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Palestine Polytechnic University

College of Engineering

Mechanical Engineering Department

Mechatronics Engineering

Designing and building automatic system for labeling mattresses for Al-Herbawi factory

Mechatronics engineering bachelor degree project

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Collage of Engineering

Mechanical Engineering Department

Hebron – Palestine

Designing and building automatic system for labeling mattresses for AL-Herbawi factory

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Submitted to the Collage of Engineering

In partial fulfillment of the requirements for the

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Supervisor Signature

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Head of the Department Signature

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Abstract

This project aims to solve a problem in al-Herbawi factory represented in the line of production which causes delay on the manufacturing process . The problem is that all the mattress manufacturing process are automatically done expect of the label adhesive tape one . We solved this problem by designing and building a system that simulates the work of the worker with high accurate taping process and faster response . This project has integrated mechanical , electrical and hydraulic systems to achieve the optimal design . We built this project by our knowledge in over all engineering which ended by solving the problem and getting the required output we planned to get . This project also made the all mattress manufacturing stages full automatic and with acceptable accuracy and faster response.

Chapter1

1.1 Introduction

Al Herbawi is one of the biggest companies in Palestine . It is for making foam and mattresses . This company had been established in 1978 in Hebron-Palestine [1].

Al Herbawi company have a massive production line for mattresses production . The final stage of its production line is that each mattress must be adhesively labeled on all sides. Labels' adhesive operation has to be done by workers manually. Sometimes the results face several problems such as slowing or even disrupt the production line . And this problems can be solved by designing a machine that acts the worker role with less effort and more accurate taping process.

The goal of this project is to increase the productivity , efficiency and the speed of the operation . This must be done of-course with a reasonable budget for this machine.

The problem of this machine is the labeling stage. All stages in this factory are automatic except the labeling stage . Thus will slow down the manufacturing process in general . Therefore there is a need to solve this to speed up the general production process.

To solve this problem we firstly must understand the steps of the process . There steps can be summarized as : The first sensor is to detect the mattress . The conveyer will move the mattress with a known distance to make it on the center of the jack. Then there is the labeling spindle . This spindle will attach the suitable adhesive label to the mattress . The jack will rotate by a 360 degree while the adhesive is still attached to the mattress. There is a sensor that will check if there is mattresses on the production line . If there is a mattress it will wait until the other mattress pass . If not it will move the production line.

1.2 Recognition of Need

Al-Herbawi company that manufactures the mattresses it needs to develop the final stage of the Mattress production line Which is represented by put the label adhesive on all side of the mattresses. Labels' adhesive operation has to be by workers Manually. sometimes, that leads to create many problems like Delay or disable production line of mattresses. so they need to Automatic the system represented by designing a machine that one better than manual performance about productivity and efficiency. the aim is to increase the speed of operation. reduce losses time with minimum worker effort, Affordable running cost ،more accurate work.

1.3 Literature review

By back to previous work related by manufacturing mattresses machines. Many companies worldwide like “ELEKTROTEKS” and “MERT|MAkiNA” companies [2],[3] have automatic mattress tape edge machine, automatic mattress stacking system and automatic mattress packing machines .But the labels adhesive of mattresses machine is not found. other mattresses manufacturing companies like “Guangdong Diglant furniture industrial company “[4] and “Dunlopillo company “ [5] we have noticed that pattern of putting label adhesive on mattresses is not found but in AL-Herbawi company they put the label adhesive around the sides of mattresses which gives it different and distinctive appearance.

In this project and By back to previous work-related there is a lot of mechanisms we used to get the mattress labeled adhesive as a final stage of its production.

1.4 Problem and Suggested solutions

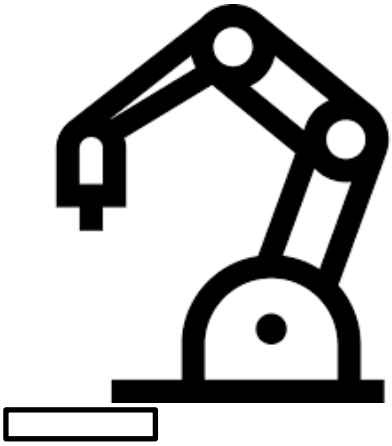
After identifying the problem and reviewing the previous work, there are many proposed solutions for the project represented in the various designs, this step is to choose the best solution and the ideal design, so the project went through many stages before reaching the ideal design.

