TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

THAPATHALI CAMPUS

A PROJECT REPORT ON

DESIGN, FABRICATION AND TESTING OF SEMI AUTOMATIC WEIGHING MACHINE

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TRIBHUVAN UNIVERSITY
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It is hereby certified that this paper, entitled

A Project report on Design, Fabrication and Testing of Semi-Automatic Weighing Machine

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is an outcome of the research conducted under

"Department of Industrial Engineering"

The facts and ideas presented in this paper are an outcome of the student's hard work and dedication to the project, undertaken as a partial fulfillment for requirements for degree of

Bachelor in Industrial Engineering.

The outcome of this project has been highly appriciated.

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Abstract

Large scale industries in Nepal have advanced technologies for automatic packaging system but for small scale industries and cottage industries applying automation is not easily possible. It is because the fully automatic technologies are expensive and cottage industries cannot afford it. Using many person for weighing and packaging purpose also increases cost due to cost of labor.

To overcome this problem, we have designed semi-automatic weighing machine. This machine can weigh at high rate and reduces the number of workers from three to one in weighing and packaging purpose. This machine is also ergonomically suitable. The electronics design and coding help to ensure the correct measurement. For cottage industry the machine is economically suitable as it is easy to operate and financially suitable due to its low cost and low maintenance. It also doesn't consume much power.

Keywords: *automation, cottage industries, weighing, packaging, measurement*

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List of Abbreviations

A	- Ampere
AC	- Alternative current
cm	- Centimeter
CNC	- Computer Numerical Control
DC	- Direct Current
EEPROM	- Electrically Erasable Programmable Read-Only Memory
ICSP	- In-Circuit Serial Programming
I/O	- Input Output
KB	- Kilo Byte
LCD	- Liquid Crystal Display
MHz	- Mega Hertz
mm	- Millimeter
PWM	- Pulse Width Modulation
SRAM	- Static Random-Access Memory
UART	- Universal Asynchronous Receiver/Transmitter
UDL	- Uniformly Distributed Load
USB	- Universal Serial Bus
V	- Volt

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CHAPTER ONE:
INTRODUCTION

1.1 Background

Automation is the technology by which a process or procedure is performed without human assistance. Semi-Automatic is a combination of human effort and automation mechanism. Automation or automatic control is the use of various control systems for operating equipment such as machinery, processes in factories, boilers and heat treating ovens, switching on telephone networks, steering and stabilization of ships, aircraft and other applications and vehicles with minimal or reduced human intervention. Some processes have been completely automated. Automation has been achieved by various means including mechanical, hydraulic, pneumatic, electrical, electronic devices and computers, usually in combination. Complicated systems, such as modern factories, airplanes and ships typically use all these combined techniques. The benefit of automation include labor savings, savings in electricity costs, savings in material costs, and improvements to quality, accuracy and precision.

Automation is the rage of the engineering world. Using automatic machine reduces manpower, time and cost. Now we are in the stage where everything needs to be automatic and faster. So, everyone needs to do work in less time. In our busy life for any purpose we want our work to be faster and easy so that it saves time and human effort.
For some of the processes, fully automation may not be possible or difficult to design. Some processes may be easier when little effort is added in automation. This results in time management, reliable and desire outcome. We focused on develop a semi-automatic machine that can easily weigh the foods. Large industries, for example beverage industries have automated the system from blow molding to filling and packaging. But, for small industries and departmental stores weighing and packaging by the human effort of more than three people can be tedious and needs more workers. In this case, semi-automation helps in single person effort to manage the work previously needed for three persons.

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1.2 Concept Generation

Few months ago when we went to Salt Trading Limited in Kalamati, Kathmandu we saw more than six people working together in weighing and packaging department where per KG pouch of salt were prepared. There few people were to fill the salts in plastic from large sacks, few others weigh in electronics weighing machine and after weighing few others to seal those pouch. In this case, the person who weighs the salt consumes more time as he needs to check every time whether the amount of salt filled in the plastic is exactly 1000 grams or not. If not, then the other person takes off some salt and weigh again. This is so time consuming and high work to be done for single pouch preparation. Then, we got an idea to design a machine where the materials are already kept in the machine and when we fix the desire amount to pack, it automatically supplies to plastic until the required amount is filled so that one other can seal. This reduces the time and number of workers as only two people are enough for the system where six were needed previously.

1.3 Objectives

The general objective of this project is to design a semi-automatic weighing machine that reduces human effort, optimizes the packaging rate that finally deduces the product cost and time.

The specific objectives are given below:

- To replace manual weighing process with semi-automatic machine
- To have flexibility in packaging size
- To be familiar with manufacturing tools and processes

1.4 Significance of the project

The semi-automatic weighing machine has notable significance in cottage and small-scale industries. If we analyze the current situation of Nepal, most of the small scale and cottage industries have poor system in packaging process. While the large industries are already using automation for these processes, cottage industries are still using manual traditional system for weighing and packaging. Because of this issue they couldn’t package sufficient

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amount of packets. This reduces their productivity and sales. This decreases the profit. There are two ways that the cottage industries can adopt for high packaging rate.

1. Using automation for weighing and packaging
2. Increasing the number of workers for packaging

Cottage industries cannot adopt expensive, fully automated machines. Because they are too expensive, and they also need high skills. If they go to increasing the number of workers then the rate of per packet cost increases as number of labors are added. To solve this issue our project will help. Our project needs only one worker to package and its not expensive though. It doesn't need high skill to operate. This machine has capable to package many packets in short period of this by only one person. In one side, this machine is automatic and in other side this machine reduces the number of workers.

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CHAPTER TWO:
LITERATURE REVIEW

Weighing scales are born of necessity. As trading developed during the Antiquity, merchants needed a way to assess the value of goods that could not simply be counted by the pieces, like irregular-shaped gold nuggets for instance. The most ancient relics of a weighing scale have been discovered in the Indus River valley, near present day's Pakistan, and date back to around 2,000 B.C. Those first weighing scales were actually balances, using two plates attached to an overhead beam, itself fixed on a central pole. The measurement was taken by putting the object measured on one plate and weight-setting stones on the other, until equilibrium was reached.

This system can be very accurate, but it can also be easily cheated. Perhaps the most famous example of a rigged balance was the one used by Celt chieftain Brennus around 390 B.C. when he captured Rome and demanded a ransom of 1,000 pounds of gold. When the Romans complained about Brennus using fixed weights, Brennus famously threw his own sword on top of the weights and proclaimed "Woe to the vanquished!" (A Short History of the Weighing Scale, 2011)

The weighing scale didn't know any major technological improvements until the industrial era. It is only starting in the late 18th century that new ways to measure mass appeared that didn't rely on counter-weights. The spring scale was invented by Richard Salter, a British balance maker around 1770. The spring scale, as the name implies, measures the pressure (or the tension) exerted on a spring to deduce the weight of an object. Spring scales are still fairly common today because they are very cheap to make, but they are not quite as accurate as the electronic systems designed and perfected during the 20th century.

