Design Analysis and Manufacturing of Automated Conveyor System

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***Abstract*— A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Many kinds of conveying systems are available, and are used according to the various needs of different industries. The purpose of this project is to improve the existing conveyor machine that located at the methodology lab in University Malaysia Pahang. The current design of the conveyer machine used timing belt that connected at the motor to move the shaft. The problem of the current design is the timing belt disheveled and shaft was slipping. For the improvement we use sprocket and chain as drive mechanism. Beyond the above improvement the conveyor system is expected to work. This project also helps student to utilize their engineering information and improve the skill of student in solving the mechanical problems.

***Keywords*— handling equipment,conveyor system,automation.**

1. Introduction

Conveyor is used in many industries to transport goods and materials between stages of a process. Using conveyor systems is a good way to reduce the risks of musculoskeletal injury in tasks or processes that involve manual handling, as they reduce the need for repetitive lifting and carrying. Conveyors are a powerful material handling tool.

They offer the opportunity to boost productivity, reduce product handling and damage, and minimize labor required in a manufacturing or distribution facility. All lifting and conveying machines can be divided by their operating principles into two large groups: (i)Intermittent motion, (ii) Continuous motion

Intermittent motion includes all types of cranes, lifts; surface transport means (trucks, loaders, prime movers), aerial tramways and cable ways, scrappers and the like.

Continuous motion includes conveyors, pneumatic and hydraulic transport means etc. which may generally called continuous transport machines or conveying machines.

Continuous machines are characterized by non-stop motion of bulk or unit loads along a given path, without halts for loading and unloading. At the same time they can distribute loads among a number of destination points, deliver them to stores, and transfer products from one technological operation to another and ensure the desired pace of a production process. Conveyors are classified into different categories those are as follows:

(i) chute conveyor (ii) wheel conveyor (iii) roller conveyor (iv) chain conveyor (v) slat conveyor (vi) flat belt conveyor (vii) Magnetic belt conveyor (viii) troughed belt conveyor (ix) bucket conveyor (x) vibrating conveyor (xi) screw conveyor (xii) pneumatic conveyor (xiii) cart on track conveyor (xiv) tow conveyor (xv) trolley conveyor (xvi) power and free conveyor (xvii) monorail (xviii) Sortation conveyor.

Conveyors are further classified as either Unit Load Conveyors that are designed to handle specific uniform units such as cartons or pallets, and Process Conveyors that are designed to handle loose product such as sand, gravel, coffee, cookies, etc. which are fed to machinery for further operations or mixing. It is quite common for manufacturing plants to combine both Process and Unit Load conveyors in its operations.

The aim of this paper is to develop a 3D model of a conveyor system and Analysis it. 3D model helps in exact visualization, an idea about what actually looking after implementing the system, also after complete assembly we can modify as per the need of a customer. This can be done by designing with the help of Pro/E software. A CAD system which can be used for the concept design and an appropriate CAD environment should be developed. And another purpose is to shorten the product development time.

The improved methodology for design and production of conveyor components is based on the minimization of materials, parts and costs, using the rules of design for manufacture and design for assembly.

Results obtained on a test conveyor system verify the benefits of using the improved techniques. The overall material cost was reduced by 19% and the overall assembly cost was reduced by 20% compared to conventional methods.

Different methods such as fork lifting, use of bucket elevators, conveyors systems, crane, etc. has been identified for lifting or transporting bulk materials or products from one place to another in the manufacturing industries depending on the speed of handling, height of transportation, nature, quantity, size and weight of materials to be transported. In today's fast moving, highly competitive industrial world, a company must be flexible, cost effective and efficient to survive.

Industrial automation has acquired importance owing to the ever-increasing demand for more productivity, better quality standard, better accuracy and optimum utilization of available resources and manpower. The main aspect of the project is to automate the process of transportation of the materials to the respective press machines.

2. Literature Review

Alspaugh M. A. presented latest development in belt conveyor technology & the application of traditional components in non-traditional applications requiring horizontal curves and intermediate drives have changed and expanded belt conveyor possibility. For Examples of complex conveying applications along with the numerical tools required to insure reliability and availability will be reviewed. This paper referenced Henderson PC2 which is one of the longest single flight conventional conveyors in the world at 16.2611 km. But a 19.123 km conveyor is under construction in the USA now, and a 23.52 km flight is being designed in Australia. Other conveyors 30-50 km are being discussed in other parts of the world.

A. Daniyan discusseed the design calculations and considerations of belt conveyor system for limestone using 3 rolls idlers, in terms of size, length, capacity and speed, roller diameter, power and tension, idler spacing, type of drive unit, diameter, location and arrangement of pulley, angle and axis of rotation, control mode, intended application, product to be handled as well as its maximum loading capacity in order ensure fast, continuous and efficient movement of crushed limestone while avoiding halt or fatalities during loading and unloading. The successful completion of this research work has generated design data for industrial uses in the development of an automated belt conveyor system which is fast, safe and efficient.

M. A. Alspaugh, Overland Conveyor Co., Inc (2004): This paper presents latest development in belt conveyor technology & the application of traditional components in non-traditional applications requiring horizontal curves and intermediate drives have changed and expanded belt conveyor possibilities. Examples of complex conveying applications along with the numerical tools required to insure reliability and availability will be reviewed. This paper referenced Henderson PC2 which is one of the longest single flight conventional conveyors in the world at 16.26 km. But a 19.1 km conveyor is under construction in the USA now, and a 23.5 km flight is being designed in Australia. Other conveyors 30-40 km.

