Design and Development of Automatic Bag Placer Machine

By

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Design and Development of Automatic Bag Placer Machine

Major Project Report

Submitted in partial fulfillment of the requirements

For the Degree of

Master of Technology in Mechanical Engineering

(CAD / CAM)

By

Jagat Desai

(16MMCC03)

Guided By

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AHMEDABAD - 382 481
May 2018

Declaration

This is to certify that

1. The thesis comprises my original work towards the degree of Master of Technology in Mechanical Engineering (CAD / CAM) at Nirma University and has not been submitted elsewhere for a degree or diploma.

2. Due acknowledgment has been made in the text to all other material used.

Jagat Desai

16MMCC03

Undertaking for Originality of the Work

I, **Jagat Desai**, Roll. No. 16MMCC03 give undertaking that the Major Project entitled "**Design and Development of automatic bag placer machine**" submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in Mechanical Engineering (CAD / CAM) of Nirma University, Ahmedabad, is the original work carried out by me and I give assurance that no attempt of plagiarism has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere, it will result in severe disciplinary action.

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Certificate

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Jagat Vijaykumar Desai
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Abstract

Packing of cement is the most critical operation of the cement industry. At present most cement companies use roto packer for cement packing. The basic process is to manually insert Polypropylene (PP) bags on the nozzle of the roto packer, with automatic system of roto packer the bags are filled with required quantity of cement and the filled bags are transferred for truck loading via conveyor belt system or slider. To deduct the manual process of inserting PP bags on to the nozzle of roto packer a bag guiding machine is placed before roto packer. Bag guiding machine has 17 fork like containers where empty PP bags in the bunch of 15 to 17 approximately are to be placed manually in each.

The present work aims to develop fully automatic bag placer machine to eliminate manual process. For placing the bundle of empty bags into the bag guiding machine, bags are collected into the bag collector of automatic bag placer machine and placed into the containers of the bag guiding machine. A study on requirement has been done and a conceptual mechanism has been developed. Automatic bag placer has been fabricated and tested. However it needs further modifications to deploy with the rotopacker.

Keywords : Automatic Bag Placer, Roto Packer, Polypropylene (PP) bags, Bag Guiding Machine

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Nomenclature

F	Force (N)
T	Torque (Nm)
r	Radius (mm)
n	Revolution per minute (rpm)
P	Power ($watt$)
v	Velocity (m / s)
HP	Horsepower
D	Diameter (mm)
J	Inertia (kg-$m\hat{}2$)
μ	Friction co-efficient
δ	Angle
H	Height *(mm)*

Abbreviations

PP	Polypropylene
PLC	Programmable Logic Controls
CAD	Computer Aided Design
FRP	Fiber Reinforced Plastic
PVC	Polyvinyl chloride
TPU	Thermoplastic polyurethane
EPDM	Ethylene propylene diene monomer
GI	Galavanized steel

Chapter 1

Introduction

In today's era improving productivity is the main target of any production and manufacturing industry. Industrial automation plays a vital role in achieving this target. Industrial automation lead to smart manufacturing by reducing waste and downtime, improving safety and efficiency. Industrial automation assist in manufacturing, quality control and material handling. It substitutes human attainment and their decision making with PLC (Programmable logic controls) and mechanized equipment. Present inclination are towards intelligent machine making by use of sensors, providing shrewdness for inspection, increasing system life-cycle, improving response time and making sustainable machine.
Computer aided technologies serves as the most important and basic tool for automation. Computer aided design is creation, modification and analysis of 2D and 3D design with assist of computer. Recent furtherance in CAD technologies helps in feature called 'Virtual Prototype' of any machine, model or system which is animation of final output of the product. This facilities improve competency of any design engineer, it improves design quality, communication in creating database and documentation of manufacturing.

1.1 Automation

In past decade or two there is a huge surge in industrial development because of automation increasing product quality, reliability and availability. Key need for controlling machine, technology, data collection and interpretation, etc of every industry is automation. In the era of globalization is one's system cannot use automation technology it cannot sustain as compared to other. Automation has variety of benefits like Improved productivity, Improve reliability, Increase accuracy, decrease in ideal time, handling of variety of product at the same time, lessen human error due to less involvement of human also with all that automation has its own limitations like initial investment of automation equipment is high, high running and maintenance cost.

1.2 Basic process of JK Lakshmi Cement Ltd.

The cement manufacturing process at JK Lakshmi Cement is shown in the form of flow chart in the below figure 1.1. As seen in figure JK Lakshmi cement has implemented various automated machines in packing plant like roto packer, automatic bag guiding machine to increase the output of the plant.

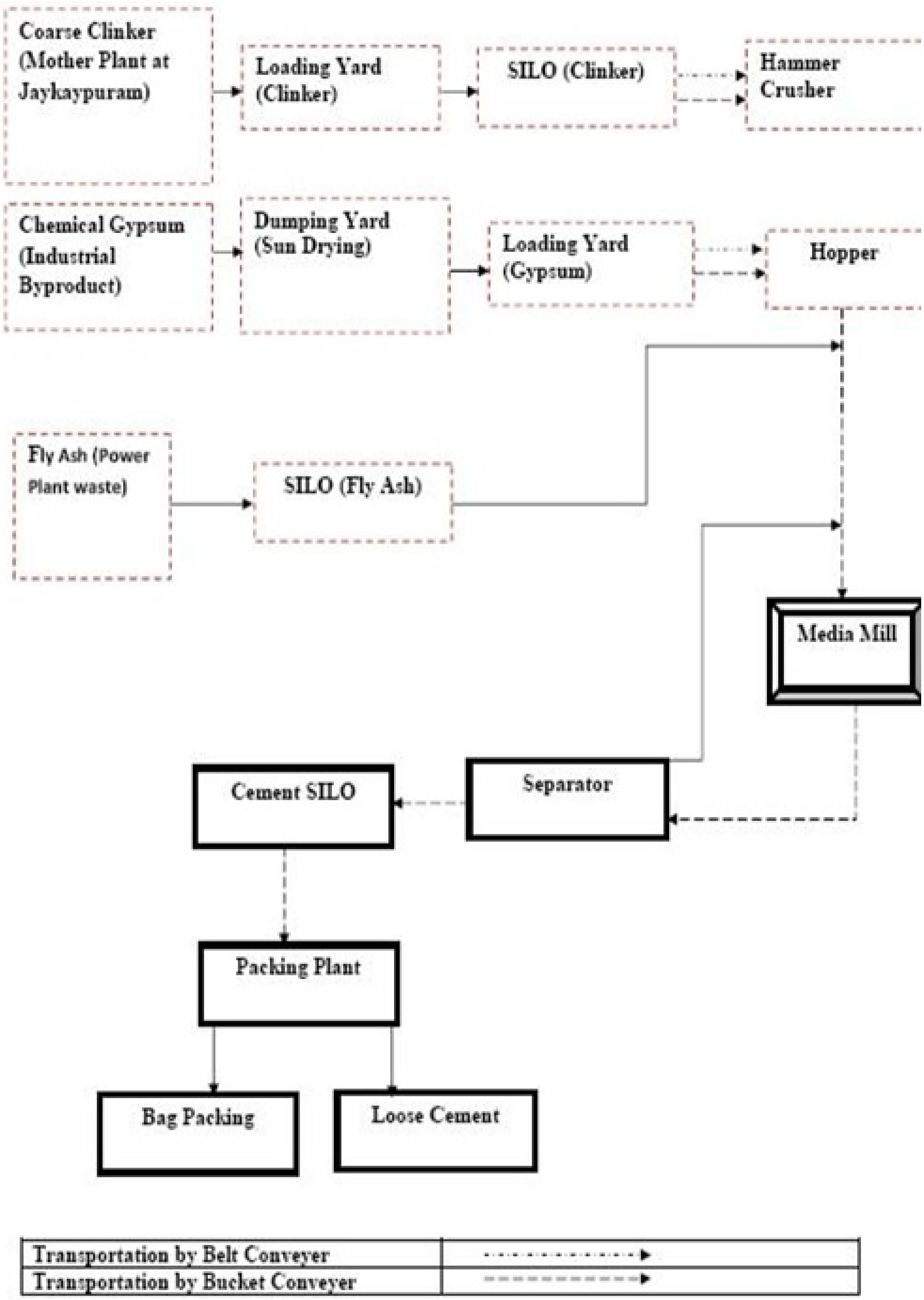

Figure 1.1: Plant Layout [1]

1.3 Roto Packer

Roto packer is high capacity rotating packing machine designed for packing cement at a maximum rate of approximately 5000 bags/hour. A photograph of such a machine is shown in figure 1.2. Roto packer deals with valve type bags for filling cement in a bag of size 25kg or 50kg and bag material like woven or paper. At JK Lakshmi Cement Ltd. cement is stored in silos, from there cement is transferred to the roto packer through pipes. The empty PP (Poly Propylene) cement bags are placed on the nozzle of the roto packer and then they are filled with cement in predefined quantity.

Figure 1.2: Roto Packer[2]

The roto packer machine at JK Lakshmi Cement Ltd. consists of 12 such nozzles with which the empty PP cement bags are filled at desired rate, the filled bags are then transferred to the automatic truck loading machine through network of conveyor belts and then they are loaded in truck as per the order.
At JK Lakshmi Cement Ltd. roto packer is integrated with Automatic bag guiding machine as shown in figure 1.3. The empty PP cement bags are kept in a bundle of approximately 15 to 17 with the assistance of man power as shown in figure 1.4.

Figure 1.3: Automatic Bag Guiding Machine [Courtesy: JK Lakshmi Cement Ltd.]

Figure 1.4: Automatic Bag Guiding Machine with Bags [Courtesy: JK Lakshmi Cement Ltd.]

The automatic bag guiding machine consists of horizontal conveyor belt with forks fixed on it which works as a repeater between two successive bundles which consists of 15 to 17 empty PP cement bags as shown in figure 1.4.

1.4 Problem Description

At present the roto packer is been integrated with automatic bag guiding machine, in which the empty PP cement bags are to be placed and those bags are shot on to the nozzle of the roto packer to get pack as required. Presently the empty PP cement bags are placed manually in automatic bag guiding machine with the assistance of man power i.e. manual stacking as seen in figure 1.5 & 1.6, because of which large amount of time is consumed also involvement of man power results in slow work progress, labour cost. Furthermore exposure of worker to cement dust leads to health issues, safety and more sick leave.

Figure 1.5: Manual filling of bags [Courtesy: JK Lakshmi Cement]

Figure 1.6: Automatic bag guiding machine with manual loading [Courtesy: JK Lakshmi Cement]

Therefore a system has to be design and develop which can automatically place the empty PP cement bags in the automatic bag guiding machine without the assistance of manpower and in sequence and bundle of approximately 15 to 17 . This will tweak the utilization of the roto packer and decrease the dependency on manpower which will result in decrease manpower cost and increase in safety and health of the workers. The objectives of the projects are identified as follows.

1.5 Project Objectives

Major objectives of the thesis are as follow:

1. To design automatic bag placer machine.
2. To fabricate automatic bag placer machine.
3. Testing and implementation of automatic bag placer machine.

Chapter 2

Literature Review

This chapter describe about the work carried out by the researchers and inventors in the various field related to automatic bag placer machine.

2.1 Paper feeding roller

In this patent Yasuhiko Terajima et al [3] describes about eccentrically mounting of an non-deformable roller on a shaft. When shaft with roller will rotate it will come into contact of sheets only when they are to be fed.

