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CUSTOMIZATION OF A STANDARD BELT CONVYER SYSTEM.

Design and customization of available belt conveyer for Sesotec India pvt ltd.

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Abstract: The conveyor systems have proved to be an important machinery in today's industry. Conveyors are used predominantly in industries such as tourism. Food, plastics, recycling, inspections, packaging industry. The project revolves around conveyor systems for FMCG industry more specifically food items. Belt conveyors are proving to be an ace choice for FMCGs, transportation of bulk material and inspection. Integrated with a metal detector we have designed belt conveyor system according to the specified requirements for thorough quality inspections. The customer was facing difficulties in finding metallic impurities (aluminum, carbon) in packed products. Sesotec India Pvt. Ltd., a leading supplier of food grade conveyors and we students decided to design the system restricted to the customer requirements and easy to modify in the future prospects

I. INTRODUCTION

The bulk material handling system consists of numerous equipment which work in a coordinated pre-planned manner to achieve ultimate functional head. The belt conveyors are very important and prominent equipment in such system, to ensure flow of material through various parts of the system. The designer's first choice is to use belt conveyors for this purpose due to its reliability and ruggedness; except when system layout of nature of the material does not permit use of belt conveyors. The design of a belt conveyor as a whole depends upon design/construction of individual component, but the design of many individual components depends upon ultimate design construction of belt conveyor. This issue is taken care of appropriately in design procedure, and also by arranging the chapters in sequence such that designer/reader has relevant information on components prior to each stage of designing. Owing to vast development in traction systems, various types of conveyors are now used in the market to target specific application. Chain conveyors, Screw conveyor, Pneumatic conveyors, roller conveyors etc. are some major varieties seen in the industry. The project focuses on Belt type conveyor system, its design based on application requirement, modifications for better efficiency etc. Belt conveyor is a continuously moving strip of material to transport the object to different places. A belt conveyor by far is the most used conveyor system in FMCG industry due to its mechanical capacities. Smooth frictionless transfer in given time and flexibility of operation makes it the preferred choice. Sesotec India Ltd. Is a leading MNC that offers various solutions for all process stages, product types, conveyor types and for all critical control points of the production process. A conveyor is an integral part in bulk material handling system to ensure proper flow of objects at various locations i.e., production lines, testing, packaging etc. The design of a conveyor system requires proper analysis of required parameters to obtain an optimal functioning unit. This project includes the parameters for conveyor design, components of a belt conveyor, and the modifications carried out according to the customer requirements.

II. LITERATURE REVIEW

1. *Design of Material handling equipment: Belt conveyors for crushed limestone using 3 roll idlers*

Author: Adefemi O Adeodu

In process or manufacturing industry, raw materials need to be moved from one point to another. Material handling equipment such as belt conveyors facilitate easy, cheap and fast material transport and loading / unloading. These systems have nominal human interference and can be integrated with other systems. The limestone transportation takes long belt lines with a number of rollers. Proper tension can be created using three idles leading to increased economic factors. The paper is all about the idler roller usage and belt tension implementing for long length belt conveyors for transporting limestone from mines to desired location

2. *Induction Motors: Construction, Principle of Operation, Power and Torque Calculations, Characteristics and Speed Control*
Author: Fady Mansour

The induction motors are an excellent choice for continuous unidirectional operations in material handling systems. The research paper begins with decoding the constructional details for a 3 phase 4 pole AC induction motor. Conclusions are based on the speed torque curves calculated during the research and the practical experimentations.

3. *Study on Investigation of Hylam Bakelite Sheet Production and Estimating Its Mechanical Characteristic.*
Authors: Harsh S. Joshi, Dr. Kushal Bhavsar

All material has a significant behaviour when exposed to varying temperature conditions. The internal structure is definitely affected at micro scale but may result in a major effect. Traditional material transportation conveyors can be upgraded by adding bakelite sheets which also show better performance in sub 0 temperatures.

4. *Parameters on the Tensile Strength of Carcass of Textile-Rubber Reinforced Conveyor Belts*
Authors: Krzysztof Frukacz, Tsegaye Sh. Lemmi.

