APPLICATION OF STATISTICAL PROCESS CONTROL ON A MATRIX CARD HOLDER PRODUCTION

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Diploma of Mechanical Engineering

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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Thank you for all your contribution to me. Forgive me if I make some mistakes that I will not recognize till now.

ABSTRACT

This thesis deals with durability assessment application of quality control in our production of card holder. The objective of this thesis is to let l know what is the exactly feature when production of card holder are made. The thesis describes the finite element analysis techniques to predict the fatigue life and identify the critical locations of the production. For material, using ABS that differ in other polypherine that also one of material that suitable to run this production. The 3D design of card holder was design by using Solid Work software. The strategy of calibration for specific measurement was established. After planning was organized, time to run Injection Molding to produce sample of card holder continuously in 3 phase, Injection Speed, Injection Pressure and Holding pressure. From the results, it is observed that the analysis using SPC tools mean process of production very incapable. By that, all factor and analysis were creating to remove all failure of process production.

ABSTRAK

Tesis ini membentangkan penyelidikan menggunakan penjagaan factor quality dalam pengeluaran *'card holder'*. Objectif bagi tesis ini ialah untuk member kita semua tahu bahawanya process yang sedia ada didalam masa kita melakukan process pengeluaran product *'card holder'*mempunyai banyak masalah. Material yang digunakan di dalam tesis ini ialah ABS berbanding dengan polypherene yang merupakan salah satu material yang dugunakan untuk menjalankan product ini. Lukisan 3 dimensi bagi *'card holder'* telah pun direka menggunakan perisian Solid Work. Selepas rancangan projek di bina, tiba masanya untuk menjalan machine, Injection Molding untuk mengeluarkan produk, *'card holder'* yang dijalankan didalam bentuk yang bertukar secara berterusan. Tiga bahagian tersebut ialah *Injection Speed, Injection Pressure* dan *Holding pressure.* Melalui data yang diambil, analisis dijalankan dengan menggunakan SPC dan keputusan menunjukkan process bagi pegeluaran di dalam keruan. Untuk itu beberapa langkah telah dilakukan untuk mengesan sebarang kebarangkalian kecacatan pengeluran *'card holder'* tersebut berlaku.

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D. Material, ABS to produce card holder55

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LIST OF ABBREVIATIONS

UCL	Upper Control Limits
LCL	Lower Control Limits
CL	Center Line
SPC	Statistical Process Control
Cp and Cpk	Process Capabilities
4M and E	Factor consist of men, material, method, machine and environment
SOP	System Operational Process

CHAPTER 1

INTRODUCTION

2.1 Project Background

SPC stands for Statistical Process Control, it is the set of operational and managerial activities that a company uses to ensure that the quality characteristics of a product are at the required level.

History of Quality Control

Why study history of quality control is to understand and foresee trends and future from the past and also companies may still be working with concepts from the past.

Quality really became and issue during the Industrial revolution (19^{th} century). Inspection-oriented quality was adopted in the emerging factories (usually through inspection department), F.W. Taylor research on quality and management in the 1890's.

History: World War II

Increase of production during World War II caused expansion of quality control activities in both the U.S.A and Britain. Statistical techniques were so effective that they were classified as military secrets during World War II!. After World War II, the U.S.A only had major production facility left. Lack of competition and enormous post-war demand caused disinterest in quality control.

2.1.1 The Aims of this project.

The aims of this project are to make all realize what the quality of processing card holder in our production of card holder. By this the end of this project the quality of processing will known.

2.2 Objectives

Objective of this project is **Statistical control study using SPC method to improve card holder production**. This means, each step of process before this was added with a lot of loss of action. Based on this quality control application, this SPC tools not only can reduced the entire problem but also increase marketing productivity at the same time.

2.3 Problem Statement

Before this injection molding process were manage in random control of parameter that will create any disadvantages. So by 7qc tools application we can tolerate the process machine that will cover up loss of raw material that will benefit us in low cost of production.

The perfect parameter will be developing to establish in producing high quality of accuracy and productivity machine.

By SPC tools hoping that process injection molding can decrease the downtime of machine and also can reduce maintenance cost.

2.4 Scope Of the Project

In order to achieve the project objective, the following scopes are identified:

a) Identify the injection moulding parameters related to name card holder production

b) Produce sample of name card holder using injection moulding process.

c) Identify defect occurs in name card holder.

d) Analyze each quality control tool for name card holder production.

CHAPTER 2.0

INTRODUCTION

2.1 INTRODUCTION

This chapter is discussing on some literature that give information about quality control and show how the concepts of quality control apply in manufacturing industry. Furthermore, some literature review that related with Diploma Level Study.

2.2 DEFINITION OF STATISTICAL CONTROL, SPC

SPC stands for Statistical Process Control, it does not refer to a particular technique, algorithm or procedure. SPC is an optimization philosophy concerned with continuous process improvements, using a collection of (statiscal) tools for data and process analysis, making inferences about process behavior and also decision making. Furthermore SPC is a key competed of Total Quality initiatives.

Ultimately, SPC seeks to maximize profit by:

a. Improving product quality
b. Improving productivity
c. Streaming process
d. Reducing wastage
e. Reducing emissions
f. Improving customer service

2.5 TOOLS USED TOOLS IN SPC

a. Commonly used tools in SPC include
    - 2.1.1 Flow charts
    - 2.1.2 Run charts
    - 2.1.3 Pareto charts and analysis
    - 2.1.4 Cause-and-effect diagrams
    - 2.1.5 Frequency histograms
    - 2.1.6 Control charts
    - 2.1.7 Process capability studies
    - 2.1.8 Acceptance sampling plans
    - 2.1.9 Scatter diagrams
b. Each tool is simple to implement
c. These tools are usually used to complement each other, rather than employed as stand-alone techniques

2.3.1 Flow charts

Flow charts have no statistical basis and are very excellent visualization tools because Flow charts show the progress of work and the flow of material or information through a sequence of operations. Flow charts are useful in an initial process analysis it should be complemented by process flow sheets or process flow diagrams (more detailed) if available. Everyone involved in the project should draw a flow chart of the process being studied so as to reveal the different perceptions of how the process operates.

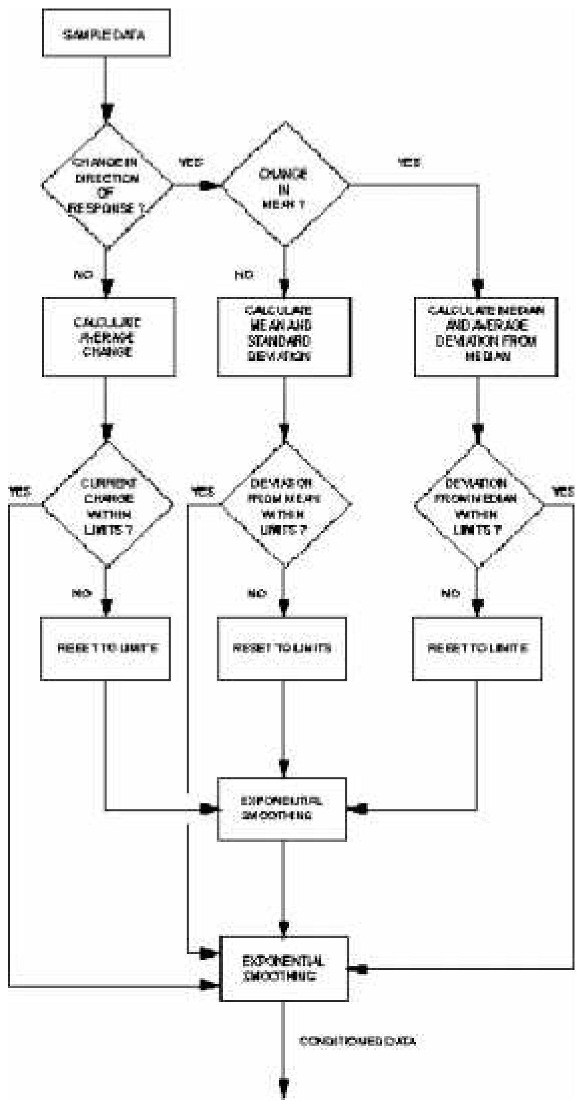


Figure 2.1.1: Example of Flow Chart

2.3.2 Run charts

Run charts are simply plots of process characteristics against time or in chronological sequence. They do not have statistical basis, but are useful in revealing trends and relationships between variables.

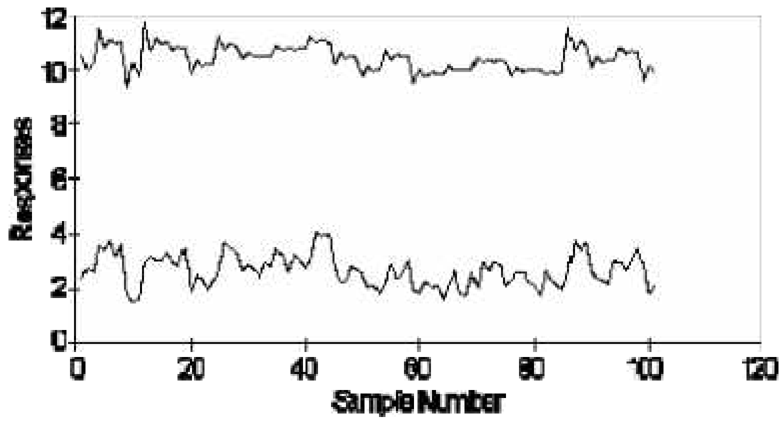


Figure 2.1.2: Run Chart with two responses

Run charts can be used to study relationships between variables. For example, in the above chart, the relationship between the 2 variables is difficult to discern. To facilitate this, appropriate scalings for the plots should be chosen. If each plotted variable has its own y-axis scale, the above run chart then becomes,

Run chart for two variables with independent y-axis scales

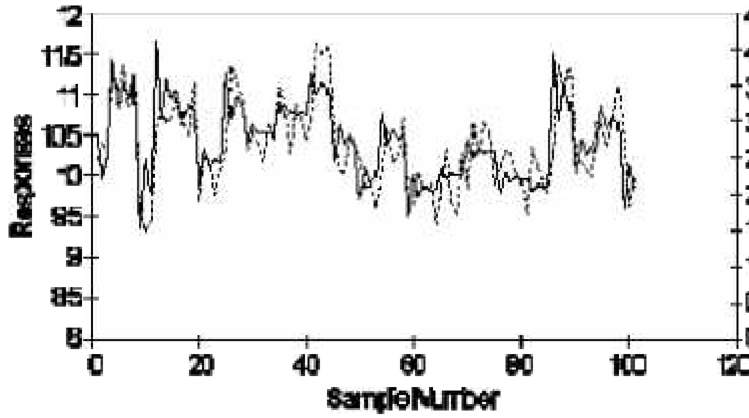


Figure 2.1.3: Run Chart with Independent y-axis Scales

Now, the relationship between the two becomes much clearer. Obviously this method will fail when there are more than two variables. However, if the variables are standardized before plotting, only a single common axis is necessary, and the results are just as clear as the previous.