Integrated design issues in mechatronics

Using concurrent engineering principle as a guide ,the designed product is likely to meet the basic requirements : high quality .robustness .low cost. Time to market . customer satisfaction .

First proposed design(4 DOF robotic arm)

Four degree of freedom robot arm with four revolute joints and moving base with rectilinear motion . represent the first suggested solution for label adhesive of mattresses problem.



Fig(1.1) 4 DOF robot arm the end effect or Carrying sticker roll.

Advantages of this solution:

-Accurate.
-Intelligent.

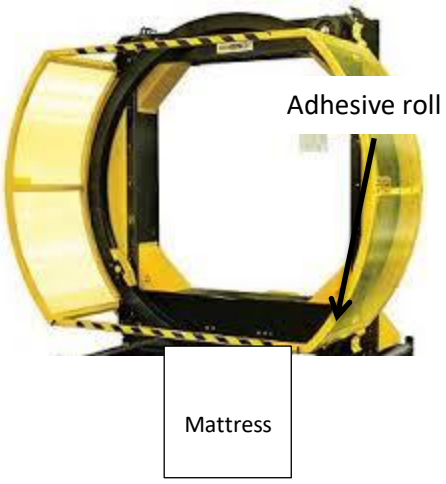
Disadvantages of this solution:

-complex.
-more cost.
-complex control.
-Difficulty in maintenance.

So this Unacceptable solution.

Second proposed design

Orbital Stretch Wrapper machine this design can be implemented in our project. it is consists of a Circular path and structure. the mattresses can be put in the center of circular structure of the machine. the adhesive roll must rotate around the mattress.



Fig(1.2) Orbital stretch wrapper machine.

Advantages of this solution:

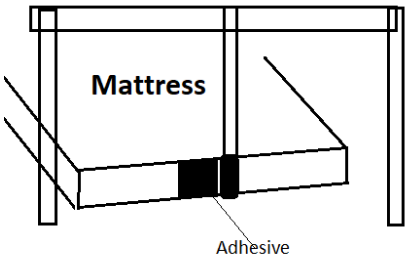
-very fast.
-Accurate.

Disadvantages of this solution: -Complex design.

-Higher cost.
-It make restriction.
So this Unacceptable solution.

Third proposed design(CNC machine)

Computer numerical control machine with three-axis. That put the adhesive on both sides of mattresses.



Fig(1.3) CNC machine with 3 axis.

Advantages of this solution:

- very Accurate.
-more safty.

Disadvantages of this solution:

-Slow.
-Complex.
-Higher cost.
-Take large workspace.
So this Unacceptable solution.

Final proposed design(Moving arm of adhesive)

This design represents a simple mechanism system that simulates the behavior of the worker. The arm of adhesive moving in rectilinear and reciprocating motion. consists of penumatic cylinder and limit switch sensors.

Advantages of this solution:

1-Simulating the worker work .
2-Faster than worker within 10 seconds .
3-Accurate process compared to the worker which gives a good looking for the mattress when finished.
4-Simple structure and manufacture.
5-Low cost.
6-Easy to control.

According to the previous advantages , we chose to design and manufacture this machine