The go to option for mining, manufacturing and construction industries for their material transport (belt conveyors) is textile reinforced conveyor belts. The process of vulcanization has proved to significantly enhance the strength of carcass by heating at high temperatures. The belt carcass has the major contribution in imparting required impact strength to the belt.

5. *Parts Handling Systems for Machine Shops of Small and Medium Enterprises"*
Author: Vivek A. Bandebuche

The most important parameter for growth of small and medium industries is efficient material handling. The paper discusses on enhancing existing conveyor technologies to help small industries with cost reductions. Belt conveyors are the best options for the medium industries for material transportations. The easy accessibility and availability of conveyor solutions over the globe has facilitated smart solutions for cost effective conveyor options.

6. *Analysis & Prospects of Modification in Belt Conveyors*

Author: D Kumar R. Mandloi
The paper gives you a brief on the future requirements for belt conveyors when the industry is leading towards vast automation. The basic design of a standard conveyors varies from manufacturer to manufacturer but the components are same. The safety, repair, replacement, maintenance of the parts can become a hassle-free task. There is a need for proper inspection before proceeding to a modification for getting the in-hand data for upcoming issues. Just by selecting few nuts and dampers you can easily make a system more flexible. Universality is the key for standardization

III. METHODOLOGY:

Introductory visit to the company where detailed explanation of the product and company resources. Next the detailed conceptualization was done with the company guide and referral survey was conducted. Requirement from the customer were recorded and design study begun Dimension, measurement were the first major parameters to get fixed after a theoretical study. Additional calculations for the auxiliaries and prime mover were carried. Individual part design using SolidWorks (software) Industrial. Visit to the vendor to verify whether the work is at par with the actual work requirements Customization and changes which involved guidance from the company guide and existing database. Assembly of parts carried to get the desired model. Detailing and editing was carried using various software. Relevant data was obtained from web. Revision of gearbox and fixtures was made since they are the critical elements. Simulation part using software and expert guidance from the company was the final step involved.

IV. THEORY:

1. BASICS OF A BELT CONVEYOR SYSTEM:

This chapter describes the belt conveyor for conveying (handling) bulk material. A conveyor is a machine which is used to transport material from one point to another. A belt conveyor is an integral part in bulk material handling system to ensure proper flow of objects at various locations (Production lines, testing, packaging, etc.). It is necessary to have design related basic information about various component of belt conveyor before attempting to design belt conveyor. Like most of the design problem of complex equipment, the design of belt conveyor is also plagued by the contradiction whether egg first or hen first. The design of belt conveyor as a whole depends upon design / construction of individual component, but the design of many individual components depends upon ultimate design construction and primary function of belt conveyor.

2. MAIN MECHANICAL COMPONENTS IN A CONVEYOR:

The Conveyor system has set of rollers, prime mover and conveying element or belt which are the main mechanical components.

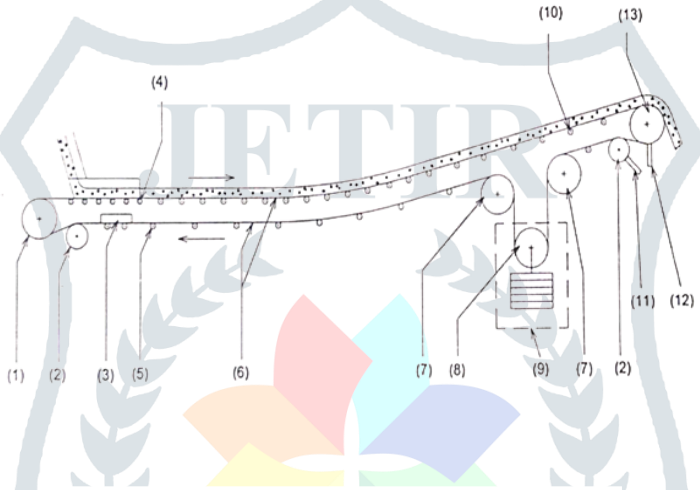


Fig: Components of a Belt Conveyor

LIST OF COMPONENTS
1: Tail roller
2: Snub roller
3: Internal belt cleaner
4: Impact idlers
5: Return idlers
6: Belt
7: Bend rollers
8: Take-up roller
9: Take-up unit
10: Carrying idlers
11: Roller cleaner
12: External belt cleaner
13: Head roller

BELT CONVEYOR FUNCTION.

