Design And Fabrication Of Cement Bags Loading And Unloading Machine

Usman Ghani, Mubashir Hayat, Fakhr ul Islam, Zia ur Rehman, Tufail Habib

Abstract: In today’s modern time the loading/unloading of cement bags in local market is still performed by workers. This method of loading/unloading cement bags is risky for workers health. Therefore, it is necessary to design and fabricate a cement bags loading/unloading machine that can fulfill the market need. This research provides to design the conveyor system used for loading/unloading cement bags which includes belt speed, belt width, motor selection, belt specification, shaft diameter, pulley, gear box selection, with the help of standard model calculation. This machine will reduce health and safety issues for workers, reduce cost and will be time saving.

Keywords: Cement Bags, Loading/Unloading Machine, Conveyor System, Health and Safety, Cost Reduction, Cad Model.

1. INTRODUCTION

In local market the loading and unloading of cement bags from truck into storage is still performed through workers. This process is time consuming, costly and unsafe for the workers. In this research an attempt has been made to design a portable conveyor belt machine which will be used for loading/unloading cement bags into trucks in local market. The term “Conveyor belt” describes belts used to convey all kinds of Semi- finished and finished industrial products from one point to another. They are mainly used for handling of unit goods, both in the food and non-food production and packaging sectors and in general materials handling for storage and distribution. A belt conveyor is a Rubber or Textile structure with a belt shape closed ring, with a vulcanized or metallic joint, which is used for material transportation. Belt Conveyors are mostly used for transport of solid objects and for bulk materials at great speed, covering long distance. A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyors are especially useful in applications involving the transportation of heavy or bulky materials. Conveyor systems allow quick and efficient transportation for a wide variety of materials, making them very popular in the material handling and packaging industries. The conveyors consist of standard parts, which are advanced and simple in structure, easy to maintain. Belt conveyor are widely used in mining, metallurgical and coal industry to transfer sandy or lump materials, or packaged materials. According to different transferring equipment, the transfer system can be one independently or multi-conveyors or combined with other transfer equipment. The belt conveyor can be installed horizontally with a slope to meet the needs of different transfer lines. Conveyor Systems are mechanical devices or assemblies that transport material with minimal effort. While there are many different kinds of conveyor systems, they usually consist of a frame that supports either rollers, wheels, or a belt, upon which materials move from one place to another. They may be powered by a motor, by gravity, or manually. These material handling systems come in many different varieties to suit the different products or materials that need to be transported. A portable conveyor belt lift machine provides the following significance:

- Easy to operate
- Less initial cost
- Easy to assemble
- Less maintainability cost

1.1 Problem statement

There are many problems with the current method of loading/unloading cement bags in the local market. The most important problem is the health and safety risk for the workers. Workers have to carry heavy cement bag on their heads which may damage the muscles of their trunk and shoulders. Similarly if a worker slip of fall while carrying heavy load can cause severe injury to their head, trunk or shoulders. Second problem with the current method is that it is a time consuming process, the workers may get tired after loading some bags and they have to get brakes for rest which consume more time on the process. The third problem is of cost, this method is more costly compared to using a portable conveyor belt machine.

1.2 Objectives

The proposed research design the conveyor system used for loading/unloading cement bags which includes belt speed, belt width, motor selection, belt specification, shaft diameter, pulley, gear box selection, with the help of standard model calculation. The machine will reduce health and safety issues for workers, reduce cost and will be time saving. The main objectives of the research are:

- To design and fabricate a cost effective machine.
- To design and fabricate a portable machine such that it can be carried in trucks.
- To enhance health and safety for the workers.

1.3 Notations

The following notations will be used throughout the article.

\[
\begin{align*}
T_b &= \text{belt tension in N} \\
\mu &= \text{Coefficient of friction} \\
L &= \text{Conveyor Length in m} \\
g &= \text{Gravitational acceleration in m/s}^2 \\
m_i &= \text{Idlers mass kg/m} \\
m_b &= \text{Belt mass kg/m} \\
m_m &= \text{Material mass kg/m} \\
H &= \text{Conveyor Height in m} \\
P_p &= \text{Power at drive pulley in kw} \\
T_b &= \text{Belt Tension in N}
\end{align*}
\]
2. LITERATURE REVIEW

