Adjustable Height Belt Conveyor for Small-Scale Food Processing Unit

Rahul. K. Bhoyar, Sandeep.M. Pimpalgaonkar, Swapnil.J. Bhadang

Abstract- In Small-scale Food processing units, material handling is taken by manually due to high capital required for an advanced material handling system. These small units are looking a conveyor system which will reduce manpower, space, money, and time for production. In many materials handling equipment's, belt conveyors are popular. This paper describes a new design and development of adjustable height belt conveyorsystem which works satisfactorily to meet design point of view. It is reliable, compact, adjustable, saves working man-hours and increasing profitability of small units engaged in material handling. These transports are versatile and it tends to be adjusted by the activity and its needA legitimate structuring of the adjustable height belt conveyor will influence its productivity, working, and life expectancyOur current attempt is towards fabricating an economical adjustable belt conveyor material unloaded by adopting the existing simple design procedure.

Keywords: Adjustable height, belt conveyor, food processing, Funnel shape hopper.

I. INTRODUCTION

In a mechanical procedure, the makes item being going through different stages and it should be exchanged starting with one place then onto the next place, the raw material is transport to the machines and after that moved starting with one station then onto the next station lastly to the store or distribution center. In substantial scale enterprises, where the generation rates are high and the item to be taken care of is with the end goal that manual transportation is beyond the realm of imagination, advanced material handling system would be required. Material handling system does not contribute specifically to the item esteem, but rather it adds to the expense of the item and is subsequently some of the time is alluded to as an important shrewdness.

R.K. Bhoyar, C.C. Handa [1-2] design a conveyor system to fulfill the requirement of feeding two different raw materials to their respective processing machines, this work is going to be used by a small-scale species unit in Nagpur. Work is to be manipulate with the requirement of Single belt conveyor with adjustable to tilting angle and turning from common loading point to transfer material to different machines.A.

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***** Correspondence Author (s)
Rahul K Bhoyar, Department of Mechanical Engineering, Priyadarshini Bhagwati College of Engineering, Nagpur, Maharashtra, India,
Sandeep M Pimpalgaonkar, Department of Mechanical Engineering, Priyadarshini Bhagwati College of Engineering, Nagpur, Maharashtra, India,
Swapnil J Bhadang, Department of Mechanical Engineering, Priyadarshini Bhagwati College of Engineering, Nagpur, Maharashtra, India,

M. Guthrie, J.R. Pilcher [3] contingent upon the state of the sugar and the amounts to be taken care of, a wide range of strategies are utilized for transporting sugar in mass. It is afascination tomany applications due to the modest count of wearing parts, due to this the cost reduces; and a nonappearance of a relative improvement between the sugar and transport segments which results in insignificant item corruption.A.W. Roberts [4] concentrate on the structure necessities for the most part utilized feed conveyor involving a gravity stream container, feeder and chute. The explicit capacity of these three segments is quickly sketched out and the requirement for the container and feeder to be planned as an essential unit is focused.G. M. Mir, Sheikh Idrees and Nadeem Bashir [5] presents a portable low cost high efficient expanding pitch sort grader as an elective for the expansive mechanical grader to establish their processing unit in small space. A. MEl-Gindy. M. A Baiomy, M. M Abdelhamed, and Sahar, A Mosa [6]design, fabricate and evaluate the mechanical system of threshing and handling rice straw directly to the baler. A conveyor belt was designed to transport the rice straw from threshing machine to the baler. Choices of all heading of the mechanical framework were done concurring to the stack carrying capacity. Martin Bohner, Isabel Barfuss, Albert Heindl, Joachim Muller [7]the author focus on the incomplete drying of products belt size in belt dryers is a result of insufficient air dispersion prompting diminished throughput and high vitality necessities. To accomplish conveyor improvement, computational liquid stream recreations were directed.I. A. Daniyan *, A. O. Adeodu and O. M. Dada [8] talks about the plan estimations and contemplation of belt transport system for limestone the different parameters are to be taken care of and additionally its most extreme stacking limit all together guarantee quick, consistent and proficient development of pounded limestone while maintaining a strategic distance from an end or fatalities amid stacking and emptying. Lu Hong-Sheng [9] built up another model as per the traditional hypothesis of shells, the creator has inferred a gathering of diagnostic articulations for the removal, stretch and worries in the shells of the drive pulleys of a transport line framework. Tobias Heidrich, Aria Alimi, Leon Grothues, Jens Hesselbach, Olaf Wünsch [10] a local cooling idea for transport lines in the bundling area of chocolate generation is portrayed, completely dissected and assessed regarding its appropriateness for a utilization case. S. S. Vanamane, P.A. Mane, K. H. Inamdar [11]plan the transport framework utilized for cooling of mould, which incorporates speed, engine choice, belt determination, shaft breadth, pulley, idler separating, gear box choice, with the assistance of standard practice and these outcomes are checked with the belt computer programming software.A.

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Ramesh, P. Karunaker and L. Ramesh [12] locate belt conveyors in industries, stockyards and general transport. It helps us to move bins and the managing of large materials. Factory people often have to tour from task to challenge before contemporary automation strategies come in, but due to the conveyor system it is handy to transport.

The applicable layout of the proposed conveyor affects its productivity, operation and life expectancy.