Chapter 2

2.1

Conceptual design

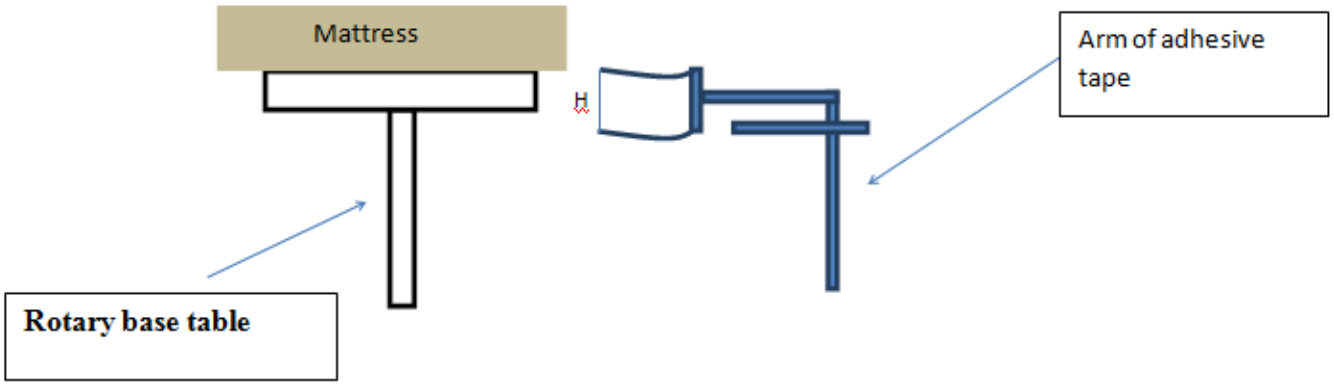
The main goal of our project is to design and build a model of integrated system represented by put the label adhesive tape on all side of the mattresses.

Fig(2.1) Herbawi mattress after adhesive label tape

This represents the label tape that it is adhesive on mattress .

This requires designing an integrated system with all its mechanical, electrical and pneumatic parts. Also to set the appropriate control for the system. We designed a system that simulates the behavior of the worker. This is to ensure that we get the same quality with a faster process.

The mattress for complete the process will pass by more than one main stage. First the mattress must detected by sensor to operate conveyer for work . second the



mattress must stop for few seconds around twenty five seconds the aim to put the label adhesive tape on all sides on it . so we design mechanism for this represented by round table this must rotates at the same time the arm of adhesive must operate.

First step the sensor must detect the mattress for operating conveyer and process will start. Second step represented by fix and prepare mattress for add adhesive tape

2.1.1 Rotary base table:

This part consists of three systems : mechanical , electrical and hydraulic. This we design it for rotate the mattress while the label tape adhesive process is operate. So there two systems work at the same time .

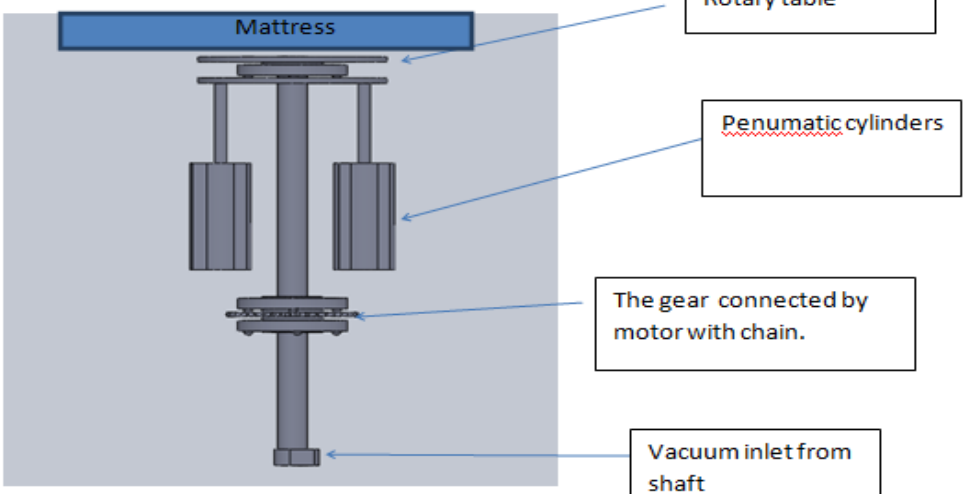
In this part we faced a problem . The application needs to rotate and rise by suitable distance on the surface of table conveyer and must make the vacuum pressure on mattress to prevent it from falling during rotation. So we solve this problem by use induction rotational motor , two of pneumatic cylinders for rising mattress to up and vacuum pressure by motor.