In the construction of cement bags lift machine various mechanical components are designed i.e. conveyor system, motor, bearing, chain, rollers and base frame. A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyor design are especially useful in applications involving the transportation of heavy or bulky materials. There are several researchers who have worked on conveyors design such as: Miroslaw Bajda [1] compared different belts design based on the puncture resistance test results. He concluded that the scale and type of puncture resistance in belt depends on many factors, such as a belt’s physical and mechanical properties and its design. When the damage is caused not only to the carrying cover, but also to the belt core, it becomes a threat to the operation of the belt conveyor. Misoslaw paper presents the results of tests which allow defining the influence of conveyor belt design on the belt’s wear and tear, in particular on punctures. Belt puncture resistance was determined using a method based on calculating mean impact energy and critical energy. The tested belts had equal nominal tensile strength of 2000 kN/m, but were of different design and comprised cores made of different materials. M.Hydergora [2] presented a paper that set selection criteria for multi ply belts conveyor. His criteria was based on the determination of belt longitudinal strength, fatigue strength of splices. Selection criteria of constructional and geometrical parameters of belts were based on the simulation model analyzing the influence of individual parameters on belt operating time on the conveyor. Devendra Kumar [3] worked on belt conveyor design modification and latest technologies or methodologies used in different applications to reduce failures, maintenance cost and equipment related fatal accidents occurs during operation. The focus is on methodologies as Design modification, Drum and pulley failures, Belt design and its failure, energy & efficiency, friction, inspection, operation & maintenance and fire & safety. His analysis shows, different design parameters required for different applications such as coal mines, cement and food industries. Different designs in the field of drive mechanism and other modification used for reducing starting torque on drive pulley and operational efficiency are performed by K. Khader et al [4], f Xie et al [5], Y Hou et al [6] and Z Tian, Y Hou [7]. Design of an electric motor has also been a prime focus of the proposed research. Most electric motors operate through the interaction between the motor's magnetic field and electric current in a wire winding to generate force in the form of rotation of a shaft. F Momen et al [8] designed a permanent magnet synchronous motor that is able to meet stringent noise and vibration requirements without implementing rotor skew, which lowers motor performance and adds complexity to the rotor manufacturing and hence is undesirable. K.T. Chau et al [9] integrates a magnetic gear into a permanent-magnet brushless DC motor so that it can share a common PM rotor, hence offering both high efficiency and high power density. Hence, the low-speed requirement for direct driving and the high-speed requirement for compact motor design can be achieved simultaneously by this method. K.M. Rehman et al [10] performed analysis of several of the most commonly used motors. In their study, the induction motor is found to be best suited for vehicle application. Permanent magnet motors owing to their restrictive speed range are found to be not as suitable for vehicle applications. They also attempted to define the standards for some of the vehicle motor design parameters such as motor rated speed, motor maximum speed and extent of constant power operation. The design of the bearing may provide for free linear movement of the moving part or for free rotation around a fixed axis, It may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Most bearings facilitate the desired motion by minimizing friction. H. Hirani et al [11] describes the optimum design methodology for improving operating characteristics of fluid-film steadily loaded journal bearings. They used the design variables such as radial clearance, length to diameter ratio, groove geometry, oil viscosity and supply pressure in the optimum design of journal bearings to simultaneously minimize oil flow and power loss. H. Hirani [12] presented a paper that deals with multiobjective optimization and discrete design variables related to the design of a journal bearing. The aim of his paper was to show the sensitivity of radial clearance, oil viscosity and length-diameter ratio on bearing power loss and oil flow. His paper attempts to remove the difficulty of selecting the weighting factor in multiobjective journal bearing optimization problems. H. Hashimoto et al [13] described the optimum design methodology for improving operating characteristics of hydrodynamic journal bearings and its application to elliptical journal bearing design used in high-speed rotating machinery. The hybrid optimization technique combining the direct search method and the successive quadratic programming was applied effectively to find the optimum solutions. Chain drive is also designed because it is used for transmission of mechanical power on conveyors. Chain consists of a series of short cylindrical rollers held together by side links. Chen and Freudenstein [14] developed a kinematic analysis for the motion of roller chain drives, which is exact for relatively slow-speed chain drives with negligible wear. Their results have revealed the existence of a remarkable degree of sensitivity of chain performance with respect to center distance including discontinuities in the motion derivatives. H. Kong and Sabbaghian [15] showed that on a roller chain drive, if the incoming engaging roller moves tangent to the pitch circle at the moment of engagement, no roller-sprocket impact should occur. Comparisons between their model and a conventional model show significant improvements made in the kinematic properties of the chain drives. Yakobus et al [16] has discussed a new design in order to reduce weight of 415 chain. Weight savings of components, obtained from thickness plate reduction 20% and its pin height reduction. The thinner plate received more stress, therefore the new plate properties must be made better with more strength. Suwannahong and