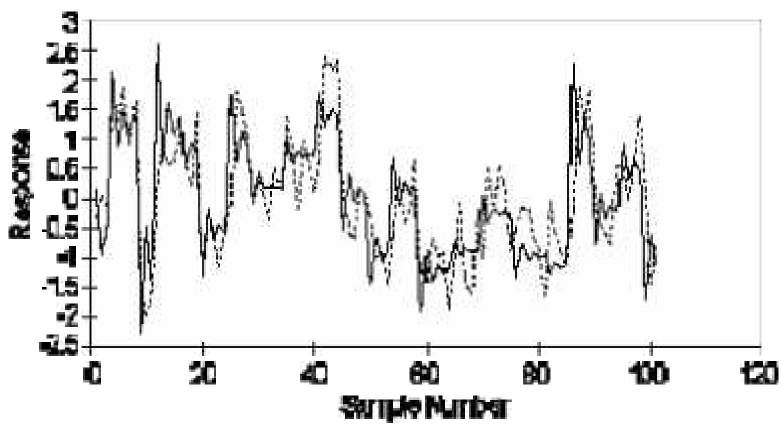


Figure 2.1.4: Run chart for two standardized variables

2.3.3 Pareto charts and analysis

Pareto Principle

The Pareto Principle states that:

"Not all of the causes of a particular phenomenon occur with the same frequency or with the same impact"

Such characteristics can be highlighted using Pareto Charts

<u>Pareto charts and analysis</u>

Pareto charts show the most frequently occurring factors and analysis of Pareto charts help to make best use of limited resources by targeting the most important problems to tackle.

For example, when products may suffer from different defects, but the defects occur at different frequency and only a few account for most of the defects present in different defects incur different costs.

So a product line may experience a range of defects (A, B, C ... J). Plotting the percentage contribute each type to total number of faults, gives the bar-plots in the following diagram. Next if, each of these contributions are sequentially summed, a cumulative line plot is obtained. These two plots together make up the Pareto Chart.

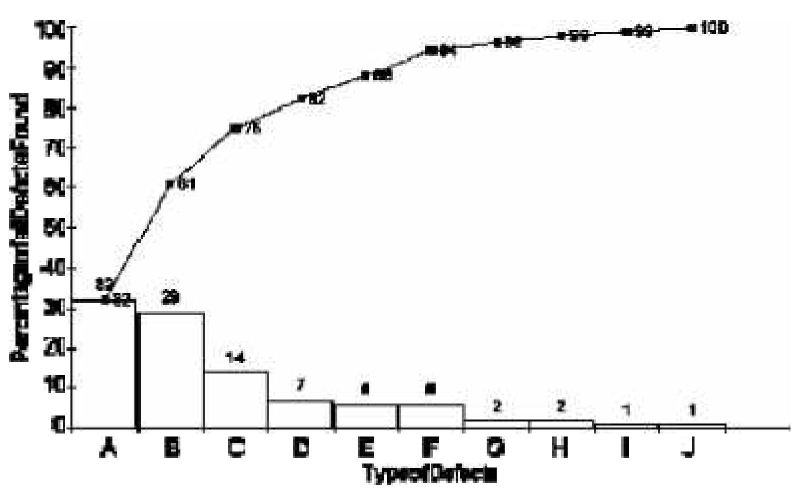
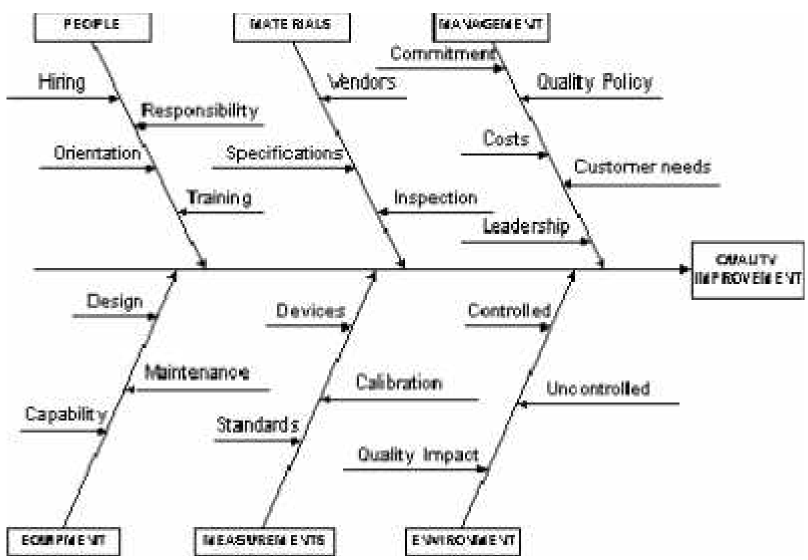


Figure 2.1.5: Example of Pareto Chart

From the information on the chart, the manufacturer could for example, concentrate on reducing defects A, B and C since they make up 75% of all defects focus on eliminating defect E, if defect E causes 40% of monetary loss.

2.3.4 Cause-and-effect diagrams

Cause-and-effect diagrams are also called Ishikawa diagrams (Dr. Kaoru Ishikawa, 1943) and fishbone diagrams. Cause-and -effect diagrams do not have a statistical basis, but are excellent aids for problem solving and trouble-shooting.
This step also can reveal important relationships among various variables and Possible causes provide additional insight into process behavior.



Adapted from Pitt (1994)

Figure 2.1.6: Example of a Cause-and-effect diagram

2.3.5 Frequency histograms

The frequency histogram is a very effective graphical and easily interpreted method for summarizing data. The frequency histogram is a fundamental statistical tool of SPC. It provides information about:

- the average (mean) of the data
- the variation present in the data
- the pattern of variation
- whether the process is within specifications

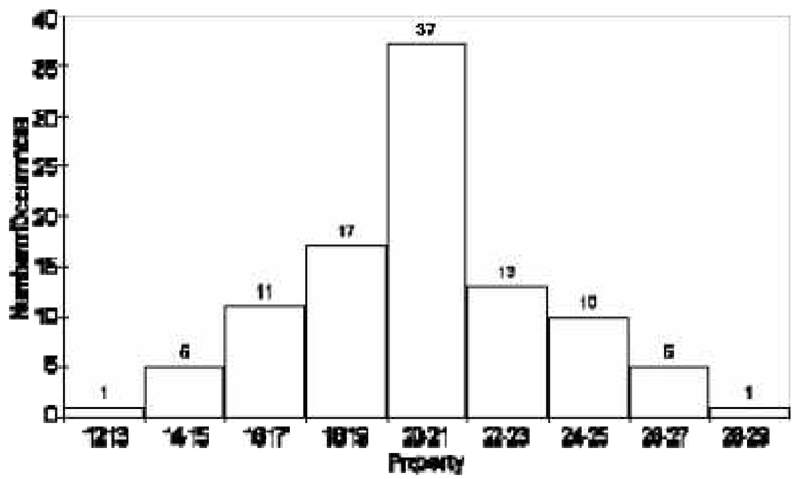


Figure 2.1.7: Example frequency histogram

<u>Drawing Frequency Histograms</u>

In drawing frequency histograms, bear in mind the following rules:

- Intervals should be equally spaced
- Select intervals to have convenient values
- Number of intervals is usually between 6 to 20
- Small amounts of data require fewer intervals
- 10 intervals is sufficient for 50 to 200 readings

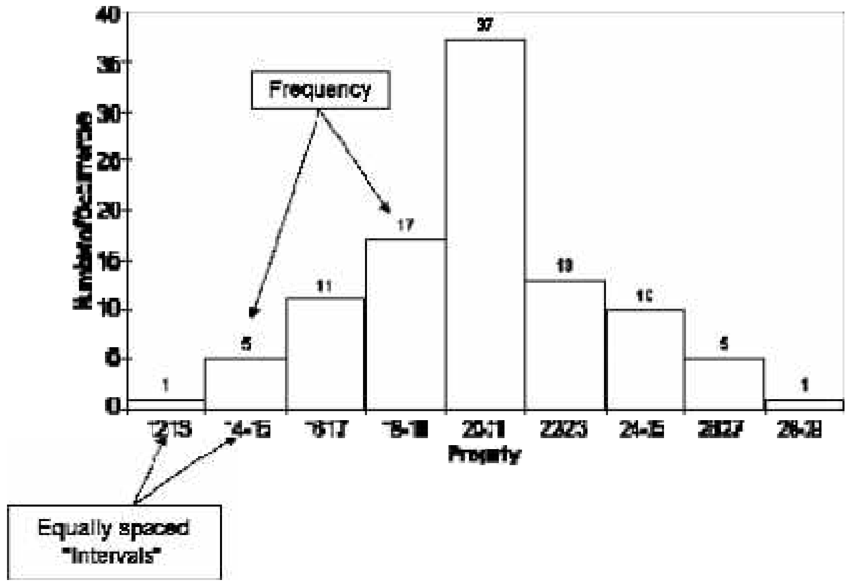


Figure 2.1.8: Histogram

2.3.6 Control charts

SPC Tools - Control charts

Processes that are not in a state of statistical control by control chart it shows excessive variations and also exhibit variations that change with time. A process in a state of statistical control is said to be statistically stable. Control charts are used to detect whether a process is statistically stable. Control charts differentiate between variations because that is normally expected of the process due chance or common causes. That change over time due to assignable or special causes

<u>Control charts: common cause variations</u>

Variations due to common causes have small effect on the process that are inherent to the process because of the nature of the system, the way the system is managed, the way the process is organised and operated, can only be removed by making modifications to the process changing the process are the responsibility of higher management.

