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Design of material transfer automation in shearing machine

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Abstract. Automation design of material transfer on the shearing machine is the process of designing a series of tools or machines with a single system to facilitate the process of transfer of the initial material to come separately one by one into the table of the shearing machine. Tools are designed to run automatically for the purpose of work efficiency.In the design process required various calculations at each stage of the system group.This is done to avoid the failure of a design whether it is major or minor. The design starts from the forklift comes laying the material along with the pallet on the conveyor waiting, then the material along with the pallet walks into the first stage conveyor. At this stage there is a hydraulic component that is designed to have its tip roller and tilt angle, so when the hydraulic working material will be separated by the pallet and slid down into the second stage conveyor.In the second stage conveyor,the material stack will be stopped by the stopper, the stack of materials will be separated one by one to the third stage of the conveyor connected to the set of tables.Separation is done by claws that are moved by a ball screw. Components of the claws and stopper can go up and down following the thickness of the sheet material. After the sheet is released from the third stage conveyor, there will be an arm with a pneumatic-driven tip clamp and ball screw to push it to the machine table and pull on the remaining cutting process.At the end cutting the arm will push the final sheet through the engine blade.The design of material transfer automation on the shearing machine is still in the early stages of research in the field of material transfer. Result before designing are , the diameter of shaft of the buffer for safety factor is 20 mm, Hydraulic tilt is formed by angle $\boldsymbol{\alpha = 5,85^0}$,Designing four hydraulics with 2-inch piston diameter, it is necessary to prepare a power pack to support the hydraulic system of at least 36 bar.

1. Introduction

Material transfer automation shearing machine is a machine to facilitate the transfer of sheet metal material from conveyor to shearing machine automatically [1].Technological developments drive industrial activity to run automatically for the purpose of work efficiency [2].With the ongoing of a system on a continuous course facilitate centralized quality control or in some areas only. Design objectives such as knowing the process of cutting the shearing machine from the arrival of the material to cut into sheet with the desired dimensions,changing workmanship on manually operated shearing machine areas to automation, increasing production effectiveness. In the design is done a limitation of the problem that the dimensions of the system designed to be in accordance with the dimensions of material sheets and layout of existing plants in the area of shearing, load resistance with the framework and the system designed should be able to withstand the weight of the material pile ie about 3 to 4 tons. The drive system ie the system must be able to separate the pile of material with the palette,and separate the material sheet from the pile and move it to the next stage without any defects. The weight per sheet of material is about 30 kg with a thickness of 2.5 to 3.2 mm, electrical systems using servo motors and ordinary motors differ depending on the type of movement,ie 1 servo motor in conveyor stage one, 2 servo motor in conveyor stage 2,1 ordinary motor for conveyor stage 3, one servo motor on the horizontal movement of the arm of the table,control system ie the whole system is controlled by PLC.

2. Research Methodology

In general, the design has five stages of the process,ie from conveyor wait,conveyor stage one,conveyor phase two, conveyor stage three, until the transfer table. Here is an overview of the system.

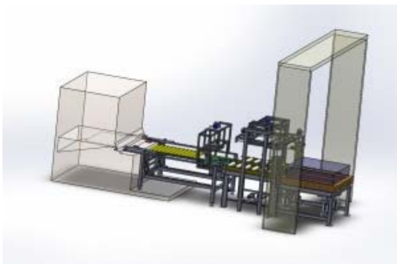

Figure 1. Design of material transfer automation on the shearing machine.

Based on the calculation added security figures, used type automated guided vehicles (AGV) 75x40 as a support. But the calculation assumes a load in the direction of the profile, without taking into account the length, width, and height of skeletal dimensions.

The concept of how the system works from the arrival of the material pile with the pallet transported by the forklift to be separated one by one until it enters on the shearing machine for the cutting process. Conveyor Wait is a process of pile material with clustered material pile weighs about 3 tons. The required calculation is the calculation of load resistance on the frame, calculation of load resistance on the pallet pad roller,calculation of load resistance on roller launching pad on hydraulic,calculation of hydraulic thrust strength, calculation of the angle of the hydraulic system. The second process is the second conveyor is the material entering from the conveyor stage one and separated one by one against the pile.When the movement ceases, there is a smart sensor going down to detect the surface of the material as the zero point of the step movement. Then the pneumatic cylinder is specially designed to pry the material.so that the top sheet material will form a gap angle to the other end. The claws will enter into the gap and move horizontally to push the sheet to the third stage conveyor.driven from the second stage conveyor will be forwarded conveyor that can go up and down adjusting the height of the sheeting material. When the sheet is already on the three conveyors entirely, the conveyor will move down self-leveling against the transfer table.