V = Speed of conveyor in m/s
B_r = Belt breaking strength in N/mm
C_f = Friction factor
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C_b = Breaking strength loss factor
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P_m = Motor Power in W
P_p = Pulley power in W
K_d = Drive Efficiency

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\[ K_d = \text{Drive Efficiency} \]
Suvanjumrat [17] employed finite element method (FEM) to analyze the roller chain drive system. They proposed multi-flexible body dynamics (MFBD) method to model and analyze the roller chain drive system. The roller chain which composed of plates, pins and rollers was meshed with solid elements under the convergence test. The eight tooth sprocket was modeled by rigid body to roll and contact with the roller chain. The dynamic load distribution of the roller chain on the rigid sprocket was compared with the analytical solution. The MFBD simulation results had a good agreement with analytic results which obtained an average error of 12.32%. B.L. Li et al [18] used the Catia software for modeling the roller chain drives accurately. They applies Ansys Workbench to analyze the modal and harmonic response of the tension side chains. They also compared the natural frequency and the theoretical calculation results of simplified model. Their results showed that the deviation increased with the increase of the order of natural frequency and modal numerical simulation provides certain reference for engineering application.

3. DESIGN OF MECHANICAL COMPONENTS

A survey was conducted in local market to select design criteria for load for the proposed research. The result of the survey report is given in table 1:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Item</th>
<th>25 Kg</th>
<th>50 Kg</th>
<th>100 Kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cement Bag</td>
<td>25%</td>
<td>75%</td>
<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>Flour Bag</td>
<td>40%</td>
<td>40%</td>
<td>20%</td>
</tr>
<tr>
<td>3</td>
<td>Wheat Bags</td>
<td>0%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>4</td>
<td>Total</td>
<td>22%</td>
<td>55%</td>
<td>23%</td>
</tr>
</tbody>
</table>

It is clear from survey report that most bags used in local market weighted 50 Kg. We set design criteria as 100 Kg (Two 50 Kg bags at a time) with 50% factor of safety therefore, it becomes 150 Kg. Further, in the construction of cement bags lift machine various mechanical components are used which are shown in figure 1.

![Basic mechanical components used in the machine.](image)

Conveyor belt: A belt conveyor system is one of many types of conveyor systems. A belt conveyor system consists of two or more pulleys (sometimes referred to as drums), with an endless loop of carrying medium, that rotates about them. One or both of the pulleys are powered, moving the belt and the material on the belt forward. Following standard calculations carried out for selecting conveyor belt.

Belt tension, \( T_b = 1.37*\mu*L*9.8 \times [2(m_i+(2m_b+m_w)\cos\theta)+H^2g^2m_n] \times 0.5^*9.8^*45 \times 660 \text{ N} \)

Power at drive pulley, \( P_p = T_b^*V/1000 \)

Belt breaking strength, \( B_b = C*P_d/C*V \)

Motor: The shaft of motor is rotating at 1450 rpm which is very high, as we required low speed of conveyor belt therefore a gear system is used to reduce the speed at drive pulley.

Motor shaft speed = 14450 rpm

Required pulley speed = 60 rpm

Gear ratio = 1450/60 = 24

So we will use a gear ratio of 1:24 which mean that the drive pulley will complete one rotation after completing 24 rotations by motor shaft.

Motor power sizing: Motor power required for conveyor belt can be calculated as:

Motor Power, \( P_m = P_p/K_d \)

Speciation of Motor used:

- Power = 0.5 hp
- Rotation speed of shaft = 1450 rpm
- Voltage = 220 V (Single phase)
- Electric current type: AC
- Brake system: The conveyor belt will stop at position where electric circuit brake.
- Bi-directional motion, the direction of motion can be changed by changing polarity of the motor from electric circuit.
- Gear box: it is used for motor speed reduction.

Bearing: Bearing is used to support a rotating shaft. It can also be used to support or guide a sliding member. Friction which offer resistance to motion generates heat, increases power requirement, and has other undesirable effects such as wear, tear and noise. Reducing or eliminating the effect of friction accomplished in two ways, one is lubrication which provides a lubricant film between moving components, the objective is provide smooth surface for the rolling member to travel on. The other means of reducing friction is the use of bearing. In addition, bearing confined the moment of shaft by acting as guide. Specification of bearing used in this project are:

- Type: Ball bearing
- Designation: 6206C3 SKF Ball bearing
- Inside diameter = 30 mm
- Outside diameter = 62 mm
- Width = 16 mm
- Dynamic load ratting: 20.3 kN
- Static load ratting: 11.2 kN