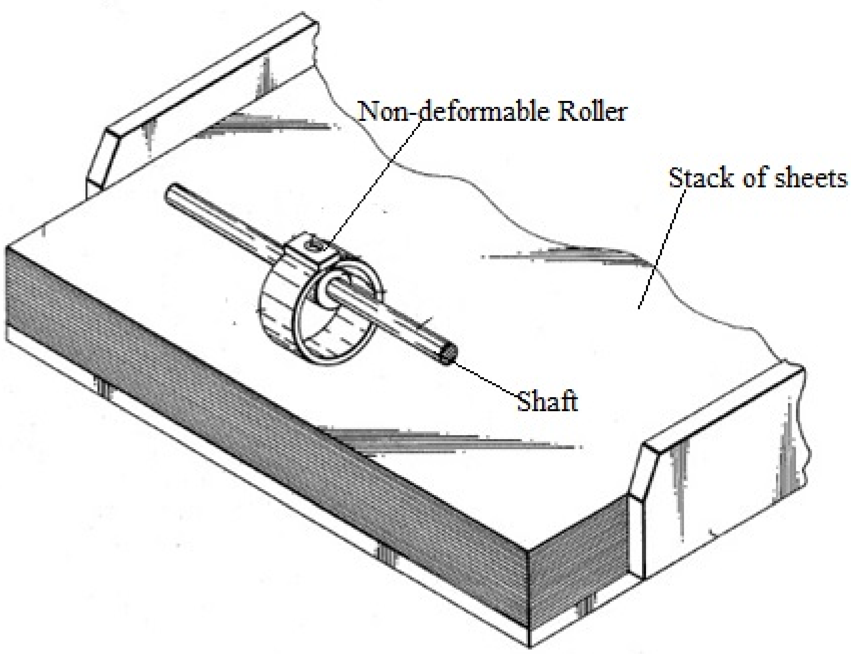

Figure 2.1: Paper feeding roller [3]

This results in increased fed force while simultaneously decreasing the pressing force which helps in reducing sheet misfeed.

2.2 Apparatus and method for dispensing bags

In this patent Doron Tam et al [4] invented a method and device for dispensing a single bag from a stack of bags. This mechanism consists of a rotatable shaft coupled with frame, rollers mounted to the shaft, additional system for rotation of shaft, additional system for automatic stopping of rotating shaft after dispensing of a single bag and constantly holding the stack of bag at initial position after dispensing of single bag.

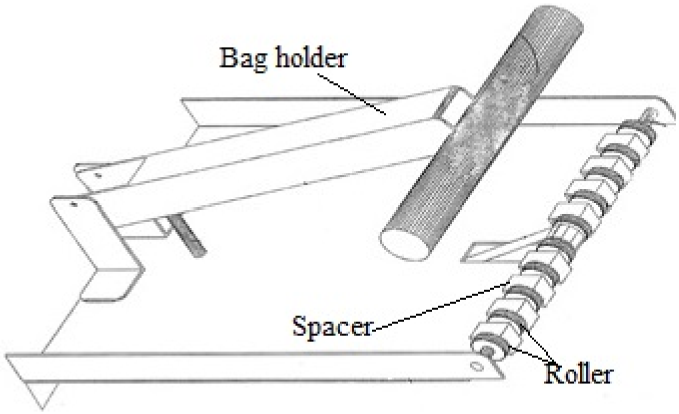

Figure 2.2: Apparatus for dispensing of bags [4]

In this paper inventors describes that stack of bags rest on the spacer and rollers with high friction surface when engages strips one bag at a time from the stack of bags.

2.3 Simulation and experimental methods for media transport system: Part IIeffect of normal force on slippage of paper

Jae-Kwan Ryu et al [5] has constructed a paper feeding system to compare experimental results with simulation results. The feeding mechanism consist three pairs of rollers with high friction material on outer surface which is mounted on pair of shafts. The feeding system spins the roller with the driving shaft, the friction force between spinning rollers and paper transfers the paper. In research simulation was carried out on a analysis tool called RecurDyn®. The results showed that the slippage of the paper intensifies with increase in the speed of the driving roller and it reduces with increase in the normal force.

2.4 Envelope / sheet feed mechanism

The feeding mechanism is invented by Jeffrey L. Trask et al [6] and this invention works for handling of sheets and envelopes automatically. This system consists of two trays mountable in the window, one tray for holding stack of paper and second tray for holding stack of envelopes. Also a roller system is deployed to engage and feed the uppermost sheet from the stack of sheets in the first tray or lower most envelope from the stack of envelopes in the second tray.

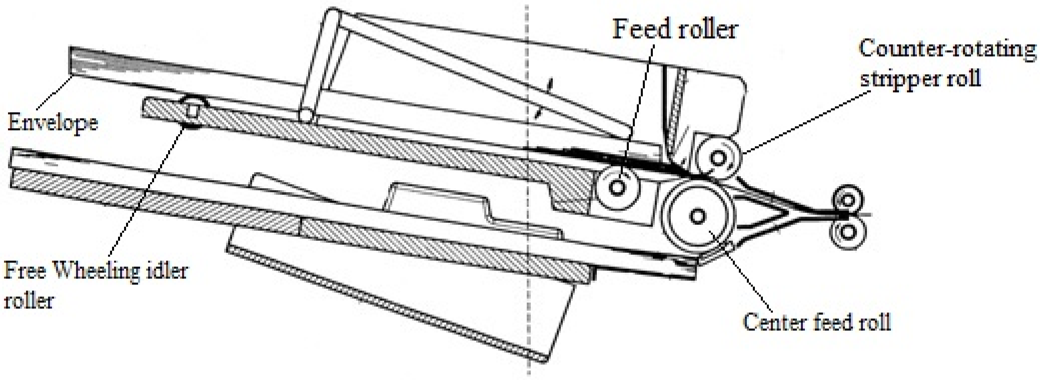

Figure 2.3: Envelope / sheet feed mechanism [6]

2.5 Document feeding method and apparatus

In this patent Douglas U. Mennie et al [7] describes about document feeding system and its apparatus. This system consists of an input receptacle, feeding wheel to strip documents, movable insert with high friction surface. Feeding wheel with high friction surface insert trip single document at a time when it engages with the stack of document. To make sure each document fed is advanced by that roller only dimension of fed roller is kept such that width of document is smaller than the circumference of the uttermost portion of the fed roller.

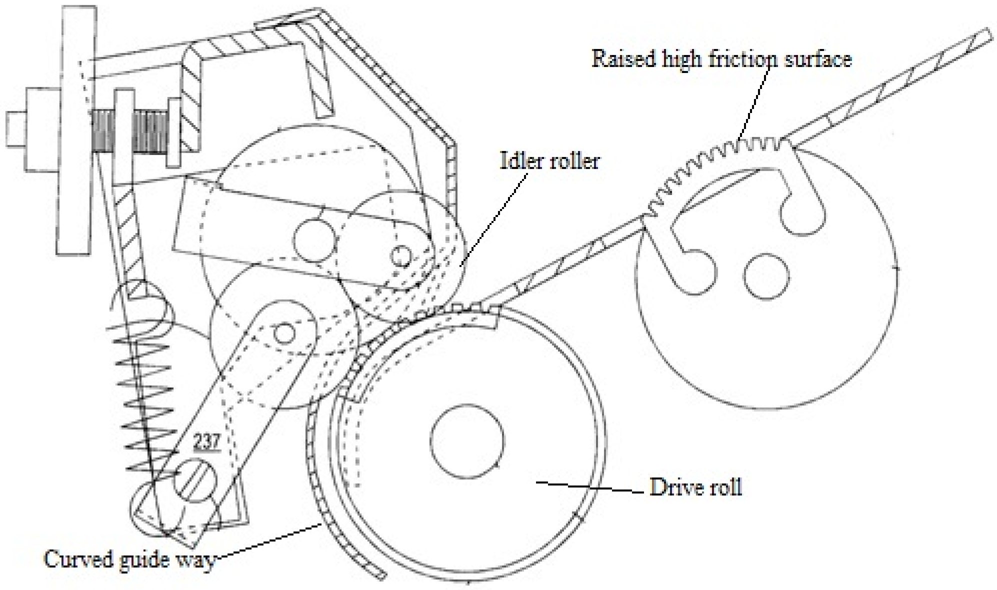

Figure 2.4: Document feeding method and apparatus [7]

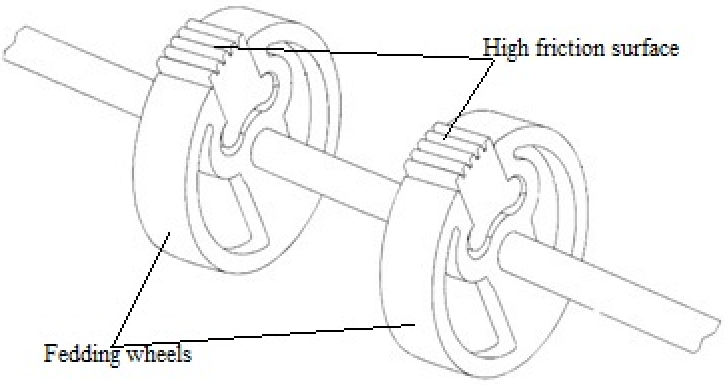

Figure 2.5: Rollers of Document feeding system [7]

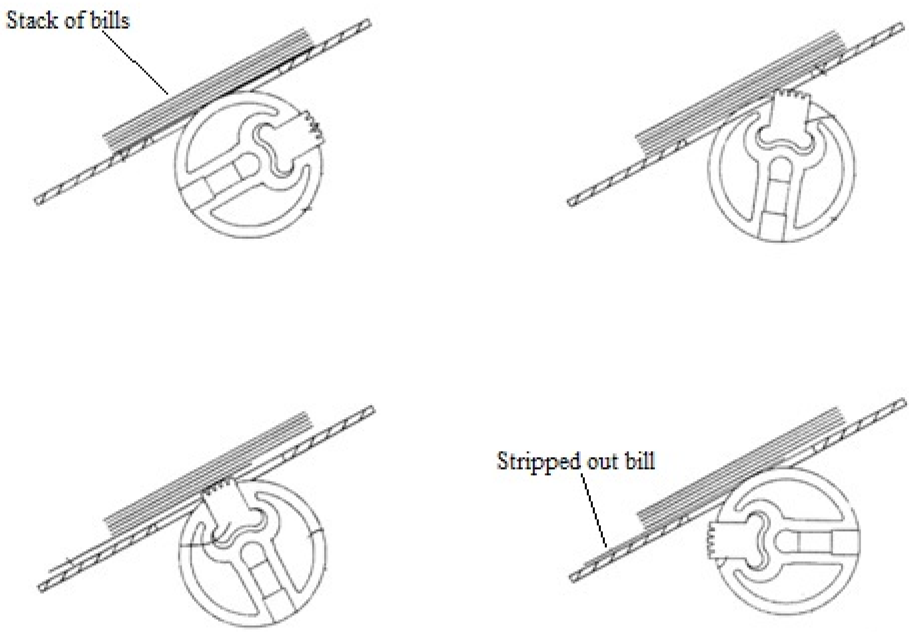

Figure 2.6: Working principle of document feeding system [7]

2.6 Bag dispensing machine for upward dispensing

This is an US patent 2010/0025415 A1 invented by Ari Bichler et al [8]. The invention is for the device which can dispense one plastic bag from the stack of bags. This system has two conveyor belt system configured to engage plastic bag. One conveyor belt is mounted on three rollers and second conveyor belt is mounted on two rollers. The conveyor belt on three rollers runs in clockwise direction and conveyor belt on two rollers run in anticlockwise direction.