The most modern body scales rely on electronics to measure the weight of their users. By sticking electrical resistances on deformable materials and running a current through them, it is possible to detect variations in the conductivity of the resistances that are correlated to the amount of pressure exerted on the material, and thus to deduce the weight of the person (or the object) standing on the scale. The most high-end body scales also act as impedance

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meters, and are able to calculate the ratio of fat mass and lean mass in the body. The impedance measurement is taken by generating a very small electrical current on the surface of the scale and measuring the resistance encountered by the current as it travels through the body. Lean mass is a better conductor than fat mass, so it is therefore possible to deduce the ratio of both in the body.

Using a balance to measure the weight of an object or to compare the weight of two objects is called “Weighing”, which has been undertaken for thousands of years. Every human being on our planet is affected by weights and measures in some way or other. From the moment we are born and all through our daily lives, weighing and measuring are an important and often vital part of our existence. Our bodies, the food we eat and all the products we use as an essential part of modern living have all been weighed and measured at some stage in their development. Weights and measures are definitely one of man's greatest and most important inventions, ranking alongside the wheel in the development of civilization. Commerce would not have progressed beyond the barter system without the invention of a system of weights and measures. There are three elements to the weighing story and each evolved over the 6,000 years of its history; first, we have the use and development of weights; then the different weighing machines and apparatus; and finally the introduction of weights and measures to control commercial transactions.

Study of weighing problem originated in a casual illustration furnished by Yates. The precise formulation of such problems is to be found in Hotelling. Hotelling and Yates have shown that the individual weights may be determined more accurately by weighing the objects in combinations rather than weighing each one separately. Over the years the problem has attained a distinctive growth, has branched out in different directions, and has acquired meanwhile the status of a problem in the design of experiments. The problem has also become associated with the name of Hadamard and has given noticeable momentum to research in the extension of the Hadmard determinant problem. The experimental designs are applicable to a broad class of problems of measurement of similar objects. The chemical balance problem (in which objects may be placed in either of the two pans of the

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balance) is almost completely solved by means of designs constructed from Hadamard matrices.

Yates showed that if several light objects such as seeds are weighed in groups rather than individually as customary and next the weights of the individual objects are estimated by the method of least squares, then the precision of the estimates increases quite considerably.

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CHAPTER THREE:
RESEARCH METHODOLOGY

Methodological research is a controlled investigation of the theoretical and applied aspects of measurements, mathematics and statistics and ways of obtaining and analyzing date food. For Industrial Research Institute, Research Methodology is a way to find out the result of a given problem on a specific matter or problem that is also referred as research problem.

Research Design

Research design is an outline, a plan or a strategy specifying the procedures to be used in investigating the research problem. It is a framework or a plan for the study used as a guide in collecting and analyzing data. It acts as the blueprint for the completion of the project. Therefore, we can say that the research design is the layout for the collecting and analyzing of data along with the completion of the project.

Source of data

We were eager to know the present scenario of weighing and packaging in Nepal.

- Primary Source

We visited different industries in Kathmandu to get the ideas and the designs. We also went to Salt Trading Limited, Satungal where the salts are packaged. From there we generated the concept.

- Secondary Data

We have searched different sites in internet. Moreover, we also got information from journals and research articles which assist to prepare this report.

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CHAPTER FOUR:
FABRICATION DETAILS

4.1 Mechanical Components

Followings are the mechanical components used in the machine.

4.1.1 Hopper

The primary function of hopper is to store the material and pass it slowly to the weighing machine. Hopper is fabricated using metal sheet. The size of upper rectangle is X*Y = 660mm*410mm. The size of lower rectangle is x*y = 160mm*160mm.The height (H) of hopper is 250mm. So,

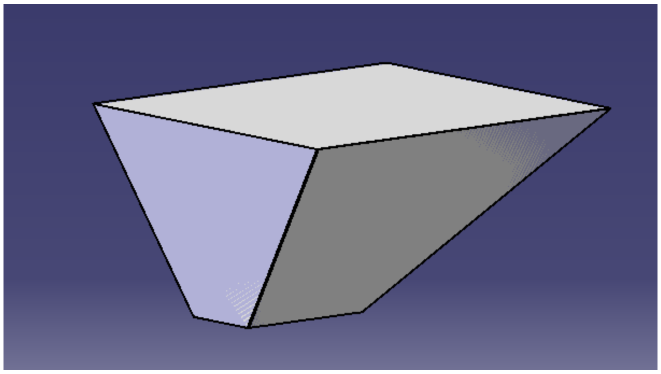

Figure 4.1 Hopper

$$\text{Volume} = \frac{\frac{1}{3}H\left(X^2Y - x^2y\right)}{X - x}$$

$$= \frac{\frac{1}{3}\times 250\times(660^2\times 410 - 160^2\times 160)}{660 - 160}\ \text{mm}^3$$

$$= 29083\ \text{cm}^3$$

From hand calculation, the size of hopper is found to be 29083 cm^3 but from Catia, the size of hopper is found to be around 32000 cm^3 which is quite similar.

The shape and size of sheet metal required to be cut is shown below where all dimensions are in mm.

Specification:

Thickness: 2 mm

Top dimension: 45mm * 65mm

Bottom Dimension: 25mm * 25mm

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4.1.2 Conveyer

Conveyer is used to transfer the food item from hopper to the conical vessel. We have used jeans as a conveyer belt because it is easily available and is reliable for the rotation of the used motor. Conveyer belt lies above conveyer bed.

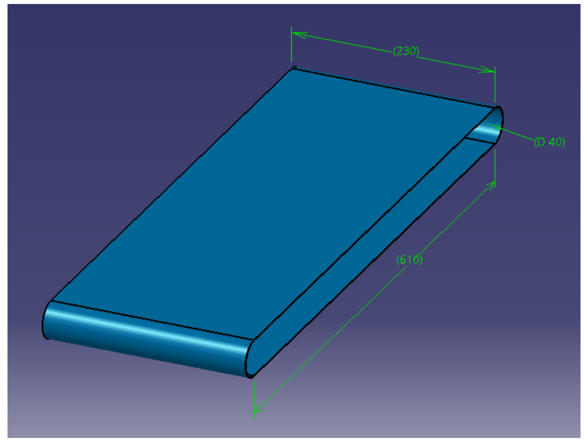

Figure 4.2 Conveyer

Specification:

Conveyer Material: Jeans

Conveyer Roller: Aluminum

Conveyer Roller Dimension: 20mm and 40mm diameter

4.1.3 Conical Passage

The primary function of conical passage is to transfer all weighted material to a plastic. It will be fabricated using metal sheet too.

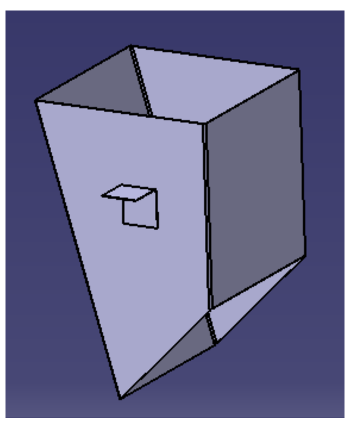

Figure 4.3 Weighing Part

4.1.4 Weighing Part

Weighing part is mounted with load cell. Its function is to weigh the material. It has opening at the bottom controlled by the four-bar mechanism.

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4.1.5 Bearings

Bearings are used to rotate the conveyer roller that further rotates conveyer belt. Four bearings are mounted at 25 cm; two before conveyer bed and two after conveyer belt.