Control charts: special cause variations

Variations due to special causes are

a. localised in nature
b. exceptions to the system
c. considered abnormalities
d. often specific to a
e. certain operator
f. certain machine
g. certain batch of material, etc.

h. Investigation and removal of variations due to special causes are key to process improvement

Note: Sometimes the delineation between common and special causes may not be very clear

Control charts

The principles behind the application of control charts are very simple and are based on the combined use of

a. run charts
b. hypothesis testing

The procedure is:-

a. sample the process at regular intervals
b. plot the statistic (or some measure of performance), e.g.
c. mean
d. range
e. variable
f. number of defects, etc.

g. check (graphically) if the process is under statistical control

if the process is not under statistical control, do something about it

Control charts: types of charts

Different charts are used depending on the nature of the charted data Commonly used charts are:

for continuous (variables) data

Shewhart sample mean (-chart)

Shewhart sample range (R-chart)

Shewhart sample (X-chart)

Cumulative sum (CUSUM)

Exponentially Weighted Moving Average (EWMA) chart

Moving-average and range charts

for discrete (attributes and countable) data

sample proportion defective (p-chart)

sample number of defectives (np-chart)

sample number of defects (c-chart)

sample number of defects per unit (u-chart or -chart)

2.4 INJECTION MOLDING PROCESS

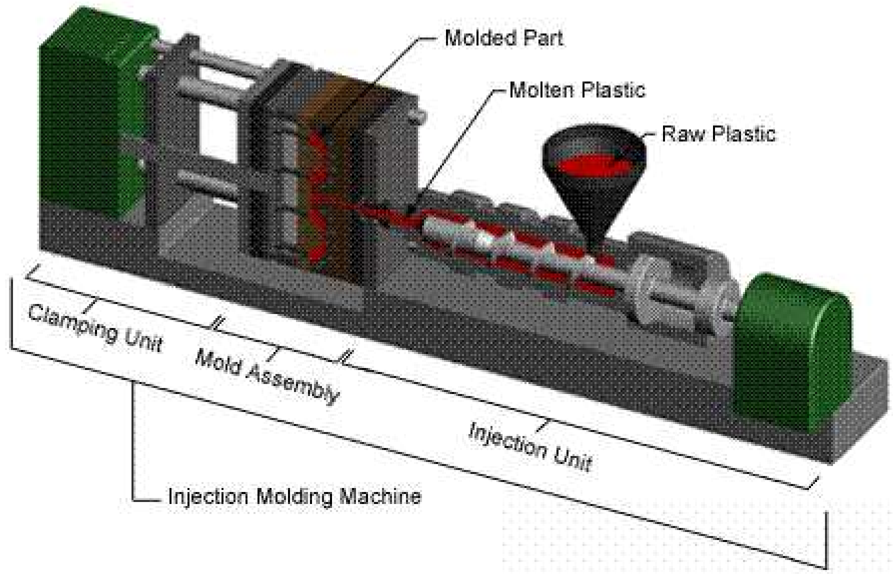


Figure 2.4: Injection Molding Process Flow

For the injection molding cycle to begin, four criteria must be met: mold open, ejector pins retracted, shot built, and carriage forward. When these criteria are met, the cycle begins with the mold closing. This is typically done as fast as possible with a slow down near the end of travel. Mold safety is low speed and low pressure mold closing. It usually begins just before the leader pins of the mold and must be set properly to prevent accidental mold damage. When the mold halves touch clamp tonnage is built. Next, molten plastic material is injected into the mold. The material travels into the mold via the sprue bushing, then the runner system delivers the material to the gate. The gate directs the material into the mold cavity to form the desired part. This injection usually occurs under velocity control. When the part is nearly full, injection control is switched from velocity control to pressure control.

2.4.1 Tell about process

Figure 2.4.1: Injection Molding

To run the Injection Molding, first we must configure how much amount of product that we want to create. By that we can estimated how much pallet that we can put into the tank. When we run the machine, pallets in the tank will gone through to the Dryer to release all humidity and then to the barrel to melt the pallets. Then after melting process, that pallets were inject to the mold to create product that we specify first before.

2.4.2 Process Capabilities

Process Capabilities to produce such a shape that we can tolerate for to produce product in such a type of mold that also help this machine capabilities more higher in manufacturing process especially.

High production rates And **Cycle time range 5 to 60 sec's** which means, the process of Injection Molding is very fast to produce. This is a advantages of industry to upgrade the rates of production that also help relation with customer because their partnership are going well and fast.

Good dimensional control, during the process by using a specific pressure to inject melt pallets to the mold we can get the best character of product.

Mold materials- tool steels, beryllium - Cu, Al

Mold life- 2 million cycles (steel molds) 10000 cycles (Al molds), this also some of advantages by using this machine because rate production in one mold is very high that also will help manufacturer in financial side.

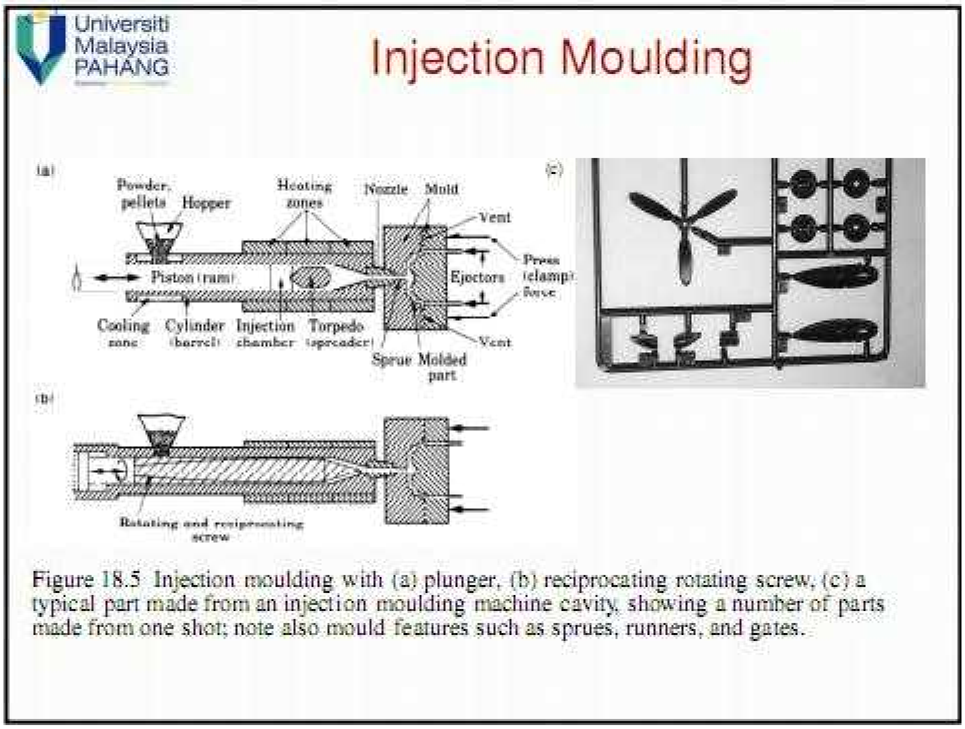


Figure 18.5 Injection moulding with (a) plunger, (b) reciprocating rotating screw, (c) a typical part made from an injection moulding machine cavity, showing a number of parts made from one shot; note also mould features such as sprues, runners, and gates.

Figure 2.3.2: Injection molding and named each part.

2.4.3 Type of mold

3-basic types of molds

i. Cold runner two plate mold

• Need trimming process to remove the channel connecting mold cavity to the end of barrel.

ii. Cold runner three plate mold

• The runner automatically separated from the part when the mold open

iii. Hot runner mold

• No gates, runners or sprues attached to the molded part

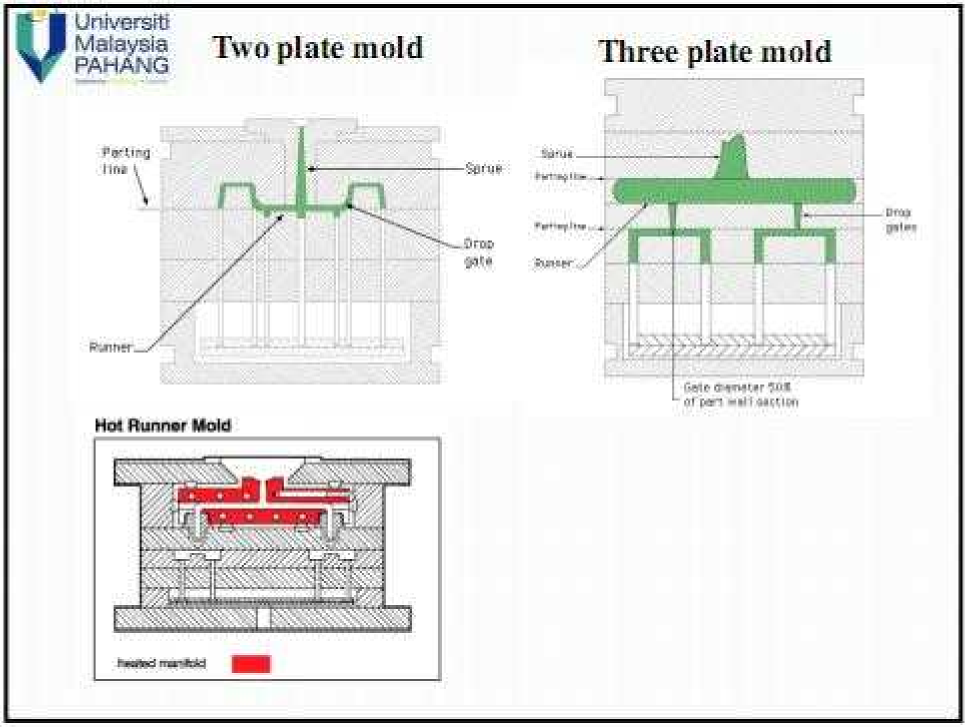


Figure 2.3.4: Types of Mold

2.4.4 Example of product

Typical products: Cups, containers, housings, tool
handles, knobs, electrical and communication components, toys and etc.

Figure. Typical products made by injection moldings, including examples of insert moldings. Source: Plainfield
MoldingInc.

2.7 DEFECTS IN INJECTION MOLDING PROCESS

Defects	Causes
flash	injection pressure too high,clamp force too low
warping	non-uniform cooling rate
bubbles	injection temperature too high, too much moisture in material,non-uniform cooling rate
short shot	insufficient shot volume,flow rate of material too low
sink mark	injetion pressure cooling rate
ejector marks	cooling time too short, ejection force too high

Table 2.1: Types of Defects

2.7.1 Flash/ burr.

Flash is a defect where the melted resin is forced out on the parting line. It is the worst trouble in molding operation. If the mold is clamped with a piece of flash kept as left in a mold half, the parting line of the mold is damage. In such an event, the damaged part causes an additional flash , thereby making the succeeding operation completely unsatisfactory. Therefore, special precaution should be taken to avoid flash.

2.7.2 Short Shot.

A short shot means the status of a product for which the resin was not completely filled in the cavity. If the resin is cooled to a solid shape before attaining the target shape, the product is a failure.