3. Results and discussion

The required calculation is the motor power to drive the ball screw dimension conveyor calculation as the up and down movement of the conveyor, power motors to drive ball screw, as well as frame calculations to support the movement system. On the machine there is transfer table where the separate sheet will be driven by a specially designed arm there is a pneumatic clamp on the end of the arm. The arm will clamp the sheet of material and move horizontally push the sheet into the shearing machine table to cut. The arm can also clamp the material to pull back the sheet when the last cutting. Then it will push again for final cutting, and move again faster to push and free the sheet clamps so that the inlet sheet is wasted into the shearing machine table.

Before doing the design done basic calculations like motor power with equations M_t= 9550x $\frac{\boldsymbol{P}}{\boldsymbol{n}}$ with P is power (KW), M_t *is* twisted moment. (Nm), $\boldsymbol{n}$ is (rpm). Press voltage with the required frame dimension calculation based on the limit value of the compressive stress in order to support the supported load using the equation $\boldsymbol{\sigma_d} = \frac{\boldsymbol{F}}{\boldsymbol{A}}$ with F_N is force, A is space area. Shear Voltage is a calculation of the dimensions of an outer force that weighs a component with a force located parallel to the surface of the component will give rise to a shear stress with the equation. $\boldsymbol{\tau_a} = \frac{\boldsymbol{F}}{\boldsymbol{A}}$ with F is force of tangential. Crooked Voltage with the following equation is used when the dimension calculation is an outer force which overloads a component, which is perpendicular to the axis and will cause a bent or curved voltage such as $\boldsymbol{\sigma_b} = \frac{\boldsymbol{M_b}}{\boldsymbol{W_x}}$. , $\boldsymbol{M_b = F\,.\; l}$,$\boldsymbol{W_x} = \frac{\boldsymbol{\pi D^3}}{\boldsymbol{32}}$. Moment of Resistance Axial Dimension of solid Cylinders is $\boldsymbol{W_x} = \frac{\boldsymbol{\pi}}{\boldsymbol{32}} \cdot \frac{\boldsymbol{(D^4 - d^4)}}{\boldsymbol{D}}$.The following equations are used at the time of calculation of Torsion Voltage or dimension there is an outer force which weighs a component, which is perpendicular to the axis and is distant from the axis will cause torsion or torque, ie: $\boldsymbol{\tau_t}$

all types of rolling bearings, except for self-rolling roller bearings - axial, the following formula applies P = x . F_r + y . F_a with Fr = radial load (N), Fa = axial load (N), x = dynamic radial factor, y = dynamic axial factor. Using rolling bearing is on the front wheel, rear, and steering wheel. Calculation of rolling pads is always leading to the calculation of service life.
The skeletal dimension is 1500 x 1500 x 800 mm by having 4 poles as the legs, it can be deduced that the weight point is in the center of the frame.It also affects the twisted moment experienced by the skeletal legs.Slope Calculations Hydraulics with four hydraulic systems will push vertically with different heights and form an angle between the two rear ends against the two front ends.The desired slide with acceleration of 1 m/s^2 can be calculated as follows,

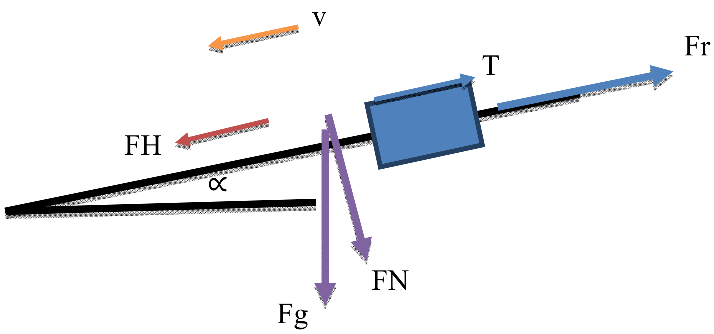

Figure 2.Gravity glide forceconveyor stage one

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The friction coefficient is ignored because the runway uses a cylinder roller to facilitate the material pile to slide down.. $\sum Fx = 0 Fr + T - F_H = 0 m\,.\,g\,.\cos\alpha\,.\,\mu_0 + m\,.\,a - m\,.\,g\,.\,sin\,\alpha = 0 \sin\alpha = \frac{m\,.a}{m\,.g} \sin\alpha = \frac{1}{9{,}81} \alpha = sin^{-1}\left(\frac{1}{9{,}81}\right) \boldsymbol{\alpha = 5{,}85^0}$