Specification:

Bearing Type: Ball Bearing (UC6204)

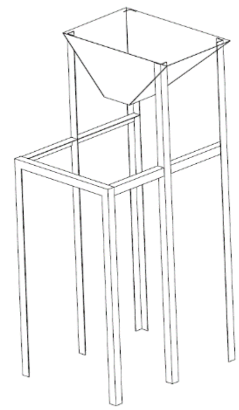

Figure 4.4 Frame

4.1.6 Frame

Frame provides support to the components. In our project we used L Channel to construct the basic frame.

Specification:

Material: Mild Steel

4.1.7 Conveyer Cylinder

Conveyer cylinder consists of cylindrical rod. Two ends are fitted with the bearing and the conveyer belt is moves in the surface.

Specification:

Material used: Aluminum

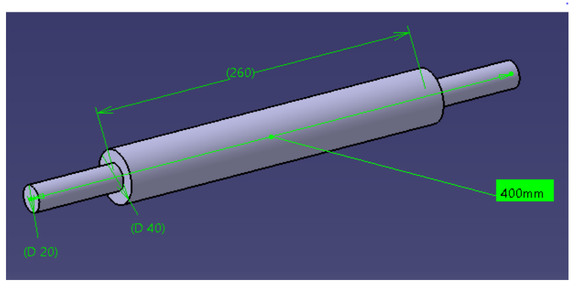

Figure 4.5 Conveyer rod

4.1.8 Rivet

A rivet is a permanent mechanical fastener. Before being installed, a rivet consists of a smooth cylindrical shaft with a head on one end. The end opposite to the head is called the tail. On installation, the rivet is placed in a punched or drilled hole, and the tail is upset, or bucked (i.e., deformed), so that it expands to about 1.5 times the original shaft diameter, holding the rivet in place. In other words, pounding creates a new "head" on the other end by smashing the "tail" material flatter, resulting in a rivet that is roughly a dumbbell shape. To distinguish between the two ends of the rivet, the original head is called the factory head and the deformed end is called the shop head or buck-tail.

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4.2 Electronics Components

Electronics components used in the projects are as follows:

4.2.1 Motor Driver

Motor drives are circuits used to run a motor. In other words, they are commonly used for motor interfacing. These drive circuits can be easily interfaced with the motor and their selection depends upon the type of motor being used and their ratings (current, voltage).

4.2.2 Load Cell

A load cell is a transducer that is used to create an electrical signal whose magnitude is directly proportional to the force being measured. Strain gauge load cells work on the principle that the strain gauge (a planar resistor) deforms when the material of the load cells deforms appropriately. Deformation of the strain gauge changes its electrical resistance, by an amount that is proportional to the strain. The change in resistance of the strain gauge provides an electrical value change that is calibrated to the load placed on the load cell. A load cell usually consists of four strain gauges in a Wheatstone bridge configuration.

4.2.3 HX711 Load Cell Amplifier

Load Cell Amplifier is a small breakout board for the HX711 IC that allows us to easily read load cells to measure weight. By connecting the amplifier to our microcontroller we will be able to read the changes in the resistance of the load cell and with some calibration we'll be able to get very accurate weight measurements. This can be handy for creating our own industrial scale, process control, or simple presence detection.

4.2.4 LCD display

LCD stands for liquid crystal display. Character and graphical LCD’s are most common among hobbyist and di- electronic circuit/project makers. Since their interface serial/parallel pins are defined so its easy to interface them with many microcontrollers. Many products we see in our daily life have LCD’s with them. They are used to show status of the product or provide interface for inputting or selecting some process. Washing

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machine, microwave, air conditioners and mat cleaners are few examples of products that have character or graphical LCD's installed in them.

4.2.5 DC Motor

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances.

4.2.6 Arduino Mega

The Arduino Mega is a microcontroller board based on the ATmega1280 (datasheet). It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

Table 4.1 Specification of Arduino Mega

Microcontroller	ATmega1280
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	128 KB of which 4 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

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4.2.8 Servo Motor

A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. Servomotors are not a specific class of motor although the term servomotor is often used to refer to a motor suitable for use in a control system. Servomotors are used in applications such as robotics, CNC Machinery or automated manufacturing.

4.2.9 Jumper Wires

A jump wire (also known as jumper, jumper wire, jumper cable, DuPont wire, or DuPont cable – named for one manufacturer of them) is an electrical wire, or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering. Individual jump wires are fitted by inserting their "end connectors" into the slots provided in a breadboard, the header connector of a circuit board, or a piece of test equipment.

4.3 Tools used in Fabrication

Various tools were used in this project. While doing this project we got chance to be familiar with various tools, know about their importance in the industries and their safety factors to be considered for the use of these tools. Some of the tools that were used in this project are discussed below.

4.3.1 Measuring Tape

Measuring tape is used to measure the length of the tools and the components, Generally the least count of measure tape is found to be 1 mm. Various components of our project's length was measured using this tape.

4.3.2 Vernier Caliper

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The Vernier caliper is a precision instrument that can be used to measure internal and external distances and diameter extremely accurately. This was used in our project to measure the diameters of hole.

4.3.3 Mallet

Mallet is used to give shape to the soft metal. This was used to make the sheet metal straight for the further on the project.

4.3.4 Sheet Cutter

This is suitable for shearing carbon plates and bars. It also slices through sheet metals manually but easily,

4.3.5 Cutter off machine

Cutter off machine is used to cut the metals in straight as well as angular pattern. This was used to cut L-Channel bars in our project.

4.3.6 Drilling Machine

Drilling machine is used to drill holes in the metals and woods, In our project, we use this to make hole in metal bars and sheet metals.

4.3.7 Welding Machine

Welding machine is used to weld two metals into a single piece and provides strength. The It was used mostly in frame.

4.3.8 Hand Grinder

Hand grinder is used to make the pointed eges blunt and also to give the metal a little bit of shape. It was used in our project to blunt the sharp and also cut the weld.

4.3.9 Lathe Machine

Lathe machine is used to make metal of require shape and size. We used this machine to make the cylindrical rods.

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4.3.10 Wood Cutter

This was used to cut the wooden plies in required size.

4.4 Manufacturing Processes

4.4.1 Welding

Welding is a fabrication process that joins materials usually metals or thermoplastics by causing fusion. Welding is performed with the heat of an electric arc that is maintained between the end of a coated metal electrode and the work piece. Welders need to have a thorough knowledge and understanding of safe working procedures and personal protective equipment. They need to gain specific knowledge of a wide range of welding equipment and processes as well as good working knowledge of metallurgy.

This process was used quite often to weld different components of the project.

4.4.2 Drilling

Drilling is a cutting process that is uses a drill bit to cut a hole of circular cross section in solid materials. The drill bit is a rotary cutting tool, often multipoint. The bit is pressed against the work piece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the work piece, cutting of chips from the hole as it is drilled. This process was used to make a hole on piston heads, cams.

4.4.3 Grinding

Grinding is used to finish workpieces that must show high surface quality (e.g., low surface roughness) and high accuracy of shape and dimension. As the accuracy in dimensions in grinding is of the order of 0.000025 mm, in most applications it tends to be a finishing operation and removes comparatively little metal, about 0.25 to 0.50 mm depth.