The belt conveyor rear end is known as tail-end. The material is fed onto belt conveyor near tail-end The material so fed onto belt conveyor rests on upper run of belt and travels forward with the belt. The material on reaching head roller drops down automatically due to gravity and discharge velocity, while turning round the head roller. The belt conveyor forward end is known as head-end. Thus, material is conveyed from tail end to head-end in continuous manner.

3. COMPONENTS AND THEIR FUNCTIONS:

a. Belt:

The most important component of a conveyor system is the belt. Belts stands as the conveying component of the system. A typical belt is made of 2 major components viz. Carcass, belt cover. The Carcass is the internal composition of the belt sandwiched between belt covers. It is the carcass which defines the properties of the belt and application determination. The belt used for conveyors is manufactured by Vulcanization at 500-600 C.

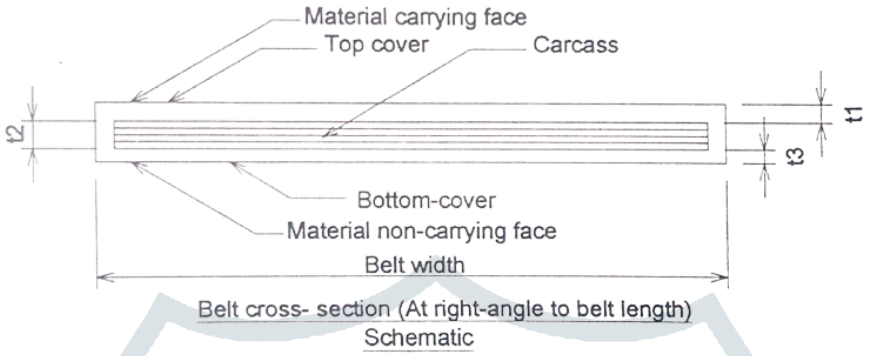


Fig: Schematic view of Belt

b. Supporting sheet for belt:

The belts require a support structure to sustain the load and maintain the required tension. Hence a support structure in accordance with belt is used. The support sheet should have low coefficient of friction and good temperature characteristics as the requirements specified by the customer shows the working environment with low temperatures (-18 to 4 ·C).



Fig: CAD model of supporting sheet.

c. Rollers:

Conveyer rollers are an integral component for material transfer. The belt is wrapped over the rollers with a proper throughability and rotation of rollers (after connecting to power source) is the primary conveying action. The material of roller which aids in smooth operation needs to be selected considering the friction and speed of rotation. Rollers are necessary in conveyor to change the direction of belt in vertical plane, and to form endless loop for continuous operation. In addition, the drive roller also transmits the motive power to belt. The rollers can be broadly categorized as

i. Drive Rollers
ii. Driven Rollers
iii. Idler Rollers.

Drive Rollers:
The rollers coupled to the prime mover are the drive rollers. These impart mechanical motion to the belt. Drive rollers are located at the end from where the product is dropped for testing also called tail end.

Driven Rollers:

These are placed at the opposite end to the drive rollers (head face). Both drive and driven rollers should have ideally same diameters.

Idlers:
These do not take direct participation in conveying action. Idler rollers have major function of maintaining sufficient belt tension. As the belt is in motion; these supports have to be in the form of rollers to avoid sliding of belt on supports. The belt movement imparts rotary-motion to rollers at matching peripheral speed, and thereby the belt moves on supporting rollers without sliding.