Roller as a launching pad is also taken into account the diameter of buffer so as not to experience the fatigue when crooked run. Pallet as a stack material with dimensions of 1200 x 1200, for 1 palette resulted there are 4 rollers on the right and 4 on the left.The load of 1 pallets with piles is about 3 tons. The roller dimension is calculated based on the following curved limits; $\boldsymbol{\sigma_b = \frac{M_b}{W_x}}$; $M_b = F\,.\,l$; $W_x = \frac{\pi D^3}{32}$.

So σ_b (bent voltage permission) = 800 $N/_{mm^2}$, the length of the roller shaft is300 mm :

$M_b = F\,.\,l$= 0,125 . 3000 . 9,81 . 150 (N).(mm)= 551812,5 Nmm

$W_x = \frac{M_b}{\sigma_b} = \frac{551512{,}5}{800} = 689{,}76\ mm^3 = \frac{\pi D^3}{32} D \Rightarrow \sqrt[3]{\frac{W_x\,.\,32}{\pi}} = \sqrt[3]{\frac{689{,}76\,.\,32}{\pi}}$ $= \boldsymbol{19{,}15\ mm.}$ From the calculation result, the diameter is rounded up for safety factor, so the diameter of shaft of the buffer is 20 mm.

In the conveyor also installed four hydraulic systems as a booster up the pile of material to slide into the second conveyor. It should be taken into account the hydraulic piston force to support the system. The surface pressure in the material pile is equal to or less than the pressure produced by the four hydraulics. If the selection of dimensions of piston is 2" or equivalent to 50,8 mm = 0,0508 m. With equation the pressure$P = \frac{F}{A} = \frac{3000\,.\,9{,}81}{4\,.\,0{,}25\,\pi\,0{,}0508^2} = 3630052{,}99\ N/_{m^2} = \boldsymbol{36\ bar.}$ So with the election of four hydraulics with a diameter of 2-inch piston, it is necessary to prepare a power pack to support the hydraulic system of at least 36 bar.

In the second stage conveyor, the material pile will come from the first stage of the conveyor and will experience braking. The roller as its base is connected to the motor below to slow the slide rate so that the right roller stops when touching the stopper at the end of the second stage conveyor. It is intended that the load received by the stopper is not so great likes figure 3.

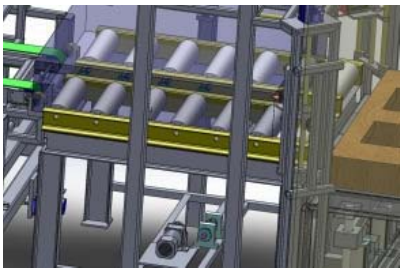

Figure 3. The design of the second stage conveyor as a deceleration.

In the second stage conveyor required calculation of motor power to slow down the slide rate.It is assumed that the displacement distance is equal to the distance to stop or to say that$s_1 = s_2$,we can calculations with g = 9,81 $m/_{s^2}$, a = 1 $m/_{s^2}$, The friction coefficient is ignored because the runway uses a cylinder roller to facilitate the material pile to slide down.

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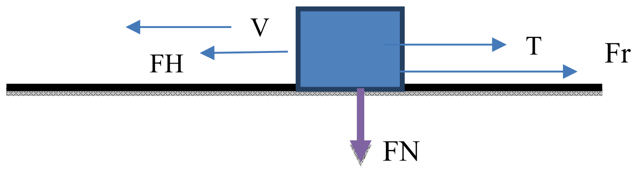

Figure 4. Deceleration force (T) conveyor stage two.

$$\sum Fx = 0\ ;\ Fr + T - F_H = 0$$

$$0 + m\,.\,a\ (\text{deceleration}) - m\,.\,a\ (\text{acceleration}) = 0$$
$$m\,.\,a = m\,.\,a$$

So it is assumed that the deceleration should be equivalent to the sliding acceleration value, which is 1 m / s^2; $F = m.a = 3000\,.\,1 = 3000\ N$ atau $\boldsymbol{F = 300\ kgF}$**.** At the stopper end there is a sensor to detect that play has stopped, after the plate stops, there will be a smart sensor down to detect the top plate surface. Smart sensors will detect the plate based on the model settings and become a reference for precision in the plate pruning process. The pneumatic cylinder driven by the ball screw will drop as thick as the plate based on the suit, then the cylinder will move outstroke to pry.