4.4.4 Facing and Turning

Turning is a lathe operation in which the cutting tool removes metal from the outside diameter of a workpiece. A single point tool is used for turning.

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CHAPTER FIVE

RESULT AND DISCUSSION

5.1 Schematic Diagram

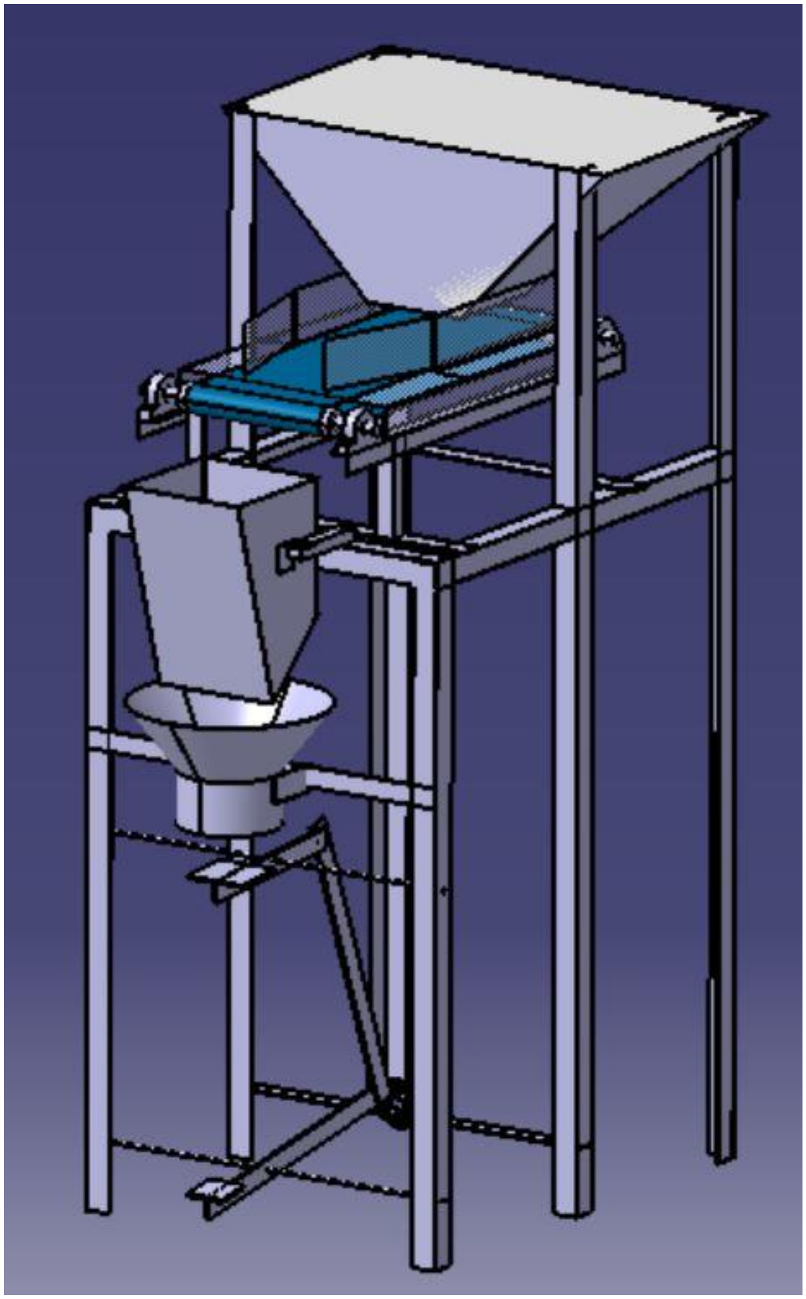

Figure 5.1 Schematic Diagram of Machine

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5.2 Working Mechanism

The materials to be weighted is stored in hopper with its opening closed. The hopper caries the maximum volume of around 30,000 cm^3 material. When we start the machine, the conveyor starts running. The conveyor is powered by DC motor. The opening of hopper is adjusted as per the user's requirement which controls the flow of material from hopper to conveyor belt. Then the material is flown through hopper to weighing part by conveyor slowly. The weighing part can measure upto 8000 cm^3 volume and around 15 kg weight of material at a time. Two load cells of 10 kg each are fitted in a weighing part which gives the false sense of having a capacity upto 20 kg but load cell also carries the load of weighing part. So it can be assumed that its maximum load capacity is 15 kg. But it is always suggested to use the load upto 10 kg for reliability.

Once the weight in a weighing part becomes equal to our required weight, the conveyor stops running and the servo motor opens the gate of weighing part dropping it to a cone shaped vessel which concentrates the weighted material into plastic bag. When the weighing part is empty, the servo motor closes the opening of weighing part and the conveyor starts running again and the process continues on and on. Electronics coding is used to control the mechanism as per our desire.

Calibration

After total assembly of machine, we should calibrate the load cells of machine. We should make the 1kg of real world equal to 1kg in weighing machine. For the calibration of machine, we should do certain calculations. We have taken 1kg of salt to calibrate our weighing machine. We put a packet of 1kg on a Weighing part, then data of weight is taken. For a calibration factor of 500, we got the loadcell reading of 914 gm. For a calibration factor of 300, we got the loadcell reading of 1528 gm. But the real weight is 1000 gm. So for this condition, we can use the interpolation formula.

Y	X
500	914
300	1528
y	1000

`

y - y_1 = $\frac{y2-y1}{x2-x1}$(x-x_1)

= $\frac{500-300}{914-1528}$(1000-1528)

y – 300 = 171.987

y = 472

Hence, our required calibration factor is 472.

5.3 Shaft and Bearing Design

5.3.1 Calculation of the cylinder shaft diameter

Since, in our case the shaft is subjected to rotational effect so twisting moment occurs and we have to consider that to find the diameter of the shaft. For consideration, we have taken the reference help from R.S. KHURMI and Design Hand Book. Our calculation follows as:

- **When subjected to twisting moment**

$$\frac{T}{J} = \frac{\tau}{r}$$

Where, T = twisting moment

J = polar moment of inertia

τ = torsional shear stress (25 Mpa)

r = d/2 (diameter of the shaft)

Now,

J = $\frac{\pi * d^4}{32}$

Or, $\frac{T}{\frac{\pi * d^4}{32}} = \frac{\tau}{\frac{d}{2}}$

Or, $d^3 = \frac{16 * T}{\pi * \tau}$

Since, T =38 Kgcm =((30*9.8)/100)*1000 Nmm

Where, N = revolution of cylinder shaft i.e. 60 rpm

Then,

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$$d^3 = \frac{16T}{\pi * \tau}$$

$$= \frac{16 * \frac{38*9.8}{100} * 1000}{3.14 * 25}$$

= 13 mm

Hence, d = 13 mm

Hence the minimum diameter should be 13 mm. For our convenience and commercially available of bearing to be fitted in it we have chosen the shaft diameter of 20 mm.

5.3.2 Selection of Bearing

Since, bearing is used to support and provide the rotational effects and bearing is to be chosen according to the diameter of the shaft. For our project, we have chosen bearing of series 6204 according as our shaft size is 20mm.

