DEVELOPMENT AND PROTOTYPING OF A TAKRAW BALL FEEDER FOR ACCURACY TRAINING BASED SYSTEM

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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 Bachelor of Mechanical Engineering.

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STUDENT'S DECLARATION

I declare that this thesis entitled *"Development and Prototyping of a Takraw Ball Feeder for Accuracy Training Based System"* is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date : 1 November 2008

DEDICATION

To my beloved father,

Mohd Nazaruddin Bin Mohd Noor

My beloved mother,

Zainaf Binti Osman

and

All my beloved family members

Thank you for everything

ACKNOWLEDGEMENT

Bismillahirrahmanirrahim

First of all, I want to thank The Almighty Allah SWT for the beautiful life that has been given to me in the past 21 years and the present. I am very thankful to be given the time and chances to finally complete this research.

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The best thanks goes to my family especially to my parent. I am very thankful to have them as my father and mother because they never gave up on me and constantly support me morally and financially which are things that I needed the most in order to complete this research. But most of all, thanks for the love and attention that they gave to me which I will cherish until the end of time. Thanks for never stop believing in me although I have let them down so many times and always pray for my success and happiness in the past, present and the future. Thanks for everything. May Allah bless you.

ABSTRACT

The development of electronic and automation in sport is well demanded to improve the training method. Ball feeder is one type of sport training equipment that is used for accuracy training purpose. Unfortunately, there is no automation equipment that had been developed for Sepak Takraw. Therefore, this work is published for the development and prototyping of takraw ball feeder for Sepak Takraw training purposes.
This ball feeder used a gravity punching concept where it consists of a rotating arm that is moved by a driver connected to a power window motor to a certain position before the arm is release. The takraw ball feeder is capable to control the launching period of the ball where it is controlled by a controlling unit. This ball feeder invention will make Sepak Takraw training more effective than the current training method.

ABSTRAK

Pembangunan elektronik dan automasi dalam penghasilan alatan sukan sangat diperlukan bagi meningkatkan mutu latihan. Pengagih bola merupakan salah satu daripada alatan sukan yang digunakan bagi tujuan tersebut. Malang sekali, pada masa ini tiada pembangunan dan penghasilan pengagih bola bagi sukan Sepak Takraw. Justeru, tesis ini dihasilkan bagi pembangunan alat pengagih bola bagi sukan Sepak Takraw untuk diapplikasikan dalam latihan ketepatan. Alat pengagih bola ini menggunakan konsep hentakan berfaktorkan graviti di mana sebuah penukul akan digerakkan oleh pemandu yang disambungkan pada satu motor elektrik ke satu kedudukan tertentu sebelum punukul tersebut dilepaskan. Pengagih bola ini berupaya untuk mengawal sela masa untuk mengagihkan bola di mana sebuah unit pengawal akan menjalankan fungsi tersebut. Lantas, penghasilan pengagih bola ini akan dapat meningkatkan lagi mutu serta kualiti latihan sedia ada.

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LIST OF SYMBOLS AND ABBREVIATIONS

h	-	Height of launch
F	-	Force
H_o	-	Angular momentum
M	-	Moment
dv/dt	-	Aceleration
N	-	Newton
kg	-	Kilogram
g	-	Gravitational acceleration
t	-	Time
m	-	Mass
α	-	angel of rotation
v	-	Speed
d	-	Distance
PIC	-	Programmable integrated circuit
AC	-	Alternating current
DC	-	Direct current
CAD	-	Computer added design

CHAPTER 1

INTRODUCTION

1.1 Introduction

Sports are one of the activities that can give many benefits to human especially in generating health to our body. Apart from dieting, involving ourselves in sports can protect us from many diseases that can threaten our lives. History has proved that sporting activities has long been apart of human lifestyle, where the first Ancient Olympic games were held in Greece back on 776BC. Since then, sports have developed into many variety and disciplines. Until now, on the 21st century, sports have become a global culture where it is being used as a symbol to unite the people around the round. Nowadays, the presence of sports is undoubted as an important medium for the world's development as it can generate a strong relation among countries, organizations and human.

Through this relation, an array of sports event is being held to promote peace and strengthen the relationship among human. This scenario produced many international sports icon and globally renowned athletes from different kind of sports. Apart from hard work, the emerged of these athletes are being help by the involvement of technology in sports through the invention and creation of training equipment. Technology has long been part of sports development. The use of basic training equipment can give a big impact not only to the athlete, but the sports itself.

Because of this situation, the demand of electronic and automation in developing training equipments have increased. Sport organizations demand the use of electronic training equipment in the training. The increased in demand is caused by many factors such as to improve the training method. Before the invention of electronic training equipment, the training methods basically depend on the coach expertise. Therefore, a sport organization needs to hire a talented, expert and experience coach to work on the training. Unfortunately, there are few numbers of sports coaching expertise available and if there is some, the cost to hire them as a coach and the demand would be the main problem to the organization.

So, the used of automation training device would be a great solution to improve the training methods. The accuracy of automation training device is also on of the main factor that it is well demanded. Accuracy training is very important in most sporting activities and through the application of electronic, surely it will help a lot. These factors not only contributed to the cost efficiency, but make the training equipment very efficient and reliable during training.

Nowadays, there are many types of automation training equipments available in the market for almost kind of sports and one of the equipment is the ball feeder machine. The ball feeder machine is being use for sport activities such as tennis, golf, volleyball, softball and cricket. The basic concept in each of the ball feeder machine is to throw the ball through the ball outlet to the user automatically within the specific accuracy and speed. For general ball feeder machine, it contains several basic components such as motor, ball inlet and outlet, throwing unit and control unit.

For an example, the Kanon tennis ball machine that has been produce since 1975 use air pressure as throwing concept to support the training purpose. Until now, this machine has been widely use for tennis training purpose because of it revolutionize design.

1.2 History of Sepak Takraw

'Sepak Takraw' was the name of an ancient game played in the Malay states and in the neighboring countries of Singapore and Brunei. It was created by the royal family of Malaysia about 500 years ago. The name itself comes from two different languages. 'Sepak' is Malay for 'kick' and 'Takraw' is a Thailand word for the rattan ball used in the game, which involved players standing in a circle keeping the ball in the air for as long as possible without using their hands. Variations of this were played in other Southeast Asian countries too where in Philipine it was called 'Sepa Sepa', in Myanmar, 'Ching Loong', in Indonesia, 'Rago' and in Laos, 'Kator'. When it is born, it looked like Japanese 'Kemari', and some became a circle and a pole was kicked, and the number of times was being competed in. It looks very similar to the Japanese traditional game, 'Kemari' where the players form a loose circle and the number of times the ball is kicked before it touches the ground is counted.

In 1965 the game was unified into the present volleyball style with the addition of a net and the adoption of international rules. The International Sepaktakraw Federation (ISTAF) is responsible of all the Sepak Takraw organizations. Modern Sepak Takraw, or Takraw for short (also known as Kick Volleyball), began in Malaysia and is now became their national sport. It combines elements of Soccer, Footbag, Volleyball, Baseball, Badminton, Gymnastics and the ancient sport of Sepak Raga. Balls woven of rattan stems have primarily been replaced by woven synthetic balls, which are much safer and more durable. A Sepak Takraw player needs to be extremely good when dealing with the ball. Under the current training method, a long period of training is needed to improve the skills. It is mainly because of the undeveloped training equipment which there is no automation tool is used during the training period. Until now, no ball feeder machine has been developed for Sepak Takraw. So, the players might have problem when it comes to dealing with accuracy training.

1.3 Problem Statement

The unavailable automated equipment in takraw training is the main problem that occurs. When it comes to accuracy training, players need a help from an expert coach or an assistant to work on the training. Currently, no individuals or company had developed the takraw ball feeder that specializes on accuracy training purposes. Like the other ball feeder available in the market, this takraw ball feeder will share the same concept, that is, to deliver the ball to the user within the specified accuracy. Unlike the tennis ball feeder [2], takraw ball has many holes which mean that a punching concept will be use to throw the ball. Previously, there is no ball feeder development for ball that contains holes like takraw ball. For this takraw ball feeder, the user can apply two specific type of training available; service and throwing. So, the invention of the takraw ball feeder will greatly improve the current training method and coaching.

1.4 Project Background

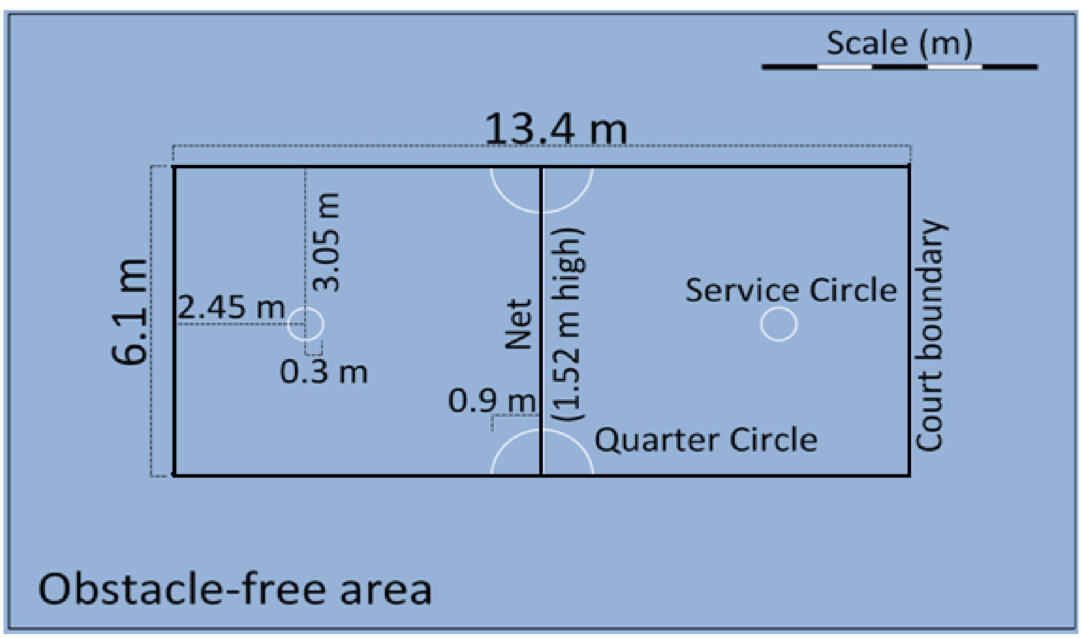


Figure 1.1 Dimensions of a takraw court

Figure 1.1 shows the dimensions of Sepak Takraw court. The Sepak Takraw court and net are of the same height and dimensions as in badminton. Area of length 13.4m and 6.1m in width free from all obstacles up to the height of 8 m measured from the floor surface.

At the corner of each at the center line, the quarter circle shall be drawn from the sideline to the center line with a radius of 0.9 m measured and drawn outwards from the edge of the 0.9 m radius. The net shall be made of fine ordinary cord or nylon with 6 mm to 8 mm mesh.

The net shall be 0.7 m in width and not shorter than 6.10 m in length and taped at 0.05 m from tape double at the top and sideline, called boundary tape. The net shall be edged with 0.05 m tape double at the top and the bottom of the net supported by a fine ordinary cord or nylon cord that runs through the tape and strain over and flush with the top of the posts.

The top of the net shall be 1.52 m (1.42 m for women) in height from the center and 1.55 m (1.45 m for women's) at the posts. From Figure 1.1, the distance from the service circle to the opposition service circle is 8.5m, and the distance from the quarter circle to the service circle is 5.23m. This is the distance for service and throwing purposes.

Using gravity punching concept is suitable to achieve that distance. The punching unit will contain a power window motor and a puncher connects by a shaft. Power window motor is being used because it has high torque transmission for lifting the puncher.

1.5 Objectives

1.5.1. To design and prototype a takraw ball feeder for sepak takraw training purpose.

1.5.2. Analyzing and testing the accuracy level of the takraw ball feeder prototype.

1.6 Scopes of project

1.6.1. Design via Solidworks, a takraw ball feeder that uses a gravity punching concept.

1.6.2. Design via Solidworks, the ball motion from the container to the punching unit by using appropriate concept (e.g. gravity).

1.6.3. Design the controlling unit for purchasing the period of launch.

1.6.4. Make a Solidworks design to test the strength of the ball feeder structure.

1.6.5. Fabricate the takraw ball feeder using appropriate material such as sheet metal, aluminum and motor that act as an actuator.

1.6.6. Testing and analyzing the takraw ball feeder and record the data.

1.6.7. Compare the result from experiment with the simulation data.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will briefly explain about the previous design and concept of ball feeder machine in variety field of sports, along with the information of the devices used throughout the process.