d. Bearings:
The rolls are fitted with antifriction bearing for connection between rotating shell and stationary spindle. The antifriction bearing could be of taper roller type or single row deep groove ball bearing type. The load acting on bearing has main component in radial direction with secondary component in axial direction (from reference 3)

e. Gearmotor:
Traditional conveyors used assembly of gear box and a motor separately procured. With the availability of gearmotors in market, the task to select the prime mover has been simplified. The motor coupled to the gearbox also called as gearmotor takes into the account "V load" (linear velocity of load), N (Speed of rotation), r (Radius of drive roller), angle of belt from horizontal.
The selection of gear motor is based on the application and the set of technical specifications required during the operation operating speed, torque, IP rating etc.). Motor torque=11.105N from calculations, speed = 152rpm, efficiency 0.7, inertia=0.002kgm^2.

f. Conveyor frame:
Conveyor frame (also known as conveyor frame work) is the structure which supports all the electrical and mechanical assemblies of the system. Since the belt conveyor system under work is log in length, it is suitable to assemble the subassemblies at the place of installation.

g. Support plates for drive and driven rollers:
The support plates act as surface between roller and other assemblies. These plates undergo vibrational stresses by the gearmotor and the compressive stresses due to other assemblies. The support plates also play in important role in easy integration, replacement and maintenance of rollers, belt, support sheet.

4. MATERIAL FOR THE COMPONENTS

a. Belt: (Flat Polyurethane Belt)
The material selected for the belt is polyurethane or PU with flat structure. The material is fit for food grade applications as it shows excellent temperature characteristics. The requirement from the customer also specified that the product to be conveyed requires friction media. These provide high impact strength, cut resistance, proper coefficient of friction, high flexibility. Flat PU belts are compatible and suitable for water cleaning.

b. Supporting sheet: (Bakelite)
Instead of normal wooden laminate sheets which may lead to wear due to friction, Bakelite sheet was selected for the sheet owing to its coefficient of friction (i.e., 0.23). Bakelite doesn't get affected by moisture, dust and outer environment. It also ensures prevention of belt slack by imparting sufficient support during metal detection.
Bakelite also has insulation to electrical currents and also doesn't intrude metal detector operation (From reference 3).

c. Rollers
The material selected for roller is stainless steel SAE 304. The selected grade is suitable for food grade applications and so was the requirement of the customer. SAE 304 is corrosion resistant which proves helpful during maintenance and cleaning operations. Stainless steel has long life and reduces the long-term costs.
For idlers, Steel C-40 (UTS 60 N/mm^2) was selected.

d. Bearings
To support smooth rotation of roller shaft, SKF 6305-2Z bearings were selected for the drive and driven rollers and SKF 7200 BEP were selected for idlers. The bearings used satisfied the customer requirements of low friction losses and selecting the available bearings.

e. Gearmotor
The gear motor selected is a coupled assembly of an AC 3 phase 4 pole induction motor and a bevel helical gearbox. The reason for selecting an AC induction motor was unidirectional operation of the system. It also facilitated easy

start stop and constant speed requirement fulfilment. The gearbox coupled is fit for customer requirements of getting a reduction ratio 1:7. The IP rating of motor is IP65.The coupling is called input or high-speed coupling. The fluid coupling which is used as high-speed coupling compensates for misalignments. (Reference1).

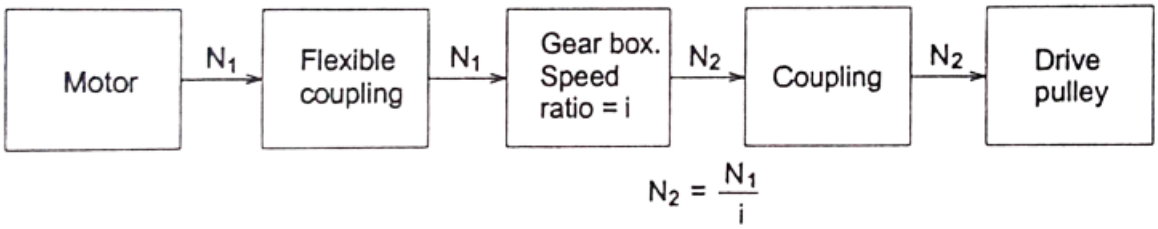


Fig: Functional arrangement of prime mover.