1. *Following basic objectives are considered while selecting material handling system:*

1. Quick and accurate load collection and efficient load transfer with a scheduled time interval.
2. Transport of loads in planned quantities, without damage and precision in delivery at the destination.
3. Robotization with a negligible human component. Low introductory and operational costs. Basic and simple to maintain

2. *Basic consideration for selecting a material handling system:*

1. Direction and Length of load travel, kind of the production process and the rate of flow of material.
2. Properties and characteristics of the material being handled as well as working and climatic conditions.
3. The capacity of conveying, method of loading and unloading, Spillage of conveyed products should be avoided.
4. An Existing layout and work-space, Initial and operational costs, Height to which the load is to be carries
5. Pollution of the environment due to noise or dust by the conveying system should also be avoided.

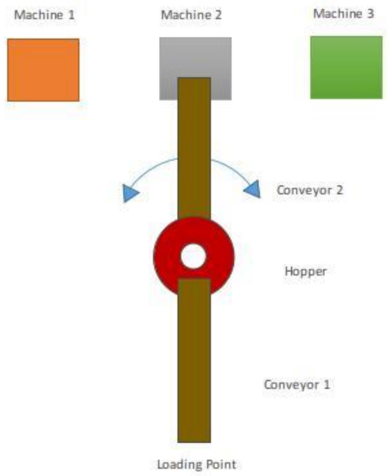

Figure 1. Position of the Hopper

Since the machines are having different height and different location as shown in Figure.1, the task is to feed the material from the same location to different hopper which is with different machines and on different height. Clear work of this work is to provide a solution to material handling as per the company requirement. And work is completed with the Support frame design which can be called dedicated to this application and feeding requirement fulfillment.

II. DESIGN PROCEDURE

The conveyor system is to be designed for the spices manufacturing industry for reducing labor and time. It also helps for increasing the output and reduces the accidents. Belt conveyor is to be designed according to the theoretical background of design and selection of belt conveyor. Components of belt conveyor are selected from the standard catalog. The Structural frame is adjusted in such a way that; it is rotated in all direction to transfer the material. Pneumatic cylinder system helps for up and down movement of a belt conveyor.

Following Data are selected for design calculation Conveyor System:

Length, Lb: 6.1 m
Width, wb: 0.0405 m
Slant angle, α:15°
Item: Food grain
load weight, W: 181.4 kg
Speed, s: 18.3 m/min

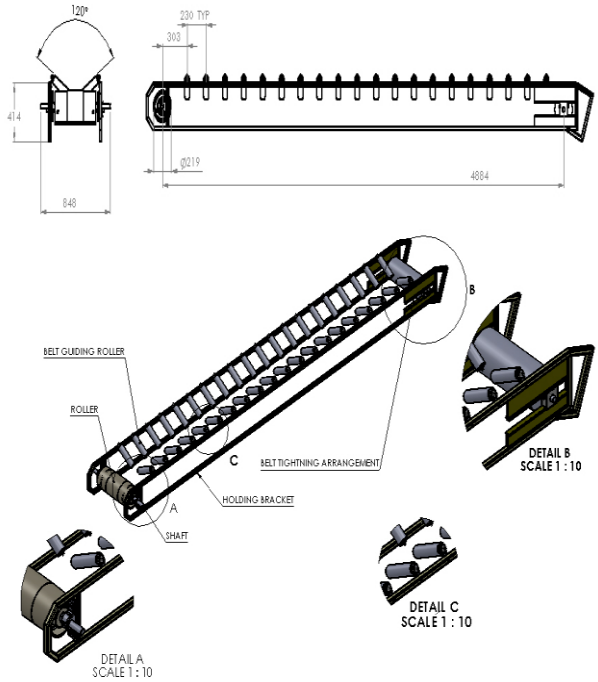

Figure 2. Different View of conveyor system

A. Design Calculation

Following are the steps are used to design conveyor belt
1.Design for Belt selection
2. Design for Pulley and drive
3.Design for Frame and Support

1. Design for Belt selection

Parameter for Belt design:

Thickness, t: 1.5 mm
Belt mass, m: 2.1 kg/m²
Pulley diameter: 200 mm
Tensile force, k1%: 7 N/mm
Max. tensile force, Tm: 11 N/mm
Friction coefficient on driving pulley, fp: 0.15
Friction coefficient on slider bed, fb: 0.2

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Geometry of the driving pulley:

Pulley diameter dp:200 mm
Pulley width, wp: 457.2 mm
Belt wrapping point, θ: 180°
time to accelerate, ta = 3 sec.

Operation forces and torque:

Pulley speed,

$$\omega = \frac{12\,s}{30\,dp} \quad (1)$$
$$= 6.0 \text{ rad/sec}$$

Pulley acceleration,

$$a = \frac{w}{ta} \quad (2)$$
$$= 2.0 \text{ rad/s}^2$$

Pulley weight,

$$Wp = \frac{\pi\, dp2wp}{4} \quad (3)$$
$$= 29.0 \text{ kg per pulley}$$

Pulleys mass inertia,

$$Jp = 2x\frac{Wp\, dp2}{8} \quad (4)$$
$$= 0.075 \text{ kg-m}^2$$

Belt weight,

$$Wb = \frac{m\;\; wb\,(24\,Lb + \pi\, dp)}{144} \quad (5)$$
$$= 9.68 \text{ kg}$$