2.7.3 Sink Mark

A sink mark is the most probable failure among those observed on the product surface. It develops on a trick-welled part due to a volumetric change caused by heat shrink. Since a sink mark may be regarded as a light degree of short shot, countermeasures against short shot described in the previous section can be applied.

A sink mark, however, develops after the resin is completely filled in the cavity, so it is mostly caused by an insufficient holding effect. Accordingly, first examine the set holding conditions including for the mold. This trouble is mostly caused by a too small gate and too low mold temperature. These adverse conditions let the gate be cooled to a solid shape before the target product in the cavity is cooled to a solid shape, thereby preventing the resin from supplementing the shrinked part at the holding stage. In such the case, the gate should be enlarged or the mold temperature should be increased.

The second probable cause of this trouble is a lack of holding pressure and time. Check them once at least prior to modification of the mold.

2.7.4 Bubbles

A thick-walled part of the product is apt to bear bubble. Cause of this trouble is the same as for sink marks. An only difference between them is that bubbles develop inside the wall while a sink mark develops on the wall surface. A cooling speed by the mold has a concern with this difference. That is, if the product surface is quickly cooled by a low temperature mold, the resin in the cavity shrinks in an order of the inside to the surface, thereby resulting in development of bubbles inside. Therefore, we should carefully control the mold temperature as well as taking countermeasures against sink marks.

2.7.5 Flow Mark

A flow mark is an annual ring-like stripe pattern developed on the product surface. This trouble occurs when the melted resin is cooled to a solid shape while circulating in the cavity throughout the course of injection or holding.

2.7.6 Spray/Silver streaks

The spray is silver white streak drawn on the product surface toward the resin flow direction.

2.7.7 Spray/Silver streaks

Molded product may bear black streak on the surface due to a stained screw cylinder or a burn of the resin due to pyrolysis. Keep the screw cylinder clean and do not use an inferior resin. If the screw has a piece of pyrolyzed resin adhered, the burn cannot be completely cleaned off unless the screw is disassembled for cleaning. Also, if the resin contains a colorant which is hard to decompose, a burn of the colorant may develop as black steaks on the product surface.

2.7.8 Jetting

The jetting is a string-like pattern developing on the product surface.

2.7.9 Weld line

The weld line is a slender seam the product may bear at the fusion site of the resin in the mold. The hair-like line may not be found unless observed carefully. But the site is inferior in strength to other sites of the product and we should make every effort to eliminate such the weld line.

2.7.10 Haze

The haze on the product surface may be caused by an inferior mold surface or use of a too much mold release agent. In such cases, it suffices to well polish the mold surface and apply a mold release agent in a proper quantity.

2.5.11 Crazing/cracking

The crazing is small is small cracks developed on the product surface. The cracking is a broken or split surface, usually without complete separation of part. These troubles are initiated by one of the two causes-one is a forcibly ejection of the product and the other is an internal strain of the product.

2.7.11 Insufficient catching of resin by screw.

Some users complain that the material resin, especially polyamide , from the hopper is not sufficiently caught by the screw.

2.8 Cp and Cpk

Cp and Cpk, commonly referred to as process capability indices, are used to define the ability of a process to produce a product that meets requirements. These indices, which are a fairly recent addition to the field of statistical process management, greatly simplify the management of statistically controlled processes.

Specifications define product requirements. In other words, they define what is expected from an item for it to be usable. Specifications are normally defined in terms.

2.6.1 Cp

The Cp index is calculated using specification limits and the standard deviation only. This index indicates, in general, whether the process is capable of producing products to specifications. No information on the ability of the process to adhere to the target value is included in this index.

2.6.2 Cpk

This Cpk index is calculated using specification limits, the standard deviation, and the mean. The index indicates whether the process is capable of producing within specification and is also an indicator of the ability of the process to adhere to the target specification.

2.6.3 Application of Cp and CpK

The following conditions must be met before Cp and CpK can be successfully used to evaluate the ability of a process:

a. the sample size must be adequate (large enough)
b. the data should be tested for normality
c. the process being analyzed should be under statistical control
d. Caution: Only after a process is under statistical control, can one safely assume that the mean and standard deviation to have a stable values over time.

Cpk is more widely used than Cp, since it takes into account the mean and the standard deviation in its calculation. Please note that the difference between Cp and Cpk is an indicator of how far the average of the process is from the target specification. When the average of the process approaches the target value, the gap between Cpk and Cp closes. When the average of the specification is equal to the target value, then Cpk is equal to Cp.

Cpk can never exceed Cp. Cpk measures how close you are to your target and how consistent you are to around your average performance. A person may be performing with minimum variation, but he can be away from his target towards one of the specification limit, which indicates lower Cpk, whereas Cp will be high. On the other hand, a person may be on average exactly at the target, but the variation in performance is high (but still lower than the tolerance band (i.e. specification interval). In such case also Cpk will be lower, but Cp will be high. Cpk will be higher only when you r meeting the target consistently with minimum variation and must have a Cpk of 1.33 [4 sigma] or higher to satisfy most customers.

CHAPTER 3

METHODOLOGY

This chapter will explain abut what method and materials that we use in this Final Year Project. Actually all equipment and tools and also raw materials easy to have because it already have in Mechanical Lab rather than other member that their materials need to buy outside of campus to complete their task.

In this Final Year Project some other machine, tools and materials that we use is:

b. Injection Molding
c. ABS (raw materials)
d. Venire Caliper

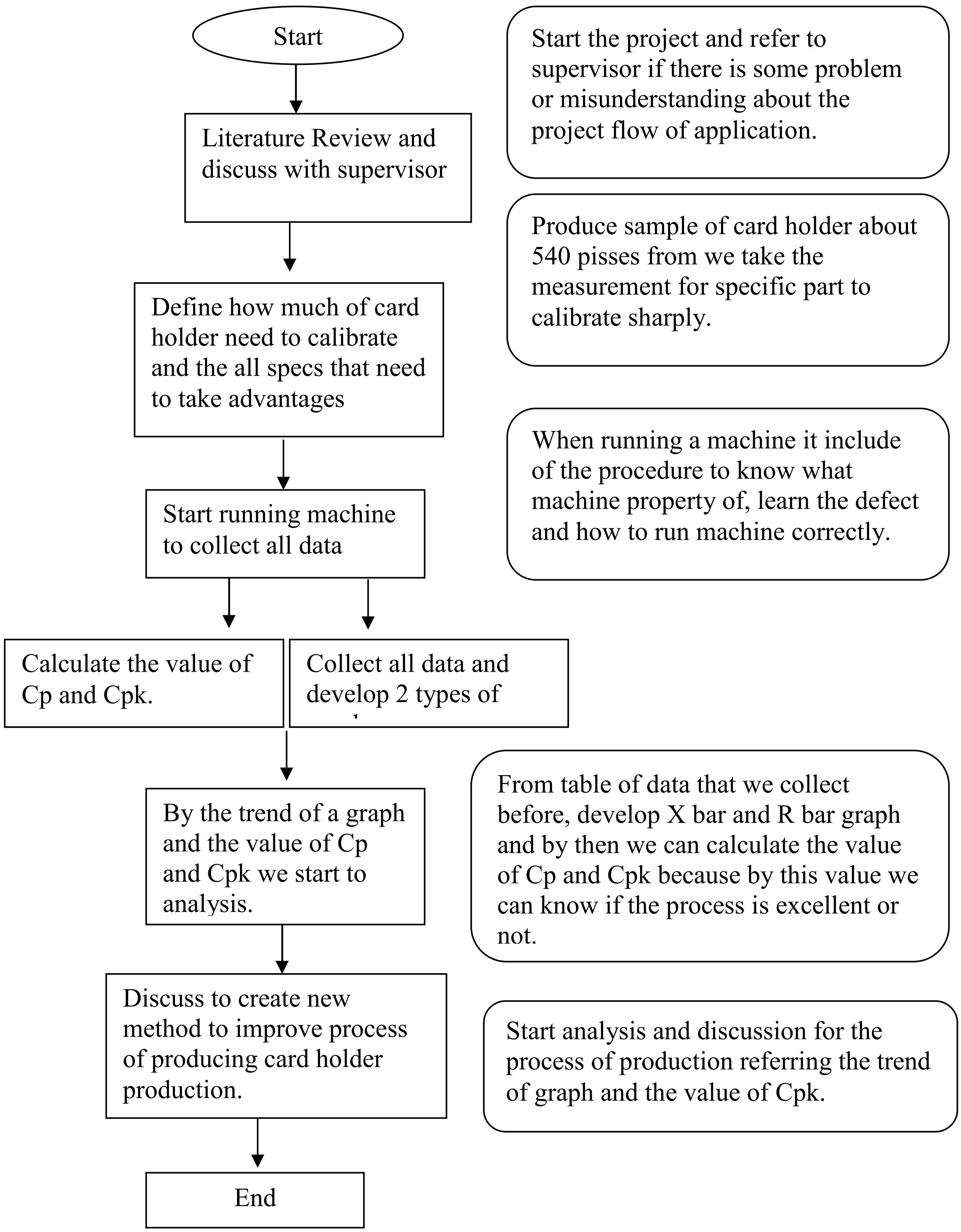


Table 3.1: Flow Chart of The Project

3.4 INJECTION MOLDING

Injection Molding is the most suitable machine to run this Card Holder production. In order to run Injection Molding we must concern with some of criteria to make Injection Molding running to produce the best character product.

The criteria are:

i. Set mold
ii. set injection rod
iii. Set mold size.
iv. Set open mold
v. Set closing mold
vi. Set ejector rod
vii. Cooling system

Explanation for that criterion is setting mold is parameter that we must set to find the best product shape. Then set injection road is actually I mean barrel, refer to 3.2 below. Set open mold, closing mold and ejector road actually is time that we want that particular movement to finish till the end. For more figures refer below. For cooling system is we must on the pipe that produce water to the mold to cool it from hot running.