This valuable information is very important to decide the best application for development of the new takraw ball feeder. It is known that no takraw ball feeder machine has ever been developed. Therefore, the previous inventions of ball feeder in any sports are being set as a reference to get the best concept for prototyping a takraw ball feeder.

The previous inventions are also important to decide the devices and mechanism that need to be used in this machine along with its functions to minimize any weakness in prototyping the takraw ball feeder. It is also important to determine the design concept that will be applied during designing the ball feeder.

2.2 Basic Concept of a Ball Feeder

The main concept of a ball feeder is to deliver the ball to the user automatically within the specified speed and accuracy. It helps the user to improve the training method and to fulfill their training period effectively. Apart from that, a ball feeder should greatly increase the training efficiency. A ball feeder should contain two separate parts; the ball container and the launcher. It also must be lightweight, movable and easy to operate. To achieve the needed accuracy, the outlet nozzle must be adjustable which means the ball can be thrown in any direction horizontally and vertically. But all the concepts of ball feeder are depending on the type of application, which is different in each sport.

There were many concepts of ball feeder available in the market according to each sport. Although the concept is the same, different kind of sport used different approach of throwing or launching the ball. Different approach means the devices used is also different, based on what the objective of the invention. For example, tennis [1] ball feeder and baseball [3] ball pitching machine used different launching approach. Basically, a tennis ball feeder can launch the ball in any direction and can simulate the stroke or curling the ball so that the user can practice like playing with a real human. Elsewhere, baseball ball pitching machine doesn't need to curl the ball because in the real game, the ball pitcher throws the ball straight to the batter. This means, both machine have different trajectory of ball. Subtopics 2.4.1 until 2.4.3 will briefly explain the available concept of ball feeder in various sports.

2.3 Automation Components

Developing a ball feeder involve the use of several automation components to realistically throw the ball away from the machine and are crucial to achieve the needed accuracy. The components come from two different types which is mechanical components and electrical devices.

2.3.1 Mechanical components

Mechanical Components covers a wide range of items and devices designed to handle, induce or drive mechanical systems. In almost all cases, mechanical components were manufactured to be part of a greater system, and do not have the ability to function on their own.

Therefore, mechanical components are always connected with electrical components to make the whole system function. The used of mechanical components is different based on the type of application. Previous invention of ball feeder machines contains several simple mechanical components such as shaft, contact wheel, carriage, frame and adjustable lifting arm.

Figure 2.1 shows an example of mechanical components involved in a ball pitching machines for baseball application. The machine uses a tripod leg that is connected to the frame. Tripod leg is suitable for baseball and softball application because it is stable and light in weight. It also can reduce the cost because of its simple yet effective design.

The first contact wheel function to propel the ball when the ball is introduce at the entry point, allowing the ball to move upward along the ball track to the second contact wheel. The contact wheel is rotated by an electric motor and is connected by a shaft.

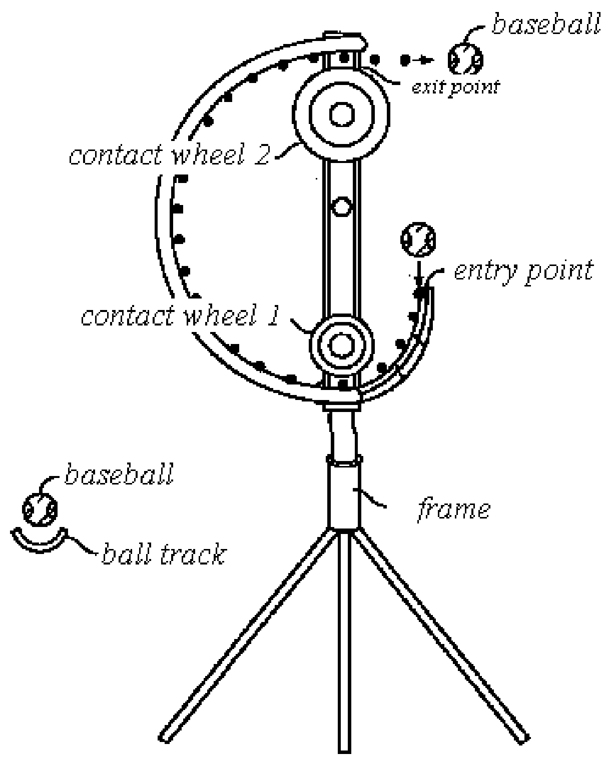


Figure 2.1 Mechanical components in a baseball ball pitching machine [3]

2.3.2 Electrical devices

Mechanical components can't perform without the use of electrical components. An electrical device is a combination of many electrical components that where attached to each other to perform a certain function. An electronic component is a basic electronic element usually packaged in a discrete form with two or more connecting leads or metallic pads.

Components are intended to be connected together, usually by soldering to a printed circuit board, to create an electronic circuit with a particular function (for example an amplifier, radio receiver or oscillator).

Components may be packaged singly (resistor, capacitor, transistor, diode) or in more or less complex groups as integrated circuits (operational amplifier, resistor array, logic gate). The used of electrical devices in a ball feeder machine is important to make sure the mechanism can perform well.

2.3.2.1 Servo motors

There are many types of electrical motors available in the market. Each types of motor are different according to its application, and one of the motor available is servo motor. Three basic types of servo motors that were used in modern servo systems:

- AC servo motors (based on induction motor designs)
- DC servo motors (based on DC motor designs)
- AC brushless servo motors (based on synchronous motor designs).

Servo motors are used in closed loop control systems in which work is the control variable as shown in Figure 2.2. The digital servo motor controller directs operation of the servo motor by sending velocity command signals to the amplifier, which drives the servo motor.

An integral feedback device (resolver) or devices (encoder and tachometer) are either incorporated within the servo motor or are remotely mounted, often on the load itself. These provide the servo motor's position and velocity feedback that the controller compares to its programmed motion profile and uses to alter its velocity signal.

Servo motors feature a motion profile, which is a set of instructions programmed into the controller that defines the servo motor operation in terms of time, position, and velocity. The ability of the servo motor to adjust to differences between the motion profile and feedback signals depends greatly upon the type of controls and servo motors used.

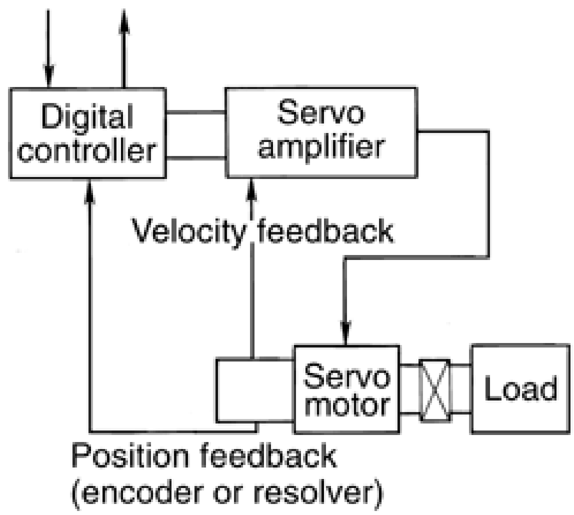


Figure 2.2 A typical DC servo motor system with either encoder or resolver feedback. Some older servo motor systems use a tachometer and encoder for feedback

Figure 2.3 Components in a servo motor

2.3.2.2 AC motors

Synchronous and synchronous electric motors are the two main categories of AC motors. The induction ac motor is a common form of asynchronous motor and is basically an ac transformer with a rotating secondary. The primary winding (stator) is connected to the power source and the shorted secondary (rotor) carries the induced secondary current. Torque is produced by the action of the rotor (secondary) currents on the air-gap flux. The synchronous motor differs greatly in design and operational characteristics, and is considered a separate class of ac motor.

Selection on the type of an electrical motor in a ball feeder machine is important to supply the input power to the machine. An AC motor is an electric motor that is driven by an alternating current. An AC motor consists of two basic parts:

- An outside stationary stator having coils supplied with AC current to produce a rotating magnetic field, and;
- An inside rotor attached to the output shaft that is given a torque by the rotating field.

There are two types of AC motors, depending on the type of rotor used:

- The synchronous motor, which rotates exactly at the supply frequency or a submultiples of the supply frequency. The magnetic field on the rotor is either due to current transported with slip rings or a permanent magnet.
- The induction motor, which turns slightly slower than the supply frequency. The magnetic field on the rotor of this motor is created by an induced current.

2.3.2.3 Microprocessor and microcontroller

Microprocessor and microcontroller are largely used in embedded system. A microprocessor is like a ‘brain’ to a machine. It incorporates most or all of the functions of a central processing unit (CPU) on a single integrated circuit (IC). Microprocessor is used to control the device connected to specific circuit. Selection of suitable microprocessor is depending on the application of the system. Usually, any microcontroller has microprocessor with limited number of RAM, ROM and timer on a single chip. Microcontroller is used as a general purpose microprocessor which has additional parts that allow them to control external device. In ball feeder application, the microcontroller is being used as the controlling unit to control the speed variation, ball launch timing and spin of ball.

In a tennis ball feeder [4], the microprocessor input mechanism contains numerical keys, mode keys and function keys. The numerical keys are used by the operator to choose the specific shot and shot sequence desired. Each shot embedded in the PLC memory bank has within its code its own combination of load, displacement, timing, and spin. The function keys are used for repeat the last shot, repeat the last two shots, repeat the last three shots and repeat last point. There is an LED device for showing the user the identity of the shot being entered and/or the sequence entered. Figure 2.4 shows one of the PIC microcontrollers available in the market currently.

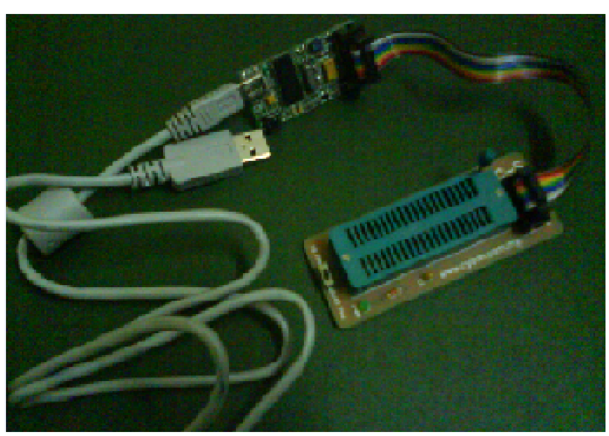


Figure 2.4 PIC microcontroller

2.4 Ball Feeder as Sports Training Equipment

There were many type of ball feeder invented nowadays. The increasing demand in sports automation has no doubt to be the drive for the invention of ball feeder machine. Sports like tennis, baseball, softball, golf, table tennis and cricket have already used ball feeder machine as part of their training equipment and to improve the training method.

The involvement of automation in sports has largely affected the training and players or users techniques. Until now, ball feeder technology has been continued developing because of the effectiveness due to its various capabilities. The factors that contribute to the effectiveness of ball feeder are the used of various parts such as speed motor and timer that control the ball speed and launching period.

Figure 2.5 Example of a tennis ball feeder

2.4.1 Ball throwing concept for tennis ball feeder

It is known that tennis ball feeder has been developed since the early 70’s trough the increasing interest in this sport. Nowadays, tennis has become a global sport that saw the rising of many great players. The tennis ball feeder also played its part in developing those players.

The development of tennis ball feeder is still continued nowadays to improve the previous design and function. Further statement in this subchapter will explain the previous and current design and concept of tennis ball feeder, including the components involve in this machine.

Tennis ball feeder is operated for player practice and the improvement of their game, with the objective of realistic ball delivery and efficient recovery of balls returned by the player. Prior invention of tennis ball feeder [1] back on the 70’s has been complex and cumbersome to the user and it required the storage of a large supply of balls.

The acceleration of ball during launching has been detrimental to ball life and the automatic simulation of serve variations has not been altogether realistic. Therefore, the machine can’t simulate the trajectory of ball required by user during training. Such weakness is unacceptable for the user especially in training where the user can’t afford to waste their time setting up the apparatus.

Therefore, the general objective of the new invention [2] of tennis ball feeder to realistically serve a small supply of tennis balls, delivering all worn balls substantially the same as new live balls, delivering balls through a true ground stroke trajectory and recycling all balls returned to the net.

Tennis balls are propelled to a person practicing the game by a head that is vertically repositioned and horizontally aimed. The apparatus involve includes a main frame, including an attached control box, having a dual hinge; a deformable parallelogram lifting arm, having a first end and a second end, attached at its first end to the dual hinge on the main frame; a movable vertically extending member, rotationally receiving and supported by the second end of the lifting arm at a first end; an oscillating bracket, disposed at a second end having at least one upwardly extending arm, rotational around a vertical axis; a ball propulsion device mounted on the oscillating bracket to be horizontally rotate; and a feed support attached to the oscillating bracket above the ball propulsion device providing a source of balls for the ball propulsion device.