Belt mass inertia,

$$Jb = \frac{Wb\, dp2}{4} \quad (6)$$
$$= 0.026 \text{ kg-m}^2$$

Load mass inertia,

$$J = \frac{Wdp2}{4} \quad (7)$$
$$= 0.468 \text{ kg-m}^2$$

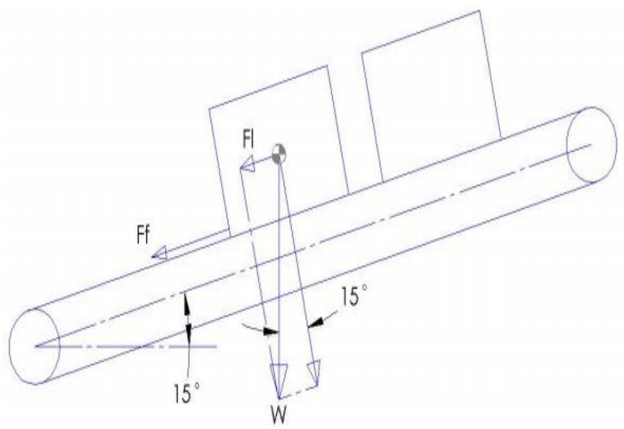
Total mass inertia,

$$Jt = Jp + Jb + J \quad (8)$$
$$= 0.568 \text{ kg-m}^2$$

Acceleration torque,

$$Ta = \frac{Jt\, a}{386} \quad (9)$$

Ta= Jt
a = 1.136 N-m



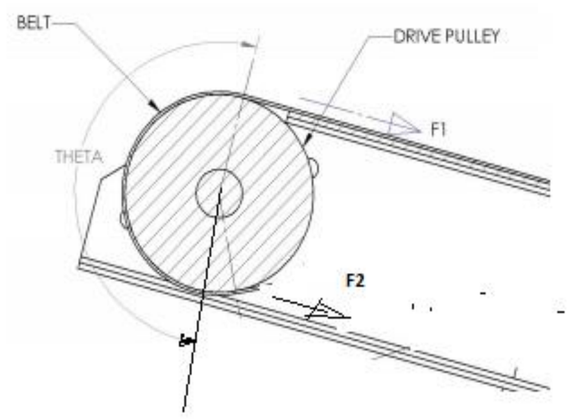


Figure 3. Section view of Pulley Drive

Friction force between belt and slider bed,

$$Ff = \left(W + \frac{12\, m\, Lb\, wb}{144}\right) fb\, \cos(\alpha) \quad (10)$$
$$= \mathbf{353\ N}$$

Friction torque,

$$Tf = \frac{Ff\, dp}{2} \quad (11)$$
$$= \mathbf{17.9\ N\text{-}m}$$

Lifting force,

$$Fl = W \sin(\alpha) \quad (12)$$
$$= \mathbf{460.7\ N}$$

Lifting torque,

$$Tl = \frac{F1\, dp}{2} \quad (13)$$
$$= \mathbf{23.4\ N\text{-}m}$$

Total torque,

$$Tt = Ta + Tf + Tl \quad (14)$$
$$= \mathbf{42.6\ N\text{-}m}$$

Power,

$$P = \frac{Tt\, \omega}{6600} \quad (15)$$
$$= \mathbf{0.343\ HP}$$

$$P = Tt\, \omega = \mathbf{256\ Watts}$$

Belt tension and stress

Tension (carrier side)

$$F1 = \frac{Tt/\,(dp/\,2)}{1 - 1/(2.718\,(fp\,\theta))} \quad (16)$$
$$= \mathbf{2221\ N}$$

Tension (return side)

$$F2 = \frac{F1}{2.718\, fp\, \theta} \quad (17)$$
$$= \mathbf{1386\ N}$$

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Belt stress,

$$\sigma b = \frac{F1}{Lb} \quad (18)$$

= 5.46 N/mm

Belt safety factor,

$$SF_b = \frac{Tm}{\sigma b} \quad (19)$$

= 2.02

Selected belt is adequate.

2. Design for Pulley and drive

Pulley design

Round and hollow tapered shape pulley is to be used to help belt following and envision overflow. The geometry is resolved from experience and is every so often given by belt makers. For our framework, the taking after pulley is used for the drive end and the loafer conclusion.

UNS G43400 material is utilized for pulley with surface complete 1.6 µm.

Pulley deflection under high load Section inertia,

$$Ip = \frac{\pi\,(dp4 - di4)}{64} \quad (20)$$

= 5.211 x 10-6 m⁴

Deflection,

$$Y = \frac{5\,(F1 + F2)\,wp3}{384 \times 29000000\,Ip} \quad (21)$$

= 0.004 mm

The high deflection is littler than the slant tallness within the cone shaped parcel of the pulley and also able to track the belt.

Gear motor torque,

$$Fm = \frac{2\,Tt}{Ds} \quad (22)$$

= 839 N

Sprocket pitch diameter, Ds= 3.990 in (101 mm)

Along the transport hub:

$$Fx = Fm \cos(17°) \quad (23)$$

= 801 N

Distributed belt force,

$$Q = \frac{F1 + F2}{C} \quad (24)$$

= 8.35 N/mm

Bearing reaction,

$$R2 = Fx + Q\,C - R1 \quad (25)$$

= 1718 N

$$M1x = -Fx\,A \quad (26)$$

= -44.3 N-m

$$Fy = Fm \sin(17°) \quad (27)$$

= 183 N

$$M1y = -Fy\,A \quad (28)$$

= -13.5 N-m

Bending torque,

$$M1 = (M1x^2 + M1y^2) \quad (29)$$

= 46.2 N-m

Calculation for driving shaft

Following parameter are considering for design shaft:

Material: UNS G10450
Tensile yield strength, Sy = 405 MPa
Ultimate strength, Su = 675 MPa
Endurance strength Se = 151 MPa
Shaft safety factor, SFd = 2.1

shaft diameter

$$dm = \left\{\frac{32\,SFd}{\pi} \times \left(\left(\frac{Tt}{Sy}\right)^2 + \left(\frac{M1}{Se}\right)^2\right)0.5\right\}^{0.33} \quad (30)$$

= 19.05 mm

Gear motor is used with following specification:

Integrated worm gear reducer
Gear ratio= 22:1
Power= 0.5 Hp
Torque= 38.5N-m
service factor = 1.9

Step 3: Frame and Support Design

This stand /weldment structure carries all the loading parameters of conveyor which helps to hold the whole mechanism and conveyor at loading point shown in figure 4 and figure 5.

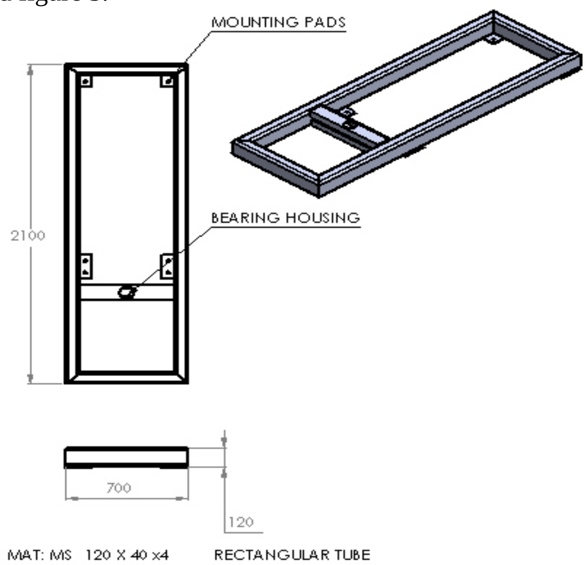

Figure 4. Structural Frame Design

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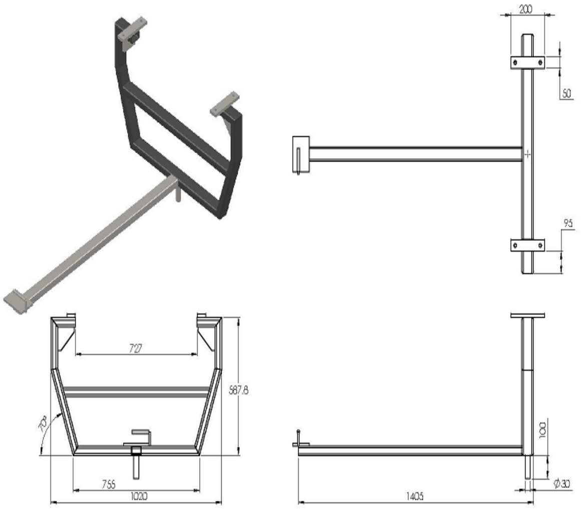

Figure 5. Support frame Design

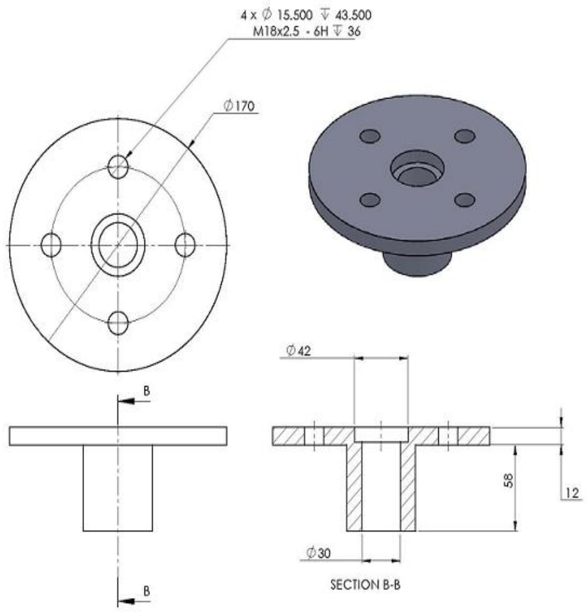

Figure 6. Bearing Housing

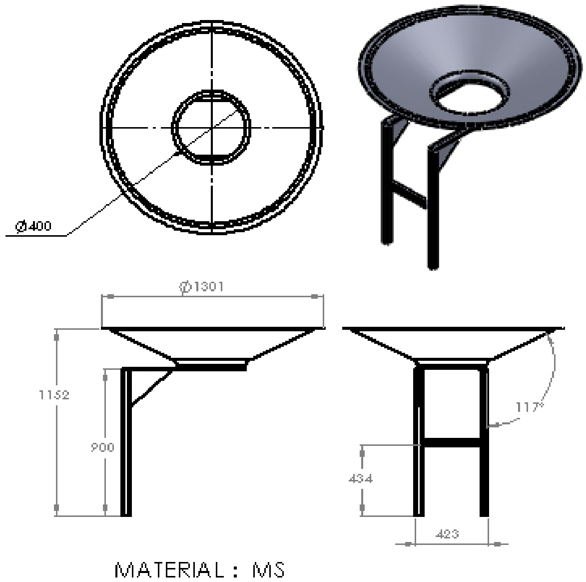

Figure 7. Hopper Diagram

Vertical bearing mounting housing is fixed on the platform made of stand, the whole mechanism rest on mounting pad.asshown in figure 6. This housing enables the rotating, turning system of the conveyor along with support frame.Funnel shape hopperis designed in such a way that itis fixed between the end of two conveyor belt system and also avoid the wastage of material as shown in figure 7. The crude material from horizontal conveyor belt drop within the middle on the funnel shape hopper and then from the hopper fall on the inclined conveyor belt.