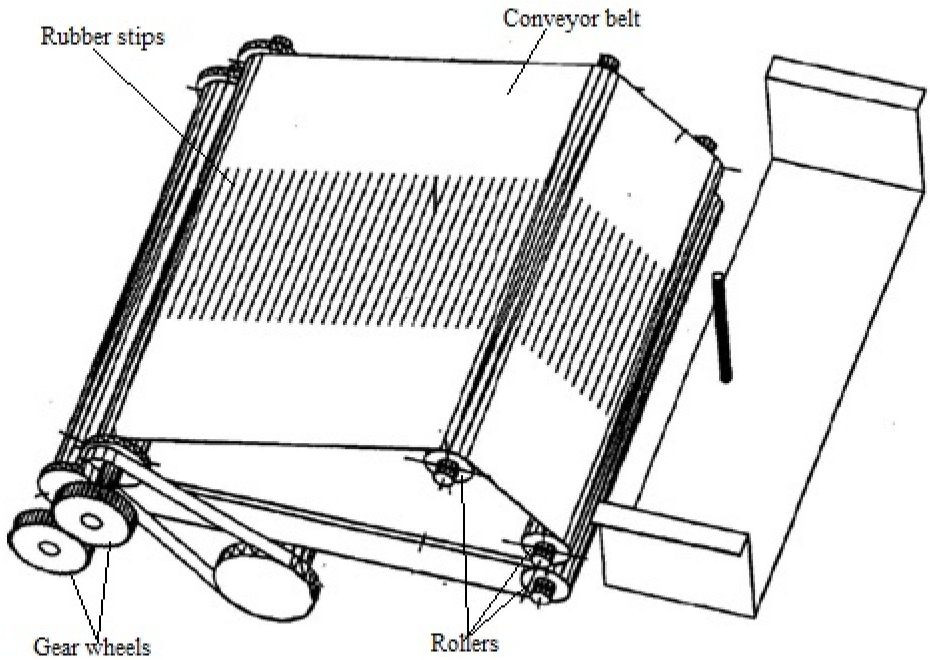

Figure 2.7: Bag dispensing machine for upward dispensing [8]

Due to this arrangement when plastic bag engages with the conveyor it is dragged in forward direction. Also for better friction and engagement rubber trips are provided on the conveyor belt.

2.7 Characteristics of paper feeding mechanism with a short rubber roller and a flat plate

This research paper was written by Hiroshi Umano et al [9]. This research describes about velocity characteristics of a feeding mechanism which consists of a flat plate and a short rubber layered roller. To experimentally measure transport velocity of roller mechanism a setup was prepared. Results showed in case of soft rubber roller load dependence of rubber friction should be taken into account.

2.8 Printing media supply device for image forming apparatus

In this US patent US 2007/0045937 A1 inventor Jin-Soo Lee et al [10] has described about printing media supply device and apparatus for feeding the same. In this invention inventor has used CAM shaped pick up rollers. The CAM shaped pickup rollers are mounted over a rotating shaft are bought into contact whenever a printing media is to be stripped from the stack.

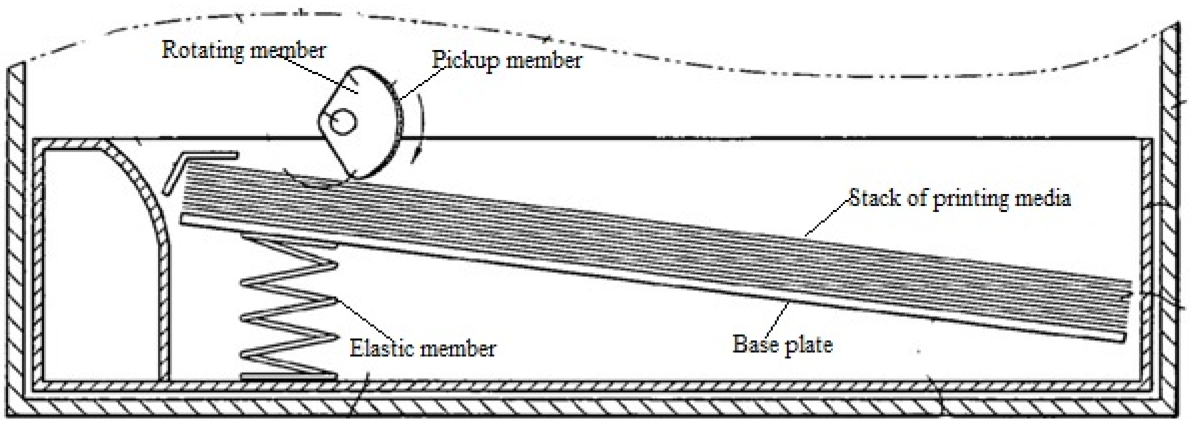

Figure 2.8: Printing media supply device [10]

A pickup member made of rubber material having high friction is attached on the circumference of the pickup rollers. Also to increase friction teethed projection are formed over the pickup member.

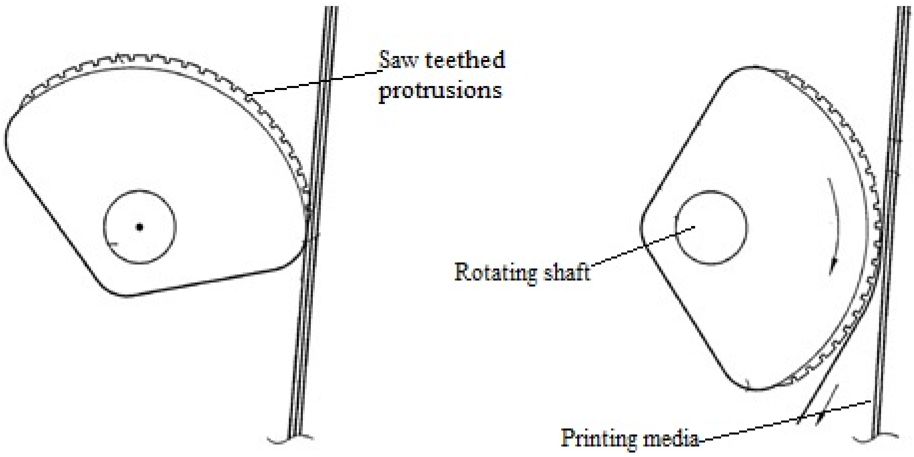

Figure 2.9: Working principle of printing media supply device [10]

2.9 Friction retard feeder

In the patent inventor Barry Paul Mandel [11] discuss about sheet feeding system and retard system. The system consists of feed roll, trailing edge retention arm, retard roll, nudger roll.

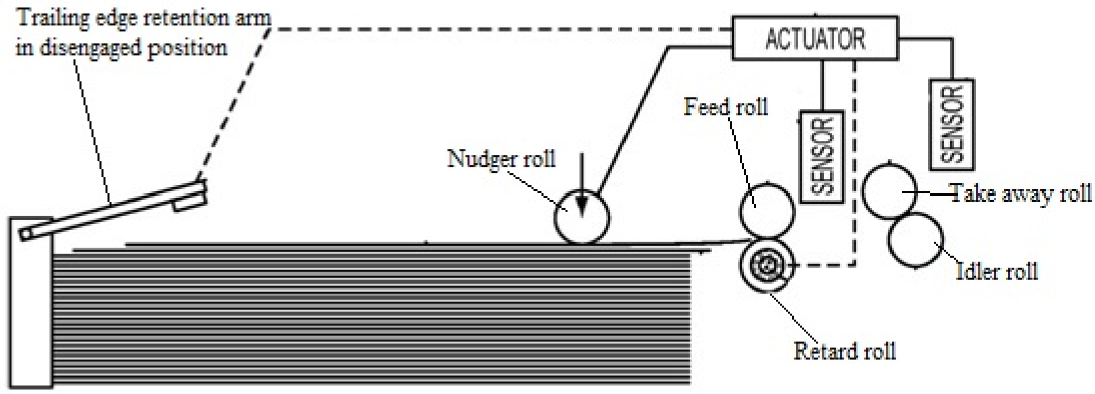

Figure 2.10: Friction retard feeder with the trailing edge retention system in disengaged position [11]

The nudger roll drives the first sheet from the stack and moves it towards the feel roll via feed nip which activates the trailing edge retention system. The trailing edge retention system prevents movement of more sheets from the stack of the sheet.

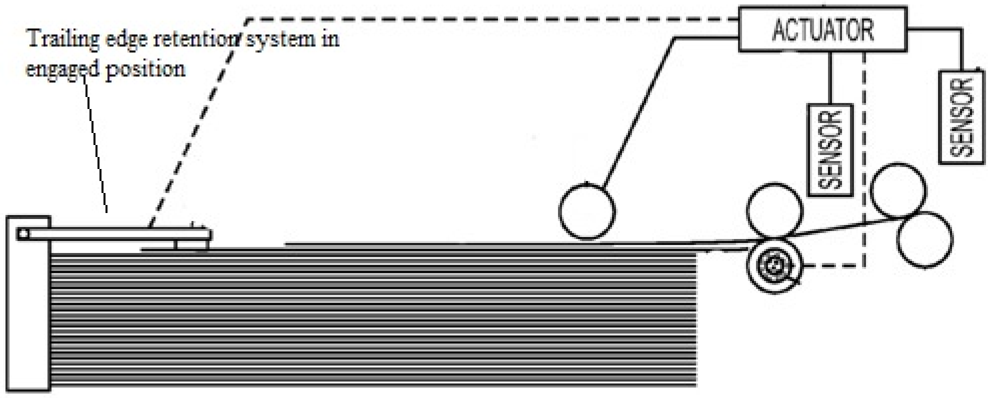

Figure 2.11: Friction retard feeder with the trailing edge retention system in engaged position [11]

2.10 Automatic sheet feeding device

In this invention by Saiki [12] automatic sheet feeding device having separating roller, a rotating mechanism, feeding rollers and conveying rollers has been described. In this device the feeding roller rotates in anticlockwise direction whereas separating roller rotates in clockwise direction.

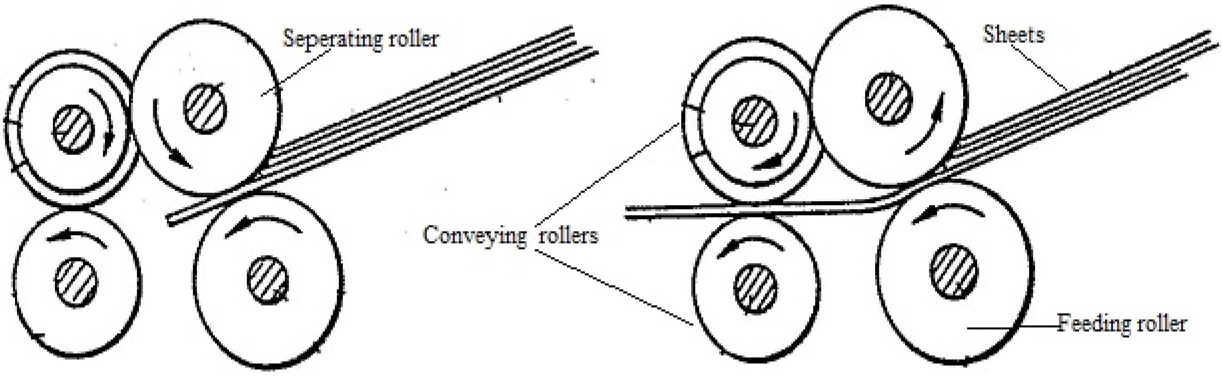

Figure 2.12: Working principle of automatic sheet feeding device [12]

Due to such arrangement feed roller will strip one sheet at a time from the stack simultaneously separating roller block other sheet from the stripping out of the stack, the conveying rollers will further advance the sheets on the conveyor belt.

2.11 Cash dispensing automated banking machine with note unstacking and validation

The automatic banking machine invented by H. Thomes Graef et al [13] describes about dispensing of financial instrument sheets to end user of the machine. The dispensing of sheets is done by the picker mechanism which includes rotating picking member. For sheet engaging a high friction segments are formed over circumference of the picking member.

