83742	8	29
	2.154786	3.82125	13	29
	4.014374	0.031513	7	19
	7.00633	6.715938	2	42
	-3.98967	16.90151	8	-9
	-4.98757	18.43639	18	-9
	9.251016	9.465175	11	13
	10.7742	6.438794	7	16
	9.981035	8.248899	7	2
	0.999957	12.98238	7	-16
	9.050472	8.953793	20	22
	7.489514	8.103753	10	-15
	4.497908	6.366272	5	-8
	9.016806	6.846501	5	31
	5.987369	15.7306	9	6
	5.987438	15.24541	12	22
	5.008421	11.36113	19	-2
	1.278826	-4.26767	2.41231	12
	3.1231	2.63039		32
	2.1343	13.05224		4
		14.42263		21
				31

APPENDIX B2

Types of material	Carbon Steel		Stainless Steel	
Feed frequency	1Hz	3Hz	1Hz	3Hz
	1.955769	2.163934	-8.96933	8
	15.04312	3.957143	-6	-9
	5.00616	20.14775	1	8
	1.851374	2.179776	8	7
	2.154786	11.75029	13	30
	4.014374	8.286953	7	-8
	7.00633	6.678082	2	23
	-3.98967	12.98582	8	4
	-4.98757	11.10384	18	12
	9.251016	4.910345	11	19
	10.7742	9.888889	7	12
	9.981035	11.15249	7	27
	0.999957	2.561458	7	-2
	9.050472	9.411348	20	2
	7.489514	12.02691	10	16
	4.497908	13.97309	5	8.67E-13
	9.016806	2.342958	5	-5
	5.987369	11.6501	9	17
	5.987438	2.937198	12	4
	5.008421	9.085185	19	16
	1.278826	7.038398	2.41231	12.4
	3.1231	-8.0466	-8.96933	
		3.20011		

APPENDIX B3

Types of material	Carbon steel		Stainless steel	
Material thickness	50µm	100µm	50µm	100µm
	1.955769	2	-8.96933	14
	15.04312	7.280915	-6	13
	5.00616	4.243777	1	4.34E-13
	1.851374	7.879098	8	17
	2.154786	11.01025	13	2
	4.014374	8.185809	7	15
	7.00633	4.275488	2	13
	-3.98967	6.295311	8	14
	-4.98757	11.48724	18	15
	9.251016	9.634575	11	7
	10.7742	4.623617	7	14
	9.981035	3.353562	7	9
	0.999957	6.380019	7	12
	9.050472	8.902686	20	20
	7.489514	3.936082	10	3
	4.497908	5.251546	5	11
	9.016806	5.192816	5	1
	5.987369	-0.0703	9	11
	5.987438	5.356895	12	13
	5.008421	4.2587	19	-3
	1.278826			9.13645
	3.1231			11.354
				9.3566
				9.846

APPENDIX B4

Types of materials	Carbon steel	Stainless steel
	1.955769	-8.96933
	15.04312	-6
	5.00616	1
	1.851374	8
	2.154786	13
	4.014374	7
	7.00633	2
	-3.98967	8
	-4.98757	18
	9.251016	11
	10.7742	7
	9.981035	7
	0.999957	7
	9.050472	20
	7.489514	10
	4.497908	5
	9.016806	5
	5.987369	9
	5.987438	12
	5.008421	19
	1.278826	2.41231
	3.1231	
	2.1343	

APPENDIX B5

Types of material	Carbon steel		Stainless steel	
	No brake force	Apply brake force	No brake force	Apply brake force
	7.00633	10.96729	2	4.968198
	-3.98967	4.030657	8	5.020909
	-4.98757	7.99793	18	1.006526
	9.251016	6.979483	11	8.006503
	10.7742	11.01844	7	6.980472
	9.981035	0.977451	7	15.01953
	0.999957	8.02669	7	6.997845
	9.050472	5.03285	20	2.995691
	7.489514	11.02668	10	8.991218
	4.497908	4.010292	5	-0.98471
	9.016806	8.004124	5	6.997855
	5.987369	10.99587	9	9.056445
	5.987438	2.991744	12	0.960983
	5.008421	10.0062	19	2.980349
	1.278826	9.987603	2.41231	8
	3.1231	5.010348	2	7.997798
	2.1343	11.00205	8	9.997817
	7.00633	3.99177	18	4.004343
	-3.98967	2.993797	11	1.000014
	-4.98757	8.004124	7	6.004306
	9.251016	1.977387	7	8.989201
	10.7742	9.032922	7	8.00432
	9.981035	9.006186	20	9.008639
		9.3565	10	1.993521
		13.1343	5	2.982721

APPENDIX B6

Types of motion profile	45-45		50-50	
Types of material	Carbon steel	Stainless steel	Carbon steel	Stainless steel
	1.955769	-8.96933	4.910145	15
	15.04312	-6	6.869208	13
	5.00616	1	-6.04909	4.34E-13
	1.851374	8	9.017641	22
	2.154786	13	16.08253	2
	4.014374	7	4.895186	15
	7.00633	2	4.935248	3
	-3.98967	8	5.047521	14
	-4.98757	18	9.026392	5
	9.251016	11	7.00431	-5
	10.7742	7	3.008734	14
	9.981035	7	3.043478	9
	0.999957	7	19	15
	9.050472	20	6.391749	20
	7.489514	10	6.384567	3
	4.497908	5	9.925242	-6
	9.016806	5	7.978267	11
	5.987369	9	16.59157	11
	5.987438	12	5.482609	13
	5.008421	19	8.974221	-9
	1.278826	2.41231		
	3.1231			
	2.1343			