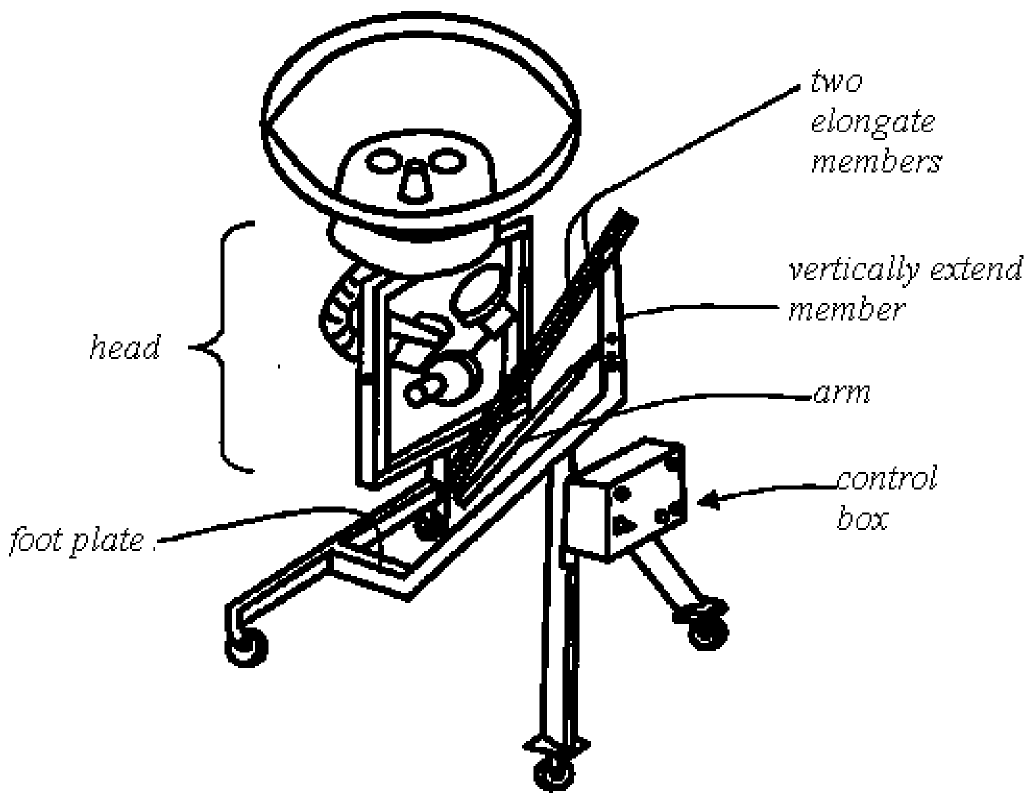


Figure 2.6 Tennis ball feeder [2]

The tennis balls will be fed from a reservoir of tennis balls mounted on top of the frame member. Referring to Figure 2.6, the balls are contained in a reservoir mounted on the top of the tennis ball propelling device. The balls fall under the influence of gravity into a ball isolating wheel. The wheel defines between one and six, preferably four, ball apertures that is large enough for a tennis ball to fall into. The ball isolating wheel is driven by a motor and rotates the captured balls around to bottom of the ball tray to a ball feeding tube for presentation to the ball propulsion head. There, the ball falls under the influence of gravity to be fed to the ball propeller head.

One of the great problems with ball feeding of any kind is that the balls tend to jam in the reservoir. To alleviate that situation, this machine used a first resilient member supported by a resilient member support, to agitate the mass of balls as it passes the resilient member mounting point. This provides a constant, although not too vigorous, agitation to the mass of balls. A second resilient member stretches across the opening to the ball feeding tube. This knocks any ball riding directly on the ball to be fed off allowing only the ball to be fed to fall into the ball feeding tube as shown in Figure 2.7.

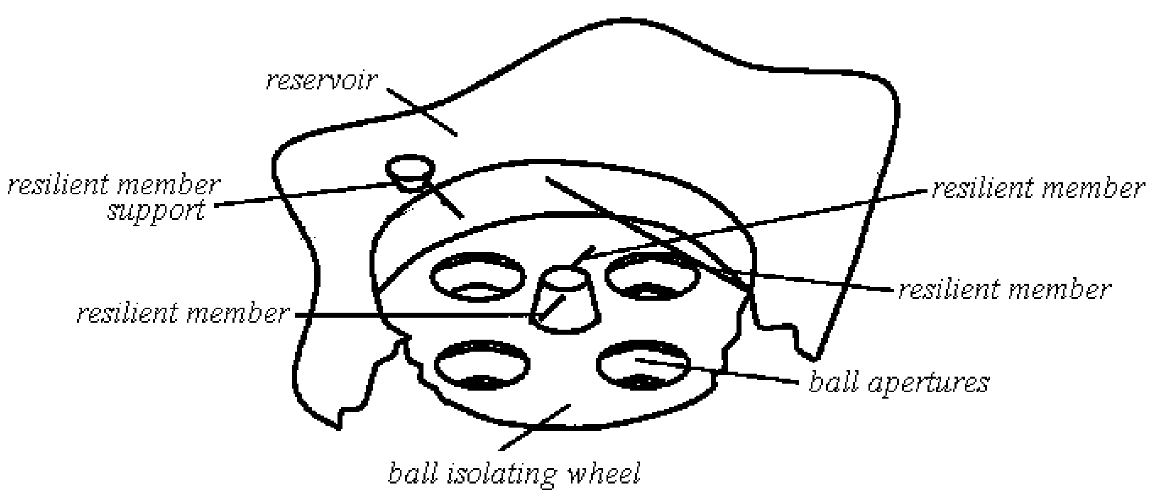


Figure 2.7 Components to feed the ball in the reservoir [2]

2.4.2 Ball pitching concept for baseball and softball ball feeder

Baseball and softball has almost similar playing characteristic. Baseball and softball ball feeder [3] is being invented because of the difficulties to find an exact motion of ball thrown by the pitcher. It also has basically the same concept as previous subchapter of tennis ball feeder, which is to simulate the speed and trajectory of balls as if pitched by an actual person. It is important to achieve the needed accuracy because of the value of this sport in certain country where the players need to be really good in pitching and hitting the ball.

A bit larger than a tennis ball, baseball and softball also already used ball feeder machine as important equipment at the training ground. Baseball and softball is separated by the way of pitching the ball by the pitcher, where different technique is used. A baseball pitcher throws the ball by rotating his/her hand from upward direction where the speed of ball is faster than softball. The path of the ball while it is accelerating to the batter (the person who hit the ball by using a baseball bat) is merely in linear motion where there is only a little projectile characteristic.

Softball used different approach of throwing, where the ball pitcher throw the ball to the batter by rotating his/her hand in opposite direction from the baseball. It means that the speed of the ball approaching the batter is slower than the baseball, and the path of the ball is in projectile motion. Although baseball and softball are different in pitching technique, both sports can use the same type of ball feeder or ball pitching machine [3]. The ball pitching machine [3] must have the ability to simulate the motion of pitcher's hand during pitching the ball in baseball or softball.

There were many component involves in the ball pitching machine. Various forms of ball pitching machines are known in the prior art devices to throw or pitch baseballs and/or softball to the receiver such as a batter or catcher. These devices include the machines to hurl a ball using a mechanical arm or lever. The arm is rotated and the ball is thrown from one end of the arm.

This ball pitching apparatus includes a propelling mechanism for propelling a ball from a first entry point to a first exit point away from the pitching apparatus in a first direction. The apparatus have a ball track to introduce the ball to the first entry point of the propelling mechanism. The ball track in this machine has a second entry point dimensioned to receive the ball and a second exit point to introduce the ball to the propelling mechanism.

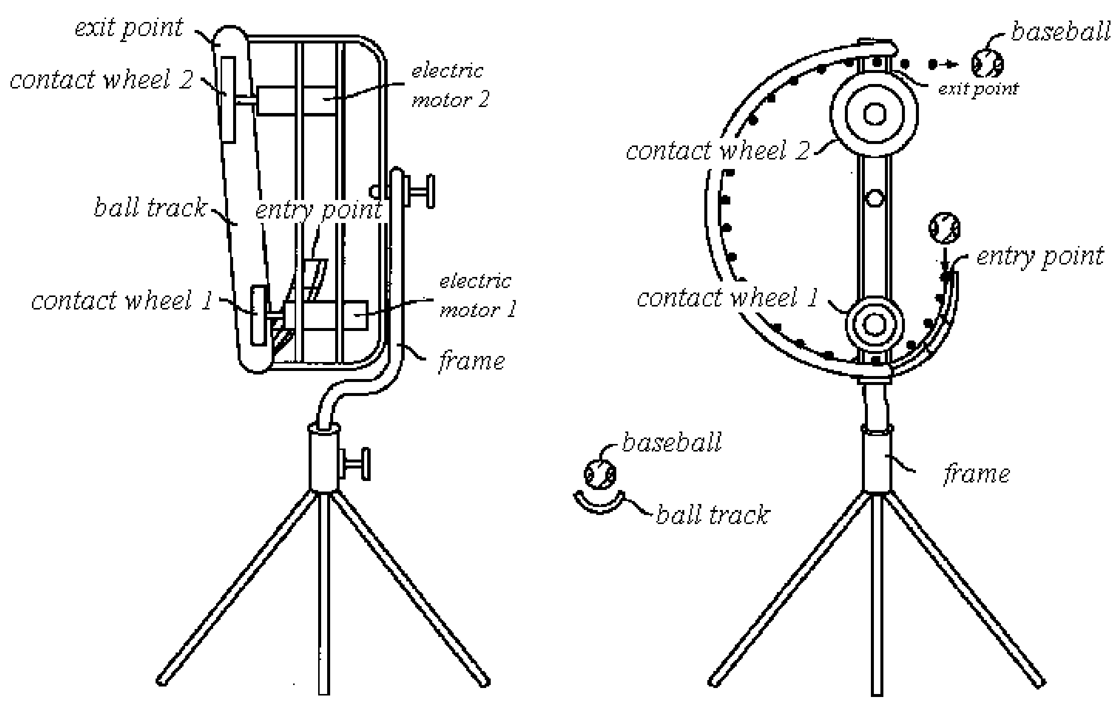


Figure 2.8 The components involve in the baseball pitching device [3]

The dimension of the ball track is in a generally circular or semicircular shape and constructed such that at least a portion of the ball is visible throughout the length of the path from second entry point to the second exit point.

This machine also included a frame support mechanism to support the propelling mechanism, the ball track and for aligning the second exit point with the first entry point. Further details are described in the Figure 2.8.

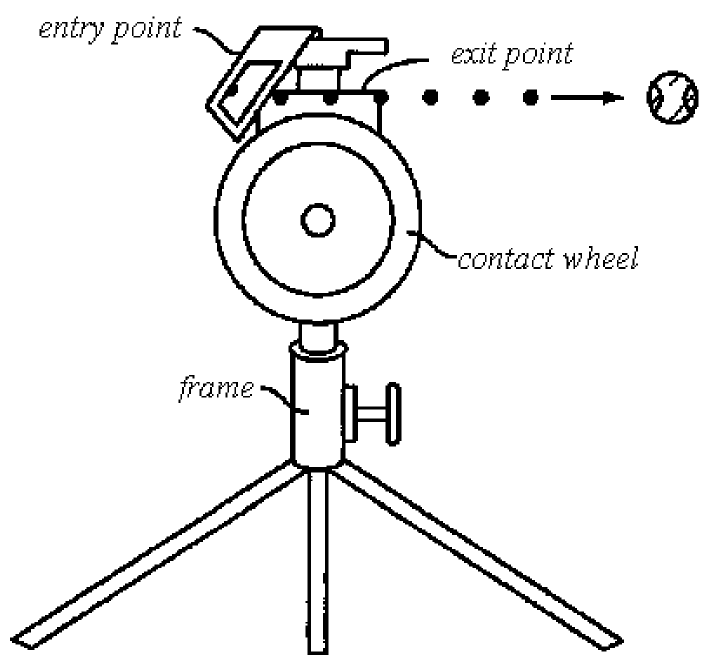


Figure 2.9 Fast pitch softball pitching machine [3]

Figure 2.9 shows a fast pitch softball pitching machine [3] having a frame and a contact wheel that rotates in a clockwise direction when a rotational force from an electric motor is received from shaft. The mechanism begins at the entry point where a standard softball is introduce and exits the machine at the exit point as the rotational force from the contact wheel propels the softball away from the machine.

According to the invention, another embodiment is attached to the machine as shown in Figure 2.10. The attachment has a ball track which is dimensioned and shaped to convey the softball in a circular motion from entry to exit point. This motion simulates the circular path of a pitcher's arm during pitching the softball.