5.4 Cost Analysis

1. **Material Cost**

Table 5.3.1 Material Cost

SN	Material	Specification	Quantity	Price. (Rs)
1	Sheet Metal	2m * 1m	2 pcs	2500
2	L Channel	Mild Steel	12 m (total)	2500
3	Bolt Nut	8 mm * 1.5”	40 pcs	360
4	Bearings	UC204 Bearing	4 pcs	1200
5	Jeans Belt			160
6	Conveyer Bed	45cm * 37cm		
7	7-Segment LCD Display		1 unit	400
8	Header Pin			35
9	Switch		1 unit	10
10	Digital Switch		2 pcs	30
11	Nub			10
12	Jumper Wire		30 Pcs	300
13	Load Cell and Load Cell Amplifier		2 pcs each	1650
14	Hinge		2 pcs	15
15	Motor Driver	60 rpm	1 unit	300
16	Arduino		1 pcs	2000
17	Battery	12 volt	1unit	2500

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18	Servo Motor	90 Kgcm	1	2000

Total: Rs 15,970

2. Overhead Cost

The overhead costs are as follows.

Table 5.3.2 Overhead Cost

SN	Process	Cost
1	Cost of Welding	Rs. 1000
2	Cost of Machining	Rs. 1500
3	Cost of Electricity	Rs. 500
4	Cost of Labor	Rs. 2500
5	Other costs	Rs. 3000

Total Cost of the Machine = Material Cost + Overhead Cost
= Rs 15,970 + Rs. 8500
= Rs. 24,470
~ Rs. 24,470

5.5 Economic Analysis and Payback Period

From our calculation, our total cost is around Rs 24,500. Here we want to identify our customer, an owner of a small-scale industry and currently three labors are being used in that factory for packaging process. Our customer wants to make a packaging process efficient and more productive, So, he wants to buy our machine at Rs. 40,000 but we can convince our customer by showing discounted payback period.

If he uses this machine, the packaging process would get faster, and labor cost could be highly minimized as only one labor would be required. Suppose the salary of a labor be Rs. 7000 per month. If only one labor would be required despite three labors, Rs 14,000 per month could be saved. This can also be treated as an income for an industry. Let us suppose the electricity bill for this machine just balances the benefit due to increased productivity. Also, let us suppose that our customer buys that machine in Rs 40,000 by taking loan from bank at 1.1% interest rate per month.

Then,

Investment = Rs. 40,000

Additional benefit at the end of each month (A)= Rs. 14,000

Interest Rate (i) = 1.1% per month

`

Also, let us suppose the operating costs like electricity bill and monthly maintenance costs be Rs. 1500.

Hence, Saving = Rs. 14000 – Rs. 1500 = Rs. 12,500

Table 5.4 Cash Flow Diagram

Month	Cash Flow (Rs)	Discounted cash flow (Rs)	Cumulative discounted cash flow (Rs)
0	-40,000	0	0
1	12,500	12363	12363
2	12,500	12229	24592
3	12,500	12096	36688
4	10,000	11964	48652

Here,

From the formula, Present worth = $\frac{Future\ Worth}{(1+Rate\ )\hat{}Years}$, we can calculate the following,

$P_1 = \frac{12{,}500}{(1+0.011)1}$ = Rs. 12363 $\quad$ $P_4 = \frac{12{,}500}{(1+0.011)4}$ = Rs. 11964

$P_2 = \frac{12{,}500}{(1+0.011)2}$ = Rs. 12229

$P_3 = \frac{12{,}500}{(1+0.011)3}$= Rs. 12096

Here, Month before full recovery = 3

Unrecovered amount of start of period = Rs. 40,000 – Rs. 36,688

= Rs. 3,312

Cash flow during the period = Rs. 11964

Now,

Payback period = Month before fail recovery + $\frac{\text{Unrecovered amount of start of period}}{\text{Cash flow during the period}}$

$= 3 + \frac{3312}{11964}$

= 3.27 Months = 3 Months and 9 Days

It means, after three months and nine days, he starts adding these Rs. 12,500 per month in his revenue till the machine works.

`

5.6 Testing and Machine Efficiency Analysis

The main objective of our project was to decrease the number of workers and increase packaging rate. We have tested the machine and obtained the following data. We have assumed that there is also a sealing machine attached nearby the machine so as to calculate the total time taken in packaging of a packet.

For 100 gram of Soyabean it took thirty-five seconds to prepare six packets of soyabean. i.e 10 packets can be prepared by one person in a minute. Similarly, 8 packets of 150 grams of Soyabean was prepared in a minute and 9 packets of 200 grams of packers was prepared.

From this analysis we found that, the number of packets produced also depend on the amount of feeding from hopper. In out 150 grams testing, there was less feed than 250 grams which results increase in time.

Lets analyze 100 grams of packaging using only one person:

1. Through Manual packaging method,

   Time for weighing = 9 sec

   Time for sealing = 3 sec

   Total time = 12 seconds

2. Through the machine

Five packets in 30 seconds i.e 6 seconds per packet

This means, from our 100 grams data we found that if only one person is used then he needs 12 seconds to prepare a packet whereas he only needs 6 seconds to prepare a packet using the machine. If we add other person in manual packaging, even if the packaging rate is higher, the cost will increase because of additional labor which is the undesired thing for any industry.

`

CHAPTER SIX:
CONCLUSION AND RECOMMENDATION

As per our objective, our project can reduce the number of workers required for weighing and packaging process in cottage industry which was verified during testing followed by the calculations of the same. This somehow helped to reduce the cost of the material as the cost of a product somehow depends on the number of workers required for producing it.

Besides that, it has also capacity to reduce the manual process. Manual process is time consuming and has low production rate for the same number of people in semi-automatic mechanism. Using semi-automatic machine made it easy, more safey and ergonomically suitable for the workers to work freely. Also, the controlling mechanism is an additional feature that can be varied according to the capacity of a worker. Hence, production rate is also increased as the worker feel less tired.

In the manual packaging process, there are many obstacles the workers face. For packaging a small amount using large plastic is waste. First thing, we can vary the size of plastic according to the size of opening in conical passage. Secondly, we can also vary the plastic according to the material to be weight. Heavy items may need small plastics and light material need huge plastic size for the same weight. This machine is flexible to the packaging of the material. For a single material, for example if we want to pack the soyabean then this machine also brought the flexibility in packaging size. The hole of conical passage is made such that change in plastic size doesn't differ in packaging rate.

In addition to all these, we have learned practical things about manufacturing tools and processes. We learned new tools that we never used before like hand grinder, riveting tool, sheet metal curving tool etc. We also learned how to repair the expired tools like the cutter of hand grinder. We learned how to work safely in the working environment and also the best suitable tool to use among alternatives. For example, in some case where arc welding is difficult, we learned that gas welding is better for thin metals to arc welding. Also, We are now capable to weld, drill, lathe and other similar activities with safety.

`

During the fabrication of this project, there were some challenges like the accuracy of load cell, its malfunctioning and also we had lots of obstacles encountered in proper alignment of the frame. Despite of all these, we almost reached the objectives of our project. Although there are still some lacks in the machine, those issues can be solved with little more effort in future development of this machine.

Future Augmentation

There are many areas that can be perfected and corrected for more better performance and better result. The project concept is new, so it is bound to face many problems and limitations. But good thing is that this project can be an inspiration and reference for more improvement and enhancement of the weighing machine.