2.1.2 Taping process

Pneumatic cylinders

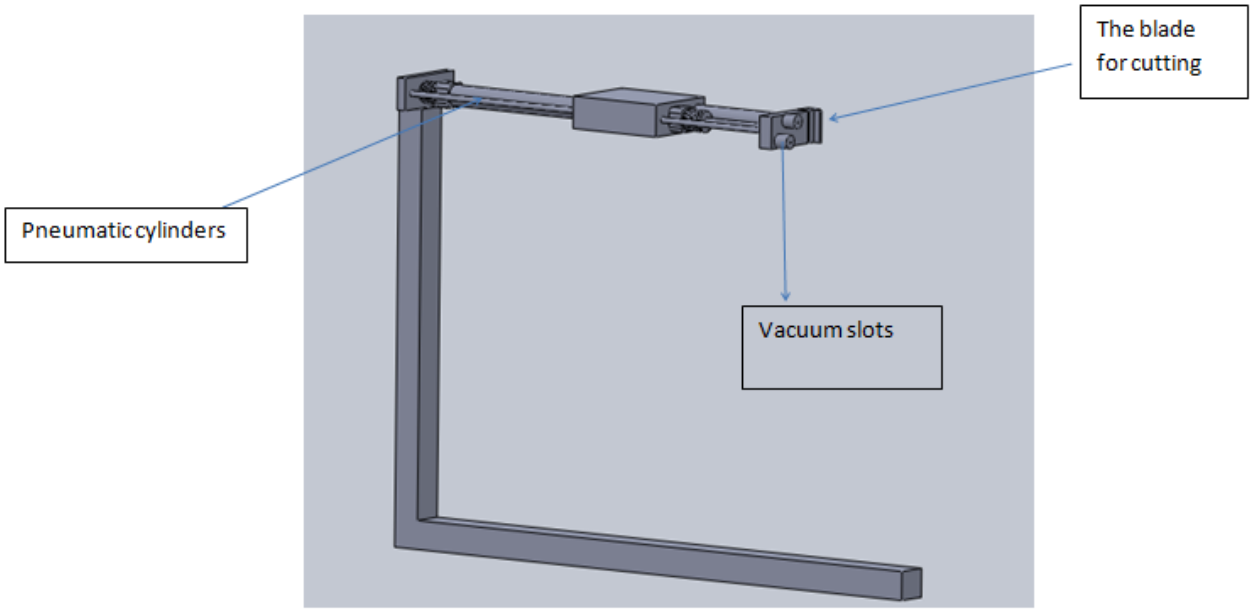
Fig(2.2) Solid work drawing for the rotary base table

Fig(2.3) Solid work drawing for the arm



Fig(2.2) Solidworke drawing for design the rotary base table.