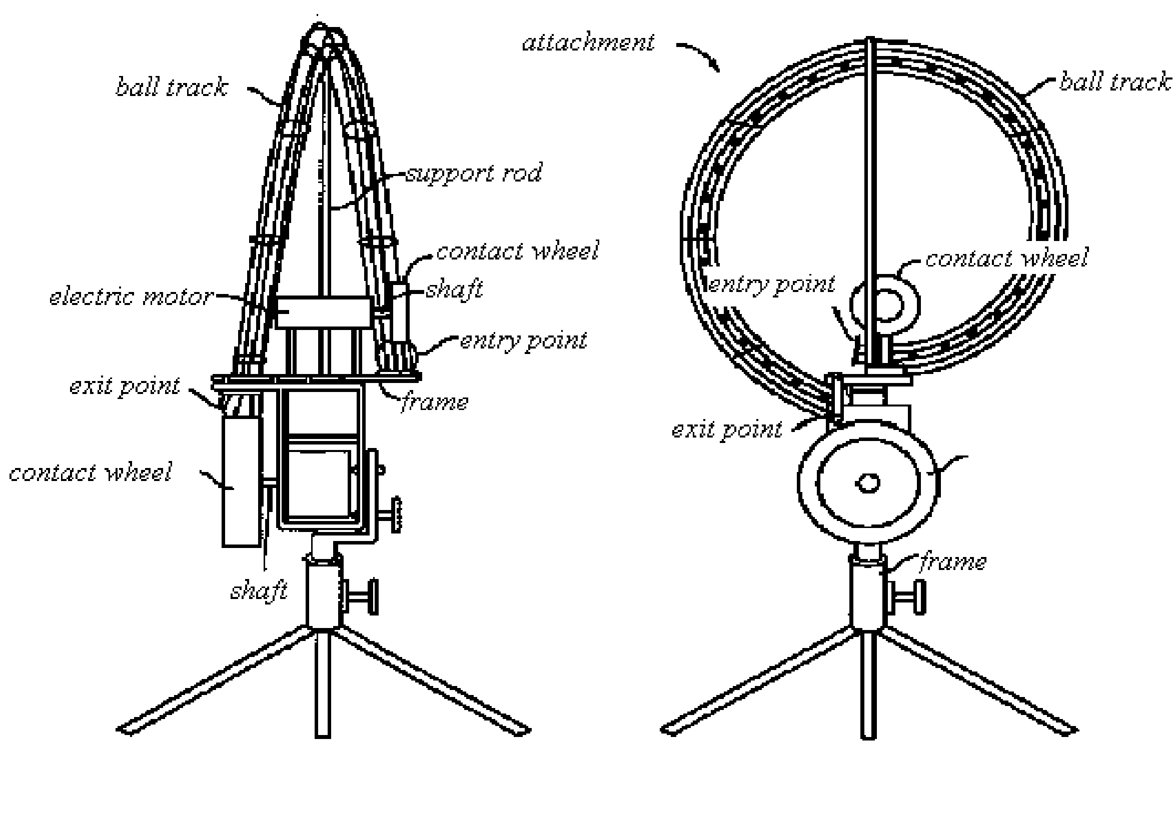


Figure 2.10 Attachment of ball pitching machine [3]

2.5 Conclusions

After a brief study of the previous concept and mechanism of ball feeder machine in various sports, it becomes clear to decide on the type of components and concept of the new takraw ball feeder. Although the type of sports application is different, most concept of the previous invention of ball feeder machine used propelling and rotating mechanism to throw or pitch the ball away from the machine.

An electric motor is connected to the rotation unit thus propel the ball towards the user. The variable such as speed of ball, period of launching, type of spin and distance of trajectory is control by a controller unit that contain a specified program. Those concepts of ball projecting will determine the best method that need to be applied on the takraw ball feeder in the next chapter.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will briefly explain the method use to develop the takraw ball feeder prototype including the specification of the design, drawing and fabrication. All of this method is important in order to control the flow of this project as well as the guideline for the development. Methodology is a system of ways of doing, teaching or studying something where the systematic study of method can be or have been applied within a discipline. During design and analysis, it is important to obtain the best method to develop this prototype where a proper methodology approaches will result in good performance and result of the required design. The determination of project methodology is based on the research of previous idea, theory, invention or development of related works in this field that has been done in the previous chapter.

3.2 Project Methodology

The study of the previous invention in ball feeder field in this chapter is important to decide the best design and concept of the new takraw ball feeder. The valuable information of the previous inventions are also important to decide the devices and mechanism that need to be applied in takraw ball feeder along with its functions to minimize any weakness in prototyping the takraw ball feeder. The main objective of this research is to develop and prototype a takraw ball feeder for takraw training purposes.

Therefore, a methodology flow chart is used to be the guideline and reference during the development of this project. Figure 3.1 below shows the flow chart for this project.

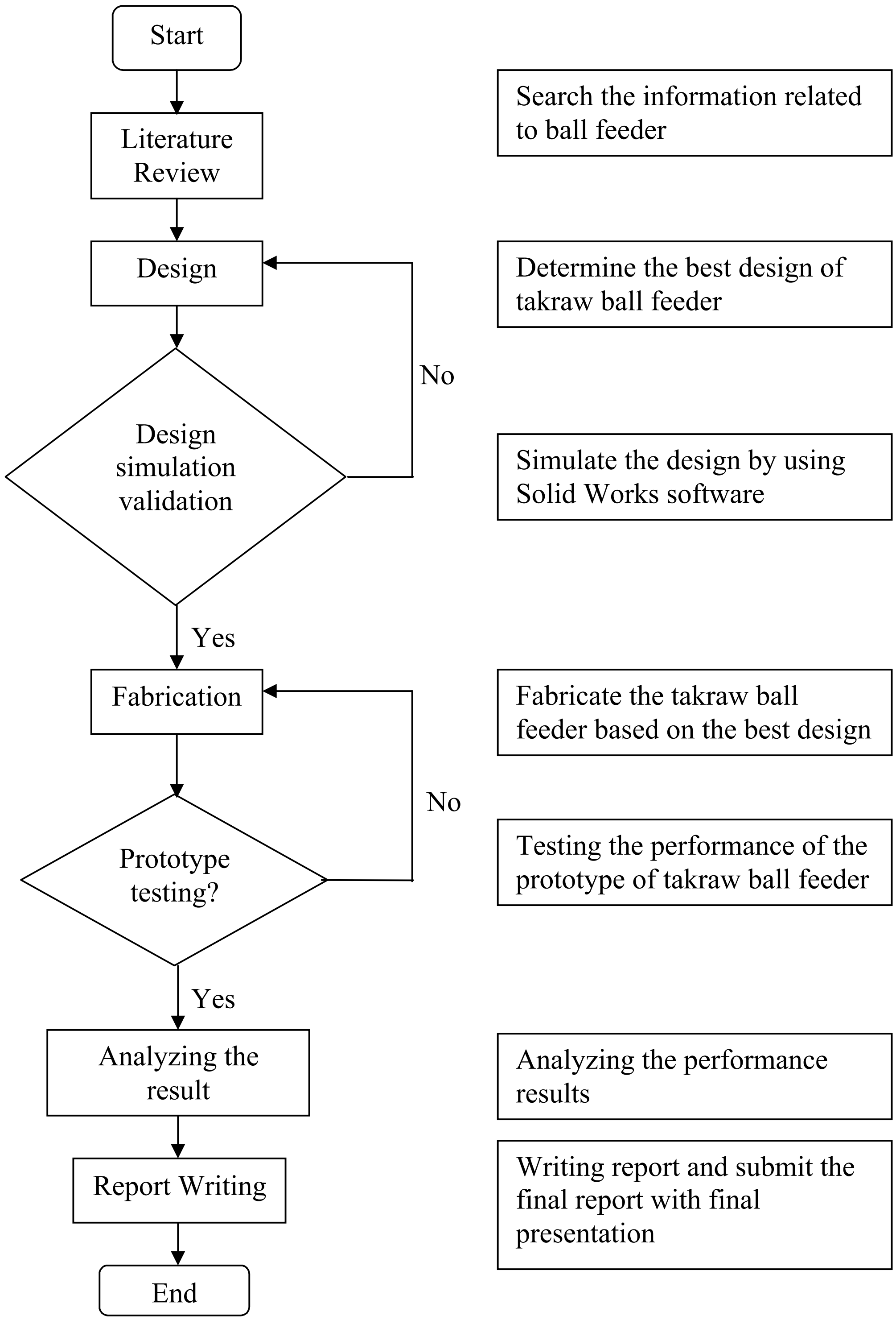


Figure 3.1 Methodology flowchart

3.3 Design Specification

The research of the previous invention of related ball feeder machine played an integral part in finding the best concept for the takraw ball feeder. This takraw ball feeder used a gravity punching mechanism where the ball is punch out from the machine by a rotating arm (puncher). The rotating arm is moved to a certain position by a driver that is connected to a power window motor. The design of the prototype started from a hand sketch where then it is converted using CAD software (SOLIDWORKS 2006) to get the three dimensional view of the prototype and to analyze the design structures. The main components involved in this machine is a rotating arm, a power window motor, a housing, body frame, ball track, a bearing and a PIC microcontroller unit that will control the launching period of the ball. Figure 3.2 until Figure 3.6 shows the picture, dimensions and CAD design of the parts.

3.3.1 Components

Components in developing takraw ball feeder prototype include mechanical and electrical components. Parts like rotating arm, ball track and rotating arm driver are the mechanical components that are function when it is powered by the electrical components (power window motor and controller unit).

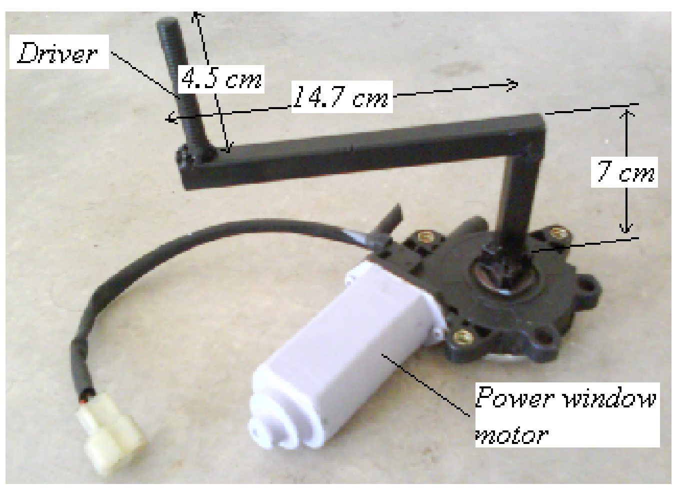


Figure 3.2 Power window motor connected with a rotating arm driver

The power window motor specifications:

Input voltage	:	12V
No load speed	:	80RPM
No load current	:	2.4A
Torque	:	7-9Nm
Rated load	:	3.6Nm
Rated current	:	6.5A