We have concluded some of the things that can be done to improve the machine and help other innovators students for further study.

- Food conveyer can be used for commercial purposes that helps in maintaining the quality of food to be weigh and packed.
- Vibration mechanism can be used instead of conveyer to withdraw the material from hopper
- Electronics components can be well managed and changed according to the requirement

Also, this machine can be advanced by adding packaging and sealing mechanism in addition to weighing so that a single man is enough for whole operation.

`

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Annex A: Designs

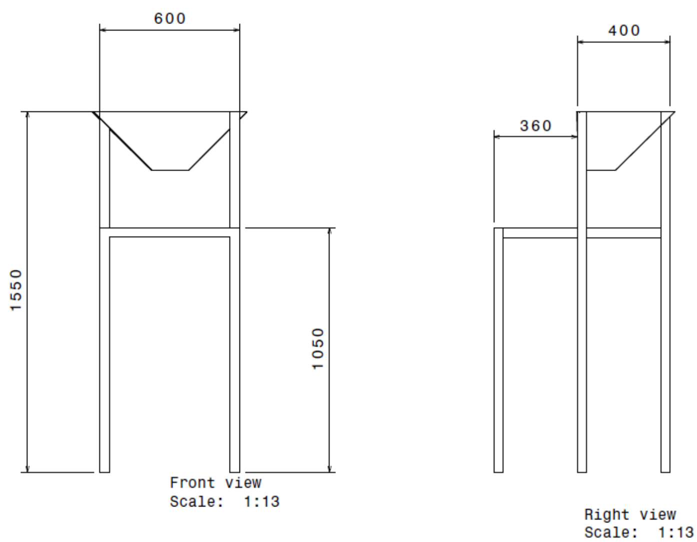

Figure A.1 Design of Frame

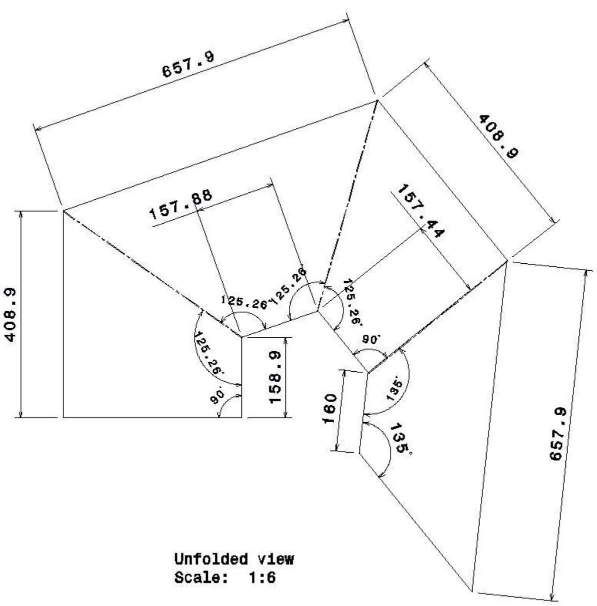

Figure A.2 Design of Hopper

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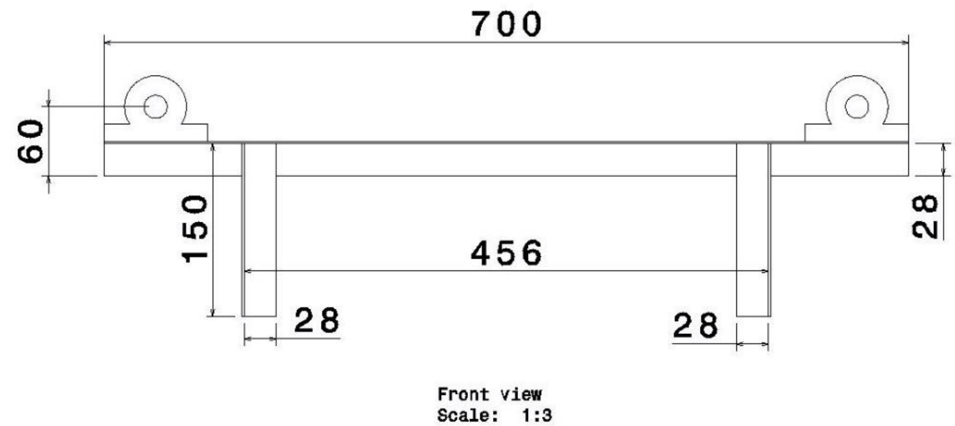

Figure A.3 Design of Conveyer Shaft

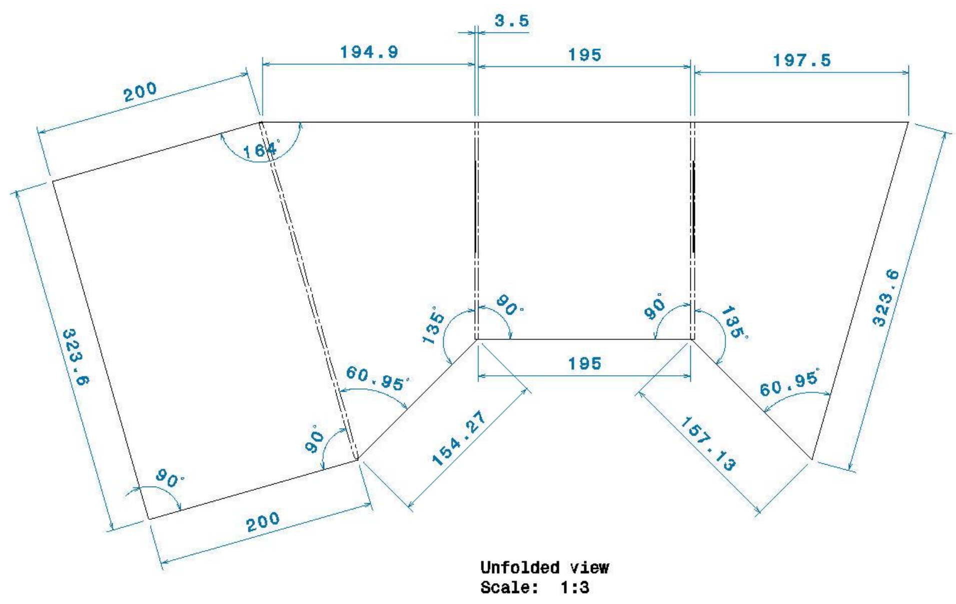

Figure A.4 Design of Weighing Part

`

Annex B: Calculations

1. **Belt tension**

Here,

f = Coefficient of friction=0.21 (Consider)

L = Conveyor length in meters. Conveyor length is approximately half of the total length =61cm

g = Acceleration due to gravity = 9.81 m/sec^2

mi = Load due to the idlers in Kg/m = neligible

mb = Load due to belt in Kg/m = negligible

mm = Load due to the conveyed materials in Kg/m = 0.05 Kg/m (Approximation)

δ = Inclination angle of the conveyor in Degree= 2 degree

H = vertical height of the conveyor in meters = 0.4 m

Belt tension in steady state,

Tb = 1.37*f*L*g*[2*mi+ (2*mb + mm)*cos (δ)] + (H*g*mm)

=1.37*0.21*0.61*9.81*[2*0+0)*cos(2)]+(0.4*9.81*0.05)

=0.42 N

The belt tension is found to be 0.42 Newton.