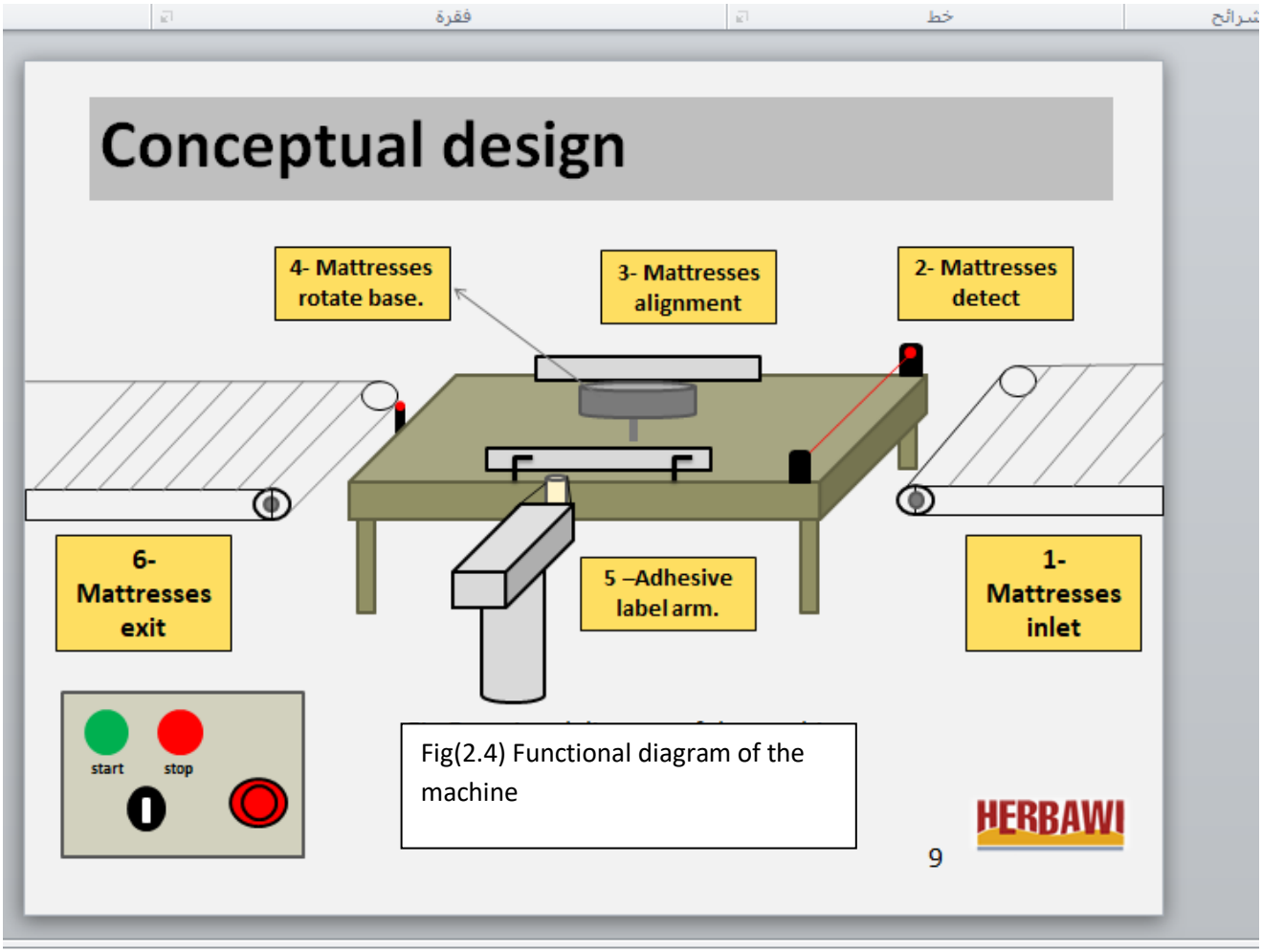
The idea simulates the behavior of the worker arm . This is consists of three main parts. First there pneumatic double cylinder move linear motion forward and back



Fig(2.3) Solidworke drawing for design the Arm.

the aim to fix the label tape adhesive on start of process instead of worker arm. Second blade for cutting the tape after complete process by single acting pneumatic cylinder . third the vacuum pressure that apply on label tape aims to continuous contact between tape roll and the arm for later processes .