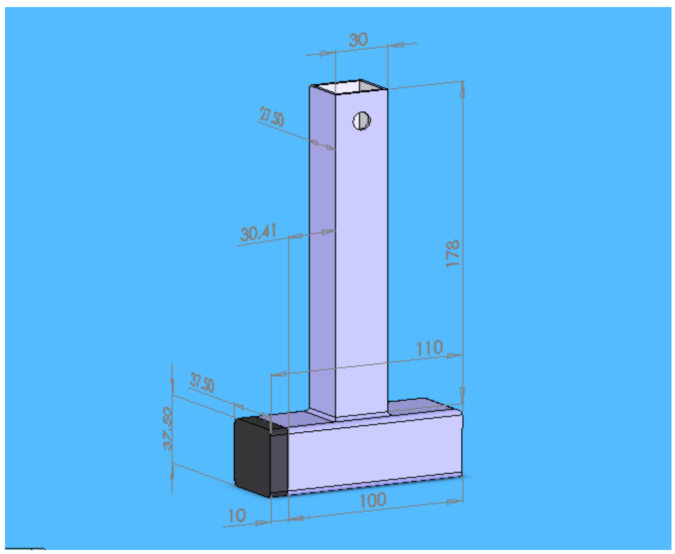


Figure 3.3 Rotating arm and rubber

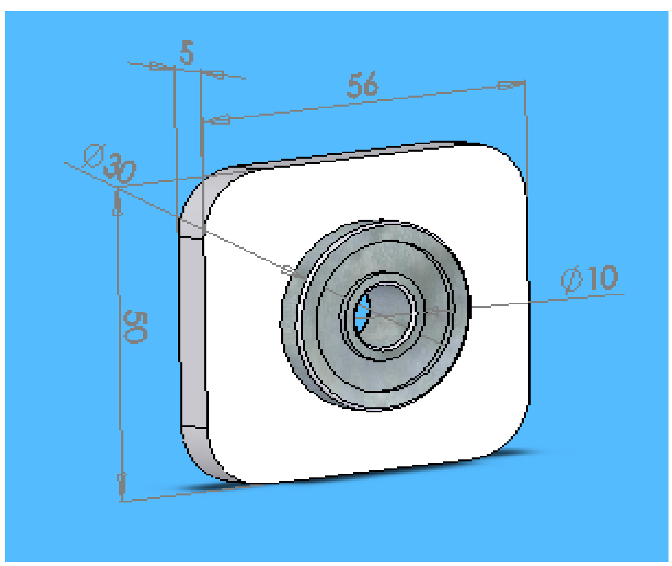
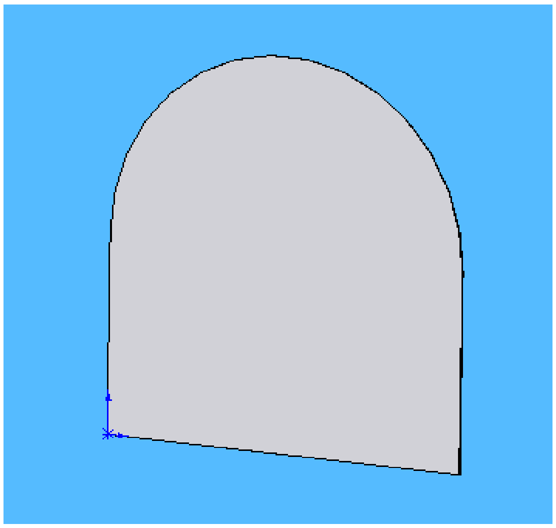
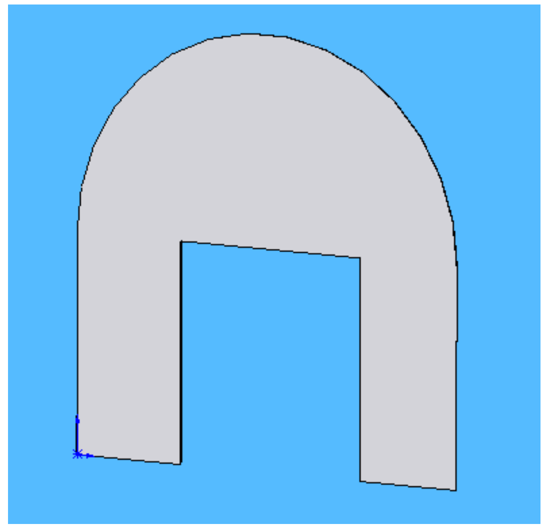


Figure 3.4 Bearing holder with bearing

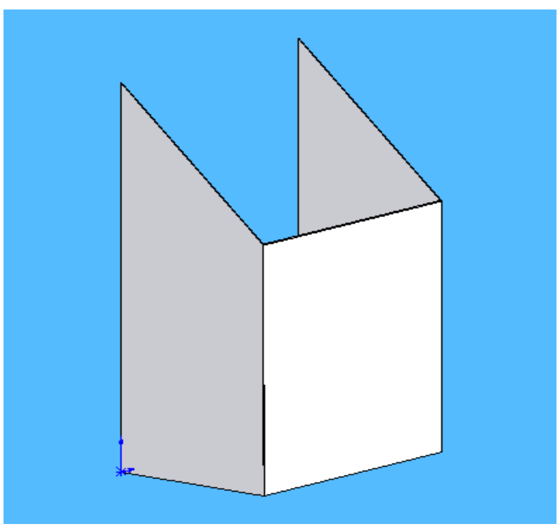
Figure 3.5 below shows the design of the housing where it is separated by four parts and it is made from sheet metal. To shape the sheet metal according to the design, a grinder and cutter machine is being used.



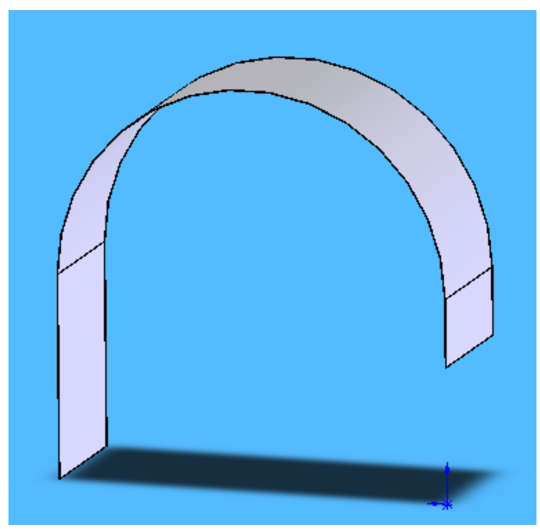
(a)



(b)



(c)



(d)

Figure 3.5 (a), (b), (c) and (d) Components of housing

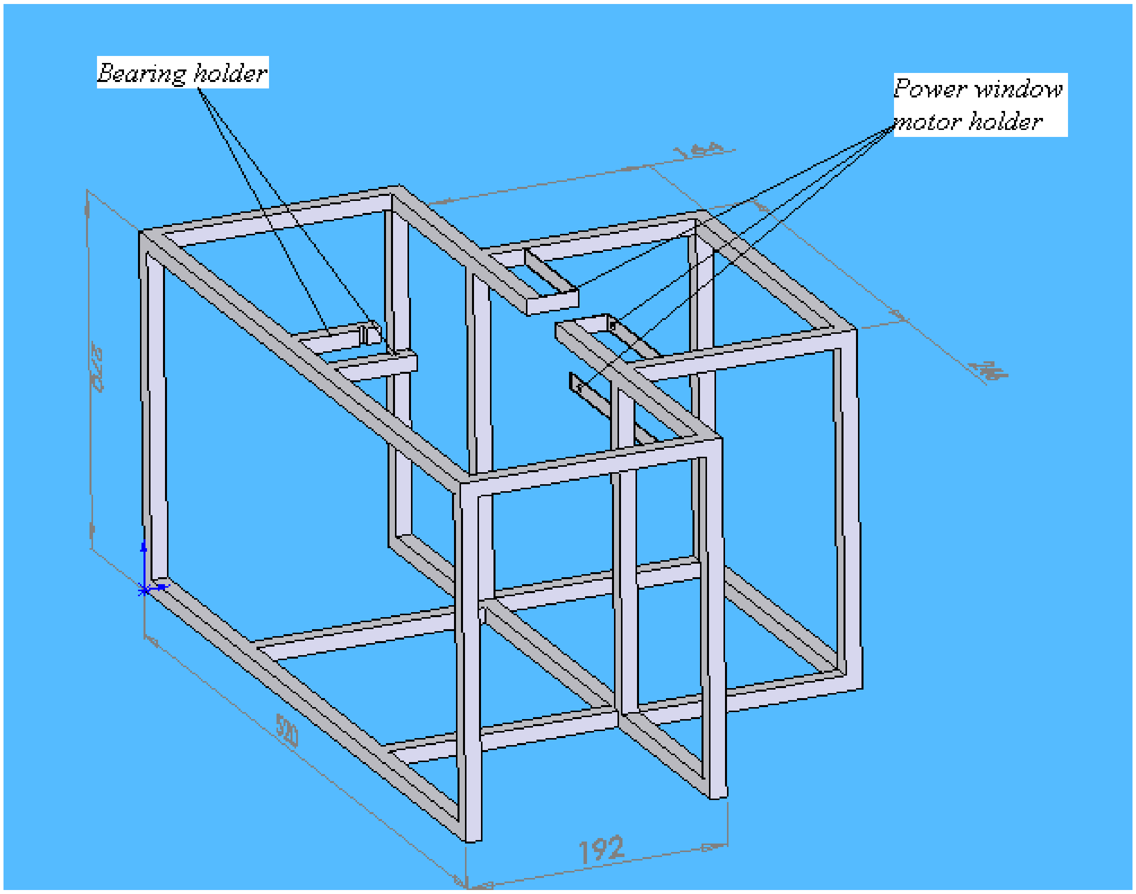


Figure 3.6 Main structures (frame)

The rotating arm (puncher) shown in Figure 3.3 is connected to a rubber at the end of the puncher to protect the ball from high impact force and to secure the life time of the ball. The flow off the ball leaving the ball feeder is guided by the ball track. The main structure which is the body frame is attached (weld) to a bearing and power window motor holder as shown in Figure 3.6.

To assembly the frame with the housing, both components need to be drill at certain position and is tightening by screw. Thus, both parts can be separated during maintenance or further adjustments. A ball track is attached to the bottom of the frame to guide the ball during launching.

3.3.2 Assembly of Design

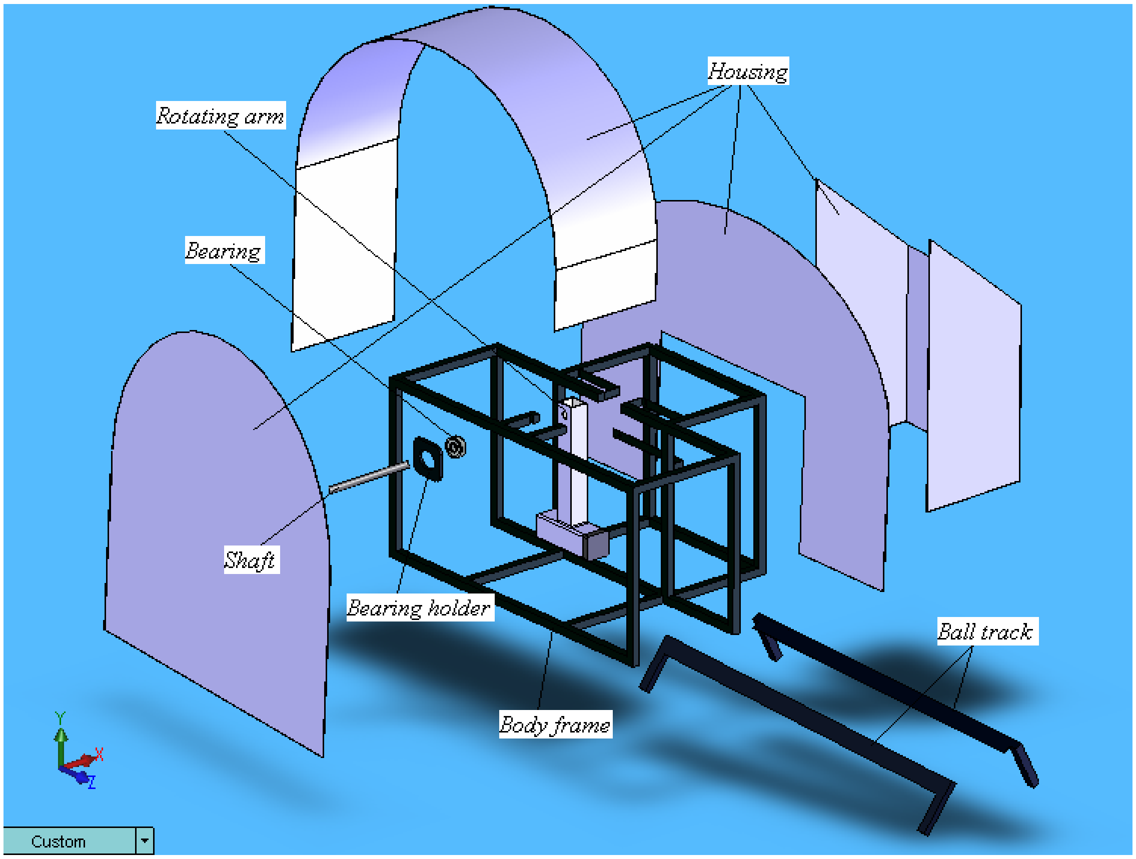
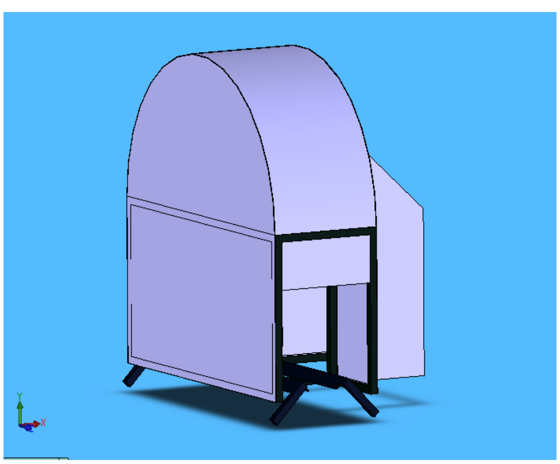
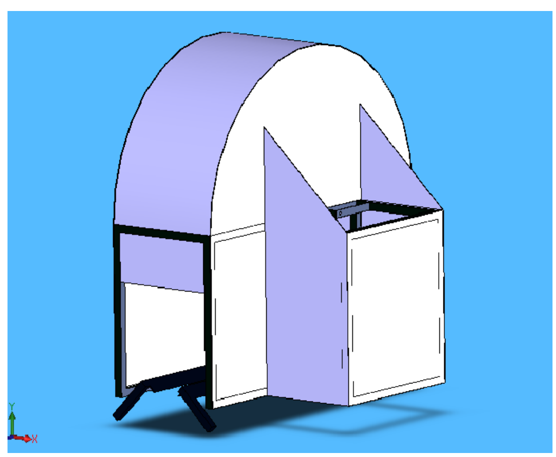


Figure 3.7 Components before assembly



(a)



(b)

Figure 3.8 (a) and (b) Components after assembly

3.4 Fabrication

Fabrication is one of the most important steps in developing the prototype. Therefore, a proper design will lead to a proper fabrication process. The dimensions and the type of material that need to be used played an integral part in fabrication process. Each part required different approach to fabricate, base on its material, design and application.