2. **Power required to drive pulley**

The power required at the drive pulley can be calculated from the belt tension value as below:

Pp = (Tb*V)/1000

= (0.42*0.0628)/1000

= 2.5*10^{-5} KW

Where,

Pp is in KW.

Tb = steady state belt tension in N= 0.42 N

v = belt speed in m/sec=0.6 m/s

3. **Belt tension while starting the system**

`

Tbs =Tb*Ks

=0.42 * 1.5

= 0.63 N

Where,

Tb = the steady state belt tension in N

Ks = the start-up factor = 1.5

4. **Sizing of Motor**

The minimum motor power can be calculated as:

Pm = Pp/Kd

= 0.00025 / 0.9

= 0.0027 Kw

Where,

Pm is in Kw.

Pp = the power at drive pulley in Kw

Kd = Drive efficiency

Annex C: Control System

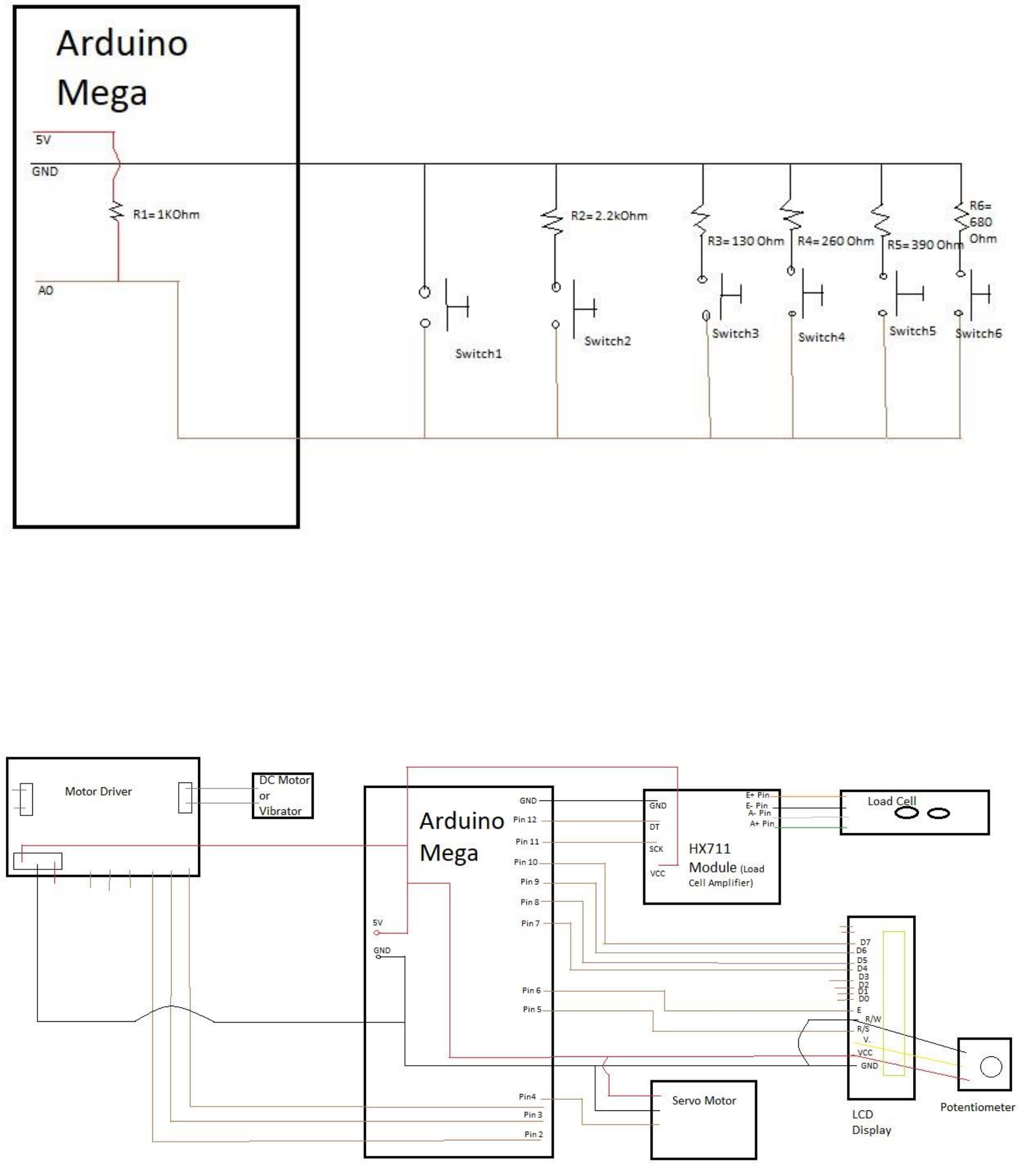

Figure C.1 Control System

`

Annex D: Picture of the Machine

Figure D.1 Picture of the Machine (Left side view)

`

Annex E: Operator Manual

1. User Manual

There are some steps the user should follow to use our Semi-Automatic Weighing Machine.

1. The power supply is turned on
2. Using a potentiometer, we should direct to 'WEIGHT' which will be shown in LCD display
3. The digital button is clicked when LCD display is showing 'WEIGHT' and the LCD display will show "Req. Wt.: 00.000kg" where first zero will be underlined.
4. The first '0' should not be greater than 1 as it is beyond the capacity of our load cells. The digit is changed by using potentiometer.
5. The button is clicked to set that digit to that place and the underline will be transferred to next zero.
6. Once again change to required value of that digit using potentiometer and click the button.
7. Continue the process to input our required weight.
8. (For e.g.: Let us suppose we need to set 257 gm. Then we have to produce "Req. Wt.: 00.257kg" in LCD display. For that, we have to go on clicking button for '0' for two times and when the underline reaches the third zero, the potentiometer is rotated till the value of that digit reaches 2. Then the button is clicked and potentiometer is rotated till the value of that digit reaches 5. The button is clicked and potentiometer is rotated till the value of that digit reaches 7. Then the button is clicked and it returns to menu which means the input is accepted. If there has been mistake in entry, the process should be repeated again)
9. Once we return to menu, rotate the potentiometer to display the 'SPEED'.
10. Digital button is clicked.
11. The value for speed of conveyor belt is given rotating the potentiometer from 0 to 9
12. Digital button is clicked.
13. Once we return to menu, rotate the potentiometer to display the 'START'.

`

14. Then the conveyor belt starts rotating. (If servo motor is not connected to linkage, then connect it to linkage keeping in mind that the weighing part should me closed in that position or situation)
15. We should make the workmen ready to work and making sure the sealing machine is ready and plastic bags are enough available & easy to reach.
16. The material is flown from hopper to conveyor by pulling the plate
17. Now the real work will begin. If there is a need to pause the machine or edit the settings, the same digital button should be clicked.
18. To turn off the machine, the power supply is removed.