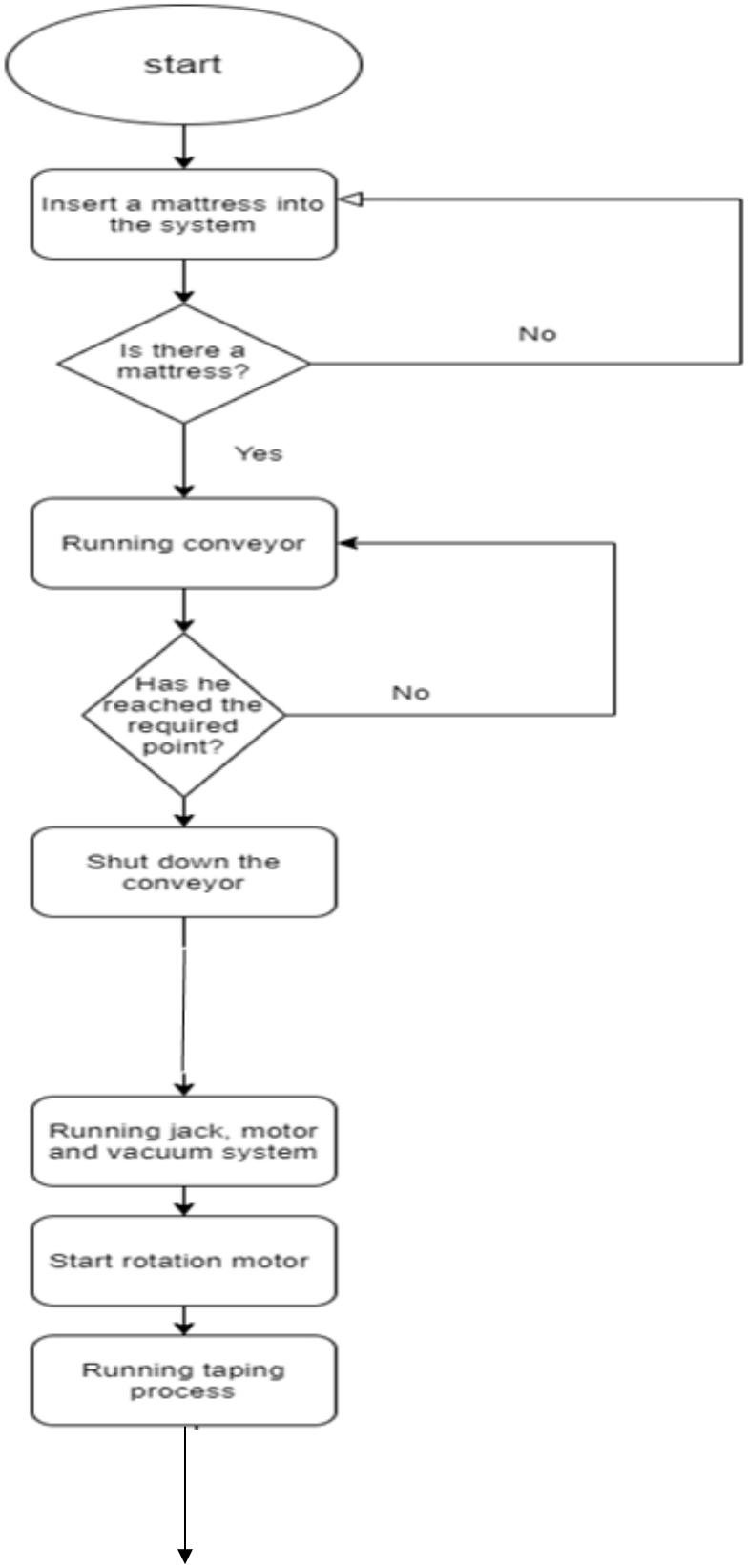
2.2 Functional diagram of the machine



Fig(2.4) Functional diagram of the machine

Figure (2.4) : conceptual design of overall system.