There are three main processes is used in fabrication that is the grinding, welding and drilling process. Grinding and cutting machine is used in housing fabrication of the takraw ball feeder where the sheet metal is shaped according to the design. Cutting machine also is used in fabrication of the body frame apart from welding. It is important to weld the frame strong enough to support the whole structure. Thus, equipment such as MIG welding machine is used for welding of the prototype while the drilling machine is used to assemble the housing with the main frame. After the fabrication of parts is finished, a controller unit that contains a program to control the period of ball launch is equipped to the machine. The flow of fabrication is shown in Figure 3.9.

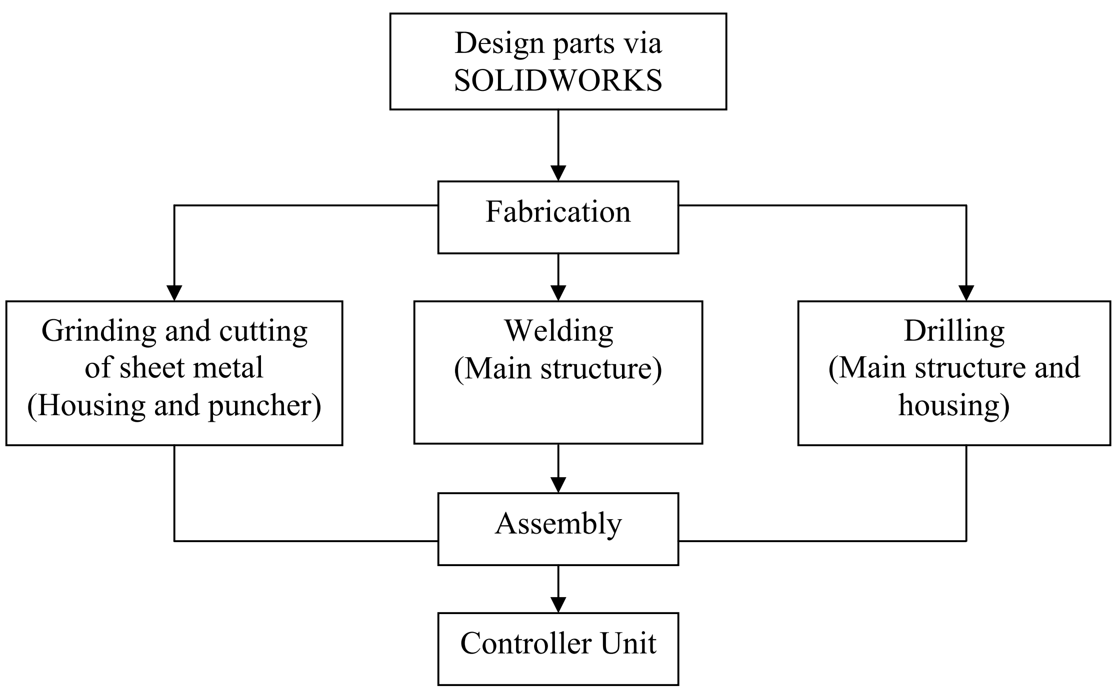


Figure 3.9 Fabrication flow

3.5 Controller Unit

The ball feeder prototype must have the ability to control the launching period. Thus, a program must be created to be applied with the power window motor application. Using PIC microcontroller, an appropriate program is downloaded to the microcontroller using ZIF socket downloader. Before downloading, the program is transferred to a HEX file and downloads to the PIC by using PCW C Compiler IDE.

3.6 Conclusion

This chapter concludes the methods involved during the development of the takraw ball feeder, starting from the design to the fabrication. All of the applied method and idea comes from the research of literature study to determine the suitable concept for this prototype. The next chapters in this research will cover the result of the test.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter will feature the result of the fabrication process alongside with the analysis than is done with the prototype of the takraw ball feeder. The dimension of certain structures or components of the prototype may not be as accurate according to the actual design and drawing. There are many barriers during fabrication that cannot be escape but the overall dimensions of the prototype are almost accurate as the actual design.

4.2 Fabrication Result

Fabrication of this prototype required a long period of time because of several complicated shape of components that required careful machining. Nevertheless, all the components are successfully fabricated thanks to available equipments and machines in the laboratory. This subchapter will explain briefly the fabricated parts and components along with its function and application in the takraw ball feeder.

There were several parts involve in fabrication of this prototype namely; the housing, body frame, rotating arm, bearing holder and ball track. Those fabricated parts are shown in the following figures with the explanations. Figure 4.1 below shows the fabricated ball feeder at each side. This is the looks of the overall structure of the prototype after assembling all the parts involved where only main parts such as the housing and body frame can be seen.

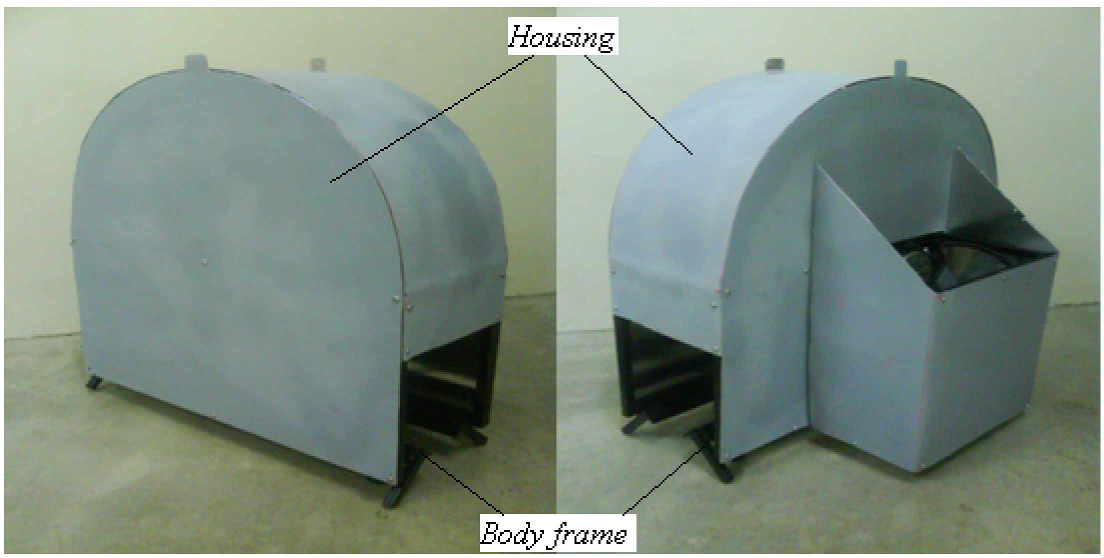
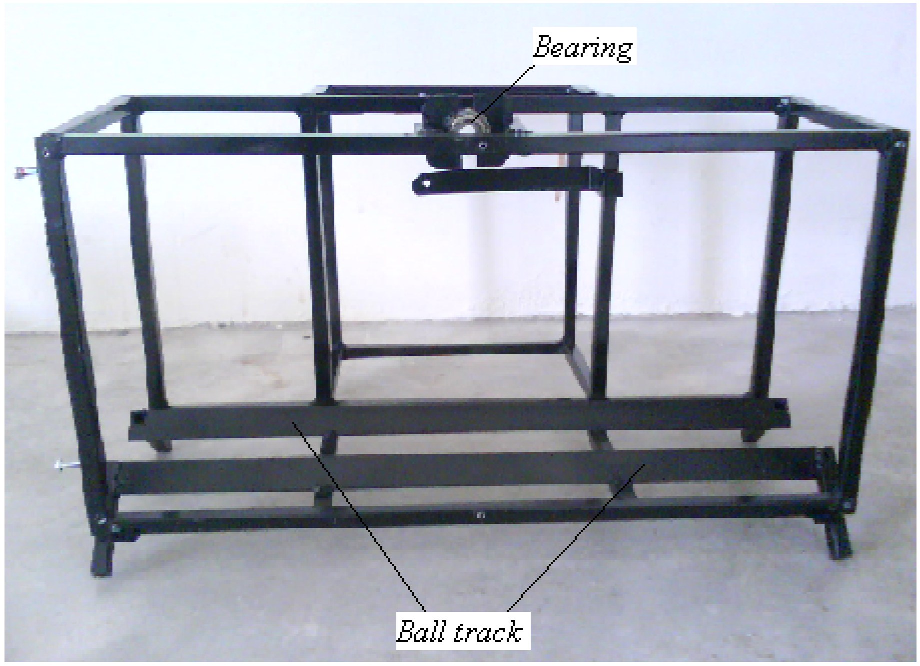


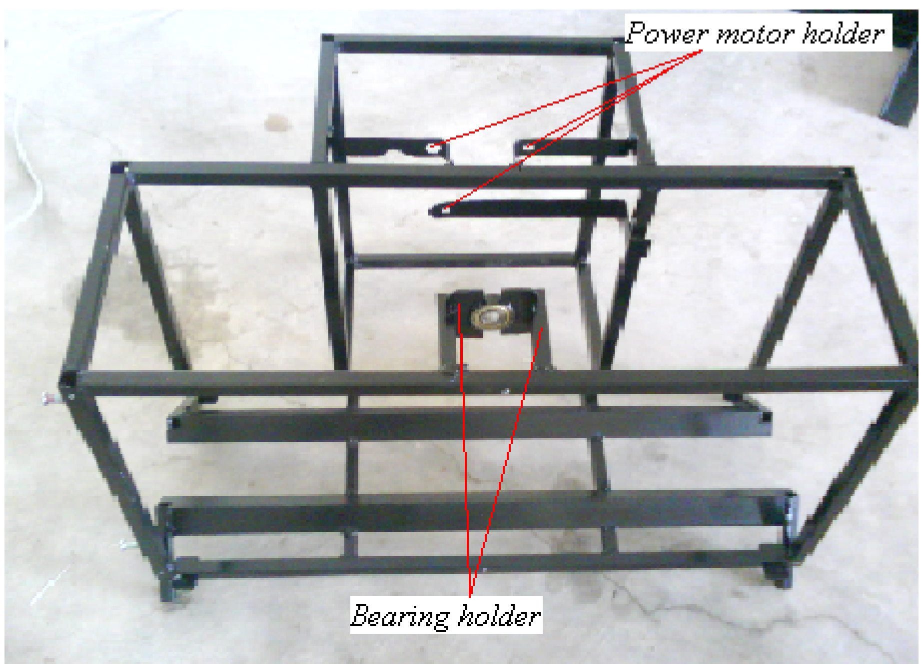
Figure 4.1 Fabricated takraw ball feeder

4.2.1 Body frame

The body frame is made from rectangular steel shape of 0.5 X 0.5 inch in dimension. The steel is cut into certain length before it is weld together. Basically, the body frame main function is to hold the rotating arm and the power window motor. It also is being used as an attachment to the housing of the prototype.



(a)



(b)

Figure 4.2 (a) and (b) Fabricated body frame

4.2.2 Housing

The housing is made from sheet metal that is fabricated according to the design and is function as a cover for the overall structure. The housing is separated into four different parts to make the prototype easy to assemble and maintains.

Figure 4.3 Fabricated housing parts

4.2.3 Rotating arm

Rotating arm is one of the main parts in the prototype where the function is to slam the ball by gravity through the outlet as it rotation is controlled by the power window motor. To make the rotation smooth, the rotating arm is connected by a shaft through a bearing.