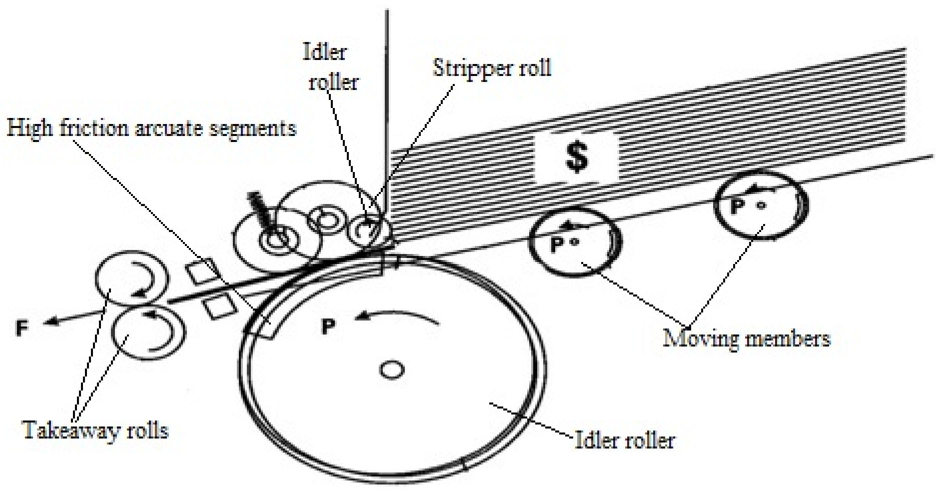

Figure 2.13: Cash dispensing automated banking machine [13]

The high frictions segments of picking member strips the sheets in the direction shown by arrow F when contact takes place with the sheet from the stack of sheets.

2.12 Sheet feeding apparatus

In this US patent 5474287 inventor Koji Takshashi descibes [14] about the apparatus of the sheet feeding mechanism. The mechanism includes separating roller, reversely rotatable roller, fed roller, pinch roller made of EPDM and conveying roller. The conveying roller conveys sheet from the stack of the sheet into feeding direction. The separating roller rotating in the feeding sheet direction and simultaneously the reversely rotatable roller rotates in the direction opposite to the sheet feeding direction, this arrangement stops the feeling of more than one sheet at a time.

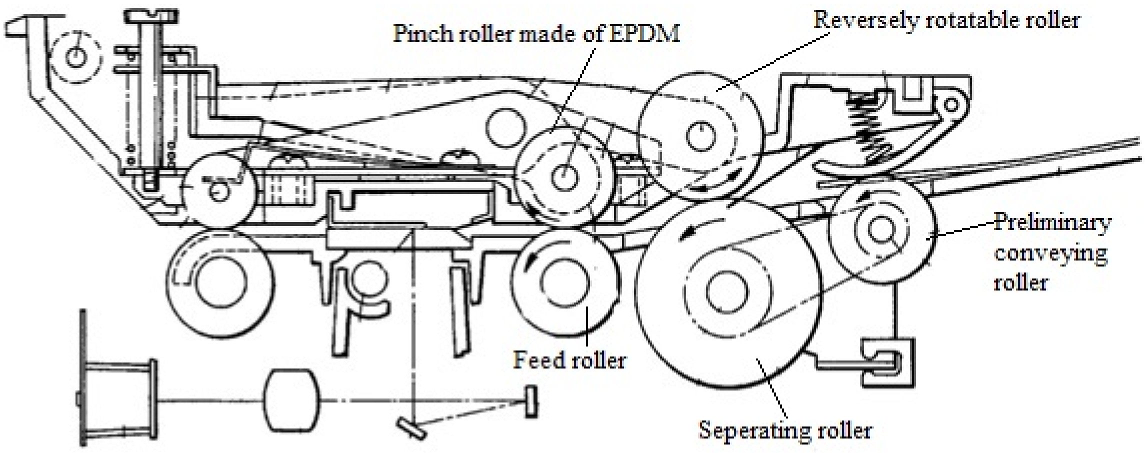

Figure 2.14: Sheet feeding apparatus [14]

The feeded sheet is conveyed further by fed rollers and pinch roller made of EPDM which had high friction coefficient. Also a drive mechanism is provided with a torque limiter to transmit drive force, the torque limiter will cut off the transmission when a predetermined torque value is reached by the drive mechanism.

2.13 Friction Coefficient Of Rubber Sliding Against Flooring Materials

This paper by El-Sherbiny, Y. M et al [15] discuss about the research carried out for sliding of rubber against different flooring materials. It also discuss friction co-efficient of rubber with respect to each of the material on which the experiment was carried out. In experiment various types of flooring materials with varying roughness was tested with different sliding conditions such as dry, water, oil, water-detergent, water-oil-detergent. Different surfaces taken are epoxy, ceramic, cement, polyvinyl chloride (PVC) and marble. Through experiments it was found that in dry sliding friction co-efficient decreased with increase in surface roughness. PVC showed lower friction values compared to Epoxy. Ceramic displayed lower friction values in compression to marble and cement, whereas cement gave highest friction co-efficient. Also with different sliding condition apart from dry, friction co-efficient values showed significant fall.

2.14 Paper picking and separator system for facsmile or copy machine

In this U.S. Patent 5537227 inventor Morad M. Samii et al [16] describes about the improved paper separating system. In this system instead of cylindrical paper feed roller inventor has used asymmetrical feed rollers to strip bottom most sheet one at a time form the bundle.

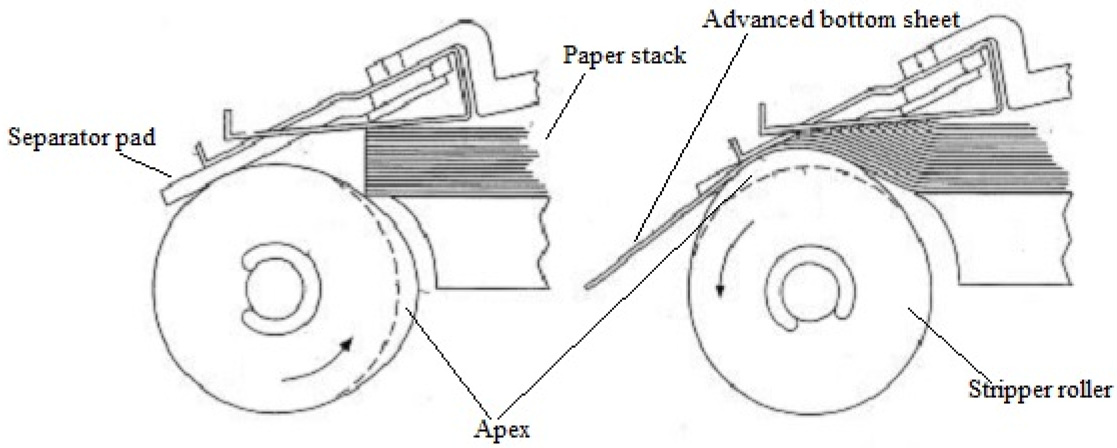

Figure 2.15: Picking and separator system [16]

The prolonged portion on the eccentric allows the prolonged portion to reach out and strip bottom most sheet even if bottom sheet has very light contact with the roller. Also with prolonged portion of the feed roller gives increased friction force which assists in better stripping of bottom sheet form the bundle.

2.15 Sheet by sheet paper feeding structure

In this patent inventor Michael Mou et al [17] describes a structure for one by one paper feeding. The structure includes separating plate, pressure plate and roller. Separating plate and roller are both formed of a high friction co-efficient material.

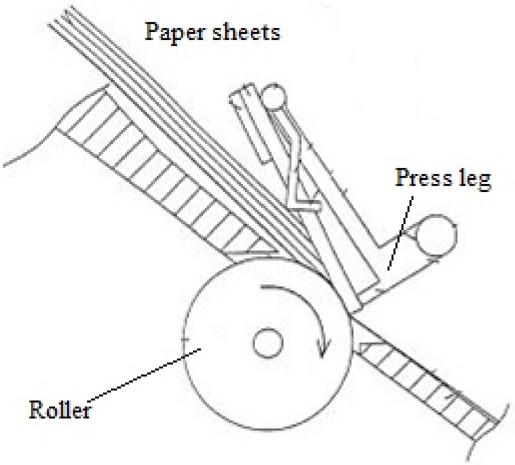

Figure 2.16: Structure of sheet by sheet paper feeding [17]

A bundle of paper is placed in the structure, the front end of the sheet presses against the sheet separating plate which in return blocks the sheets from displacing forward. The bottom most sheet is in direct contact with the roller. On forward rotation of rollers the bottom most sheet will advance forwardly while keeping rest of the bunch in the same position.

Chapter 3

Design Methodology

This chapter elaborates about requirement of automatic bag placer machine, time study, conceptual design, selection of material, analytical calculations related to it and working principle of the design.

3.1 Introduction

At present the PP bags available in the company are handled manually by workers. The bunch of bags is manually formed by the workers and is placed into the fork like containers of the automatic bag guiding machine. Also the process is very monotonous and tedious which makes workers less productive. Moreover it take more time for forming bundles manually which decreases the optimum efficiency of roto packer. so it has been decided to automate or to develop a mechanism to overcome the above problem. So with proper logic, literature, dimensions of bags and study of automatic bag guiding machine it is possible to automate or develop a mechanism for the current problem which will increase efficiency and output of plant, it will also decrease exposure of workers to dusty and harmful environment.

3.2 Time Study

Time study is very important study specially in process or production line because in that there is huge scope of improvement of productivity. Time study is not about measure the time of any activity or relate every activity to time but it is continues type of observation of particular activity or process are find the process which consume more time as compare to other activity. With the help of time stud we can find out non productive activity which can consume the resource as well as time but cannot produce any significant output. Time study makes our process very efficient and reduce overall completion time.
Time study is very important tool in Industrial Engineering, according to that it is process

measuring technique which include time measurement with time measuring instrument and it also can give some allowance to the process due some delays, fatigue and personal need.

First step in time study is to breakdown the whole process in small activity which can easily study independently. after dividing whole process in small activity observer is carefully study the behavior if the activity, resource and time consumption, output of the activity, and its contribution in whole process. after critically analyzing the whole process observer identify some non value added activity then they have to take decision whether the process should be removed or replaced by some better activity, so continuously doing time study in current process it give us robust process which will be better than the previous.

The time study has been done in following way :

- Material of cement bag = PP
- Dimension of cement bags = 750*450*5 *mm*
- Weight of cement bag = 0.07 *kg*
- No. of containers in automatic bag guiding machine = 17
- No. of spout in roto packer = 12
- Bag dispatch capacity of roto packer max = 3000 *bags/hr*
- Time taken by worker to fill on container of automatic bag guiding machine = 25 to 40 *sec*
- Current bag dispatch capacity of roto packer = 2000 - 2300 *bags/hr*

3.3 Cement Bag

The cement bags used at JK Lakshmi Cement Ltd, are made up of PP woven sacks as shown in figure 3.1. Woven sacks are the best and most economic solutions for industries like sugar, cement, chemicals, fertilizer, etc. Varity of bags are made out of PP woven sacks and with or without lamination. The cement bags consist of valve on one side of the bag which is used to fill cement and then the valve is sealed with the help of Roto packer.

Figure 3.1: Empty PP cement bags [Courtesy: JK Lakshmi Cement Ltd.]

The main features of PP Woven sack are :

- High strength fibers
- Water and Dust resistant
- Printing on both sides
- Valve opening on one side
- Single fold or Double fold bottoms

The Technical Specifications are :

- UV resistance up to 200 to 1600 *hours*
- Bag length 730 $mm \pm 5\ mm$
- Bag width 480 $mm \pm 5\ mm$
- Bag color green and white
- Capacity of bag 50 Kg

3.4 Automatic Bag Guiding Machine

To make the process fast and easy the empty PP cement bags are placed into fork like containers of the automatic bag guiding machine that are made available on it. The Bag guiding machine is placed in front of roto packer as shown in figure 3.2., so as the roto packer rotates the bag guiding machine picks one bag at a time and shoots it on to the nozzle available on the roto packer.