Chain: Chain is used for transmission of power over long distances. The basic feature of chain drive include a constant ratio, since no slippage or creep involved, long life and the ability to drive number of shafts from a single
source of power. Specification of chain used in this project are:

- Designation: ANSI Standard chain#25
- Pitch = 0.25 inch
- Ultimate tensile strength = 350 Kg

Rollers: The load bearing rollers support weight of material and it may also help movement. These are mainly used for carrying weights. The conveyor rollers provide less noise for the conveyor system. They aim to decrease wear and tear of method for extended life. Specification of roller used in this project are:

- Material: Mild steel
- Diameter = 0.09 m (3.5 in)
- Length: 0.52 m (1.7 ft)

Base Frame: It provides support to the main structure of conveyor belt system. Specification of base frame used in this project are:

- Material: Mild steel
- Length = 1.5 m
- Width = 0.6 m
- Thickness = 0.1 m (5 in)
- Joint: Welded

4. MANUFACTURING PROCESSES INVOLVED

The manufacturing processes which are performed in the fabrication of “cement bags lift machine” are shown in figure 2.

![Fig 2. Manufacturing processes involved in fabrication of the machine.](image)

First of all the cutting process was performed. Cutting processes work by causing fracture of the material that is processed. Usually, the portion that is fractured away is in small sized pieces, called chips. Common cutting processes include sawing, shaping (or planning), broaching, drilling, grinding, turning and milling. Although the actual machines, tools and processes for cutting look very different from each other, the basic mechanism for causing the fracture can be understood by just a simple model called for orthogonal cutting. After cutting, the parts/pieces were welded according to the required shape. Welding is a permanent joining of two materials usually metals, by coalescence, which is induced by a combination of temperature, pressure and metallurgical conditions. Shielded metal arc welding is used to join different parts together. Shielded metal arc welding is the most common of arc welding processes because of its wide versatility and it requires low cost equipment. It is also easily available everywhere. After that the welded parts were drilled in a precise manner. Drilling is a cutting process that uses a drill bit to cut a hole of circular cross-section in solid materials. The drill bit is usually a rotary cutting tool, often multi-point. 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 off chips (swarf) from the hole as it is drilled. Before drilling the center of hole is located on the work piece by drawing two lines at right angles to each other and then a center punch is used to produce an indentation at the center. The drill point is pressed at this center point to produce the required hole. After drilling operation reaming operation is performed for accurate sizing and finishing of hole. The tool used for reaming is known as reamer, which has multiple cutting edges. Reamer cannot originate a hole, it simply follows the path which has been previously drilled and removes a very small amount of material. The existing holes were then bored. Boring is a process of enlarging a hole by a boring tool. This can also done on a drill machine and manually. After that internal threads of smaller diameters were made, using a multiple cutting tool called the tap. A tape of required size is held on special fixture is mounted on the tailstock spindle. The axis of tap should coincide exactly with the axis of work. In order to produce a flat surface, a facing operation at the ends of the work piece was performed. The facing operation is performed on lathe machine. This operation involves feeding the tool perpendicular to the axis of lathe machine. Finishing processes was employed to improve appearance, adhesion or wettability, solder ability, corrosion resistance, tarnish resistance, chemical resistance, wear resistance, hardness, modify electrical conductivity, remove burrs and other surface flaws, and control the surface friction. At the end, Paints are used for protection and decoration. We used spray paint of black color for the whole frame surface and yellow color for conveyor belt to protect against corrosion. Spray painting is probably the most widely used paint application process because of its versatility and the economy in the use of paint. In the conventional technique, the paint is atomized and transported by flow of compressed air.

5. CAD MODEL AND ACTUAL MACHINE

SOLIDWORKS was used for modeling purpose. SOLIDWORKS CAD software is a mechanical design automation application that lets designers quickly sketch out ideas, experiment with features and dimensions, and produce models and detailed drawings. 3D model and actual picture of the machine are shown in figure 3 and 4 respectively.

![Fig 3. 3D model of the machine](image)
Each assembly and drawing we create is made from parts. Parts are the building blocks of every SOLIDWORKS model. First of all a 3D base feature is produced using an extrude command but before we create an extrude feature, we need to make a sketch. After we sketch the rectangle, we use the extrude tool to create a 3D base feature. After then the material is removed using the cut extrude command. The Cut-Extrude tool is similar to an extrude feature, except that it removes material from the model instead of adding material. The object is revolved using the revolve command. The Revolve tool revolves a sketch profile around a centerline at a specified angle. To cut the model at the same angle on the opposite side, we use the Mirror tool to mirror the original cut about the plane of symmetry. After the mirror we use the linear pattern tool to copy the original tab a specified number of times. The linear pattern creates multiple instances of a selected feature along a linear path. At the end we attach the assembly components using various types of mates such as coincident, concentric, and distance mates. An assembly is a collection of related parts saved in one SOLIDWORKS document file with a .sldasm extension.