III. ASSEMBLY AND MOUNTING

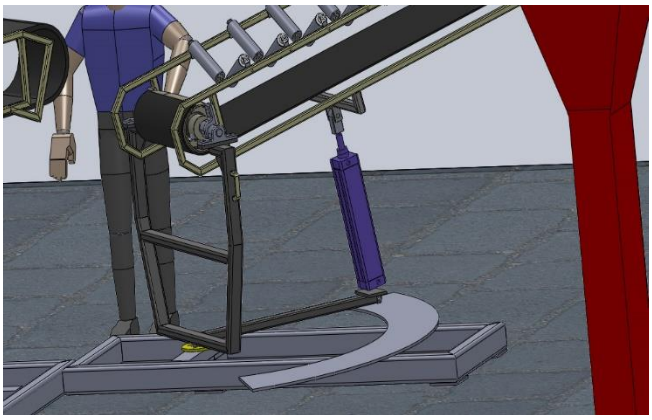

Figure 8. Caster wheel arrangement in Support frame

Bottom stand is fixed in the floor with the help of nut and bolt.it need a strong concrete base for sustain the vibration and the forces which create during the running of a belt conveyor. It is low weighted, but sustain all types of load. Bearing housing is fixed on the base stand in which bearing is fixed to provide radial movement of the Support frame on which belt conveyor is mounted. A Pneumatic cylinder is used to move up and down of conveyor belt for transferring the material into the hopper. A funnel shape rounded track is fixed with Support frame on the bottom stand. A caster wheel is attached at the bottom of the supported rectangular frame which is attached with the conveyor belt. When the belt is required to move in radial direction then the caster wheel is moving on the funnel shapetrack as shown in figure 8.

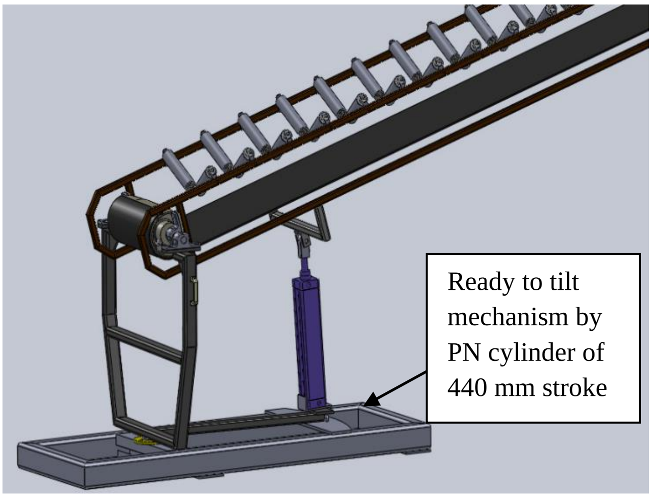

Figure 9. Pneumatic cylinder-bracket Assembly

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Pneumatic cylinder-bracket and Conveyor are assembled on the bottom stand as shown in figure 8. Double acting type pneumatic cylinder is used of 440mm stroke, which gives the up and down movement of conveyor belt. It is also move radially.

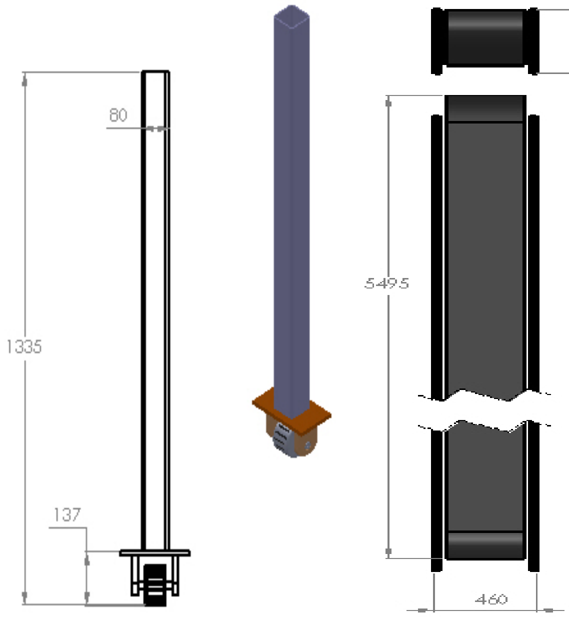

Figure 10. Vertical stand Arrangement

A vertical stand made of steel is attached with the belt conveyor for supporting the first part of conveyor belt system and also provided wheel on the base for move in all direction for loading the raw material which is stock in any direction and transfer to second belt conveyor system as shown in figure 10. Two vertical stands with wheel are sufficient to sustain the load. A lock system is attached with the wheel to lock the movement of wheel when the belt is in running. The lock is easily applied by using small force of human leg. It is also easily unlocking also.

