



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**DESIGN OF AUTOMATIC METAL STRIPS PALLET STACKER FOR SLITTING  
MACHINE**

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia  
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(Robotic and Automation) (Hons)

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## ABSTRACT

This project report presents the work done on the design of automatic metal strips pallet stacker for slitting machine. Slitting machine is a machine used in food can manufacturing to cut the tinplate sheet into equally small rectangular shape metal strips. The machine delivers the cut metal strips to the metal strips stacker which located at the end of the machine. The collected metal strips are transferred to the wooden pallet manually by at least one operator. The automatic metal strips pallet stacker is an upgraded of the slitting machine collector for which the cut metal strips from the slitting machine is deposited at the wooden pallet automatically without any manual process. The design constraints of this project is determined by the specification of the slitting machine used in Comfish Industries Sdn. Bhd.. Several software are compared in terms of ease of use, export capabilities and material properties based on the information from the referred journal to select the software for designing the automatic metal strip pallet stacker for the slitting machine. The initial sketching of the design ideas have been produced after studied the existing slitting machine metal strips stacker in the existing market. The detail design and assembly drawing of the designed idea is created using the SolidWork software. After the detail drawing is produced, the functional components of the design have been subjected under the stress and displacement analysis to ensure that it will not fail when the load is acted on it. In addition, the factor of safety of the Conveyor A and Conveyor B also have been computed and both of them are considered safe to be used in the real application. At the end of this project, the designed machine and it soft model are successfully done. For future work, it was suggested to fabricate and test the machine and improve it if necessary.

## ABSTRAK

Mesin pencelahan ialah mesin yang telah digunakan di industri pembuatan tin bagi mencelah lapisan plat timah kepada kepingan kecil yang sama saiz dan berbentuk segi empat. Mesin pencelahan akan menghantar kepingan kecil plat timah ke tempat pengumpul produk mesin yang terdapat di bahagian hujung mesin. Kepingan kecil plat timah yang telah dikumpul di mesin pencelahan akan dialihkan dari mesin ke palet secara manual dengan sekurang-kurangnya satu operator. Automatik pengumpul kepingan kecil plat timah pencelahan mesin adalah pengubahsuaian versi pengumpul kepingan kecil pencelahan mesin dimana kepingan kecil yang telah dihasilkan oleh mesin akan terus dihantarkan ke palet. Mesin pencelahan yang terdapat di Comfish Industries Sdn. Bhd. telah dijadikan panduan untuk menentukan spesifikasi projek. Beberapa perisian telah dibandingkan dari segi kesesuaian pengguna, kemampuan eksport, dan ciri-ciri sifat bahan bagi menentukan perisian yang sesuai untuk menghasilkan reka bentuk projek. Laporan ini juga mengandungi langkah-langkah termasuk mengenalpasti, membuat senarai, kajian produk dan perbandingan hasil. Selain itu, idea lakaran awal automatik pengumpul kepingan kecil plat timah pencelahan mesin juga telah dilukis dari rujukan mesin pencelahan yang terdapat di pasaran industri terkini. Selain itu, SolidWork telah diguna untuk menghasilkan lukisan terperinci reka bentuk projek. Dengan menggunakan SolidWork, reka bentuk projek telah dianalisis supaya projek boleh digunakan tanpa sebarang masalah. Selepas analisis telah dibuat terhadap reka bentuk projek, faktor keselamatan (FOS) telah dikira untuk memastikan komponen-komponen projek boleh berfungsi dengan lancar. Kesimpulannya, objektif-objektif yang telah dinyatakan dalam projek telah tercapai. Pada masa yang akan datang, reka bentuk projek ini berharap boleh dapat dihasil dan diuji supaya kekurangan yang belum dikenalpasti boleh dapat dikesan dan diperbaiki.

## **DEDICATION**

I would like dedicate this report to my lecturer, technician, my family and my friends for helping during the research activities. There is no doubt in my mind that without their continued support and counsel I could not have completed this project.