2.3 Flow chart of machine Processes



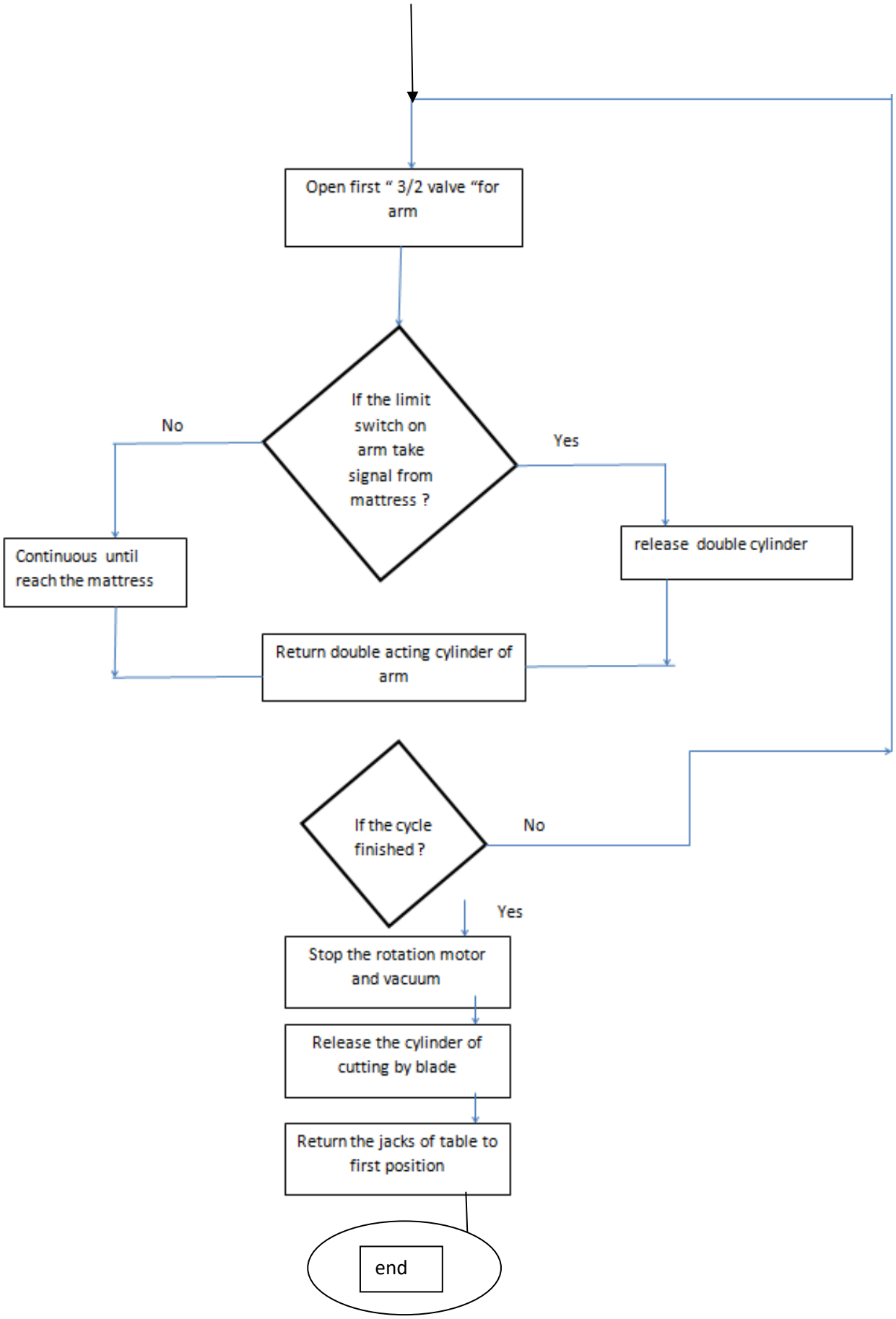


Figure (2.5) : Flow chart for the processes

Chapter 3 : Mechanical design

In this chapter we are going to describe each mechanical part with a illustrative sketch of each of them alone .

3.1 Conveyers : We have a conveyor belt to transfer the mattress from one place to another which is shown in the figure(3.1).