6. MAINTENANCE
All actions necessary for retaining an item, or restoring to it, a serviceable condition, include servicing, repair, modification, overhaul, inspection and condition verification increase availability of a system. For keeping systems equipment in working order for proper working and better efficiency of machine, certain maintenance instructions have to be followed for different components of machine.

- The motor should be provided with constant electric voltage, avoiding fluctuations in voltage. To avoiding heating of the motor a break of ten minute should be given to the motor after every twelve hours of operation.
- Regular inspection of conveyor belt should be done. In case of wear or failure they should be replaced with same specified belt.
- They should be properly lubricated. Bearings should be properly inspected and in case of wear or tear they should be replaced with same dimension bearing.
- For smooth motion, long life to avoid noise chains and sprockets should be timely lubricated.
- To avoid wear and tear, noise and for long life, these should be properly lubricated.
- It should be inspected after some period of time. Repairing on time should be performed. Replace the rollers with same specifications in case of permanent wear and tear.
- To avoid corrosion frame should be painted. The frame surface should be cleaned on daily basis. Repaint the frame after some period of time.
- Before starting the Machine it should be checkup for their lose assembly. Machine should be cleaned up before and after the operation. Conveyor belt should be also cleaned after operation to avoid frequently wears.

7. SAFETY PRACTICES
Conveyors are very helpful in moving material and supplies within a facility. However, they are a common cause of injury in a plant. We’ve compiled this list of safety practices that will help keep the workers safe.

- Don’t sit, stand, or walk on conveyors:
- Conveyors are never meant to be occupied by a person.
- Conveyors have many features, including pinch points that can catch clothing or people and cause serious injuries.
- A limb stuck in a pinch point can be severely damaged or even torn off.
- Industrial conveyors are not designed for people so you should never ride on conveyors.
- Make sure conveyor controls are operating correctly:
- Controls that don’t work properly can cause serious problems.
- Inspect your conveyor controls to make sure no employee has misused, modified, or disconnected them.
- Controls should be easy to read and use, as well as easily accessible.
- Place emergency stops in highly visible and accessible locations.
- Keep hair, clothing, jewelry, and other loose items away:
- Conveyors can catch loose clothes or long hair, resulting in severe injuries.
- Make sure long hair is tied back or tucked under a cap.
- Don’t wear bracelets, rings, watches, or other jewelry.
- Avoid wearing baggy clothing; remove ties or tuck them into your shirt.
- Check that all conveyor guards are in place:
- Don’t operate a conveyor if guards are not securely mounted.
- Conveyors contain gears, chains, belts, and other moving parts that can be hazardous if exposed.
- Employees should not be able to bypass, remove, or alter conveyor guards.
- Guard openings should be small enough to keep workers from entering danger zones.
- Be watchful of pinch points:
- Conveyors are filled with pinch points by their very nature.
- Conveyors contain gears, chains, belts, and other moving parts that can be hazardous if exposed.
Employees should not be able to bypass, remove, or alter conveyor guards.
Guard openings should be small enough to keep workers from entering danger zones.

- Alert management of any potential safety or operational concerns:
  - If you see something, say something.
  - The best way to correct an unsafe situation (e.g., loose guards, a person riding the conveyor) is to alert the person responsible for the area.
  - Make sure it is clear who the point of contact is and how to reach that person.
  - Training about safety issues and when to report them should be made available to all employees.

- Allow only authorized personnel to operate or maintain the conveyor:
  - This ensures technician safety and optimal conveyor performance.
  - Material handling equipment can be dangerous to those who do not understand how to safely work on it.
  - When something needs to be fixed, contact your trained maintenance person.
  - Only those employees who are trained to operate and perform maintenance on conveyors should do so.

8. CONCLUSION

The main components of portable conveyor machine considered in this research were conveyor belt, Drive unit (motor), chain and sprocket, bearings and base frame. The design calculations for these main components were performed. The tension in the belt was calculated to be 660 N and the breaking strength of the belt as 160 N/mm. A drive unit (motor) of 0.5hp was selected with a rotation speed of 1450 rpm and a gear ratio of 1:24. The fabricated machine is portable and can easily be transported in trucks. Also, it is cost effective having low operational cost and can recover its capital cost in short period of time. It is also concluded that the machine reduces the health and safety risk for the workers. The proposed machine is recommended for use in local market.

REFERENCES