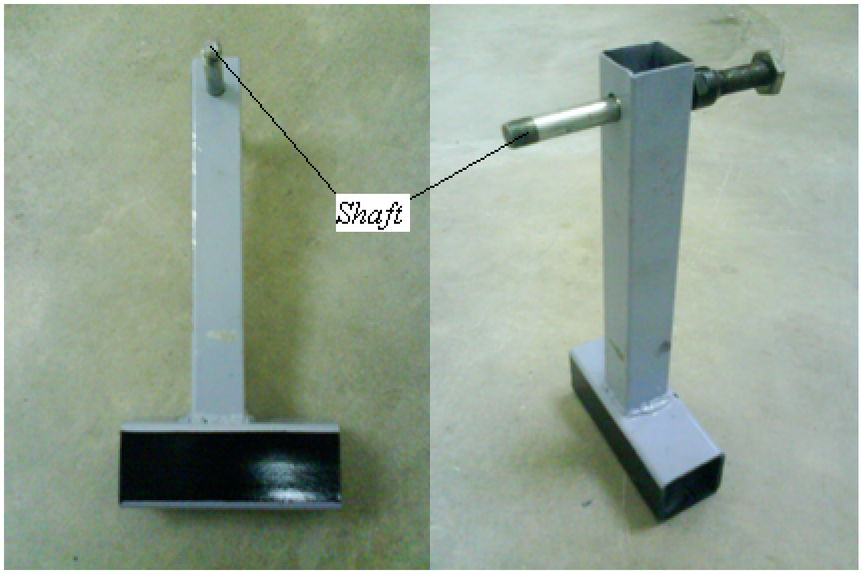


Figure 4.4 Rotating arm with shaft

4.2.4 Driver with power window

The driver (arm driver) is used as the rotating arm's lifter where it is connected through welding with a power window motor. The motor is supplied with a microcontroller program and a DC power supply where the supplied voltage can be adjusted. The microcontroller program is shown in the next subchapter.

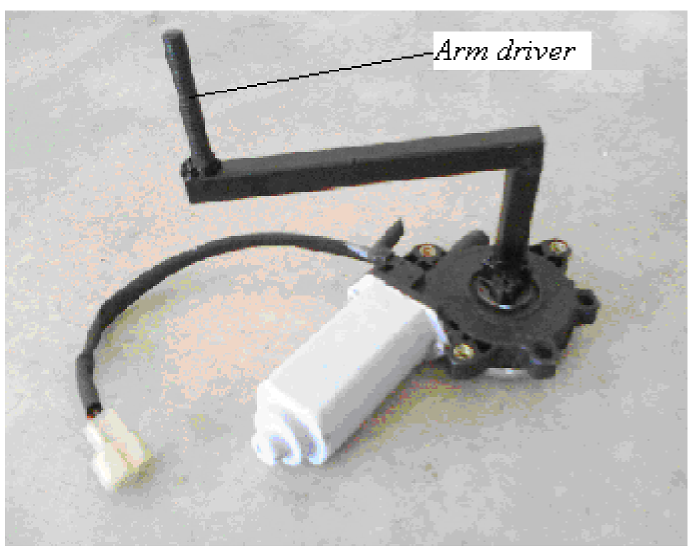


Figure 4.5 Arm driver

Microcontroller program

The prototype must be able to control the period of ball launch. Therefore, a program is needed to control the rotation of motor in order to control the period of launch. Different motor application uses different program. Thus, PIC microcontroller is the most suitable program to be applied. For this ball feeder, the program is set with 10 seconds time interval. Figure 4.6 below shows the applied program.

PIC program capiq - Notepad

File Edit Format View Help

```
#include <16f877a.h>
#USE DELAY (CLOCK=20000000)
#FUSES HS,NOWDT,NOPROTECT,NOPUT,NOLUP

#byte portA=5                              // register port by memory location
                                           // define adress portA at memory
                                              location 5
void power_window ( );

main ( )
{
Int i;
setup_ADC(ADC_off);                        // all port is off when ADC is off

set_tris_a(0);                             // set portA as output

for (i = 0; i = 1; i++)
{

power_window ( );
DELAY_MS (10000);

}
return;
}

void power_window ( )
{
portA=0b00010000;
DELAY_MS (5000);
portA=0b00000000;
DELAY_MS (5000);

return;
}
```

delayed power motor by 10 seconds

Figure 4.6 PIC program

4.3 Analysis

This subchapter includes three analysis of the prototype that is momentum analysis, distance analysis and structure analysis. The next subchapter will briefly explain each of the analysis.

4.3.1 Momentum analysis

The takraw ball feeder uses a gravity punching concept to throw the ball. Thus, several variable speed of ball launch and the acceleration of rotating arm need to be determined in order to done the next analysis. In order to find the speed of ball launch, the acceleration of hammer must be determine first.

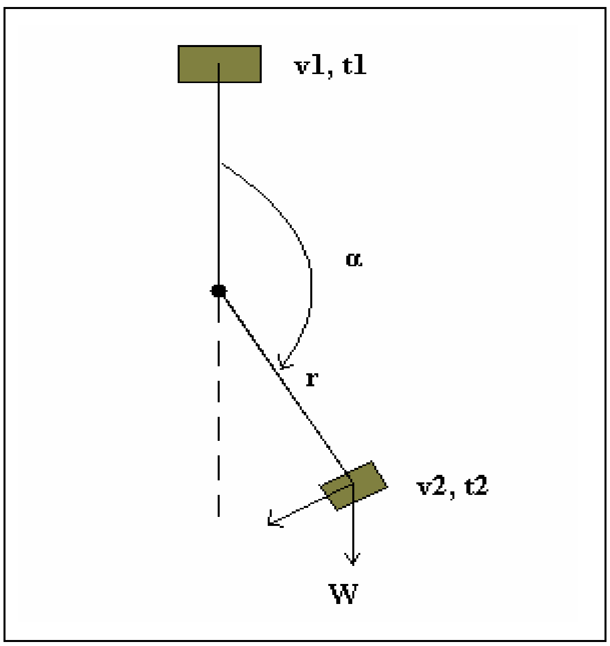


Figure 4.7 Rotating arm motion

Since V is tangent to the path, the angular momentum is:

$$H\,o = rmV \quad \text{(clockwise direction)}$$

To find the rate of increase in speed (dV/dt), use:

$$\sum M\,o = H'; \quad mg(r\sin\alpha) = d/dt.(rmV)$$

*Only weight W=mg contributes a moment about point O

Thus: $mgr.\sin\alpha = rm.dv/dt$

$dv/dt = g\sin\alpha$

$= (9.81) \sin 160$

$= 3.36 m/s^2$ (acceleration of hammer)

<u>*Principles of Angular Impulse and Momentum</u>

$$\boxed{mv_1 + \sum t_1 \int t_2 \, F \, dt = mv_2}$$

Where; $v_1 = 0$ m/s

$F = ma = 3.36 \text{ x } m$

$t_2 = 0.7s$

$m = 0.5kg$

Thus; $0 + \sum t_1 \int t2 \; 3.36m \, dt = mv_2$

$(3.36m).t = mv_2$

$v_2 = 3.36x0.7$

$= 2.352$ m/s (speed of lunch)

*Because the weight of hammer is fixed, the speed of launch is remains constant.

4.3.2 Distance analysis

After the value of ball launching speed is determined, the value of distance covered by the ball can be calculated. Given that from previous analysis, launch speed v_2 is 2.352 m/s. To achieve maximum distance, the ball feeder needed to be put at a high position and for this analysis, the highest position is assumed at 2 m. Before finding the value of distance the ball covered, the time taken to reach the ground is calculated by using projectile motion equation.

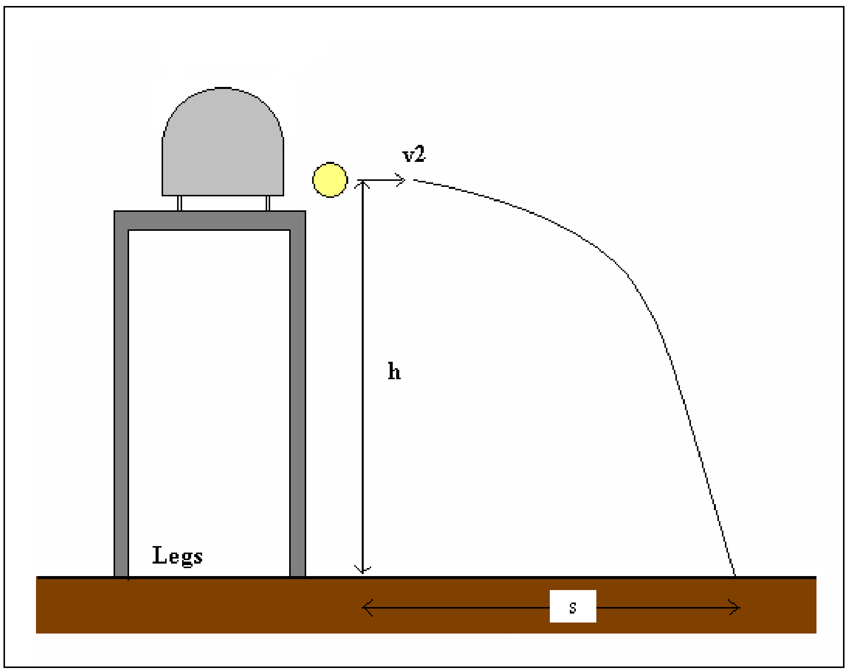


Figure 4.8 Distance covered

Using the equation of projectile motion:

$$\boxed{s = s_o + v_o t + 0.5at^2}$$

and

$$\boxed{d = do + v_2 t}$$

Sample of calculation:

Let h = 2.0 m, v_2 is 2.352 m/s, a = g = 9.81 m/s^2, v_o = 0 m/s, s_o = 0 m

$$s = s_o + v_o t + 0.5at^2$$

Thus;

$$h = h_o + v_o t + 0.5gt^2$$

$$-2 = 0 + 0 + 0.5(-9.81)\ t^2$$

$$t = 0.639\ s$$

Substituting value of t;

$$d = do + v_2 t$$

$$d = 0 + (2.352)\ (0.639)$$

$$= 1.503\ m$$

The result for other height application is shown in **Table 4.1**, **Figure 4.9** and **Figure 4.10**.

Table 4.1 Table of launch speed, height of launch, time and distance travel

Weight of hammer (kg)	Speed of launch, v_2 (m/s)	Height (m)	Time (s)	Distance (m)
0.5	2.352	2.0	0.639	1.503
0.5	2.352	1.8	0.606	1.425
0.5	2.352	1.6	0.571	1.343
0.5	2.352	1.4	0.534	1.256
0.5	2.352	1.2	0.495	1.164
0.5	2.352	1.0	0.452	1.063

From table, the maximum value of ball travel is quite less than expected. This problem occurs due to various problems during fabrication or the defect of certain parts. Further adjustment will be discussed in the next chapter of this thesis.