3.5 PROCESS IN INJECTION MOLDING

Step 1

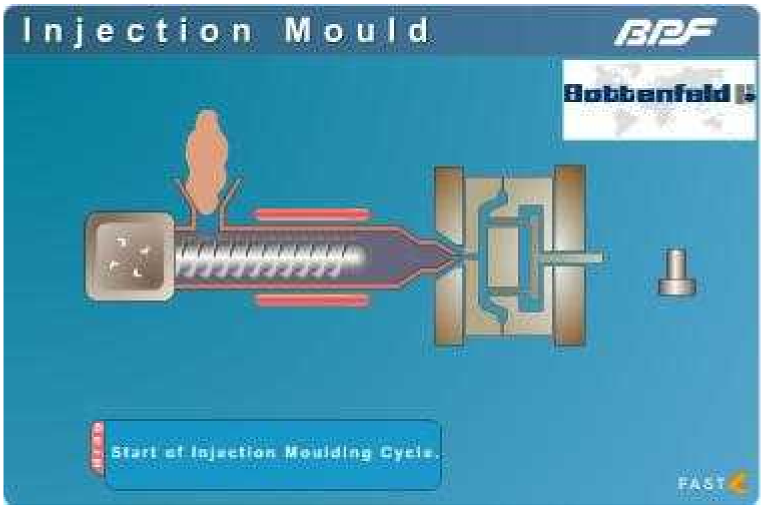


Figure 3.1.1: Process 1

Start of Injection Molding cycle with put some ABS to the Hopper Dryer, in this side ABS will be remove all humidity to make it possible to the next section which is Barrel.

Step 2

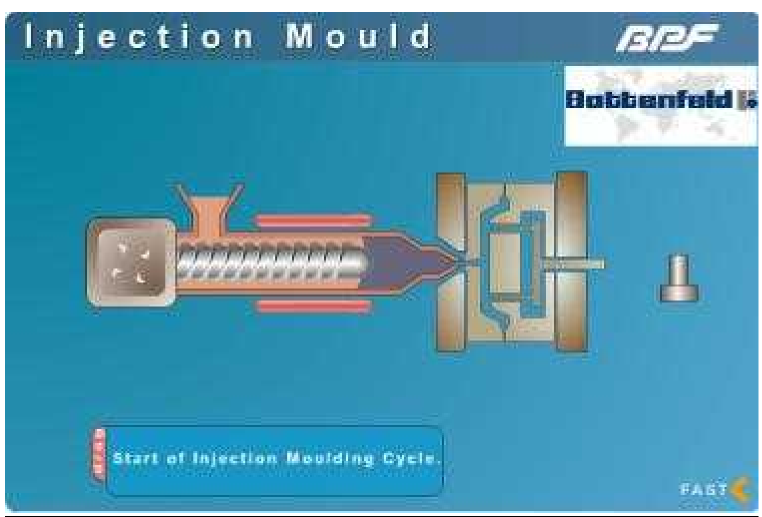


Figure 3.1.2: Process 2

In this side raw materials (ABS) will through to the barrel that was push by a screw inside it. Through this barrel we must set the perfect temperature to ABS melt before it inject to the mold. To set the temperature we must using table or any references to guide us how hot that we can melt this ABS. In production of Injection Molding there is a two type of raw materials, one is ABS that we use here, and then the other one is Polypropylene. Setting temperature between ABS and Polypropylene is differ, by table of references to set ABS raw materials we must set the temperature from 200 C to 260 C. in barrel is consist of 3 stage. So, we just set 200C till 260 C for the last columns in last 3rd stage. See below for more easy explanations.

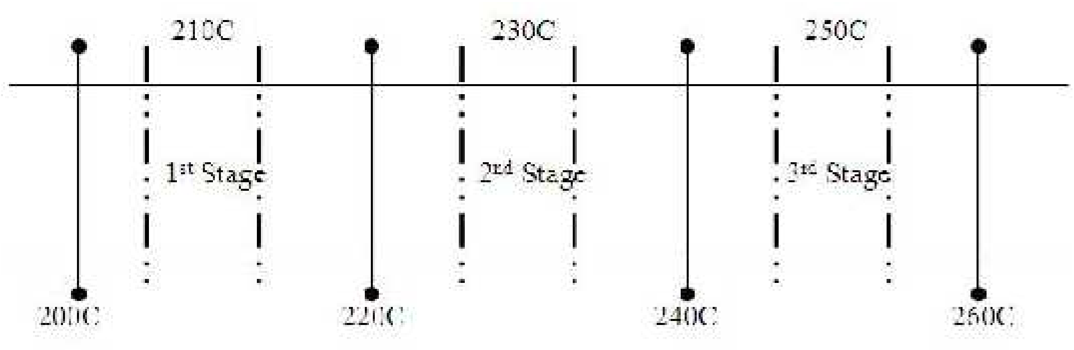


Figure 3.1.3: Process 3

Step 3

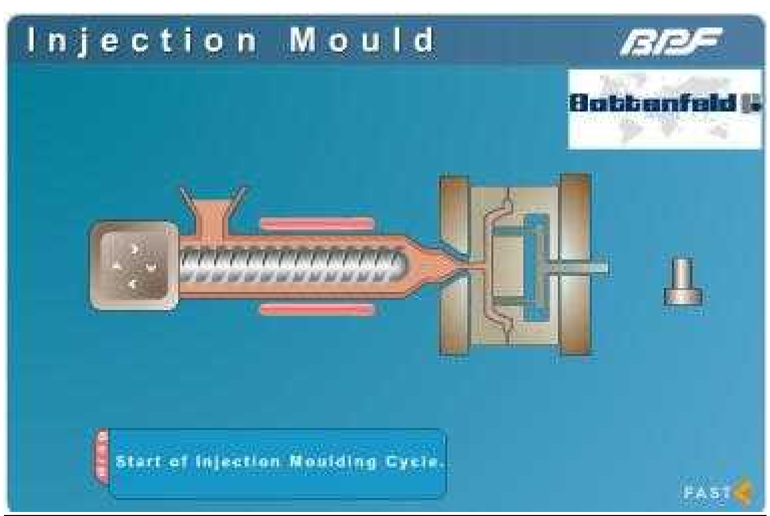


Figure 3.1.4: Process 4

Mold packing stage under injection pressure- in this stage all raw materials that were inject were get inside the mold. And it will produce a product by a hole shape inside the mold. But, aware here before raw materials were inject inside mold we must set the reliable raw that were inject in the mold to avoid loss of raw happen. 15 dos is a minimum value of injection material to a mould. Example here, if we inject 200 dos and after one cycle the value of dos is 50 dos. But the max is 15 dos. So we must reduce the value of those 200 dos. In this thesis 85 dos were suggest and the max of dosage leave is about only 9 to 10. By then it still acceptable most users.

<u>Step 4</u>

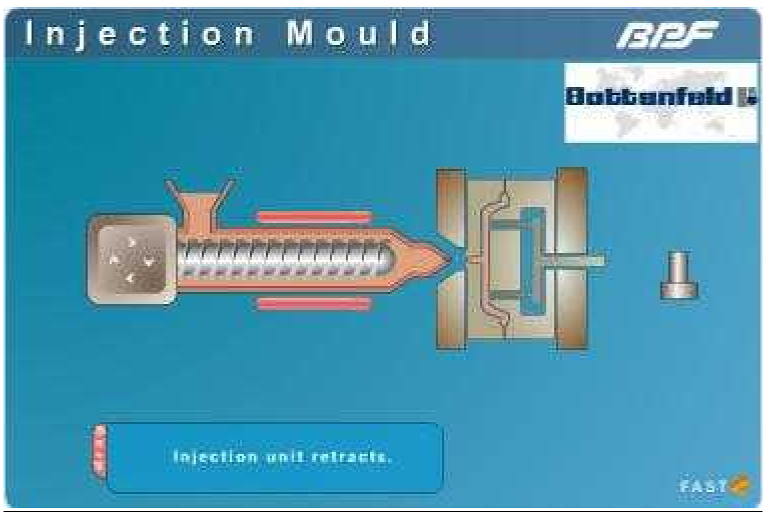


Figure 3.1.5: Process 5

Injection unit retract- this an automatically procedure when the raw materials were inject after that barrel were retract behind a little bit.

Step 5

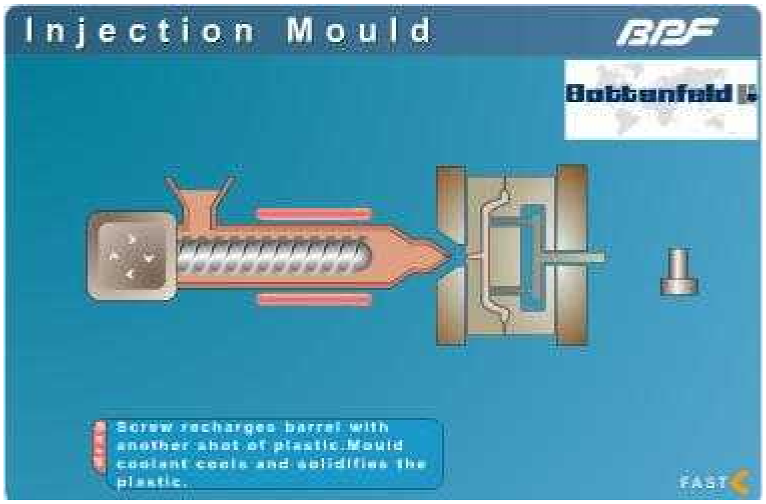


Figure 3.1.6: Process 6

Screw recharge barrel with another shot of plastic. Mold coolant cools and solidifies the plastics.

Step 6

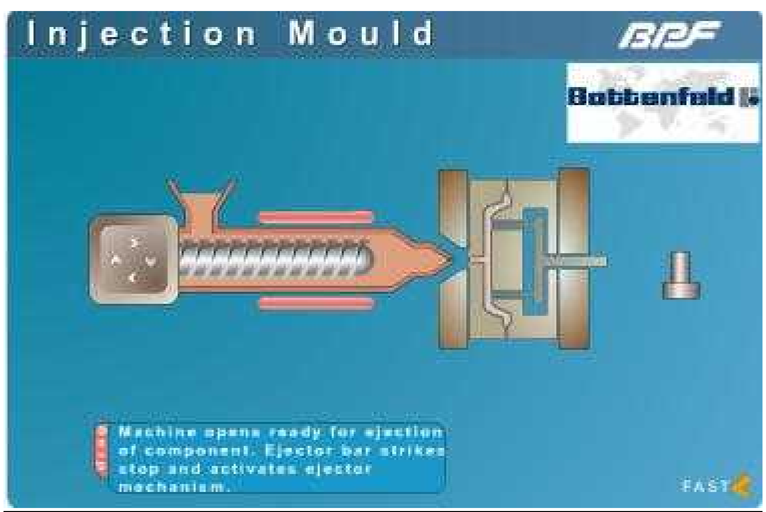


Figure 3.1.7: Process 7

Machine open ready for injection of component, ejector bar strikes stop and activates ejector mechanics.