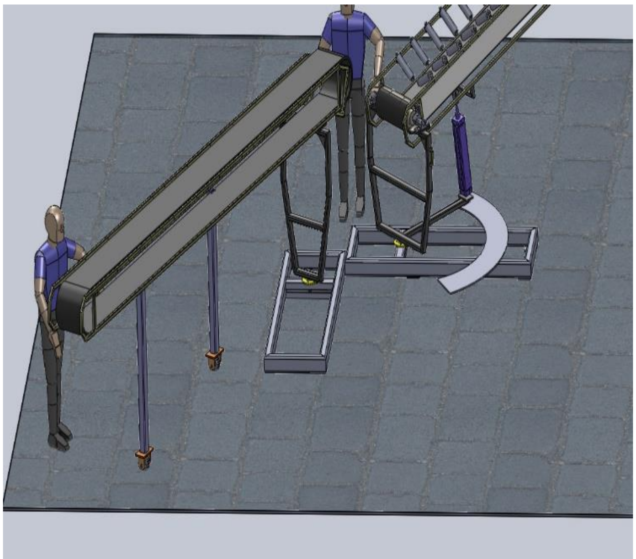

Figure 11. Assembly of two conveyor system

Figure 11 shows the assembling of two conveyor belt of different operation in which one belt conveyor transfer material horizontally while other unkindly. Both are attached pivot type joint. One belt conveyor consists of Support frame, verticalstand with wheel and bottom stand, while other consists of Pneumatic cylinder-bracket and bottom stand. Both bottom stand is arranged in L-shaped. Funnel shape hopper is attached in between them.

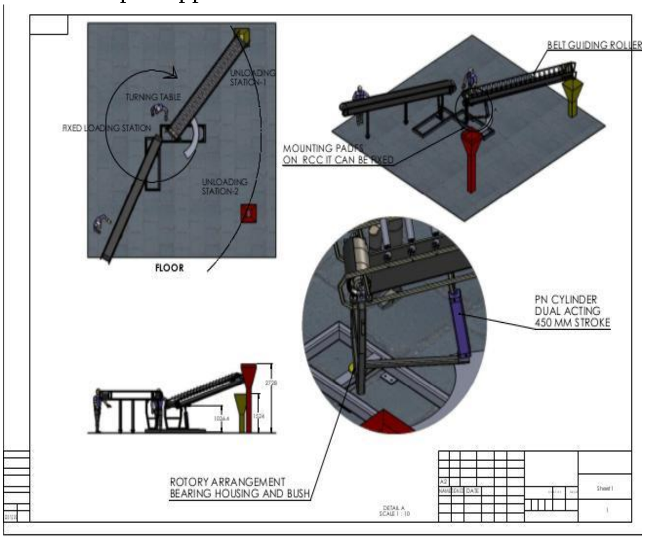

Figure 12. 3-Dimensional view of Belt conveyor system

IV. OPERATIVE PROCEDURE

Figure 12. shows the belt conveyor system consisting of a horizontal and inclined conveyor system, Support frame, pneumatic cylinder, foot stand and funnel shape hopper. The raw material is supplied to loading point froma yard or warehouse. At the loading point labour manually feed the raw material on the horizontal conveyer. This belt transport the raw materialupto the funnel shape hopper and drop in middle portion of the hopper due to this the material fall on the inclined belt conveyor without spillage anywhere. The inclined belt conveyor transport material to the ultimate destination and fall on the hopper of crushing machine All crushing hopper are of various stature, conveying system accomplished the stature with the assistance of pneumatic system. Due to the bearing support at the bottom of frame the inclined belt rotates upto 180^0 rotation, the top portion of the inclined belt conveyor system rotates because of the vertical stand with caster wheel arrangement. The locking system is provided to the caster wheel to control throughout running condition. The whole system is run with the assistance of drive unit consists of gear motor and speed controlling unit. The crushing hopper of all the machines having totally different height in order that the peak of inclined belt conveyor is adjusted by pneumatic system. These system is intended to transfer every kind or raw material utilized in species industries due to its light weight.

V. ANALYSIS

The conveyor belt design methods were made on beat of Computer aided draftingmethod and master tools. These approaches were primarily concerned with design arrangement and there was small investigation on the parts of the conveyor system.