f. Frame

The material selected for frame is structural steel st52. The material is suitable to withstand the compressive stresses from the assembly. Frame is designed for strength and rigidity. (Reference 6)

g. Support plates for drive and driven roller:

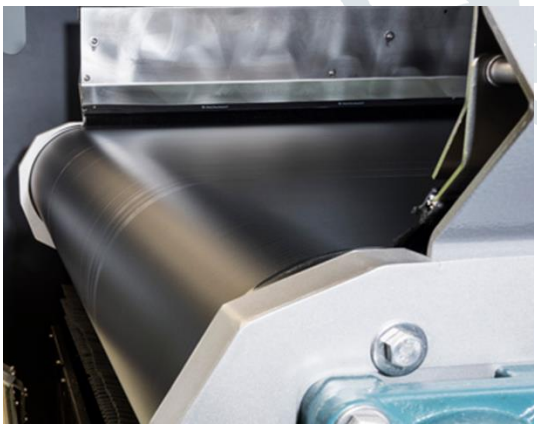
The material selected for the supporting plate is structural steel st314 owing to its vibration isolation and tensile strength.

5. DESIGN AND CUSTOMIZATIONS:

a. Customizations for Belt

The belt is manufactured using vulcanization process which involves sandwiching the carcass between two belt cover layers at 500-600. C. Customization's for the belt involves

1. ***Providing K-notch at the centre:*** Ensured firm mounting of blet on the Bakelite sheet avoiding slip. The notch is given at the center to give accurate results in discharge conditions i.e., the movement of the material on the belt remains within required range. Option to provide notches on the both sides of belt equidistant from centre was not considered as it results in increased alterations in belt structure and increased cost.



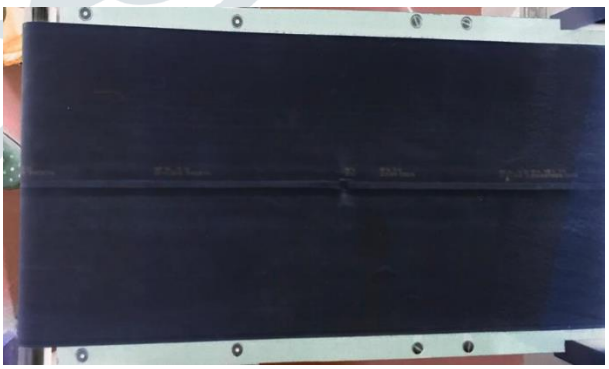
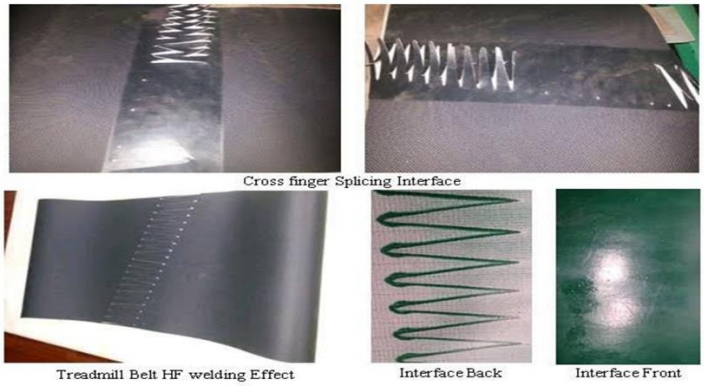


Fig a: Flat PU belt (With no notch) Fig b: Flat PU belt with K center notch.

2. ***Suggesting cross finger joining link for the belt:*** This technique of belt joining resulted in better impact strength since the belt is joined from both ends to form a circular loop. The cross finger or endless splicing resulted in reduced wear, smooth flow and throughability. (Reference 4)



3. ***Belt length and width according to customer data:*** Length = 2.2m, width= 0.3m

Calculations for impact force on the belt:

Mass of the object= 6kg.
Drop height/ height from which object falls: 0.1m
Velocity= 1.4m

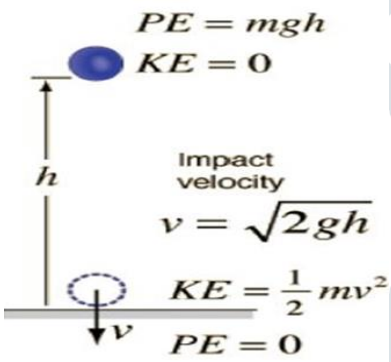


Fig: Illustration of object falling from a height on the belt.