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## **LIST OF ABBREVIATION, SYMBOLS AND NOMENCLATURE**

CAD	-	Computer-Aided Design
VRML	-	Virtual Reality Modeling Language
API	-	Application Program Interface
2D	-	Two Dimensional
3D	-	Three Dimensional
FOC	-	Factor of Safety
AC	-	Alternating Current
DC	-	Direct Current
N	-	Newton
kg	-	Kilogram
FEA	-	Finite Element Analysis

# CHAPTER 1

## INTRODUCTION

### 1.1 Background

The food can is a tool to preserve foods in a safer and longer time. The way of preserving food inside the can is called canning. Canning is an effective method of food preservation. The canning includes food preparation, can fabrication, storing of food inside the can, sealing of filled can, heating of sealed can, cooling and labelling. The can in the market now day is generally made of steel. Steels can is environmental friendly product because it is recyclable. The food can be classified based on several aspects. In terms of structure, the can is classified into 2-piece can and 3-piece can. The 2-piece can is consist of seamless cylindrical can body with one integral end (base) shaped from a flat disc and the other end mechanically joined to produce a closed container. The 3-piece can is consist of cylindrical body rolled from flat rectangular sheet with the side seams overlapped and joined using electrical resistance welding and two ends mechanically joined to produce a closed container Anne Emblem (2012). The manufacturing of the tin is consists of several processes which include shearing, coating, printing, slitting, flanging, spray coating and baking.

For the project, the focus is stress only on slitting process. Slitting is a process for which the metals sheet is cut into small equal size metal strips. The slitting machine is used to cut the metal sheet into short metal strips that is used as tin body. The cut metal strips are deposited at the collector of the slitting machine and load to the wooden pallet manually.

The idea of carry out this project is to help the Comfish Industries Sdn. Bhd. to improve the productivity of the slitting machine. The project is to develop the new concepts for the slitting machine metal strips collector to collect the cut metal strip at the pallet in a more effective way in term of man power and time consuming.

## 1.2 Problem Statement

The inability of the existing machine to collect the cut metal strips continuously has caused the bottleneck operation. The machine has to stop from time to time after the collector has received 20 to 30 cut metal strips. The slitting machine is generally run by 2 to 3 operators. Two operators will be responsible to manually transfer the metal strip from the collector to the pallet and 1 operator is needed to control the operation of the machine. A lot of time is wasted during the transferring of the metal strips from the collector to the pallet. By having the automatic wooden pallet metal strips collector, the metal strips can be transferred to the machine automatically. The automatic metal strips collection at the wooden pallet will result in smooth continuous operation of the machine. The operator no longer needs to stop the machine to transfer the metal strips from the collector to the wooden pallet. The productivity of the process will increase as the total process time is reduced. The number of workers needed to operate the machine also can be reduced and result in reduction of labour cost. So, the project is needed to be designed to solve the above problems.



Figure 1.1: The type of double slitting machine collector in Comfish Industries Sdn. Bhd. (Comfish Industries Sdn. Bhd., 2014)

## 1.3 Objectives

- i. To design automatic metal strips pallet stacker for slitting machine.
- ii. To develop a soft prototype of the above designed machine.

## 1.4 Scope

The scopes of the project are as described below:

- i. The design of automatic metal strips pallet stacker for slitting machine is based on the design requirement in Table 1.1.

Table 1.1: The design constraint of the automatic metal strip pallet stacker for slitting machine

No.	Design Criteria	Constraint
1	Material	Tin coated steel
2	Number of metal strips output at 1 time (pieces)	Less or equal to 7
3	Dimension of wooden pallet, width x length (mm)	816 x 925
4	Size of metal strip (mm)	230.05 x 115.65
5	Thickness of metal strip (mm)	0.22
6	Wooden pallet load weight (kg)	1600
7	Feeding Speed of Feeder Machine	20 pieces/minutes

- ii. Develop a soft prototype (model) of the designed automatic metal strip pallet stacker for slitting machine using suitable CAD software.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Introduction of slitting process**

The slitting process is very important to the 3-piece can manufacturer now days. The use of slitting machine in slitting process is a better way to produce high quality cut of tinplate compare to other cutting method. The slitting machine use roller cutter to cut the tinplate by shear force. There are many type of slitting machine available in market today. Each type of slitting machine has different function and specifications according to the manufacturer. There are two type of slitting machine used in Comfish Industries Sdn. Bhd., single slitting machine and double slitting machine. The single slitting machine involves only the first slitting operation which cut the sheet into strips as wide as the body circumference, including seam. The double slitting machine includes both the first slitting operation and second slitting operation. The tinplate sheet is firstly cut into strips according to the tin body circumference, and the second cuts these into blanks of the required height. Sheet edges are cut precisely square during these operations (E. Morgan, 1985). The figure of the single slitting machine and double slitting machine is shown in Figure 2.1 and 2.2.