Dima Nazzal, Ahmed El-Nashar Department of Industrial Engineering and management Systems, University of Central Florida.(2007) This paper discusses literature related to models of conveyor systems in semiconductor fabs. A comprehensive overview of simulation-based models is provided. We also identify and discuss specific research problems and needs in the design and control of closed-loop conveyors. It is concluded that new analytical and simulation models of conveyor systems need to be developed to understand the behaviour of such systems and bridge the gap between theoretical research and industry problems.

3. Constructional Details

Belt Dimension, Capacity and Speed

The diameter of the driver and driven pulley is determined by the type and dimension of conveyor belting. The diameter of the pulley must be designed such that it does not place under stress on the belt. The length of a belt conveyor in metres is the length from the centre of pulley parallel to belt line. Belt length is dependent on both the pulley diameters and centre distances.

$$V = d * 2\pi = 0.18*2*3.14 = 1.13 m/s$$

Where:

V = Belt speed; d = diameters of rollers; π = pi

Belt Capacity

Capacity is the product of speed and belt cross sectional area Generally, belt capacity (kg/sec) is given as:

B.C=3.6 × A× ρ×V = 3.6 * 1.532*0.09 *1.13 = 0.560 kg per sec.

Where:

A= belt sectional area (m2); ρ = material density (kg/m3); V= belt speed (m/s)

Conveyor Capacity

The mass of material Mm (live load) per metre (kg/m) loaded on a belt conveyor is given as:

Mm = C/ (3.6×V) 50 = C/ (3.6 × 1.13)*50

Where

C= Conveyor capacity (tonnes/hr); V= belt speed (m/s).

Cc= 508.5 kg/hr

Roller diameter

The relationship between the maximum belt speed, roller diameter and the relative revolution per minute is given as:

n = (1.13×60) / (d × π)

n=119.8 rpm.

Where

n = no of revolution per minute; d = roller diameter (mm); V= belt speed (m/s)

Belt basic length

Belt basic length= 2 × (length along conveying route)

= 2 * 2.2352= 4.4704 m

Belt Power and Tensions

The longer the length of the belt, the more the power required for the conveyor and the higher the vertical distance of the lift, the higher the magnitude of power required.

Power required driving the pulley

P = (C×L×3.75)/1000

P = (254.25*4.4*3.75)/1000

P=4.19 kw.

The belt of the conveyor always experience tensile load due to the rotation of the electric drive, weight of the conveyed materials and due to the idlers. The belt tension must be great enough to prevent slippage between the drive pulley and the belt.

Belt tension at steady state

Belt tension at steady state is given as:

Tss = 1.37 × μ × L × g × [2 × Mi + (2 × Mb + Mm)cos(θ)] + (H × g × Mm)

= 26.79*10^3 N.

Belt Tension while starting

During the start of the conveyor system, the tension in the belt will be much higher than the steady state.

The belt tension while starting is

Ts = Tss × Ks

= 26.79 * 1.08 = 28.93 KN.

Where

Ts= Belt tension while starting (N); Tss =Belt tension at the steady state (KN);

KS=Start up factor (1.08).

Fig: Regular conveyor system

The effective load F (N)

F = μT×g(Mm+Mb/2)+μR×g(Mb/2+Mi)

=0.03 * 9.81(2+2.5/2)+0.33* 9.81(1+1.5)

=8.09 N.

Where:

μT= Coefficient of friction with support rollers(0.033);

μR=Coefficient of friction with skid plate (.033); g =Acceleration due to gravity (9.81m/s2); Mm=Total load of conveyed materials (50 kg) Mb = Mass of belt (55.7 kg); Mi= Mass of roll idlers (50 kg)

Torsional moment

$Mt = 0.5 \times d \times (F + \mu W g)$

$= 0.5 * 0.09 (8.09 + (0.02 * 2 * 9.81))$

$= 0.19$ Nm.

Where:

d = Diameter of pulley (m); F= Effective load (N); μ = Coefficient of friction;

W = Weight of material and Belt (kg/m); g = Acceleration due to gravity (m/s2)

The cycle time of conveyor

$Ct = 2L/V$

$= 2 * 4.4/1.13$

$= 7.78$ sec.

Where,

L=Length of conveyor (m); V= Belt speed (m/sec)

Fig: Automated conveyor system using light emitting sensor

4. Expected Outcomes

When light falls on LDR, the resistance of the motor circuit is infinite and thus the current in the circuit is zero. But when some block is put between the laser and LDR then in absence of light the resistance of LDR circuit becomes zero and thus the motor starts working and the belt starts moving.

The conveyor system is successfully improvised using belt drive. The conveyor move without causing any slippage although the conveyor need a regular maintenance to avoid any casualties in the future. This project also helps student to utilize their engineering information and improve the skill of student in solving the mechanical problems.

5. Acknowledgement

Authors are thankful to Principal and members of local management committee of SCSMCOE, Nepti, Dist-Ahmednagar, Maharashtra, INDIA, for their encouragement and necessary support.

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