Therefore,
Kinetic energy 0.5x m x v^2
Kinetic energy= = 0.5x (6kg) x $(1.4)^2$
Kinetic energy= 5.9J

Work done = Change in Kinetic energy= 0.5 x m x V_{final}^2- 0.5 x m x$V_{initial}^2$
As, $V_{initial}$=0
Work done= Change in Kinetic energy = 59N

Change in Kinetic energy= Average impact force x distance travelled
Average impact force (f) = Change in kinetic energy / Distance travelled
= 59/2.2

Average impact force= 27N

b. Customizations for Rollers:

1.Using stainless steel material for better life

2. Restricting number of idlers to 3 instead of 6 or 8:

The idlers play in important role but increasing the number of idlers raises the cost unnecessarily. Hence, we have optimized the system by use of 3 idler rollers with a slight increase in their diameters. (Reference 1)

3. The angle between return idlers made obtuse:

The orientation angle between the idler rollers on the driven side for a standard conveyor system is supposed to be acute or right angle. By making this angle obtuse, we got better belt tension that to for prolonged periods. This customization also reduced the belt slip and belt slack.

4. Calculation for roller diameter:

$$N = V \times 1000 \times 60 / \pi \times D$$

Where, N= No of revolutions in minute = 152rpm (motor specification)
V= belt speed (m/s)
D= diameter of roller(mm)

$$N = 0.4 \times 1000 \times 60 / \pi \times D$$

D= 50mm

c. Customizations for Frame:

1. Lower beam inclined at an angle of 45 degrees:

By inclining the lower beam at an angle of 45 degrees, the frame had better balance and stability.

2. Supporting columns added beside the existing ones:

3. By adding a sufficient number of support columns to the Bakelite sheet, it prevents the sheet from bending due to the load of products moving on top of it.

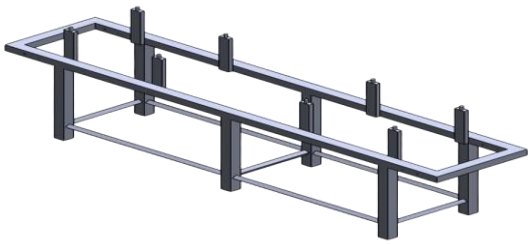


Fig: CAD model of the initial frame

V. WORKING PRINCIPLE:

The conveyor systems use a prime mover (motor) coupled to a roller which imparts motion in the form of rotation to the connected rollers and wrapped belt to move along the length of conveyor. The metal detector integrated with the belt conveyor assembly detects the minute ferrous and nonferrous impurities and alarms the operator when an impure product passes through it. The metal detector works on electromagnetic effect where the field generated by the metal detector coil gets cut by the product with its magnetic field. As the impurity in the products alters the electromagnetic field, the metal detector connected to alarm and rejection system activates thus allowing only safe and pure products to go further.