Step 7

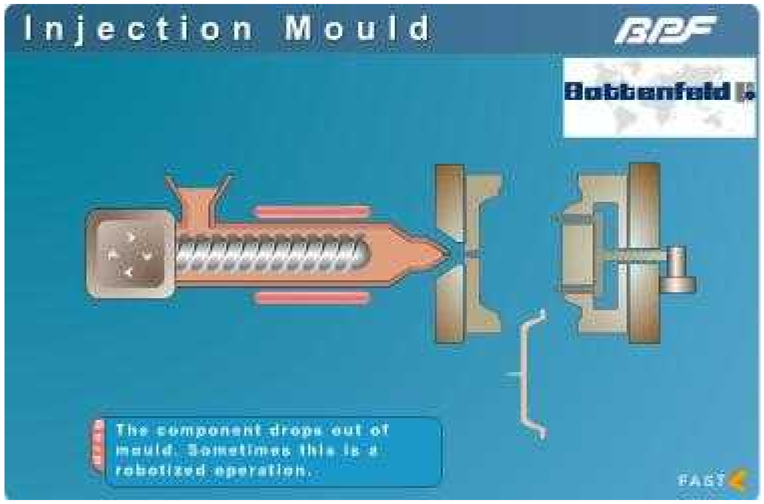


Figure 3.1.8: Process 8

The component drops down out of mol

Step 8

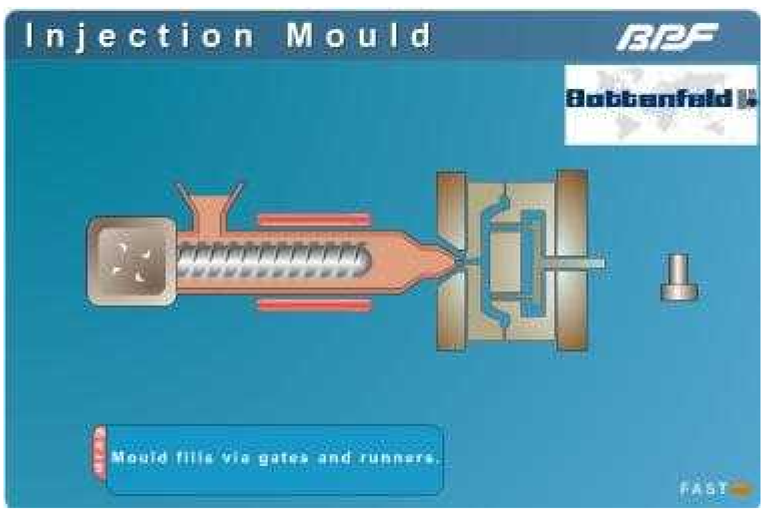


Figure 3.1.9: Process 8

Machine mold tills via gates and runners.

3.3 SETTING MOLDING CONDITIONS

i. Temperature

- Resin temperature slightly lower than estimated to ensure a high cycle time.
- Mold temperature lower than estimated.

ii. Pressures

-Injection pressure, holding pressure and screw back pressure slightly lower than estimated, to protect the mold against damage due to over pack.

iii. Clamping Force

- Slightly larger than estimated to prevent flash.

iv. Speeds

- Injection Speed must be lower than estimated to prevent over pack.
- Screw Speed must be lower than estimated.
- Mold open & close must be lower than estimated.
- Metering stroke volume must lesser than estimated to prevent over pack.

3.8 MATERIALS

3.4.1 ABS

Acrylonitrile-Butadiene-Styrene

ABS resins are available in a wide range of melt flow rates, impact, tensile and flexural strength and heat resistance for a wide variety of high and low gloss injection molding applications. The product demonstrates good mechanical properties, resistance to chlorine, and deflects heat at 210 degrees F.

3.9 TYPE OF DEFECT OCCURED

As refer to literature before defects in injection molding when produce plastic production had many defects that might be occur. But, in this table is the most of defect that might be happen.

i. Short shot mean the status of the product for which the resin was not completely filled in the cavity.
ii. Surface Imperfections such as burr..
iii. Sink Mark is failure among those observed on the product surface.

Defects	Causes
Flash	injection pressure too high, clamp force too low
Warping	non-uniform cooling rate
Bubbles	injection temperature too high, too much moisture in material, non-uniform cooling rate
short shot	insufficient shot volume, flow rate of material too low
sink mark	injection pressure cooling rate
ejector marks	cooling time too short, ejection force too high

Table 3.2: Defects Injection Molding

Figure 3.2: 2 types of major defects, right is flash defect and another is short shot.

3.10 PROJECT PLANNING

Every injection of machine of materials to mold will create 6 of card holder. To reassure that this project verification succeeds, we manage to verify each of 6 card holder. And for accurate result we defined to locate that selected side of card holder. For more view detail see image below.

We manage to run 90 times of injection cycles, which mean it will produce 540 pisses of card holder. That 540 pisses of card holder were categorized with 3 types of requirement that need to verify.

This 3 factor were establish or were collected continuously from Injection Speed and past to Injection Pressure and lastly to Holding Pressure. There is 30 cycles in 3 times in each of 1 cycle. This means we got 540 pisses of card holders.

The results of upper table were put in Result and Discussion side.

3.11 PARAMETER PROCESS

Dosage Strokes	: 70
Time	: 0.5
Screw Strokes	: 73.4 mm
Temperature	
(T801)	: 200 deg.C
(T802)	: 210 deg.C
(T803)	: 222 deg.C
(T804)	: 230 deg.C
(T805)	: 240 deg.C
(T806)	: 250 deg.C
(T807)	: 260 deg.C

Injection Speed	: *see result and discussion*
Injection Pressure	: *see result and discussion*
Holding Pressure	: *see result and discussion*

This parameter process is most of requirement that we need to decide before running machine.

After data above complete collect, start to make an analysis and discussion to research the process data. As a simple explanation, create a control chart in two types, one is X bar control chart and another R bar control chart. Start analysis the trends of control chart and then find the value of Cp and Cpk. Details explanation about Cp and Cpk, flashback to literature review or Analysis and Discussion.

Figure 3.3: Full Product View

CHAPTER 4

DATA CALCULATIONS

4.1 DATA CONTINOUSLY COLLECTED

Like just told before below data even there are in 3 phase but basically it run continuously from Injection Molding, Injection Pressure and then lastly Holding Pressure.

	INJECTION SPEED									
	1	2	3	4	5	6	7	8	9	10
Data 1	55.2	54.96	55.12	55.08	55.14	55.16	55.15	54.97	54.98	55.14
Data 2	55.21	54.97	55.12	54.89	55.17	55.14	55.05	54.88	54.93	55.17
Data 3	55.2	54.98	55.04	55.12	54.93	55.15	55.13	54.98	55.19	55.16
Xbar	55.2	54.97	55.09	55.03	55.08	55.15	55.11	54.94	55.03	55.16
R	0.01	0.02	0.08	0.23	0.24	0.02	0.1	0.1	0.26	0.03

First Phase Continued

	INJECTION PRESSURE									
	11	12	13	14	15	16	17	18	19	20
Data 1	55.27	55.14	55.2	55.2	55.2	55.1	55.3	55.1	55.2	55.09
Data 2	55.27	55.17	55.3	55.15	55.11	55.2	55.29	55.2	55.27	55
Data 3	55.26	55.19	55.3	55.16	55.2	55.3	55.3	55.2	55.27	55.13
Xbar	55.27	55.16	55.27	55.17	55.17	55.2	55.3	55.17	55.25	55.07
R	0.01	0.05	0.1	0.04	0.09	0.2	0.01	0.1	0.07	0.13

Second Phase Continued

	HOLDING PRESSURE									
	21	22	23	24	25	26	27	28	29	30
Data 1	55.26	55.2	55.2	55.2	55.21	55.2	55.2	55.2	55.2	55.18
Data 2	55.29	55.19	55.2	55.2	55.2	55.2	55.2	55.09	55.2	55.18
Data 3	55.28	55.2	55.21	55.2	55.21	55.2	55.2	55.09	55.2	55.18
Xbar	55.28	55.2	55.3	55.2	55.2	55.2	55.2	55.13	55.2	55.18
R	0.03	0.01	0.01	0	0.01	0	0	0.11	0	0

Third Phase Continued

Table 4.1: Data Collected

4.2 X BAR AND R BAR COTROL CHART

4.2.1 X bar Control Chart:

Central Line (CL) = X double bar figure you calculated.

Upper Control Limit (UCL) = X double bar + A2 * R bar.

Lower Control Limit (LCL) = X double bar - A2 * R bar.

n	*A2*	*D4*	*D3*
2	1.88	3.267	---
3	1.023	2.575	---
4	0.729	2.282	---
5	0.577	2.115	---
6	0.483	2.004	---
7	0.419	1.924	0.076
8	0.373	1.864	0.136
9	0.337	1.816	0.184
10	0.308	1.777	0.223

Table 4.1: Data Recommendation for X bar

$$\text{CL= X double bar} = \frac{\text{X bar}_1 + \text{X bar}_2 + \text{X bar}_3 + \ldots \text{X bar}_{30}}{30}$$

$$= \frac{1658.88}{30}$$

$$= \mathbf{55.16\ cm}$$

Referring to the formula above in 4.2.1, it will help to how to define the value of Center Line, CL. This CL will help us the average measurement in the graph that will be develop after this. That X bar defines by an average calculation in each of three data that were collected. Refer to table 4.0 again for more accurate information. For data above means that the value of all average in data measurement is 55.16 cm.

$$R\ bar = \frac{R_1 + R_2 + R_3 + \ldots R_{30}}{30}$$

$$= \frac{2.06}{30}$$

$$= \mathbf{0.07}$$

This value for conclude in R bar chart that defer from data above for X bar graph. By then, the value of Center Line in R bar is 0.07.

UCL =	X double bar + A2 * R bar	LCL =	X double bar - A2 * R bar
=	55.16 + 1.023 * 0.07	=	55.16 - 1.023 * 0.07
=	**55.23** cm	=	**55.09** cm

For data calculations above, UCL means Upper Control Limits and LCL means Lower Control Limits. This value of CLC and LCL will contribute to develop graph and by then in analysis it will interpret whether the measurement that we take before in control or out of control.

After all calculation finished, start plot a graph, below is the result of a graph. For the analysis of the graph please move on the next sub chapter.