2. Coding

Arduino Program

(Sentences after // are comments which intends to help readers to understand code)

```
#include<LiquidCrystal.h>
#include <HX711_ADC.h>
#include <Wire.h>
#include <Servo.h>

#define VIBRATION 2
#define WEIGHT 1
#define START 0
#define DOUT 14
#define CLK 15

LiquidCrystal lcd(12,11,5,4,3,2);
HX711_ADC LoadCell(DOUT, CLK);
HX711_ADC LoadCell2(6, 7);
Servo servo1;

float w1, w2, netwt, x1, x2;

int potPin=A0;
int switchPin=19;
int a=0,b=0,c=0,d=0,e=0,v,y=1;
int weight=0;
int vibration=0;
int mode;
int button = 0;
```

`

```
void setup() {
  Serial.begin(9600);
  pinMode(9,OUTPUT);      //For LCD Display
  analogWrite(9,130);
  lcd.begin(16,2);
  lcd.clear();
  pinMode(potPin,INPUT);
 // pinMode(switchPin,INPUT);

  LoadCell.begin();      //For Load Cell
  LoadCell.start(2000);
  LoadCell.setCalFactor(660.0);
  LoadCell2.begin();
  LoadCell2.start(2000);
  LoadCell2.setCalFactor(660.0);
  servo1.attach(13);

  pinMode(8,OUTPUT);     //For DC motor
  pinMode(23,OUTPUT);//Dir pin
  pinMode(24,OUTPUT);//Dir pin
}

void loop(){
  int rotate = analogRead(potPin);
  int gate;
  if(rotate <300){
    mode = WEIGHT;
  }else if(rotate < 600 && rotate > 300){
    mode = VIBRATION;
  }else {
    mode = START;
  }


  switch(mode){

    case WEIGHT:
      lcd.clear();
      lcd.print("WEIGHT->");
      button=digitalRead(switchPin);              // click the button to input weight

    delay(100);

    if(digitalRead(switchPin)==1){     //button pressed
      gate=0;
```

`

```
delay(500);
while(gate==0){
  rotate = analogRead(potPin);
  lcd.clear();
   a = map(rotate,0,1023,0,10);          //for fifth digit of weight in gm
  lcd.print("Req.Wt: ");
  lcd.print(a);
  lcd.print(b);
  lcd.print(".");
  lcd.print(c);
  lcd.print(d);
  lcd.print(e);
  lcd.print("kg");
  lcd.setCursor(8,0);
  lcd.cursor();
  delay(100);
  lcd.noCursor();
  delay(100);
  lcd.clear();
   button=digitalRead(switchPin);

  if(digitalRead(switchPin)==1){
    while(gate==0){
      lcd.clear();
      rotate = analogRead(potPin);
      b = map(rotate,0,1023,0,10);            //for forth digit of weight in gm
      lcd.print("Req.Wt: ");
      lcd.print(a);
      lcd.print(b);
      lcd.print(".");
      lcd.print(c);
      lcd.print(d);
      lcd.print(e);
      lcd.print("kg");
      lcd.setCursor(9,0);
      lcd.cursor();
      delay(100);
      lcd.noCursor();
      delay(100);
      lcd.clear();
      if(digitalRead(switchPin)==1){
        while(gate==0){
          lcd.clear();
          rotate = analogRead(potPin);         //for third digit of weight in gm
          c = map(rotate,0,1023,0,10);
```

`

```
lcd.print("Req.Wt: ");
lcd.print(a);
lcd.print(b);
lcd.print(".");
lcd.print(c);
lcd.print(d);
lcd.print(e);
lcd.print("kg");
lcd.setCursor(11,0);
lcd.cursor();
delay(100);
lcd.noCursor();
delay(100);
lcd.clear();
if(digitalRead(switchPin)==1){
  while(gate==0){
    lcd.clear();
    rotate = analogRead(potPin);     //for second digit of weight in gm
    d = map(rotate,0,1023,0,10);
    lcd.print("Req.Wt: ");
    lcd.print(a);
    lcd.print(b);
    lcd.print(".");
    lcd.print(c);
    lcd.print(d);
    lcd.print(e);
    lcd.print("kg");
    lcd.setCursor(12,0);
    lcd.cursor();
    delay(100);
    lcd.noCursor();
    delay(100);
    lcd.clear();
    if(digitalRead(switchPin)==1){
      while(gate==0){
        lcd.clear();
        rotate = analogRead(potPin);      //for first digit of weight in gm
        e = map(rotate,0,1023,0,10);
        lcd.print("Req.Wt: ");
        lcd.print(a);
        lcd.print(b);
        lcd.print(".");
        lcd.print(c);
        lcd.print(d);
        lcd.print(e);
        lcd.print("kg");
```

`

```
                    lcd.setCursor(13,0);
                    lcd.cursor();
                    delay(100);
                    lcd.noCursor();
                    delay(100);
                    lcd.clear();
                    if(digitalRead(switchPin)==1){
                      weight = a*10000 + b*1000 + c*100 + d*10 + e;
                      Serial.println(weight);
                      gate=1;
                    }
                  }
                }
              }
            }
          }
        }
      }
    }
  }
}

  break;

case VIBRATION:
    lcd.clear();
    lcd.write("SPEED->");
    delay(100);
    if(digitalRead(switchPin)==1){        //button pressed
      gate=0;
      while(gate==0){
        rotate = analogRead(potPin);
        lcd.clear();
         v = map(rotate,0,1023,0,10);       //Input Speed
        lcd.print("Speed: ");
        lcd.print(v);
        lcd.setCursor(11,0);
        lcd.cursor();
        delay(100);
        lcd.noCursor();
        delay(100);
        lcd.clear();
        if(digitalRead(switchPin)==1){
          vibration = map(v,0,10,50,255);
          gate=1;
        }
```

`

```
    }
  }
break;

case START:
lcd.clear();
lcd.print("START->");
delay(100);
if(digitalRead(switchPin)==1){      //Click to run the machine
  delay(500);
  gate=0;
  while(gate==0){
  lcd.clear();
    lcd.print("W:");
    lcd.print(weight);
    if(y==1){                                    //Making initial load zero
        LoadCell.update();
        x1 = LoadCell.getData();
        LoadCell2.update();
        x2 = LoadCell2.getData();
       }
     LoadCell.update();
     w1 = LoadCell.getData()-x1;
     LoadCell2.update();
     w2 = LoadCell2.getData()-x2;
     netwt = w1 + w2;
     lcd.print("///");
     lcd.print(netwt);
     y=0;
     if(netwt>=weight-10){
       servo1.write(0);                    //opens the path
       digitalWrite(23,LOW);         //Conveyor stops
       digitalWrite(24,HIGH);        //Conveyor stops
       analogWrite(8,0);                 //Conveyor stops
       y=2;
     }
     else{
       servo1.write(60);             //seals the path
       if(y==2){                         //Making load value of empty weighing part zero
        LoadCell.update();
        x1 = LoadCell.getData();
        LoadCell2.update();
        x2 = LoadCell2.getData();
       }
       digitalWrite(23,HIGH);         //Conveyor runs
       digitalWrite(24,LOW);          //Conveyor runs
```

`

```
            analogWrite(8,vibration);      //Conveyor runs
          }
         delay(100);
           if(digitalRead(switchPin)==1){    //Exits to Menu
             gate=1;
           }
         }
       }
   default:
     break;

  }
          digitalWrite(23,HIGH);
            digitalWrite(24,LOW);
            analogWrite(8,0);                      //Conveyor stops
}
```