VI. DESIGN:

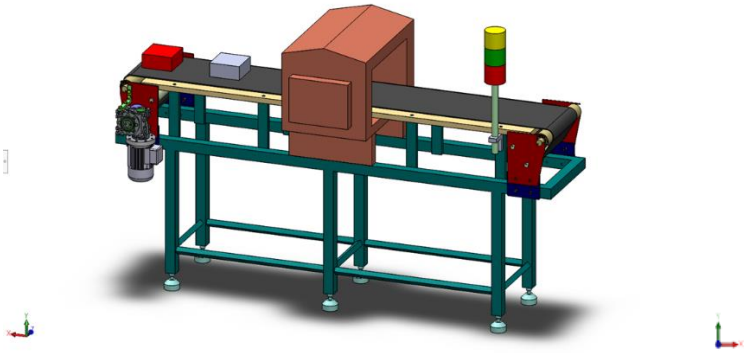


Fig: Isometric view of the Final CAD model

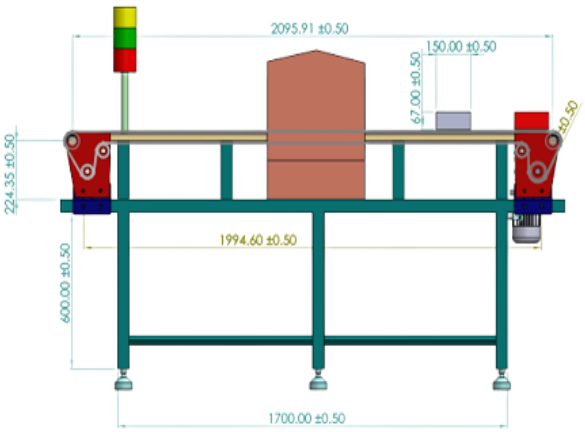


Fig: Side view of the Final CAD model with dimensions

SR No	Dimensions	Value
1.	Belt Length (ETE)	2.1m
2.	Belt width	0.3m
3.	Belt length (CTC)	2.0m
4.	Frame length	1.7m
5.	Total height from the ground	0.824m
6.	Support plate height	0.224m
7.	Thickness of support plate	4-8mm
8.	Belt thickness	6mm
9.	Damper height	9.67mm

VII. DISCUSSION ON RESULTS:

The length of the standard belt conveyor system has significantly increased to 2.195m. This added to better metal detection capacity and streamline flow of products. The material handling for required application based on prescribed requirement is made flexible for different operating conditions by suitable customizations. Sure, a rise in the cost will be observed but considering the long-term investment, this system proves to be an efficient choice. A major drawback that may come forth is increased manufacturing time. This can be reduced by assembling the subassemblies at the place of installation. The gear motor selected has a torque value of 11.105N, 152 revolutions per minute, suitable to provide a belt speed of 0.4m/s. The selection of motor definitely reduced the operating cost but consumed more area in the assembly. Proper orientation of motor can help to deal with ergonomic issues and space management. The customization in frame enhanced the stability of structure and ability to withstand the compressive stresses but is complex to manufacture. Use of advance manufacturing processes like precision welding and various joining processes can be implemented while manufacturing stage for faster production.

VIII. FUTURE SCOPE:

The standard system was highly restricted to specific operations and operating conditions. The customized system is flexible to changing operating conditions including revised prime mover and belt assembly. The changes include 1 spanner, multi bolt (M6, M8) removal strategy which specifies assembling, disassembling and maintenance by adjusting/ removing a single screw, facilitated ease of operating and new part integration. For further electronic improvements, the system can house variety of sensors at suitable locations. Existing sensors such as photoelectric sensors, retroreflective sensors, hall effects sensors, speed sensors, tachometers etc. are used for metal detection and conveyor operation. The advancements in these sensors will also be compatible to the system. This was enabled due to use of tunnel type metal detector with coil GLS 350-200 which is in house product of Sesotec. It is a highly advanced system with touch screen control system, intuitive user interface, high sensitivity. The system being inhouse reduces procurement cost and is suited to the customer requirements for detection sensitivity.

IX. CONCLUSION:

Thus, we have successfully designed a customized belt conveyor system according to the customer requirements. The system is studied by the customer using different software and experimental procedures like stress strain analysis, belt speed and product detection, belt tension ratings etc. The system is more efficient than the standard one and also offers better adaptability to the given working environment. Maintenance and integration of the designed system is easier and life of system increased significantly. Impurities in the product are detected with better accuracy hence helping to improve efficiency. Use of AC motors has reduced the operation cost and electricity can be drawn easily from the normal supply points. Rollers which are the most expensive parts are economical in the long run. The wear and tear of belt dure to friction is reduced imparting better belt life. The overall efficiency of the system is increased by keeping the cost rise to minimal. Difficulties to be faced during manufacturing are also kept under consideration and changes are made accordingly.

X. ACKNOWLEDGEMENT:

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Last but no the least, we would thank the Almighty God whose blessings are valuable in successful completion of the project.

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