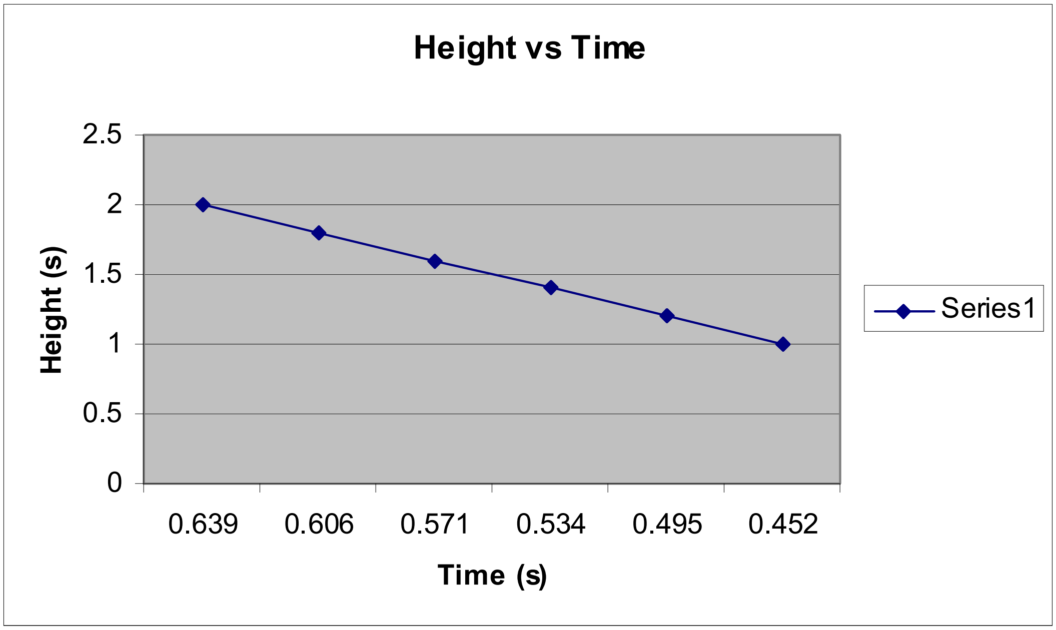


Figure 4.9 Graph of height versus time

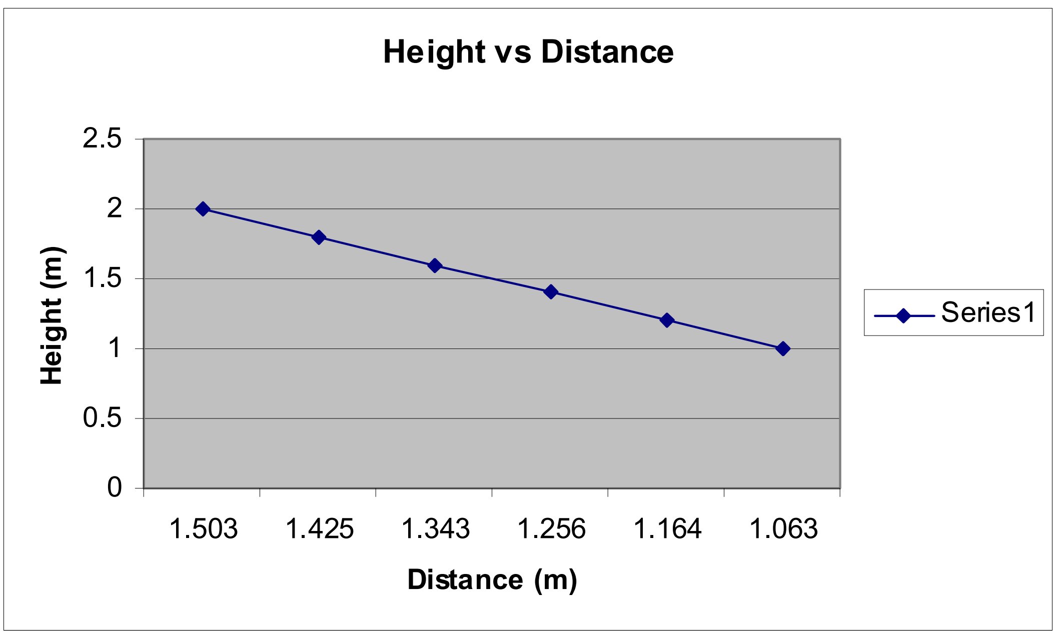


Figure 4.10 Graph of height versus distance

Figure 4.9 and 4.10 above show the relations between height, distance and time. From graph, it is shown that the higher height will result in higher distance and time.

4.3.3 Structure Analysis

Structure analysis is important to determine the strength of the structure so it can support the whole body. The body frame is being analyzed because it has certain crucial parts that involve rotation and force such as the bearing holder and power window motor holder. ALGOR program is used to determine the crucial sections that involve high tensile loads in the structure.

The structure will undergo an axial force and moment in certain part because the mechanism of this prototype involves rotational motion. From Figure 4.12, the axial force is applied at the bearing and power motor holder. The value of force applied is depend on the application where the bearing holder is used to hold the rotating arm (with shaft) that weight approximately at 0.5 kg (4.905 N) and the power motor weight is 0.8 kg (7.848 N).

Thus, the ALGOR analysis will determine the value of stress occurs in the structure. Brick element is used for the analysis and the material used is AISI 1010 steel, cold drawn where the steel properties is shown in Table 4.2.

Table 4.2 Properties of AISI 1010 steel, cold drawn

Mass density	0.00000000787 $N.s^2/mm^4$
Modulus of Elasticity	205000 N/mm^2
Poisson's Ratio	0.21
Shear Modulus of Elasticity	80000 N/mm^2
Thermal Coefficient of Expansion	0.0000122 $^oC^{-1}$
Tensile Strength	365000 N/mm^2
Yield Strength	305000 N/mm^2
Elongation	20%
Hardness	105 HB

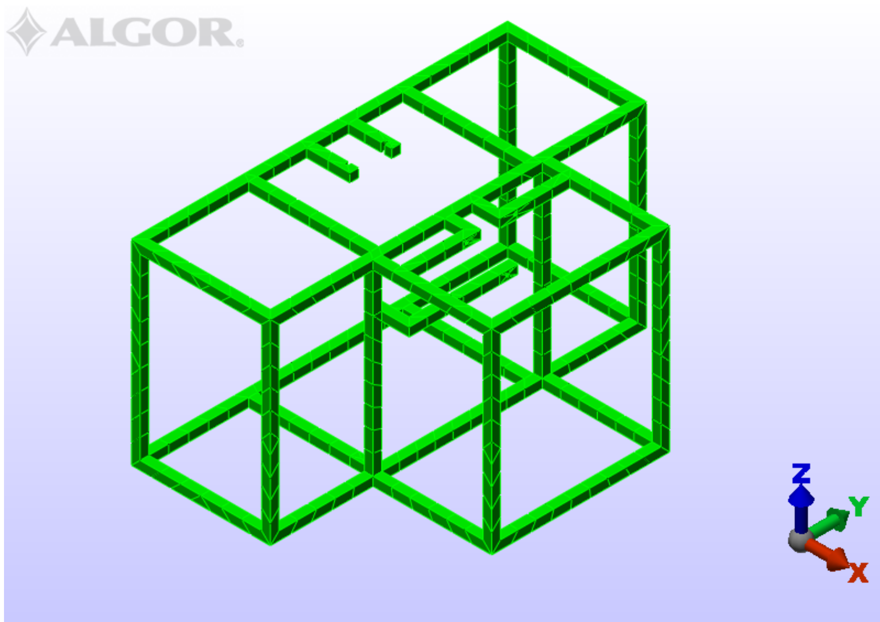


Figure 4.11 CAD model for the structure

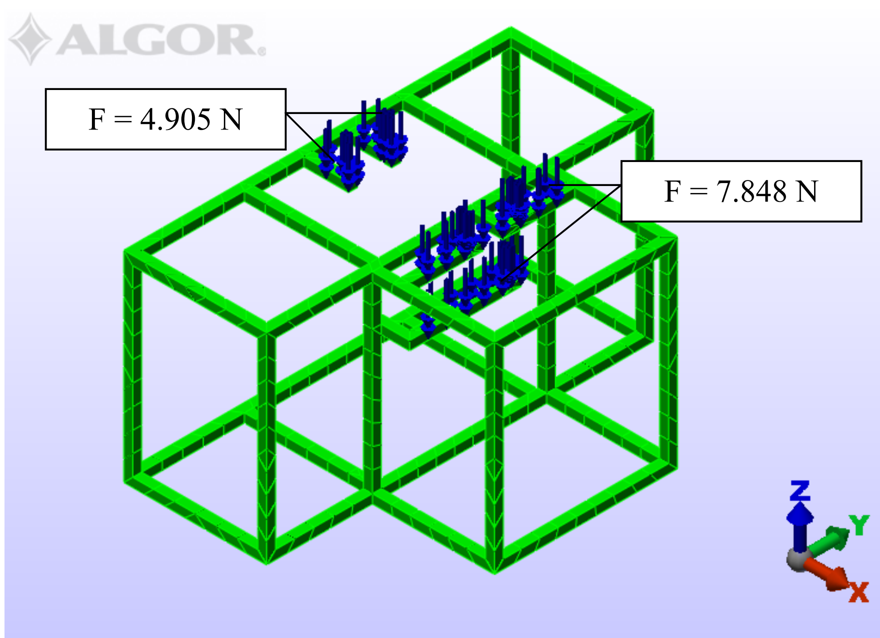


Figure 4.12 Applied force on the structure

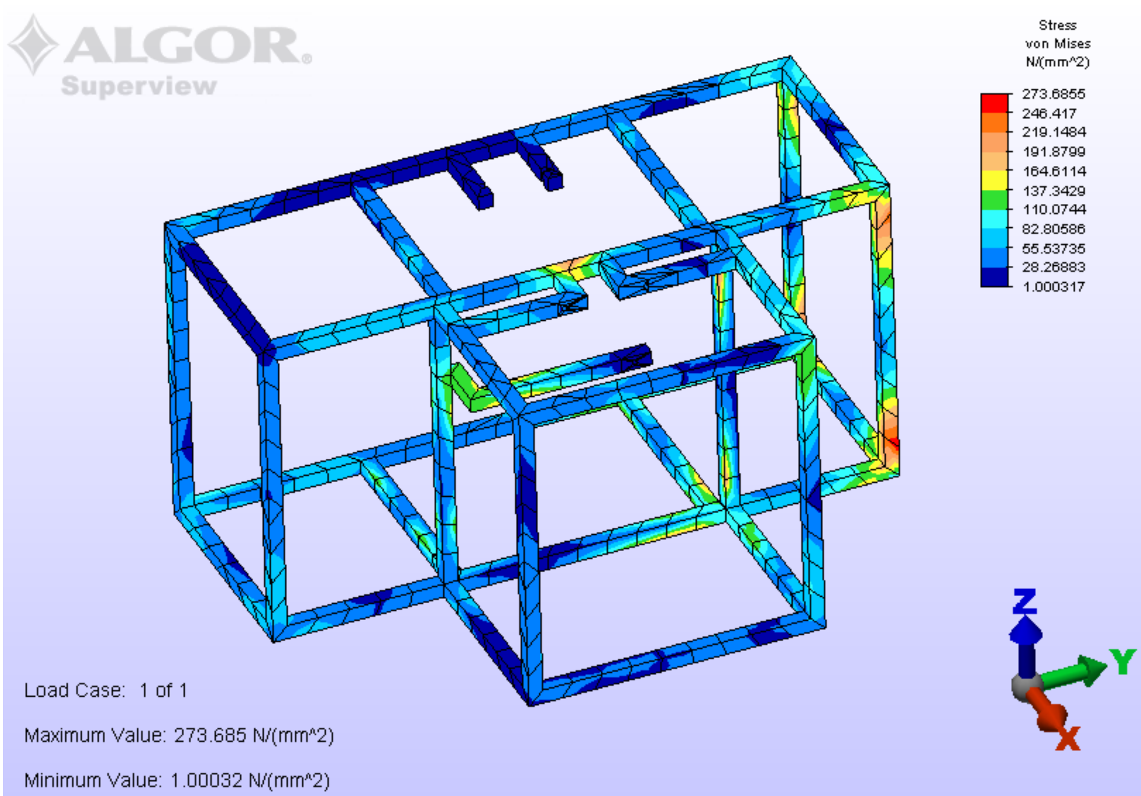


Figure 4.13 Analysis result

Taking the result for von Mises stress, it appears that the maximum value is 273.685 N/mm2 and the minimum value is 1.00032 N/mm2 as shown in Figure 4.13 above. The maximum stress value (red region) only appears at small part of the structure.

From the properties of AISI 1010 cold drawn steel (Table 4.2), the yield strength of the steel is 305000 N/mm2. Thus, the value of maximum stress from the finite element analysis which is 273.685 N/mm2 does not exceed the yield strength of the steel. Therefore, this structure can withstand the force exerted by the power motor and rotating arm weight to its holder.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, the prototype has been successfully developed based on the proposed design. The prototype is developed to achieve a distance that can cover at least half of the court. Based on calculations, the prototype can achieve a maximum distance of 1.503m and it is less than expectation.

Thus, to achieve further distance, some adjustment to the prototype is needed and will be explained in the next subchapter. Future development is needed to increase the ball launching speed and it can be achieved by adding the mass of the rotating arm.

Nevertheless, the prototype is easy to operate and removable (light in weight) and it help during training where the user can moved it easily. The prototype is also easy to operate and maintain because of its simple assembly design.

5.2 Recommendations

This takraw ball feeder can be improved in many ways to achieve the training objectives. To achieve a more realistic projectile motion, a functional legs or adjustable ball track can be attached to this ball feeder prototype. By doing this, user can set the degree of launch during training.

To further improvement of this takraw ball feeder, it is recommended to focus on its throwing concept whether using the current concept or other throwing concept that can achieve higher ball speed and distance. Therefore, it is highly recommended to use a high speed motor to throw the ball.

For more practical use during training, this prototype can be equipped with a ball container where the ball is stored and flow to the throwing unit where it is control by the program. Part from period of launch, the program also can control the distance covered and trajectory of the ball.

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APPENDICES

A Gantt chart

Due to time limitation, arrangement is needed to organize the works for the development of this project. The Gantt chart below shows the work plan for the first and second Final Year Project (FYP 1 & FYP 2).

FYP 1															
Tasks / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Literature study															
Define problem statement															
Define objectives and scopes															
Design															
Identify methodology															
Project Proposal															
Presentation preparation															
Final Presentation															
FYP 2															
Report writing															
Fabrication															
Analyzing result															
Presentation preparation															
Final presentation															

B Assembly of Components