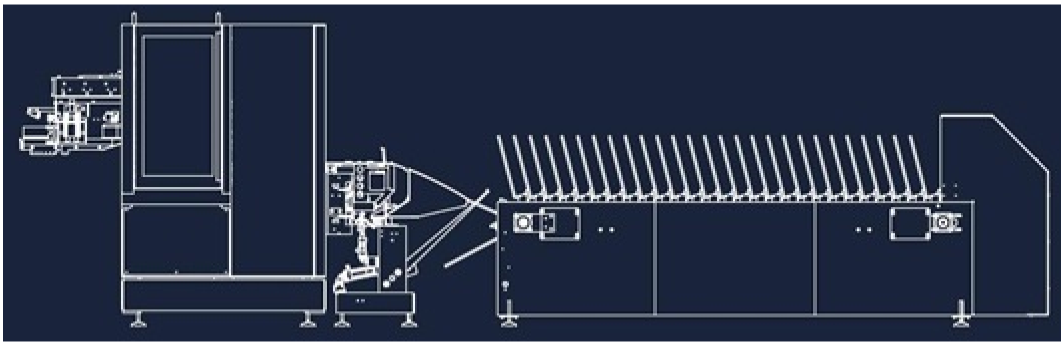

Figure 3.2: Automatic Bag Guiding Machine

The bundle of 15 to 17 are placed in to the forks like containers of the bag guiding machine which is built on the moving horizontal conveyor belt which keeps on rotating after every 16 seconds to make the new bundle available for the filling.

Specification :

- Rotating time of bag guiding machine: 16 seconds
- Bag holding capacity: 225 bags

Advantages:

- It automates the entire packing process
- Helps in optimum utilization of packing machines filling capacity.
- Flexible and quick changeovers for different bag size and types are possible.
- Reduces Manpower and cost related to it.

3.5 Conceptual Design and Working principle

As seen in section 1.3 & 1.4 about the existing practice followed and problems faced in that practice. A conceptual design of automatic bag placer machine is presented in the below figure 3.3.

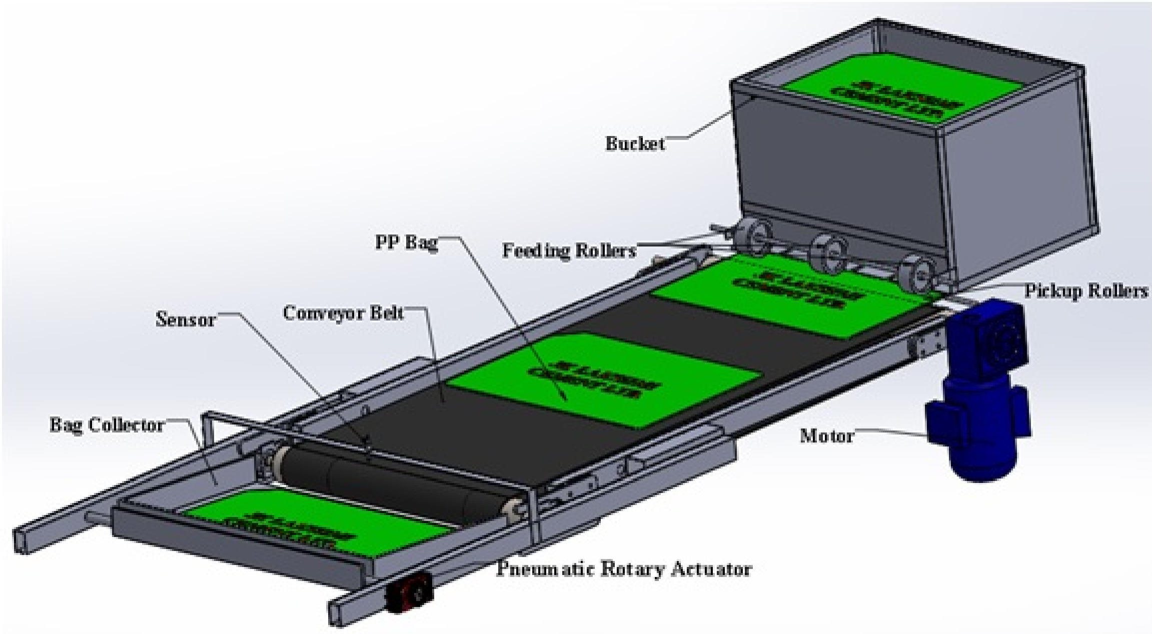

Figure 3.3: Conceptual design of automatic bag placer machine

As the conceptual design suggest, the basic idea used behind is to strip one bag at a time from the bucket and collect it into the bag collector. To achieve this task a mechanism with conveyor belt, feeding rollers, pickup roller and conveying roller system has been proposed. This in turn will aid in optimum utilization of roto packer furthermore no worker will be needed for manual loading of empty PP cement bags into the automatic bag guiding machine which will decrease dependency on manpower and also cost related to it. As seen in figure 1.6 & figure 1.7 bundle of cement bags has to be made and placed in the automatic bag guiding machine. For that the first challenge is to strip one bag at a time form the bucket of the automatic bag placer machine. To accomplish this task the proposed system employs feeding rollers shown in figure 3.4.

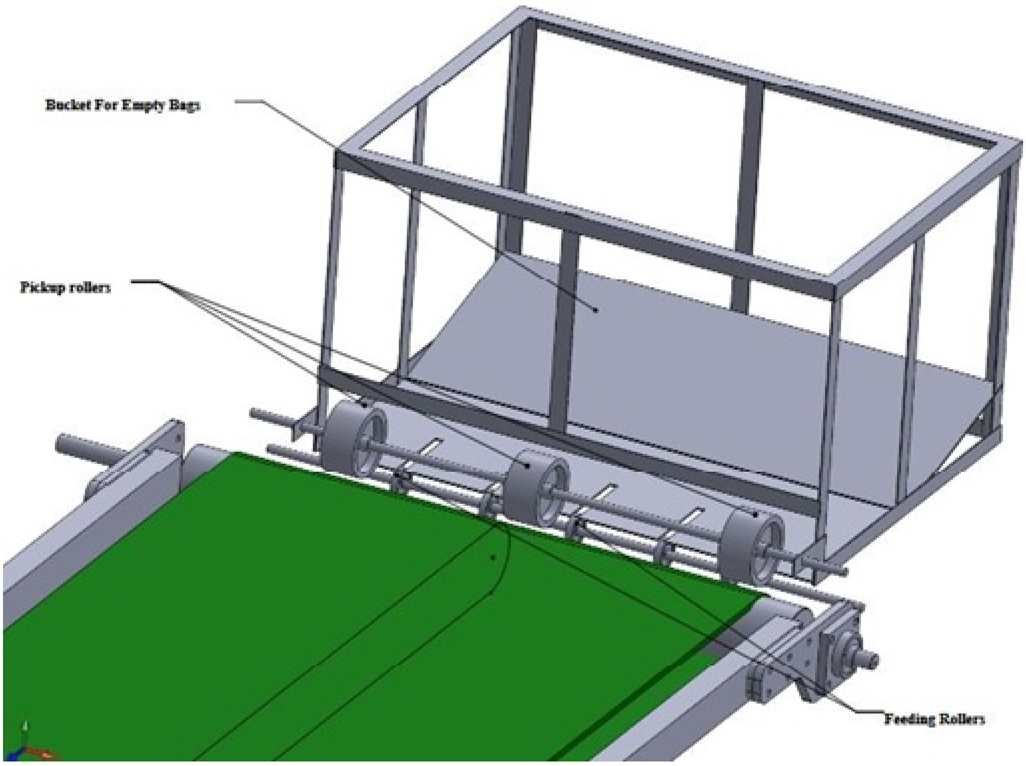

Figure 3.4: Conceptual design of automatic bag placer machine

Through feeding rollers bag will be stripped for further movement. After stripping of one bag at a time by feeding roller the challenge is to transport that bag to the bag collector and make a bundle of 15 to 17 approximately in the bag collector. The basic process start with the filling of empty PP cement bags into the bucket of the automatic bag placer machine as shown in figure 3.3. After filling of bags into the bucket, the feeding roller with high friction co-efficient material on the circumference of the roller will rotate in the given slots of the bottom plate. The feeding rollers will strip one bag at a time from the bundle. The stripping of bags by feeding roller will take place only when the extended surface of the roller will come in contact with the bags. The stripped bag will be guided further to the conveying belt system with the assistance of pickup rollers. The conveying belt system restrict any free moment of the bag and transport it to the bag collector. The same process will be repeated till a bundle of 15 to 17 is formed in bag collector. After formation of bundle the conveyor belt system will stop and bag collector will be operated. For operation of bag collector a pneumatic rotary actuator has been installed. The rotary actuator will operate in such a way that it will align with the angle of the fork like container of the automatic bag guiding machine due to which the formed bundle of bag will slide into it and bag collector will be operated back to its initial position

3.6 Conveyor Belt

In the conceptual design of automatic bag placer machine a flat belt conveyor is proposed. The main use of the conveyor belt is to convey the bags which are being stripped from the bottom of the bucket to the bag collector.
Factors considered for selection of conveyor belt:

- Speed
- Environment
- Application
- Cost

The following table 3.1 shows the different type of materials with their pros and cons.

Table 3.1: Comparison of various materials

Sr.no.	Materials	Pros	Cons
1	Polyamide	-Elastic -Handles shocks -Easy to bond	Hygroscopic
2	NBR	-Oil resistant -Abrasion resistant -Good shock damping	-Will age on exposure to light
3	Polyester	-Non-hygroscopic	-Not elastic -Not chemically bondable
4	Teflon	-Excellent release -High temperature resistance	-Medium abrasion resistance -Very expensive
5	Aramid	-Very strong -Non-hygroscopic	-Not elastic
6	PVC (polyvinyl chloride)	-Acid resistance Low cost	-Low oil resistance -Low abrasion resistance
7	TPU (thermoplastic polyurethane)	-Oil resistanc -Abrasion resistance	-Expensive -Yellows on exposure to light
8	Silicone	-High temperature range -Excellent release properties	-Low abrasion resistance -Difficult to bond
9	EPDM (ethylene propylene diene monomer)	-Excellent temperature range -Low aging rate	-Difficult to bond -Low oil resistance
10	Cotton	-Good heat insulator -Absorbent	-Low strength -Stretching is high
11	Rough top belt	-Excellent grip -Wear-resistant -High durability	-Low oil resistance -Expensive

Many material were studied and their pros and cons were compared. On the basis of their properties, pros and cons the correct material was chosen. On the basis of the above table, Rough top conveyor belt was chosen because it provides excellent grip between belt top and PP bags compared to others, high durability and also rough top conveyor belt was easily available at the plant.
Conveyor belt dimension:

- Belt type: Rough top belt

- Belt width: 1000 *mm*
- Belt thickness: 5 *mm*
- Belt length: 1000 *mm* (center to center distance)

Head and Tail pulley specification:

- Drum Diameter: 101 *mm*
- Length: 1100 *mm*
- Material for drum: Carbon steel EN-8

Selected conveyor belt will experience tension during operation, to make sure belt having more tensile strength than what it will experience belt tension calculation needs to carried out. Next topic shows the calculation of belt tension.