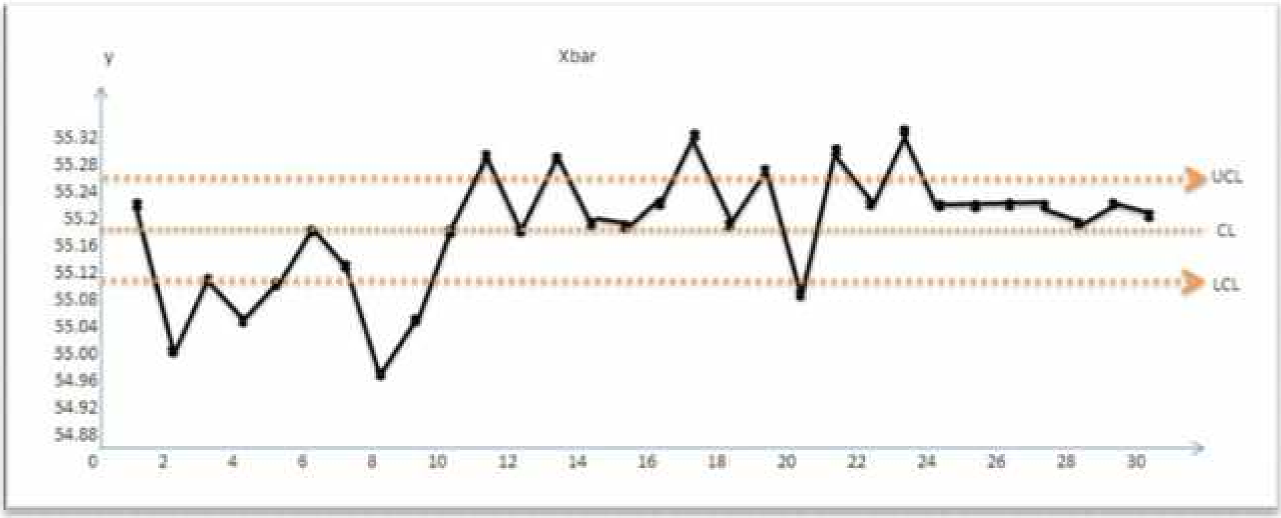


Figure 4.1: X bar Control Chart

4.2.2 R Control Chart:

Central Line (CL) = R bar figure you calculated.

Upper Control Limit (UCL) = D4 * R bar.

Lower Control Limit (LCL) = D3 * R bar.

Table 4.2: Data Recommendation R bar

n	*A2*	*D4*	*D3*
2	1.88	3.267	---
3	1.023	2.575	---
4	0.729	2.282	---
5	0.577	2.115	---
6	0.483	2.004	---
7	0.419	1.924	0.076
8	0.373	1.864	0.136
9	0.337	1.816	0.184
10	0.308	1.777	0.223

CL = 0.07 (refer above)

LCL =	D4 * R bar	UCL =	D3 * R bar
=	2.575 * 0.07	=	0 * 0.07
=	**0.18**	=	**0**

This data above shows the value of control limit for R bar Control Chart. The value of LCL is 0.18 but for UCL is 0, because of referring to the table 4.2, it show there is no value for D3.

And the graph is,

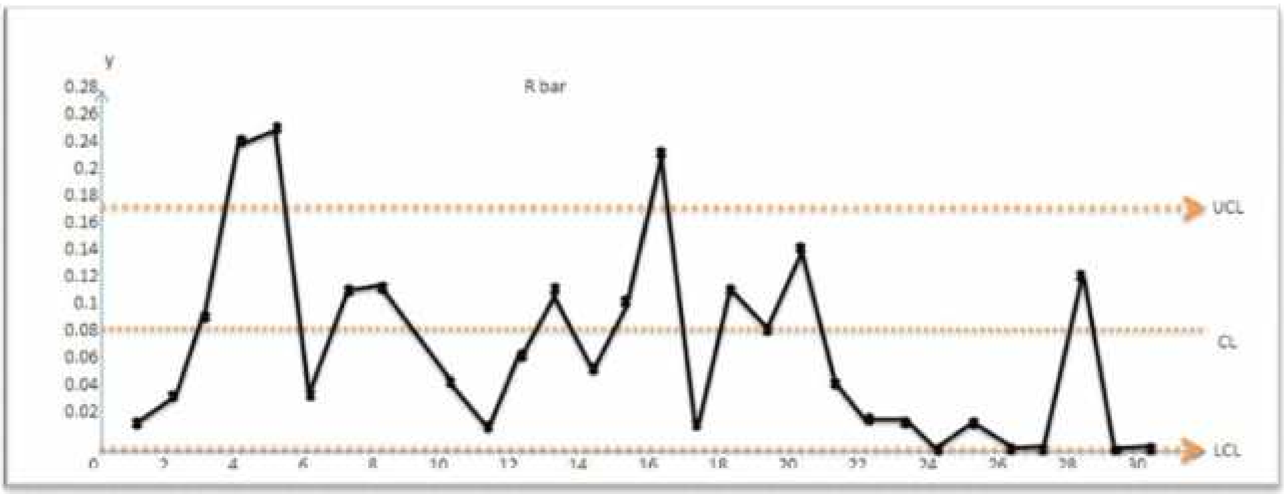


Figure 4.2: R bar Control Chart

5.3 CALCULATE THE VALUE OF CP AND CPK

Procedure to find Cp & Cpk Values:

Terminology:

б: Sigma or Standard Deviation

Xav: Average of all the readings

X1, X2,…. Xn: Various Readings Noted Serially.

n:no. of Readings

HSL: Upper Limit of Tolerance

LSL: Lower Limit of Tolerance

$$б = \sqrt{\frac{(X_{av}-X_1)^2 + (X_{av}-X_2)^2 + (X_{av}-X_3)^2 + (X_{av}-X_4)^2 + \ldots\ldots(X_{av}-X_n)^2}{n-1}}$$

$$C_p = \text{Tolerance} / 6б$$

TOLERANCE= HSL – LSL

Cpk1 = ((HSL - Xav) / 3 σ)

Cpk2 = ((LSL - Xav) / 3 σ)

Ideally Cpk1 ≈Cpk2

However practically, it is never so. Hence one of the two Cpk , whichever is lower is taken as the actual Cpk.

If Cpk1 < >Cpk2 (if both the values are not very close), please repeat the process.

Figure 4.3: Formula for Cp and Cpk.

5.3.1 Calculations

σ = Sigma or Standard Deviation

X av = Average of all reading

= **55.16**

X n = X1, X2, X3,… X30

UPL = 55.23

UPL = 55.09

Above statement is a all number that need to fill out in the formula of Figure 4.3 in order to define the value of Cp and Cpk.

$$\sigma = \left[\left(\frac{(55.16-55.20)2 + (55.16-54.97)2 + (55.16 - 55.09)2\ldots + (55.16-55.18)2}{30-1} \right) \right]$$

$$\sigma = \frac{0.1338 + 0.069 + 0.0305}{29}$$

$$\sigma = \mathbf{0.08969}$$

$$Cp = \frac{UPL - LPL}{6\sigma} \qquad Cpk = \frac{(UPL - Xav)}{3\sigma}$$

$$Cp = \frac{55.23 - 55.09}{6\,(0.08969)} \qquad Cpk = \frac{55.23 - 55.16}{3\,(0.08969)}$$

$$Cp = \mathbf{0.26} \qquad Cpk = \mathbf{0.26}$$

Process Capabilities, Cp and Cpk above are 0.26. This value of Cp and Cpk has their means itself. Refer to the Analysis and Discussion for more accurate meaning.

4.4 RESULT AND DISCUSSION

4.4.1 Trends reading

Refer to Figure 4.1, it shows in the first variation were in control but through to the 2nd and 5 cycles it began to out of limit. From cycle's number 6 and 7 it still in range but after cycles number 8 to 9 it again below range of limit. From 24 to 30 data shows 7 point was too close. And also from point 17 to 23 data above center line limit, and out of control limit especially in point 23.

4.4.2 Factor that effect production side

Basically 4 M & E are the main group of factor that was subject to this process of data collection. 4 M stand for machine, method, men and material and E stand for environment.

Man factor that cover up the process of production, first is training. The practice of trainee to control machine is very low that will damage the criteria or product. From this is also will affect the maintenance capabilities of human to repair machine problem. Men also not many that is skilful to do maintenance and even control the machine specs before it started. By men factor also it will increase the cost of financial to employed supervisor to lead the machine.

Machine factor we conclude that it need maintenance especially to control the heat in mould. To control the temperature of mould we must on the water pipe that through to the mould to lower the temperature. In machine factor, the factor of 5S was not applied. And the result from this will damage the specs or criteria of production like an example for card holder. Mould also maybe were not look out, because usually just start the machine for running their product and stop running process without concern the ability of mould criteria.

Method factor maybe we establish the factor in System Operational Process, SOP. The way of we control the machine is also effect the result. Especially when we want start running the machine we must find the possible time to heat up the machine, around 33 minutes. So we must develop SOP to validate the new era of machine. Method factor also cover up the important this to applied 5S factor.

Material factor is also one of the most common difficulties that we must control. For this material we use ABS that defer than Polypherene that use before this. The value temperature to melt ABS material can refer in Methodology. And also another reason by material is after complete running operation by injection molding; the '*baki'* of material inside of injection molding creates. So before start another running process of injection molding we must throw away all eternal inside the injection molding screw (usually happen material eternal inside).

Environment, for environment factor what we can consider of is how frequent this machine running and how much time mould has been change. Basically environment factor has meant to men factor also. Full of it when machine running it control by environment that just control by men power.

4.5 R BAR CONTROL CHART

4.5.1 Trends

Referring to the Figure 4.2 In R bar Control Chart above the trends shows had 3 point out of limit, UCL. From the first point until 5th cycles it move up. Non random pattern shows in the middle of process. From point cycle 21th until 27th, data shows 7 point below range and close up together.

4.5.2 4 M + E

Men factor is factor that contributes to the process mostly. Without men contribution this process was less than ever. But from that contribution it also gives some damage or bad result because of bluntness of human factor. From that data above there is first cycle point not in good result after from human factor key in the unperfected value for injection speed. This value was too high. Defer with point 2nd and 3rd. From man power factor this value of injection speeds in excellent, not like in point 4 and 5, also in the last of process of injection speed. That R bar data shows graph drop down which means injection speed that too low were gave bad result for production. Basically in the middle of process by using the injection pressure it gave more result of product specifications. Rather than in last group of data used too low holding pressure were gave bad result for production also. Man also not to skilful to control injection molding machine.

Machine factor we conclude that it need maintenance especially to control the heat in mould. To control the temperature of mould we must on the water pipe that through to the mould to lower the temperature.

Method factor maybe we establish the factor in SOP, System Operational Process. The way of we control the machine is also effect the result. Especially when we want start running the machine we must find the possible time to heat up the machine, around 33 minutes. So we must develop SOP to validate the new era of machine.