Figure 2.1: The SGS 120 Guillotine Slitter (Source: <<http://www.soudronic.com/3-piece-cans/slitters>>)



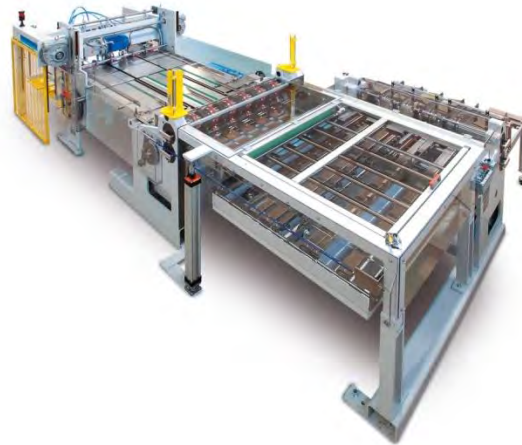


Figure 2.2: The Cepak Duplex Slitter 110 MK2 CAR (Source: <<http://www.soudronic.com/3-piece-cans/slitters>>)

Basically, the slitting machine has a stacker or collector to collect the output of the machine. The blank collecting process can be done in either automatically or manually depend on the machine capability. Due to the incredible advantages of automation, the can manufacturers now days have gradually transform their production operations into fully automatic system. The can manufacturing processes are integrated into a single production line to increase the productivity of the process. Therefore, the slitting process will integrate with the next process which the blank output from the machine will be send to the next workstation automatically by robots or machine. However, the implementation of the fully automated system will incurred very high cost in purchasing of machine and long term maintenance fee, so the small and medium scale company will usually prefer the conventional can making processes due to limited amount of capital. For the Comfish Industries Sdn. Bhd., the can making process is not integrated and the work station of each process is separated with each other. Therefore, the loading and unloading of material using wooden pallet and a fork lift to transfer the material from workstation to workstation is needed. The output of the slitting machine will be move to the wooden pallet and transfer to the next work station by fork lift.

This section will show the information about the design of machine based on online article, books and journal. The design of automatic wooden metal strips pallet stacker is made for the double slitting machine in Comfish Industries Sdn Bhd.. The design

requirement, specifications and analysis that need to invent the machine is also included in this section.

### 2.1.1 The GT10A6 Duplex Slitter Machine Manual, 2014

The guideline of the design is based on GT10A6 Duplex Slitter Machine manual which is available from the website. The technical specification data is shown in the manual which include the feeding speed of feeder machine, cutting speed, thickness of cutting sheet and minimum width of horizontal cut iron sheet. The metal strip collector is comes with the slitter machine because the collector is a part of the slitter machine. The collector of the different slitter machine may different from each other as the specification of each machine is different. The collector of the machine is made based on the specification of the slitter machine itself. The technical specification of the machine is shown in the Table 2.1.

Table 2.1: The technical specification of the GT10A6 Automatic Tinplate Duplex Slitting Machine  
(Source:< <http://jx-yixin.en.alibaba.com/>>)

Slitting Machine Spec.	Unit	Constraint
Feeding speed of feeder machine	Piece/min	0~32 (frequency control of motor speed)
Iron Cutting Speed (Speed of Feeding Chain)	m/min	0~59
Application range of cutting iron sheet	mm	600~1150, 600~1250
Thickness of cutting iron sheet	mm	0.15~0.5
Min width of cut iron sheet	Piece	1~6
Min width of horizontally cut iron sheet	mm	48(if less than 48, tool apron needs to be replaced)
Total unit power	kw	5.45
Exterior Dimension of Machine (L*B*H)	mm	6650 x 3880 x 1530
Weight of Machine	kg	6700

The specification of the slitter machine is a very important data in determining the suitable collector specification. For example the feeding speed of the feeder machine determine the total output rate of metal strips at the collector, the iron cutting speed determine velocity of the projected metal strips from the slitter machine and the thickness of the cutting iron sheet will determine the maximum stacking height of the metal strips at the collector.

### **2.1.2 The metal strips collector of slitting machine**

The collector of the slitting machine is consists of multiple runway cavities, damper and stopper. Each runway provides a space that it area is fit with the size of the cut metal strip. As the metal strip is send out of the machine cutter, it will project to the runway and hit the stopper. The stopper will absorb the impact from the metal strips and fit the metal strip to the runway cavity. The next metal strips will undergo the same process and stack on the runway cavity until the operator stop the process. Figure 2.3 and 2.4 has shown the diagram and structure of the metal strips collector of the slitting machine used in Comfish Industries Sdn. Bhd..