3.7 Belt tension calculation

The belt of the conveyor always experience a tensile load due to the rotation of the electric drive, weight of the conveyed materials, and due to the idlers. So to check the minimum requirement belt strength belt tension calculation is require. The belt experiences tension at steady state and maximum at start of conveyor belt.
The belt tension at steady state can be calculated as:

$$T_b = 1.37 \times f \times L \times g \times [2 \times m_i + (2 \times m_b + m_m) \times cos\delta] + (H \times g \times m_m) \tag{3.1}$$

Where,
$T_b$is in Newton.
f= Coefficient of friction
L= Conveyor length in meters
g= Acceleration due to gravity = 9.81 m/sec2
m_i= Load due to the rollers in Kg/m.
m_b= Load due to belt in Kg/m.
m_m= Load due to the conveyed materials.
δ= Inclination angle of the conveyor in Degree.
H= vertical height of the conveyor in meters.

$$T_b = 1.37 \times 0.64c \times 1 \times 9.81 \times [30 + (2 \times 12 + 0.07) \times cos0] + (1 \times 9.81 \times 0.07)$$

$$T_b = 465.05N \approx 470N$$

The belt tension while starting:

$$T_{bs} = T_b \times K_s \tag{3.2}$$

Where,

$T_{bs}$is in N.

T_b= the steady state belt tension in N.

K_s= the start-up factor

$$T_{bs} = 1.5 \times 465.05 = 697.575N \approx 700N$$

So a rough top belt having steady tension of 470 N and starting tension of 700 N should be selected for optimum operation of system.

3.8 Motor selection criteria for conveyor belt

Motor used in conveyor belt must be able to transmit power at constant speed also motor must stop at any instance should sustain the position. Thus the load on conveyor belt is less a high speed low torque motor is to be used.
Torque calculation :

$$T = F * r \tag{3.3}$$

$$F = F_\mu + F_N \tag{3.4}$$

Where,

T= Torque required *(Nm)*

F= Maximum load *(N)*

$F\mu$= Friction Force *(N)*

F_N = Normal Load *(N)*

μ= Friction co-efficient

$$F_N = m \times g = 42.35 \times 9.81 = 415.45N$$

Where,

m= Total weight *(kg)*

$$F_\mu = F_N \times \mu = 415.45 \times 0.64 = 270N$$

$$F = F_\mu + F_N = 415.45 + 270 = 685.49 \approx 686N$$

r = radius of roller = 50.5 mm = 0.0505 m

$$T = 686 \times 0.0505m = 34.643 \approx 35Nm$$

Inertia calculation :

$$J = J_1 + J_2 \tag{3.5}$$

Where,

J= Total Inertia
J_1= Roller moment of inertia
J_2= Work and belt moment of inertia
m_1= Weight of rollers
m_2= Weight of belt
D= Diameter of roller

$$J_1 = \frac{1}{8} \times m_1 \times D^2 \times 2 \tag{3.6}$$

$$J_1 = \frac{1}{8} \times 30 \times (0.101)^2 \times 2$$

$$J_1 = 0.07650\,(kg - m)^2$$

$$J_2 = m_2 \times (\frac{(\pi \times D^2)}{(2 \times \pi)})^2 \tag{3.7}$$

$$J_2 = 12 \times (\frac{(\pi \times 0.101)}{(2 \times \pi)})^2$$

$$J_2 = 0.00255\,(kg - m)^{\,2}$$

$$J = 0.07650 + 0.00255 = 0.079057\,(kg - m)^{\,2}$$

$$J = 7.9 \times (10)^{\,-2}\,(kg - m)^{\,2}$$

Now, velocity at which the system should rotate,$v = 1.109m/s$

$$rpm(n) = \frac{(v \times 60)}{2\pi r} \tag{3.8}$$

$$n = \frac{(1.109 \times 60)}{(2{\times}3.14{\times}0.0505)}$$

$$n = 209.81 \approx 210$$

Therefore, power required can be given by,

$$P = \frac{2n\pi T}{60} \tag{3.9}$$

Where,

P= power required (watts)
n= output rpm of motor = $210rpm$
T= torque required = $35Nm$

$$P = \frac{(2 \times 3.14 \times 210 \times 35)}{60} = 769.3watts$$

$$P = 1.031HP$$

Considering factor of safety as 1.5 to be on safer side.

$$F.O.S = 1.5$$

$$P = 1.031 \times 1.5$$

$$P = 1.5465 \approx 2HP$$

Hence, a geared motor of $2HP$ can be selected with $210rpm$ at its output.

3.9 Design of Bucket

In automatic bag placer machine, the bucket play a vital role as it will hold the bunch of empty PP cement bags in it. Different types of bucket mechanism has been proposed on the basis of the application.
Dimensions of bucket:

- Length: 760 mm
- Width: 560 mm
- Height: 450 mm

Material used for bucket frame:

- L angle (Mild steel) - 3 mm thickness

Material used for main body of bucket:

- GI sheet - 0.5 mm thickness

Capacity of bucket - 300 bags
The bucket was fabricated in-house with the help of JK Lakshmi members. The material used for frame of the bucket was mild steel and the main body was fabricated with the use of GI sheet. The thickness of the mild steel was 3 mm while the thickness of GI sheet was 0.5 mm.

3.9.1 Proposed Bucket Mechanism

Bucket mechanism with inclined bottom plate. In this mechanism the bundle of bag will be resting on the inclined bottom plate. Bottom plate being little short in width gives an opening to the bags to be in direct touch with the conveyor belt. Due to this on rotation of conveyor belt because of friction between conveyor belt and bags, conveyor belt will strip one bag at a time from the bundle. Figure 3.5 shows CAD model of the bucket mechanism. Also detailed drawing of bucket is shown in appendix B

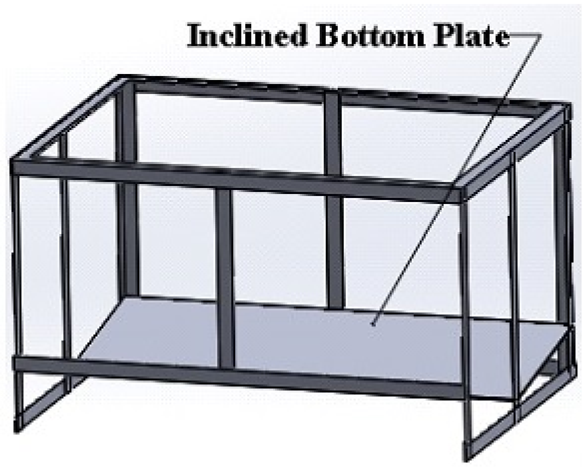

Figure 3.5: Proposed Bucket Mechanism

In this mechanism more than one bag are getting stripped because of high static charge between bags also bags are getting tangled in the front L angle while stripping because of which system is getting stuck and bags are getting torn while tangling. Because of mentioned problem faced in bucket mechanism- I a new mechanism was proposed with modification in it which is described in new topic.

3.10 Pneumatic Rotary Actuator

Figure 3.6: Rotary Actuator

Main aim of rotary actuators is to provide partial or multiple turn rotary action and acceleration and stopping of rotary output with precision and accuracy as per required degree of moment. Rotary actuator is shown in figure 3.6.

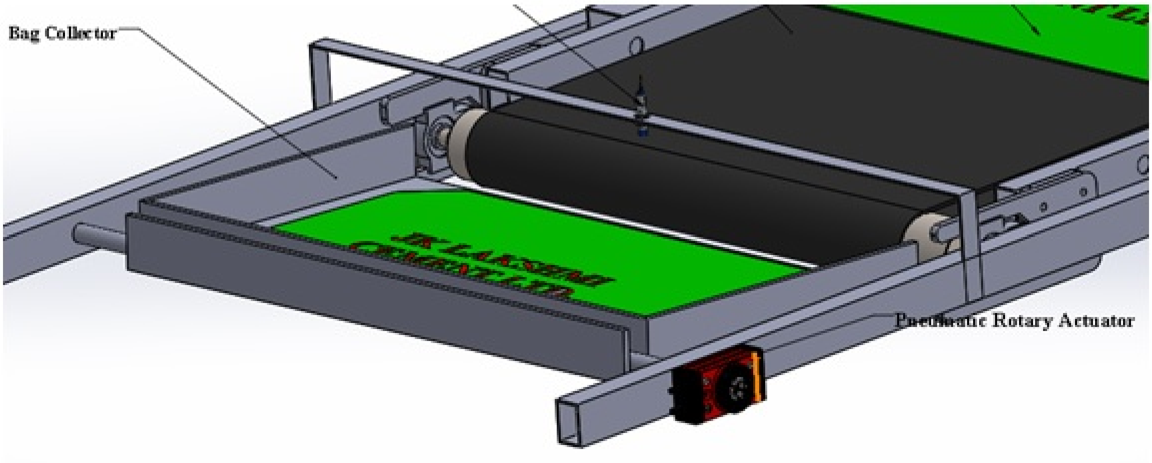

Figure 3.7: CAD modeling of rotary actuator attachment

As shown in figure 3.7 in our system rotary actuator is attached with the bag collector. The function of the rotary actuator will be to move the bag collector at an angle and align it with the fork like containers of the automatic bag guiding machine and back to its initial position on receiving signal from the controller. As the bag collector will align with the fork of the bag guiding machine the bundle formed in it will slide into the containers due to gravity. After certain predefined time the bag collector will be rotated back to it initial position. Table 3.2 shows the specification of the rotary actuator being selected. Using a motor gives inaccuracy as it is difficult to accurately stop a motor at a specified degree of rotation also it draws more current at starting. So for better accuracy and precision a rotary actuator pneumatically operated has been selected.
Following table 3.2 shows the specification of rotary actuator :

Table 3.2: Specification of Rotary actuator

Sr. No.	Parameter	Value
1	Type	Pneumatic rotary actuator
2	Fluid	Air
3	Rotation angle	Adjustable angle type (0° to 360°)
4	Cushion	Adjustable pneumatic
5	Pressure	7 *bar*
6	Torque	6 *Nm*
7	Shaft	ø 25 *mm*
8	Angular velocity	0.8 *rad/sec*

3.11 Controlling

Prime components of the control systems are:

- Arduino uno
- SMPS
- Pneumatic valve
- Capacitive proximity sensor
- Industrial power supply

Figure 3.8 shows the logic control of the system.

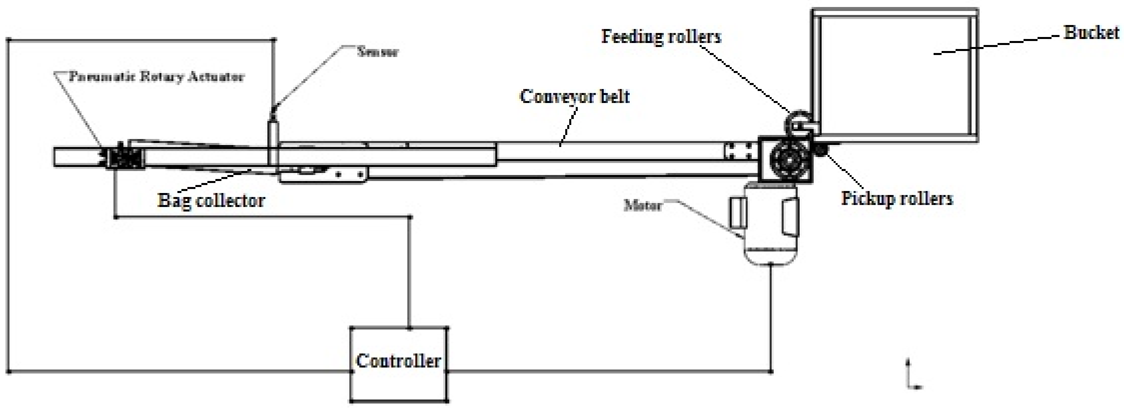

Figure 3.8: Logic Control

As seen in figure 3.8 sensor is mounted between bag collector and conveyor belt which gives signal to controller on counting of bags. The signal provided by sensor is processed and input in given to motor and rotary actuator. The motor input will stop motor and actuator input will start the rotation of the bag collector and it will align with the fork like containers of automatic bag guiding machine. The bag collector will stay aligned for a predefined time after that controller will give signal to rotary actuator and bag collector will be moved back to its initial position and at the same time input to motor is also given to start. For our controller sensor output works as input for actuator and motor operation. Figure 3.9 shows the closed loop flow chart of the controlling system.