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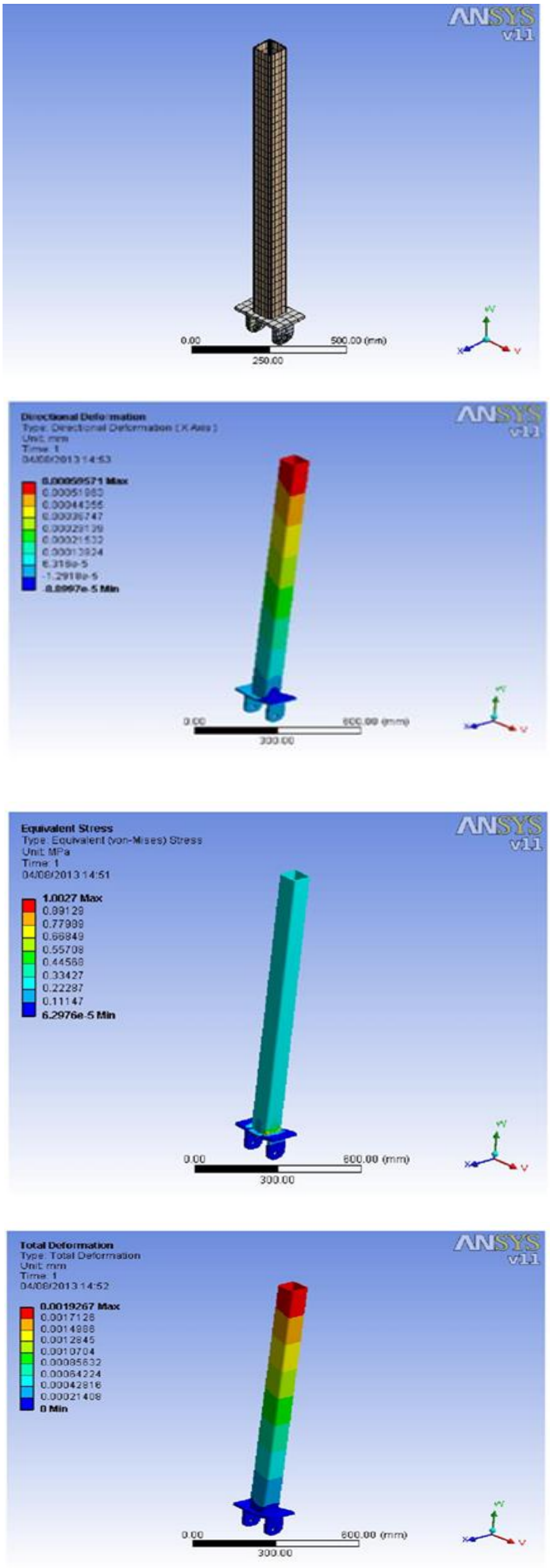
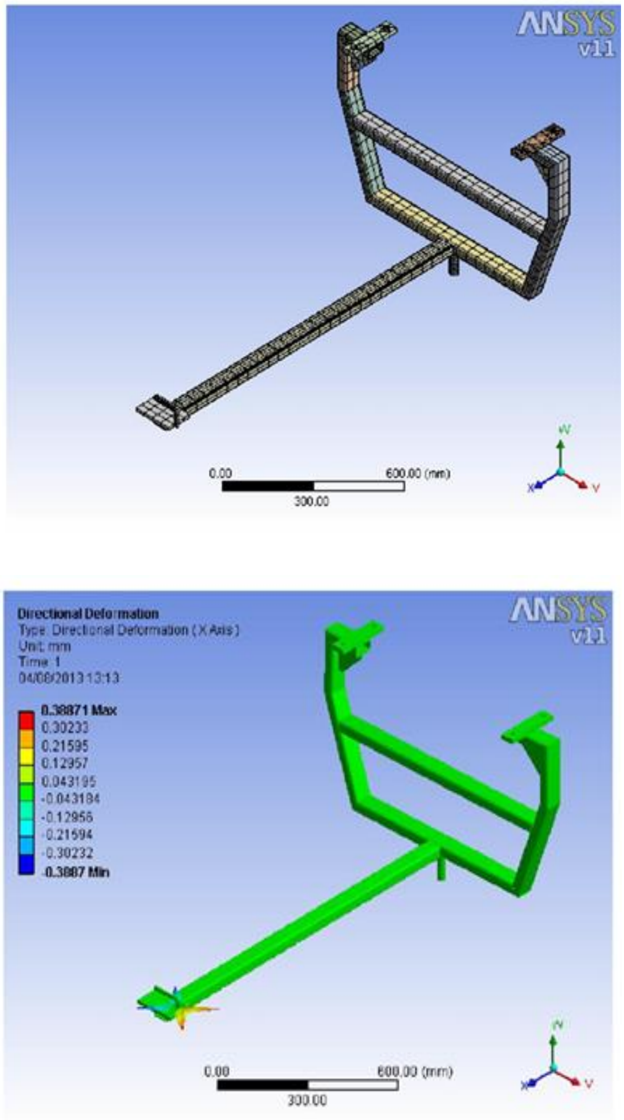


Figure 13. (a)Meshing of vertical stand, (b) Directional Deformation, (c) Total Deformation, (d) Equivalent stress

Sometime recently examination of vertical stand of conveyor belt system, it is having to be meshing of all the portion of vertical stand as appeared in Figure 13(a). After meshing process, the analysis is continuing on standin software package and the solutions is gotten on directional deformation, total deformation and equivalent str esses. The most commonly used method in analyzing vertical stand deformation and the forces is the finite element method. "Ansys-V11" software is used to analysis the vertical stand. Figure 13(b)appears that the high deformation is 0.059 mmand directional deformation is -8.9e-5 mm to 0.059mm. Figure 13(c) appears the total deformation created within the vertical stand and it observe that the distortion stresses is 0.019 mm. The total deformation stresses are 0 mm to 0.019 mm. Figure 13(d) appears the equivalent stress created within the vertical stand. It is observing that the greatest proportionate stretch stressis 1 Mpa. The stresses of comparable push are 6.2e-5 Mpa to1 Mpa.