Material factor is also one of the most common difficulties that we must control. For this material we use ABS that defer than Polypherene that use before this. The value temperature to melt ABS material can refer in Methodology. And also another reason by material is after complete running operation by injection molding, the lost of material inside of injection molding create. So before start another running process of injection molding we must throw away all eternal inside the injection molding screw (usually happen material eternal happen).

Environment, for environment factor what we can consider of is how frequent this machine running and how much time mould has been change. Basically environment factor has meant to men factor also. Full of it when machine running it control by environment that just control by men power.

4.6 PROCESS CAPABILI CP AND CPK

Cp = 0.26 **Cpk = 0.26**

Referring to the data and Data Calculation the value of Cp and Cpk is 0.26. this value of data has their meaning itself. Refer to the table below to see each of specs that Cpk value above means.

Cpk Value	Explanations
1/2	means you've crunched nearest the door edge (ouch!)
1	means you're just touching the nearest edge
2	means your width can grow 2 times before touching
3	means your width can grow 3 times before touching"

Table 4.3: Cpk Value Means

4.7 DISCUSSION

By convention, when a process has a Cp value less than 0.26, it is considered potentially **incapable** of meeting specification requirements. Conversely, when a process Cp is greater than or equal to 1.0, the process has the potential of being capable. Ideally, the Cp should be as high as possible. The higher the Cp, the lower the variability with respect to the specification limits. However, a high Cp value doesn't guarantee a production process falls within specification limits because the Cp value doesn't imply that the actual spread coincides with the allowable spread. What this project in order to get the best value of Cp we must select the reliable value of Control data which means the value of Injection Speed, Injection Pressure and Holding Pressure.
For the value of Cpk which is is below 1, 0.26 mean that process incapable. Cpk must equal 1 or little higher than 1 to prove that process running machine are in capable. The Cpk is inversely proportional to the standard deviation, or variability, of a process. The higher the Cpk, the narrower the process distribution as compared with the specification limits, and the more uniform the product. As the standard deviation increases, the Cpk index decreases. At the same time, the potential to create product outside the specification limits increases.

4.8 FUTURE PLAN AND PROPOSAL

4.8.1 4 M + E

For future this factor of 4 M + E is really advisable to locate the functionality of process. First is *man*, after this improves the training schedule. Find there are skilful in control Injection Speed to train trainee to increase their skill. Technician should always check or does a maintenance on the machine especially the screw which is the part of material melt and inject into a mould and also in mould too. Check it weather mould is capable to going through the running machine again or not.

Material factor is before start a running machine, check the eternal of melt inside the machine weather there is eternal or not. To check it just selects the button in the control panel. This procedure must follow before start the running product which is after we wait about 33 minutes due to heat up the machine.

Method factor will cover up what step we acquire to run the machine perfectly. To improve it, level up the splendor of Standard Operating Procedure. 5S application should also apply because before this the procedure of running injection molding not follows the 5S rule.

Machine factor is more attach to maintenance factor, maybe also 5S not applied that make machine look dirty and not adequate properly to run machine. Mould also not change since it can't use any more. 5S also not applied that will damage the capability of machine production.

4.8.2 5S

Basically 5S is a factor to the successful of production that need to follow. In consist of 5 factor which *seiri, seiton,seiso, seiketsu* and *shitsuke*. This 5 factor have their meaning itself. In industry or production line the application of this 5S will give good advantages of industry.

First is seiri, which means separate the equipment that no needs to use in work area and throw it away. This is important to make we all confuse because in production line there is a lot of tool or equipment. Second is *Seiton*, arrange the equipment that useful in order in rack or shelf as an example, by this it easier to use or to take when we want to use it soon. For an example for venire caliper that much use in Injection Molding side to calibrate product. This equipment must keep and arrange smoothly. *Seiso* is to clean up work area from dirty especially dusk and oil. By then our safety precautions will go to the next level. *Seiketsu* means uniform the spec of sanitary of work area and arrangement of equipment frequently.

Lastly is the *Shitsuke,* train workers to follow the rule in work area and concern about how important of sanitary in production.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

SPC is a powerful technique that has been applied effectively on continuous and large batch size processes. Practitioners of Statistical Process Control must appreciate that the focus of an SPC initiative needs to be shifted from product characteristics to process parameters, as it is the process that builds quality into the product. With special considerations discussed above, and a process focus, SPC can be equally effective for small and short runs as well.

SPC is a very powerful tool if properly applied and utilized. It can lead the way to very effective process and quality improvements. However, used the wrong way, it is a waste of time and money and would certainly prevent your company from achieving certification to the ISO standards and requirements. SPC will identify when a problem (or special cause variation) occurs. If only the usual - or common cause - variation exists in a process then 'fixing' only one or two things will not improve the process.
In summary, Cp tells us how capable our process is. If there is tons of variation your process may not be very capable at all. In this case you will want to reduce variation which will improve your Cp.

When you are happy with Cp you can move onto to Cpk which tells us how centered our process is. If your process is capable (good Cp) but is hugging the upper customer specification limit your Cpk will be poor. In order to improve Cpk you will need to work on “shifting” the process back towards the mean of the process.

There are some rules to all this Cp and Cpk fun. One giant rule is that your data must follow the normal distribution. Here is an excellent article from Keith Bower on this very topic.

5.1 RECOMMENDATION

Action that need to improved Cp and Cpk value.

First, recognized the value of Cp and Cpk weather it below range or not. If Cp and Cpk are less than one, there are two actions need to take. The first (an unadvisable one) is to widen the specification particularly on the side that has the spec limit closest to the center of the process. The second and more advisable answer is to improve the process by reducing variation in the process. If the process is off-center, it would be advisable to try to center it as you try to improve it.

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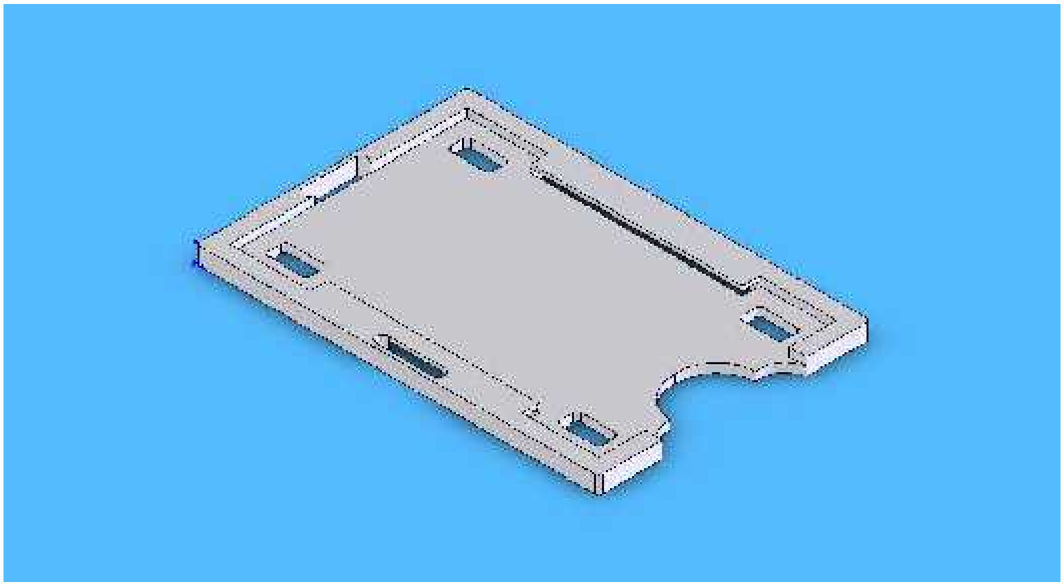
APPENDIX

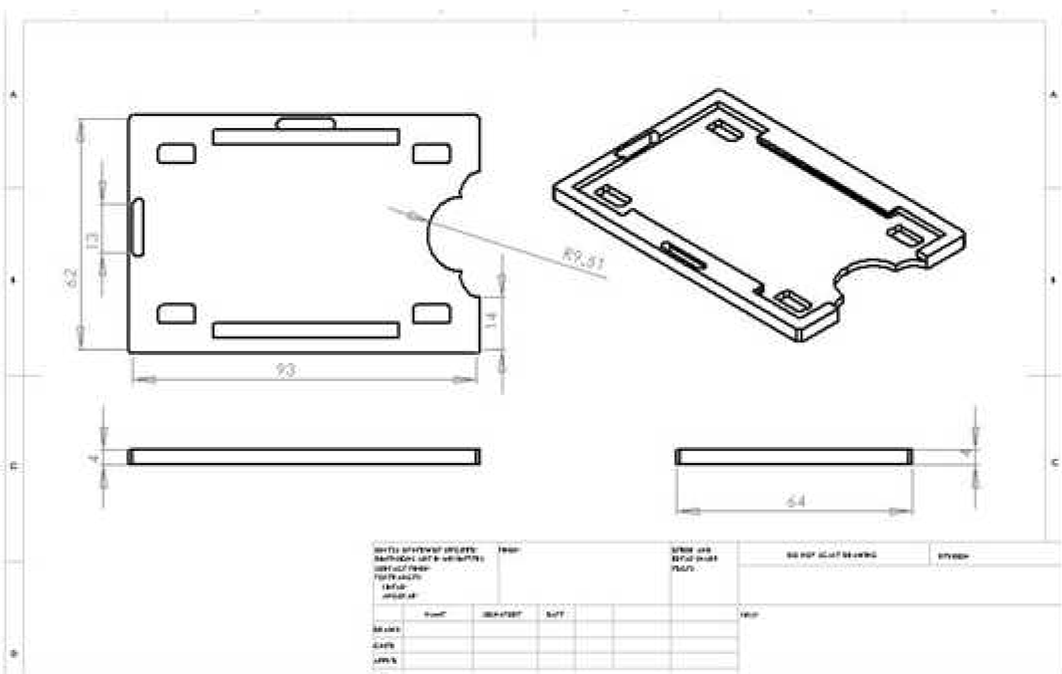
GUN CHART


Research Activities
Frequency
July
August
September
October
W1
W2
W3
W4
W5
W6
W7
W8
W9
W10
W11
W12
W13
W14
Briefing and meeting with
plan
Discuss about the topic
plan
Identify injection
plan
Produce samples
plan
Identify type of defects
plan
Analyze quality control
plan
Writing report
plan
Writing summary report
plan
Present the project
plan

B. GUN CHART

View of Card holder that design using Solid Work software (actual measurement)





B. MATRIX CARD HOLDER

Pictures that related to the successful of this project

C. Actual Shape for Card holder

D. Material, ABS to produce card holder

E. Water pipe that flow to Mould to cool is down.

F.Place that need to mould tight for.

G. Injection Molding

H. Injection Molding of each part.