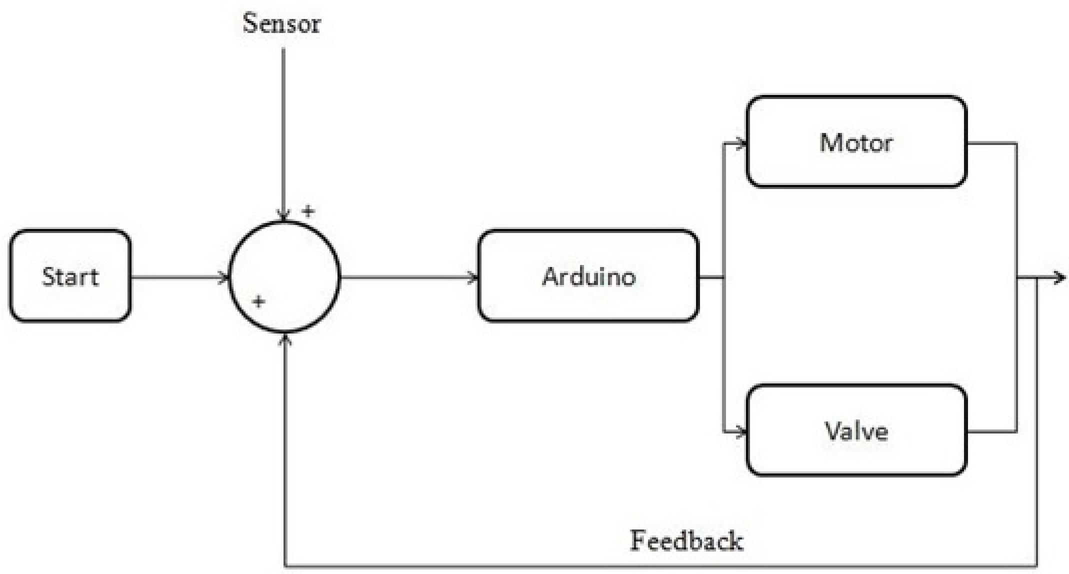

Figure 3.9: Closed loop Controlling flow chart

as show in figure 3.9 logic diagram elicits, the control process can be explained with a simple feedback loop. As the system power up, the arduino controller checks the input values of the sensor and provides signals to motor and rotary actuator. The basic logic behind the control is that the controller provides the output signals to the motor and actuator in such a manner that the system operates in steady accurate and smooth way.For controlling various components has been used which are described in further topics.

3.12 Circuit Board

For controlling the movement of the bag collector by rotary actuator we have to develop the controlling system as shown in figure 3.10 such that it can operate accurately within time range. Main components of this controlling system is pneumatic valve, rotary actuator, arduino board and power supply. In our system valve is operated on 12V DC power supply but in plant 240V AC, 50 Hz supply is available so we cannot give power supply to the valve for that SMPS (Switched Mode Power Supply) is required which convert 240V AC to 12V DC supply. One capacitive proximity sensor is required for identify the number if bag being transferred to bag collector.

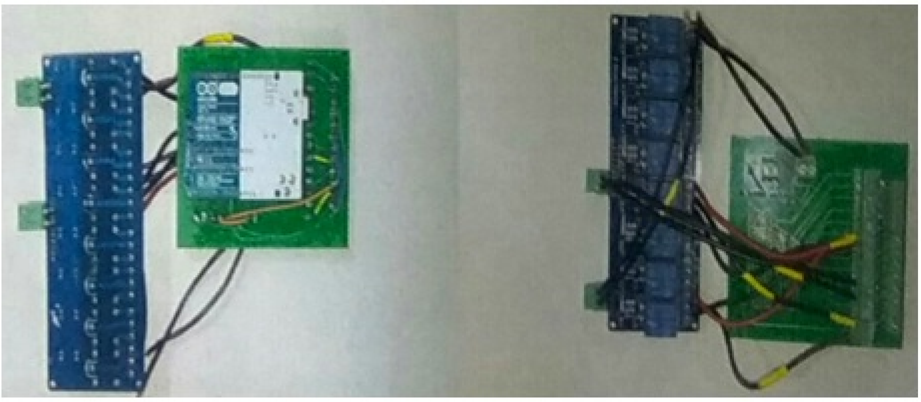

Figure 3.10: Actual logic circuit board

3.13 Arduino

Arduino is an open source electronics platform based on easy-to-use hardware and software. As shown in figure 3.11, boards are able to read inputs - light on a sensor, a finger on a button, and turn it into a output- activating a motor, turning on an LED, publishing something online. So via arduino we can send set of instruction to micro controller board. Same thing we can do by PLC but it is costly for small factory automation.

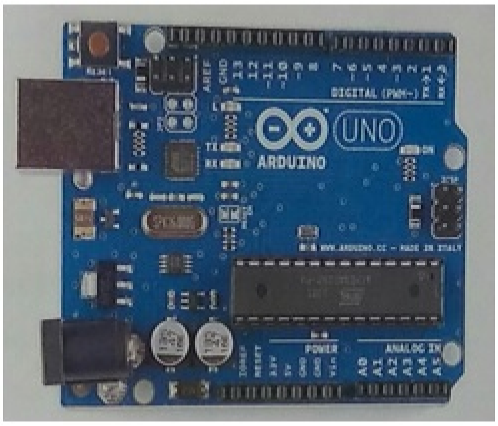

Figure 3.11: Arduino board

3.14 SMPS (Switched Mode Power Supply)

SMPS is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a DC to AC source to Dc loads, such as a personal computer, while converting voltage and current characteristics. Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy.

Components of our systems works on 12V DC supply so we required SMPS for converting AC power to DC power. Figure 3.12 shows the actual SMPS.

Figure 3.12: 12V DC SMPS

3.15 Capacitive Sensor

The capacitive sensor reacts to the presence of any object that has a dielectric constant more than 1.2. Capacitive proximity sensors can detect both metallic and non-metallic targets in powder, granulate, liquid, and solid form. This, along with their ability to sense through nonferrous materials, makes them ideal for sight glass monitoring, tank liquid level detection, and hopper powder level recognition. In capacitive sensors, the two conduction plates (at different potentials) are housed in the sensing head and positioned to operate like an open capacitor. Air acts as an insulator; at rest there is little capacitance between the two plates. Like inductive sensors, these plates are linked to an oscillator, a Schmitt trigger, and an output amplifier. As a target enters the sensing zone the capacitance of the two plates increases, causing oscillator amplitude change, in turn changing the Schmitt trigger state, and creating an output signal. Figure 3.13 shows the capacitive sensor.

Figure 3.13: Capacitive Sensor

Chapter 4

Fabrication and Testing

Automatic bag placer machine implementation has been done in two phases fabrication of structure and testing it on existing conveyor belt system at the plant. The main aim behind this multiple phase testing is to identify the feasibility of the mechanism in current working environment and if its feasible we can manufacture completer mechanism out of prototype structure.

4.1 Fabrication of Structure

As per the design drawing fabrication of bucket has been carried out, for the conveyor belt existing conveyor belt system at the plant has been used for the initial trail bases.

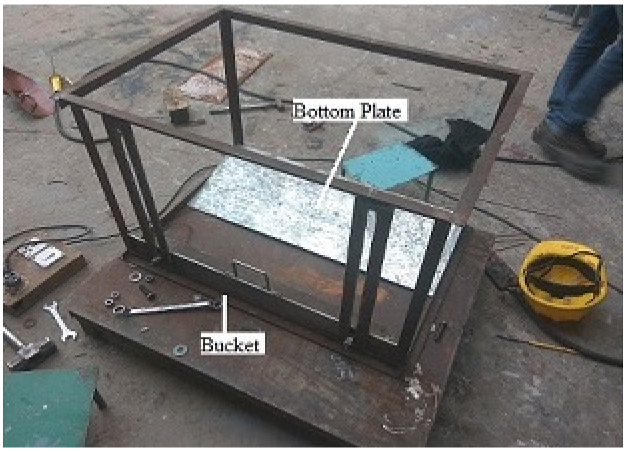

Figure 4.1: Fabricated structure [Courtesy: JK Lakshmi Cement Ltd.]

Structure of bucket is made from L angles of mild steel and body is made from GI sheet. Figure 4.1 shows image of fabricated structures.

4.2 Testing

Testing of different mechanism is carried out in multiple phases.

4.2.1 Phase - I

Testing of the prototype was done on the conveyor belt present in the packing plant. The prototype of the bucket with inclined bottom plate was used. In this bags are filled into the bucket and the bundle of bag is resting on the inclined bottom plate. Bottom plate being little short in width gives an opening to the bags to be in direct touch with the conveyor belt. Due to this on rotation of conveyor belt because of friction between conveyor belt and bags, conveyor belt strips one bag at a time from the bundle. Figure 4.2 shows the Phase - I testing.

Figure 4.2: Phase - I testing [Courtesy: JK Lakshmi Cement Ltd.]

During testing of this mechanism more than one bag are getting stripped because of high static charge between bags also bags are getting tangled in the front L angle while stripping because of which system is getting stuck and bags are getting torn while tangling. Because of mentioned problem faced in bucket mechanism a new mechanism was proposed with modification in it which is described in new topic.

4.2.2 Phase- II

As seen with problem faced in phase-I testing modification where made to it during the testing and modified bucket mechanism-I was proposed and fabricated. Figure 4.3 shows the CAD model and figure 4.4 shows the fabricated structure of modified bucket mechanism-I. In this bucket mechanism with inclined bottom plate feeding rollers has been added to counter the problem faced in phase-I testing. Here the function of feeding rollers is to assist in transporting the stripped bag on to the conveyor belt system which will further guide bags to the bag collector.

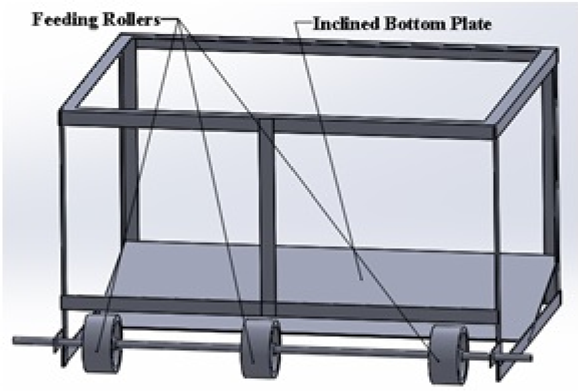

Figure 4.3: CAD model of modified bucket mechanism-I

Figure 4.4: Phase - I testing of fabricated structure of modified bucket mechanism-I [Courtesy: JK Lakshmi Cement Ltd.]

As observed in phase-I testing bags are getting tangled in front L angle in modified mechanism-I it has been replaced by feeding rollers having a smooth curved surface. Because of rotation of rollers it assist in transporting bag further on the conveyor belt with ease. Because of this modification problem of tangle in bags has been resolved but still problem of stripping of more than one bags persists. To eliminate both the problem a third modification in system has been done which is described in next topic.

4.2.3 Phase - III

With problem faced in both testing phases new modifications where made in the bucket mechanism and a new Bucket mechanism with inclined bottom plate, feeding roller and pickup roller was proposed and fabricated. Modified Bucket Mechanism - II is an integration of initial bucket mechanism and modified bucket mechanism- I, with integration of two mechanism pickup rollers are been added. Figure 4.5 shows the CAD model of modified bucket mechanism-II and figure 4.6 show testing of mechanism.