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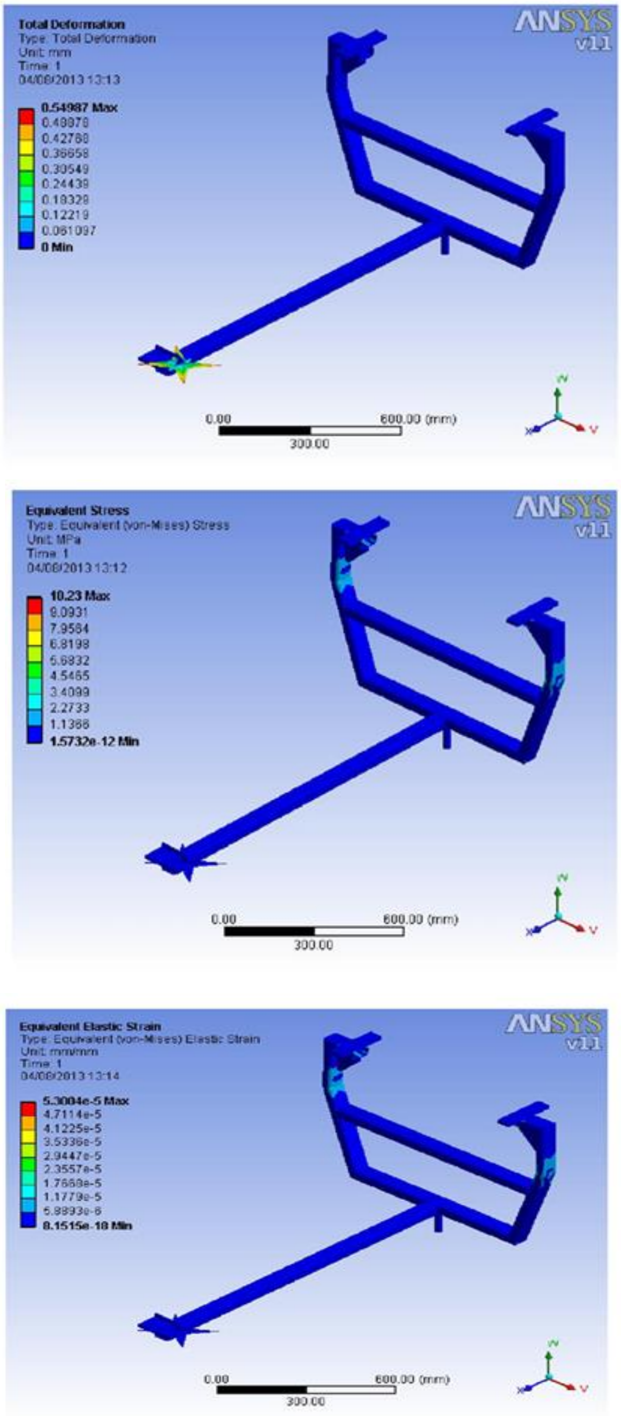

Figure 14(a) Meshing of Support frame, (b) Directional Deformation, (c)Total Deformation, (d) Equivalent stress, (e) Equivalent Elastic Strain

Sometime recently examination of Support frame of conveyor system, it is having to be meshing of all the portion of Support frame's appeared in in Figure 14(a). After meshing process, the analysis is continuing on Support frame in software package and the solution is gotten on equivalent elastic strain, total deformation, directional deformation and equivalent stresses. Once more due to complexity of strengths interaction Support frame deformation can be qualities to a combination of variables. Within the show investigation, it is expecting that Support frame distortion is generally due to the high strengths. The foremost commonly utilized strategy in analyzing Support frame deformation and the forces are the finite element method. Figure 14(b)appears the directional deformation and it is observing that the most extreme deformation stress is 0.39 mm and directional deformation is -0.39 mm to 0.39 mm. Figure 14(c) appears the full deformation created and it is observing that the greatest distortion stress is 0.53 mmand distortion stress 0mm to 0.53 mm. Figure 14(d) appears the equivalent stress and it is observing that the equivalent stress is 10.23 Mpa. The equivalent stress is 1.57 Mpa to 10.23 Mpa. Figure 14(e) appears the equivalent elastic strain and it is observing that the high equivalent elastic strain esteem is 5.30e-5 mm/mm. The esteem of equivalent stress developed ranges from 8.15e-10 mm/mm to 5.30e-5 mm/mm.

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AUTHOR PROFILE

Rahul.K. Bhoyar passed Bachelor of Engineering in Mechanical Engineering and Master of Technology in Mechanical Engineering Design from Rashtrasanta Tukdoji Maharaj University, Nagpur, Maharashtra, India. Pursuing Ph.D. in Mechanical Engineering from Sarvepalli Radhakrishnan University, Bhopal, India. Currently working as Assistant Professor in Mechanical Engineering Department, Priyadarshini Bhagwati College of Engineering, Nagpur, India. Published 12 articles in national and international journals. Author having Professional Membership like ISTE, IAENG, ISRAD, IRED, HKSME.The areas of interest include composite materials, agriculture waste, machine design, engineering graphics and drafting.

Sandeep M. Pimpalgaonkarpassed Bachelor of Engineering in Industrial Engineering and Master of Technology in Industrial Engineering from Rashtrasanta Tukdoji Maharaj University, Nagpur, Maharashtra, India. Pursuing Ph.D. in Mechanical Engineering from Sant Gadge Baba Amravati University, Amravati, India. Currently working as Assistant Professor and Head in Mechanical Engineering Department, Priyadarshini Bhagwati College of Engineering, Nagpur, India. Published 09 articles in national and international journals.Author having Professional Membership like ISTE. The areas of interest include operation research production design.

Swapnil J. Bhadang passed Bachelor of Engineering in Mechanical Engineering and Master of Technology in Heat Power Engineering from Rashtrasanta Tukdoji Maharaj University, Nagpur, Maharashtra, India. Pursuing Ph.D. in Mechanical Engineering from Sarvepalli Radhakrishnan University, Bhopal, India. Currently working as Assistant Professor in Mechanical Engineering Department, Priyadarshini Bhagwati College of Engineering, Nagpur, India. Published 07 articles in national and international journals The areas of interest include composite materials, agriculture waste, renewable energy, engineering design.

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