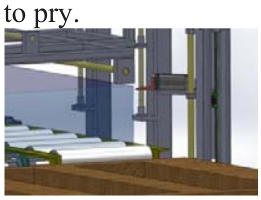

Figure 5. Pneumatic cylinder equipped with additional tool (fork lever).

When the end stroke sensor of the cylinder is active, it indicates that the movement is precisely in the gap between the plates (attachment passing between plate slits).When the end stroke sensor is not activated, the cylinder installs back and adds a downward movement per 0.1 mm. If it fits and falls between the gaps, the pneumatic cylinder will go up with a certain suit so that between the front and rear plate ends an angle is formed. This aims to have a gap for the horizontal arm to carry the plate to the transfer table.
Calculation of Pneumatic dimension cylinder using shovel as attachment to pry the plate has 70mm lever surface. Assuming the gap between the shovel with the tip of the plate is 50 mm, so it takes a step length of 120 mm. Means the critical point is at a distance of 50 mm with a load of 30 kg plate. The 30 kg load is halved because the work is 2 pneumatic cylinders in the right and left corners. Taking into account the broken force that occurs as Fig.6 .

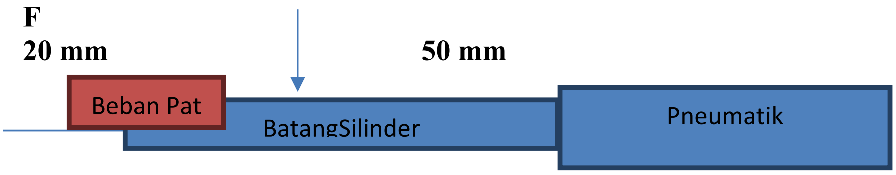

Figure 6. Styles received by pneumatic cylinders.

For the cylinder thrust force during the prying, the force should not be equivalent or more than the plate material load. It is intended that at the time of improper cylinder down movement and outstroke moving cylinder does not cause the plate to shift or change its position against the pile group.If the spoon tip on the pneumatic cylinder is the same as the plate slit, no platter-weight thrust is required to separate the plate from the group.With the weight of the plate split in two and should not be equivalent or more than the weight of the plate, so it is determined that the force of thrust is 120 N in each pneumatic cylinder. From these assumptions can be calculated the required wind pressure to push the cylinder to move outstroke, $P = \frac{F}{A} = \frac{15\,.\,9{,}81}{0{,}25\,\pi\,12^2} = 1{,}301\ {}^{N}/_{m^2} =< 1\,bar$; So it takes regulator with range 0 ~ 2 bar. The regulator functions as a wind regulator that enters the pneumatic system.

After the plate is lifted and a gaping angle is formed, the horizontal arm moves from the end to the base of the conveyor to push the plate toward the transfer table likes Fig 7.

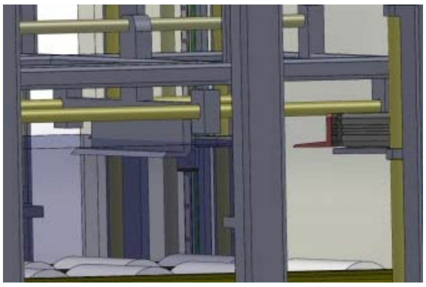

Figure 7 . Horizontal arm

The third stage conveyor can be said to be a bridge between the second stage conveyor and the transfer table. The third stage conveyor becomes a continuity with the second stage conveyor. The conveyor can equalize the altitude setting against the horizontal arm.

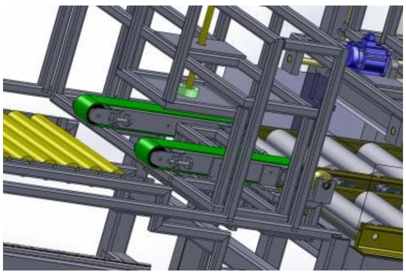

Figure 8. Conveyor Phase Three.