Figure 2.3: The metal strip collector in Comfish Industries Sdn. Bhd. (Comfish Industries Sdn. Bhd., 2014)

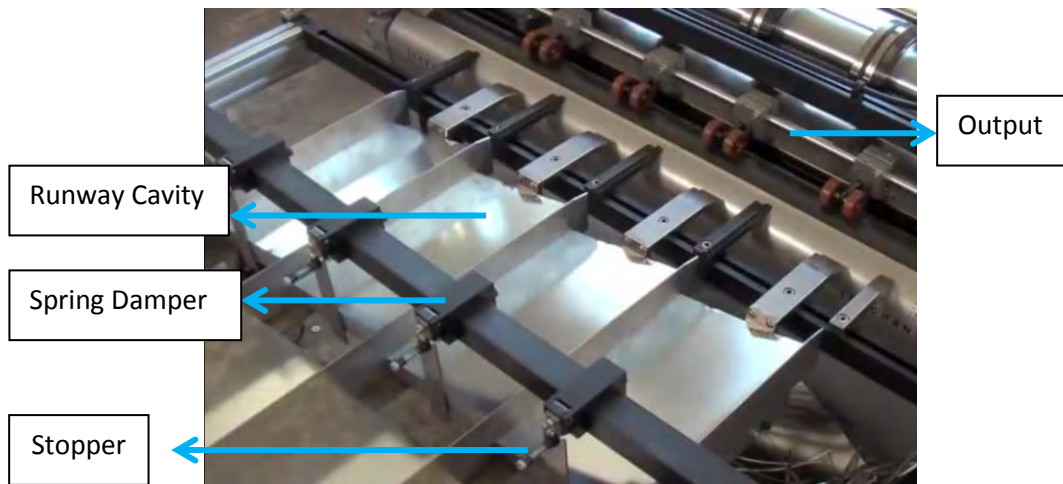


Figure 2.4: The structure and name of the metal strips collector for the slitting machine (Comfish Industries Sdn. Bhd., 2014)

## 2.2 Design guidelines for slitter collector

Generally, machine design is defined as a process of creation, invention, and definition, involving an eventual synthesis of contributory and often conflicting factors into a three-dimensional form capable of multiple reproductions, at marketable price, with acceptable quality of products and with specified reliability (Andrew D. Dimarogonas 2001).

The metal strips collector of the slitting machine is consider as part of the slitting machine. In other words, the metal strips collector is also a machine. In order to design the automatic metal strips stacker for slitting machine, the design guidelines are needed.

The design process of a product is very important because it determines the cost that will spend to manufacture the product. The design effort usually determines more than 70% of the manufacturing cost of the product and only 30% of the product's cost can be changed once the design is finalised and drawings are prepared (V. B. Bhandari, 2010). So, in order to design a product and minimize manufacture cost, the importance of manufacturing must be recognized early in the design stage. Design for manufacture and assembly is guidelines formulated by Bart Huthwaite to help designer design the project. The guidelines are simple and able to simplify design,

reduce assembly cost, improve product reliability and reduce operation time needed to launch the product to the user (V. B. Bhandari, 2010).

By following the design and assembly created by Bart Huthwaite, the automatic metal strips pallet stacker for slitting machine needs to design according to the guidelines as follows:

- i. **Reduce the Parts Count**  
The designer should minimize the number of parts when he designs a product. Smaller number of components will result in reduction of costs. Besides that, the assembly also is simpler and the flaw is less likely to occur.
- ii. **Use Modular Design**  
Modular design decreases the number of components being assembled and simplifies final assembly. Field service becomes simple, fast and cheap because disassembly process is quicker and used fewer tools.
- iii. **Optimize Part Handling**  
The components should be designed so that they do not become tangled stuck together or require special handling prior to assembly. Flexible parts should be avoided because it will cause the automated assembly more complicated.
- iv. **Assembly in the Open**  
Assembly process should be conducted in a clear vision. This will ease the manual assembly process as the components can be seen clearly.
- v. **Do not Against Gravity**  
The product is design in a way that it assembly is from the bottom to top along the vertical axis. The bottom to top assembly method enables the simple robots and insertion tools since the gravity is assisting the assembly process. In addition, the expensive clamping fixtures which are required for assembly along horizontal axes can be avoided.
- vi. **Design for Part Identity**  
Either manual or automated assembly operation, the symmetric parts are easier to handle and position. As the assembly rate rises, symmetry becomes more critical. The features will be added to improve symmetry. Asymmetric

parts should be designed so that their other surfaces make them easily identifiable. Asymmetry can be added or exaggerated to force correct alignment and orientation and make mistakes impossible (V. B. Bhandari, 2010).

vii. Eliminate Fasteners

Fasteners are the main problem to efficient assembly and should be avoided. The fasteners are hard to handle and may hard to remove if it is rusted or defected. In manual assembly operation, the cost driving a screw can be six to ten times the cost of the screw itself. If the use of fasteners cannot be avoided, limit the number of different types of fasteners used (V. B. Bhandari, 2010).

viii. Design Parts for Simple Assembly

The parts from different vendor may cause misalignment problem which make the assembly operation more difficult. The product needs to design with part compliances so that the misalignment problem can be solved.

ix. Reduce, Simplify and Optimize Manufacturing Process

The number of assembly operation should be minimize and kept at the least level. Operations that are hard to manipulate, for example soldering or brazing, should be avoided.