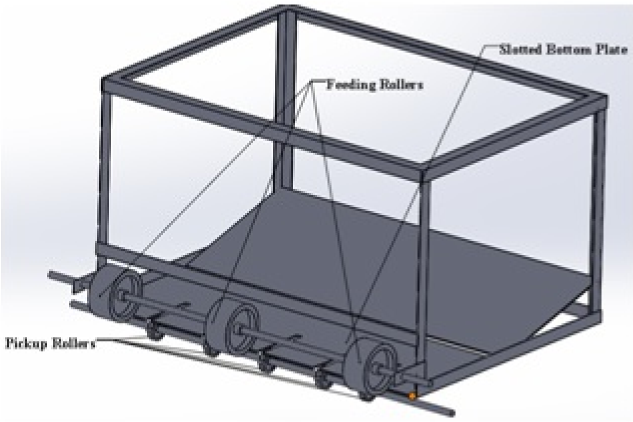

Figure 4.5: CAD model of modified bucket mechanism-II

Figure 4.6: Phase - II testing of testing of fabricated structure of modified bucket mechanism-II [Courtesy: JK Lakshmi Cement Ltd.]

In this mechanism the bottom plate has been modified as seen in figure 4.5 . The bottom plate is extended till the width of the bucket and five slots are made in the bottom plate. The slots are made so that pickup rollers can rotate into it. The pickup rollers are designed in such a way that it has an extended surface over it circumference made up of high friction co-efficient material. In this mechanism bags is resting on the slotted bottom plate, the pickup rollers will rotate and when extended surface of it come in contact of the bag it starts stripping bag one at a time. Further the stripped bags will be guided on to the conveyor belt with the help of feeding rollers. Due to such arrangement problem faced in previous mechanism has been eliminated. Various components which are used in testing of different mechanism are discussed in next topic.

4.2.3.1 Components Used For Testing of Mechanisms

Chapter describes about the major components used for testing of different mechanism.

- DC Motor
  - For the testing purpose Motor was chosen from the available spare motors at the industry. Figure 4.7 shows the DC motor used also table 4.1 gives specification of DC motor

Figure 4.7: DC motor [Courtesy: JK Lakshmi Cement Ltd.]

Table 4.1: Specification of DC motor

Sr.No	Parameter	Value
1	HP	0.25
2	Voltage	24
3	Ampere	8
4	KW	0.18
5	RPM Motor (rpm-1)	2000
6	RPM Geared (rpm-2)	30
7	Motor Torque (T-1)	0.6565 Nm
8	Torque at output shaft (T-2)	43.76 Nm
9	Output Shaft Dia.	16 mm

- Coupling
  - Type: Sleeve Coupling

Figure 4.8: Coupling [Courtesy: JK Lakshmi Cement Ltd.]

- Solid Shaft & Wheels:
  - Solid Shaft
    - Diameter: 10 *mm*
  - Wheels
    - Diameter: 100 *mm*
    - No of wheels: 4

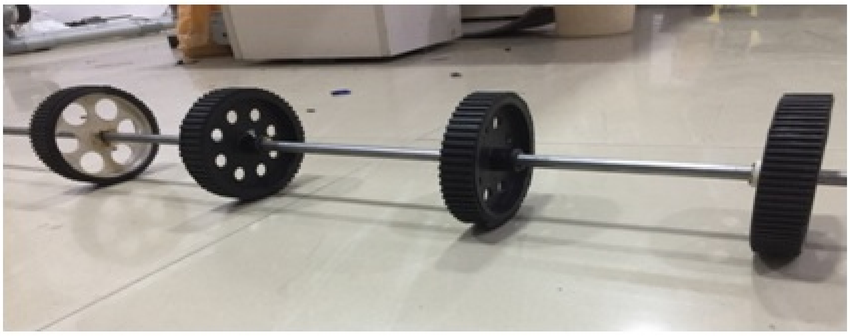

Figure 4.9: Solid shaft & Wheels [Courtesy: JK Lakshmi Cement Ltd.]

- Bearing
  - Type: Ball bearing with oil seal
  - Diameter.: 10

Figure 4.10: Standard Bearing [Courtesy: JK Lakshmi Cement Ltd.]

Chapter 5

Conclusion and Future Scope

This chapter includes conclusion of the project work and its future possibilities of automatic bag placer machine.

5.1 Conclusion

- A bag placer mechanism was conceptualized and fabricated to overcome the problem of human exposure to dusty atmosphere.
- Arduino controller was adopted which resulted in low cost bag placer machine.
- The system was tested for accuracy of delivery of bags. It was observed that static charge between bags caused inaccurate delivery.
- The system needs single operator which was four when bag placing was done manually.
- This has lead to less exposure of human being to dusty atmosphere.

5.2 Future Scope

- The whole system can be automated to increase the dispatch of cement and decrease manpower
- Antistatic device can be installed for more satisfactory results
- Controlling through PLC can be done for more accurate result

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Appendix

Appendix A

Bag Placer Assembly Drawing

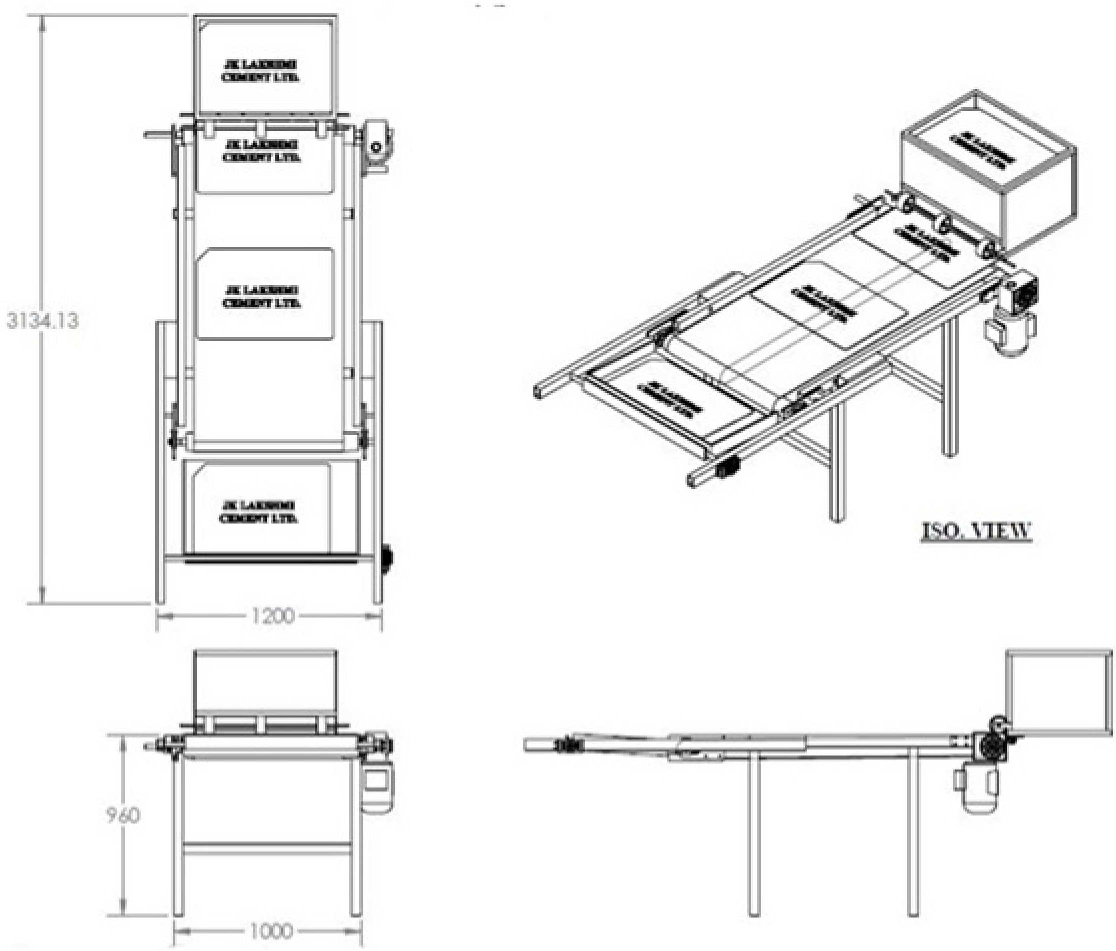
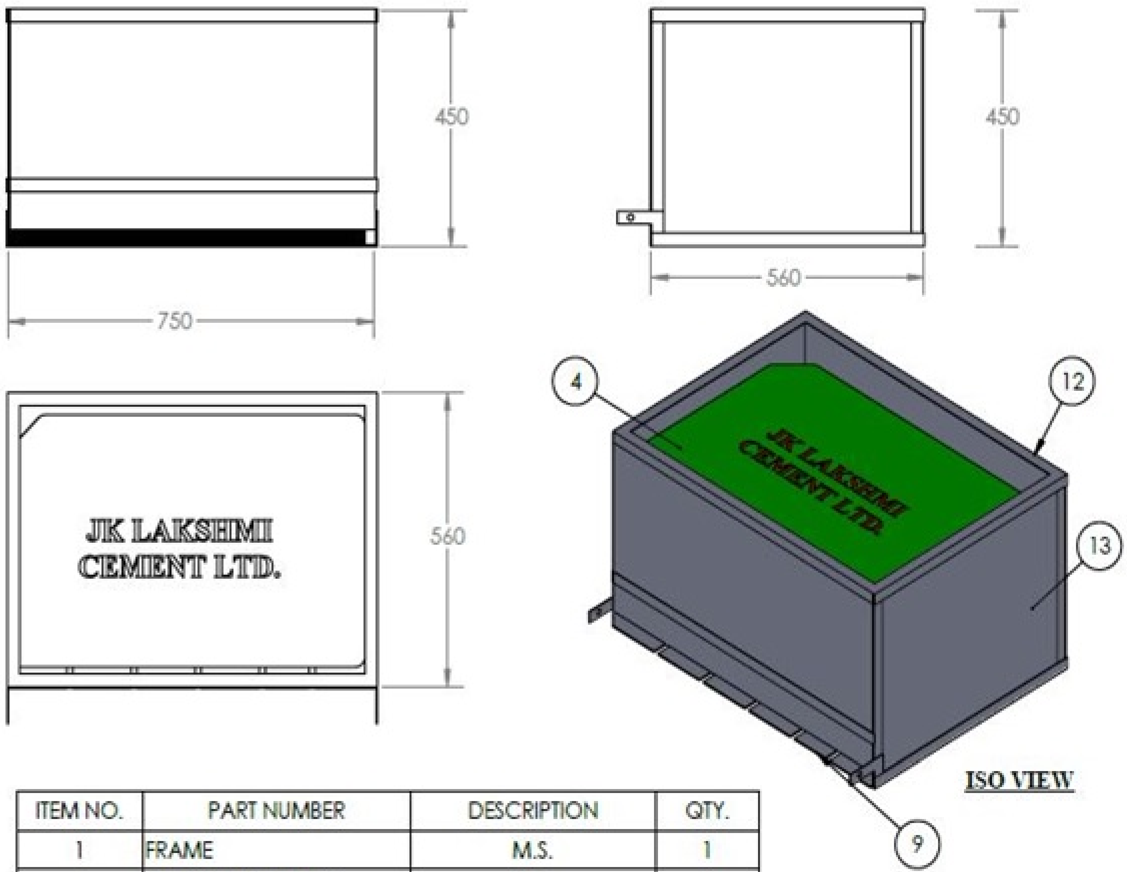


Figure 5.1: Automatic Bag Placer Assembly

Appendix B

Bucket Assembly Drawing



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	FRAME	M.S.	1
2	GI SHEET FOR BODY	M.S.	4
3	SLOTED BOTTOM PLATE	M.S.	1
4	BAG	POLYPROPYLENE	300

Figure 5.2: Bucket Assembly