The material transferred from the second stage conveyor is forwarded to the third stage conveyor, then after the sensor detects that the material is fully shifted then this pair of third stage conveyors will descend aligning the altitude to the transfer table, so the plate can be passed to the next stage. After the plate is released from the third stage conveyor, the conveyor will rise again to equalize the height with the horizontal arm for the next process. The transfer table likes Fig 9. is the end of the system and the material is directly fixed on the shearing machine. In this section, the table receives a plate from the third stage conveyor.

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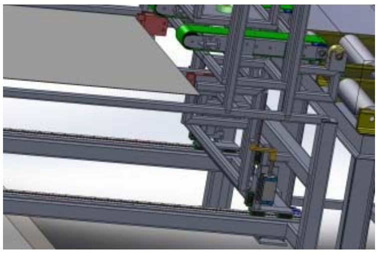

Figure 9. Transfer table with pneumatic clamp

The sensor will detect that the plate has been transferred completely to the transfer table, the system will instruct the third stage conveyor to rise again to equalize the horizontal arm's height to receive the next plate.

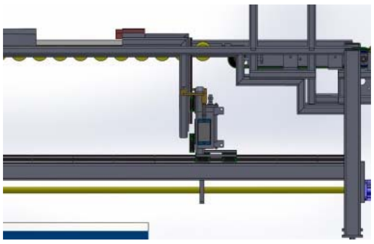

Figure 10. Arm Brace.

After the third stage conveyor has risen, the clamping arm moves down so that the clamps are below the plate height, then move backwards. This is to prevent from crashing the plate. Backward movement using ball ball screw and linear motion as guide to keep the arm on track.

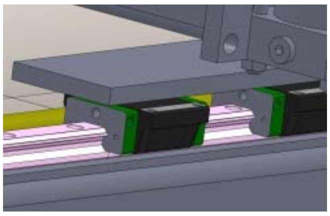

Figure 11. Linear motion (block & rail).

The clamping arm will move up and with the pneumatic gripper will clamp the plate to be pushed forward. Pneumatic Gripper (pneumatic clamp) is a tool to clamp that is driven by wind power. The clamping arm will move forward towards the shearing machine table.

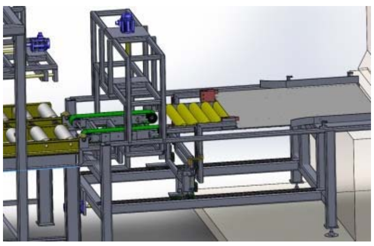

Figure 12.Movement of plate to machine.

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On the base of the transfer table using a roller with the aim of minimizing the friction force so that the plate easily to be pushed into the shearing machine to cut. At the end of the transfer table is equipped with a guide that can be adjusted to direct the plate to remain aligned with the shearing machine table so that when the cutting process, the plate is not shifted.Servo motors will move based on the settings, so when the plate has reached the machine stopper (already on the machine), there will be over load or more load during the push then the motor will stop. This system is in sync with the movement of the shearing machine blades to cut the plate. So when the motor has stopped rotating the ball screw, the system will order a knife to move the plate cut. The clipped plate will fall on the rear side of the machine.

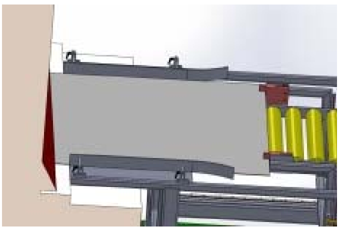

Figure 13. The process of cutting forward.

After the plate is cut off, the knife will return to the starting position and the servo motor will activate again to move the ball screw to push the clamping arm. This process continues continuously based on the desired cut width setting.

4. Conclusion

- The skeletal dimension is 1500 x 1500 x 800 mm by having 4 poles as the legs, it can be deduced that the weight point is in the center of the frame.It also affects the twisted moment experienced by the skeletal legs.Slope Calculations Hydraulics with four hydraulic systems will push vertically with different heights and form an angle between the two rear ends against the two front ends.
- Hydraulic tilt is formed by angle $\boldsymbol{\alpha = 5,85^0}$so that material levers are formed as in Figure above
- The diameter of shaft of the buffer for safety factor is 20 mm,
- Designing four hydraulics with 2-inch piston diameter, it is necessary to prepare a power pack to support the hydraulic system of at least 36 bar.

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