So, the automatic metal strips pallet stacker should design with minimum amount of components, modular design, optimize part handling, bottom to top assembly process, minimum amount of fasteners, simple assembly process and minimum amount of assembly processes.

### 2.3 Conceptual design of the machine

The concept of the design is very crucial to produce idea and select the option for the automatic wooden pallet metal strips collector for slitting machine. There is a lot of slitting machine now days in the market.

For the project, the most important thing is the metal strips or blank collector of the slitting machine. The market currently still do not has the automatic metal strips pallet stacker for the slitting machine, so the information about the modification of slitting machine collector is very limited. However, the design concept or working principle of the collector of the double slitting machine is still can refer to other machine that has similar operation or process for example the single slitter machine. The single slitter machine has the automatic metal strips pallet stacker which it working mechanism can be study to develop the concept of the project. However the size of the cut metal strips for the single slitting machine is longer compare to the output of double slitting machine. The output of the slitting machine is short rectangular metal strip, so the working mechanism which refers from the single slitting machine must be modified and change to accommodate the shorter length metal strips.

The design starts with the confrontation with a particular problem, a task associated with a number of (usually loosely) defined specifications or requirements. A phase of further data collection must then be initiated (Pahl and Beitz, 1996). The Comfish Industries Sdn. Bhd. has faced a problem of slow production rate due to the used of current slitting machine collector. After the information is obtained, the design requirement can be known. Design requirement also can be called demands and wishes. The demands are requirements that must be meet under all circumstances, requirements without which the solution is not acceptable (Andrew D. Dimarogonas, 2001).

The main objective for the project is to increase the production rate of the slitting machine. In other words, the design requirement of the project is to improve the production rate of the slitting process. The production rate of the current slitting machine can be calculated by using the following formula (Mikell P. Groover, 2008).

$$R_p = \frac{60}{T_p} \quad (2.1)$$

$R_p$  = Hourly production rate (pc/hr),  $T_p$  = average production time per minute (min/pc), and the constant 60 converts minutes to hours.

For batch production, the time to process one batch consisting of  $Q$  work units is the sum of the setup time and processing time; which is,

$$T_b = T_{su} + QT_c \quad (2.2)$$

$T_b$  = batch processing time (min),  $T_{su}$  = setup time to prepare for the batch (min),  $Q$  = batch quantity (pc), and  $T_c$  = cycle time per work unit (min/cycle).

$$T_c = T_o + T_h + T_{th} \quad (2.3)$$

$T_c$  = cycle time (min/pc),  $T_o$  = time of the actual processing or assembly operation (min/pc),  $T_h$  = handling time (min/pc), and  $T_{th}$  = tool handling time (min/pc). The tool handling time includes the time used at changing tools when wear out.

Dividing batch time by batch quantity, the average production time per work unit  $T_p$  for the given machine is:

$$T_p = \frac{T_b}{Q} \quad (2.4)$$

Given data from Comfish Industries Sdn. Bhd., the time to setup machine to prepare for the bath is 60 minutes, batch quantity is 1200 piece of tinplate, actual processing time is 0.05 min/piece, handling time is 0.0083 min/piece, tool handling time of 0.00556 min/piece and setup time to prepared the slitting machine for the batch is 120 minutes. Therefore, the production rate of the current machine is,

$$T_c = T_o + T_h + T_{th} = 0.05 + 0.0083 + 0.00556 = 0.06386 \text{ min}$$

$$T_b = T_{su} + QT_c = 120 + 1200(0.06386) = 196.632 \text{ min}$$

$$T_p = \frac{T_b}{Q} = \frac{196.632}{1200} = 0.16386 \text{ min}$$

$$R_p = \frac{60}{T_p} = \frac{60}{0.16386} = 366.166 \text{ pc/hour}$$

After the automatic metal strips pallet stacker is installed to the slitting machine, the batch quantity, actual processing time and setup time is remain the same. However,