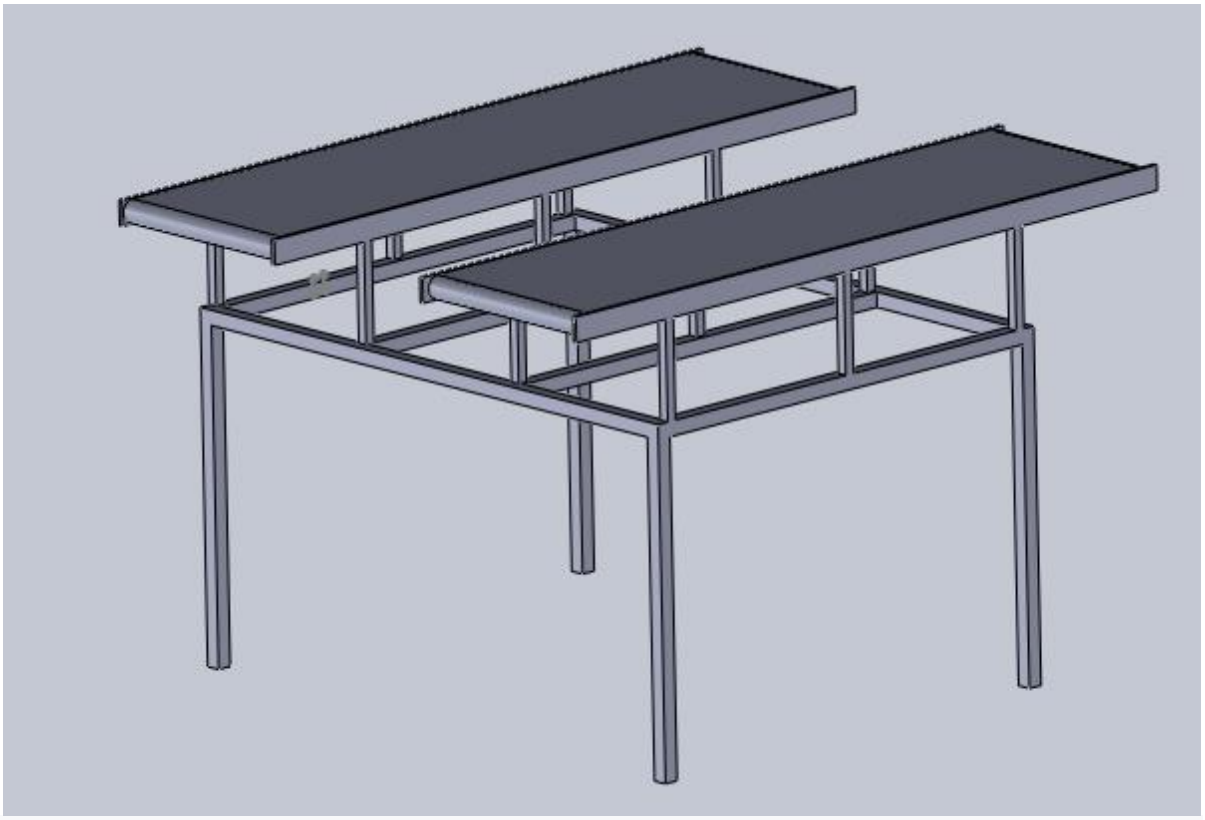


Figure (3.1) : mechanical design of the conveyers

As shown there are six meeting points between the conveyor belt and the basic structure for each conveyor . Also we have motor weight and mattress weight and conveyor weight which is distributed over all parts of structure.Each conveyer have a

motor where these two motors are connected to the same contactor to run them both together with the same displacement and speed.

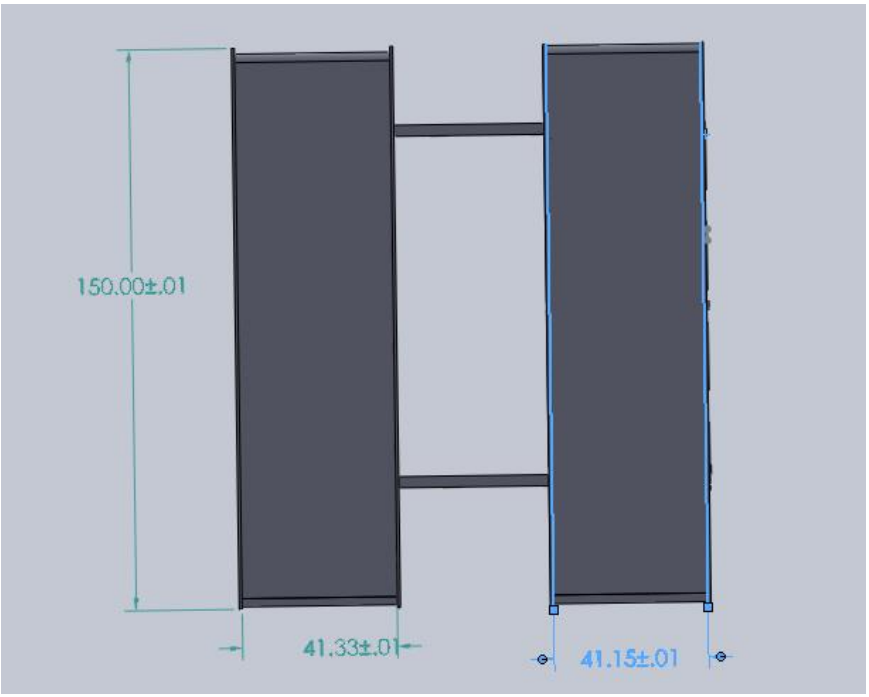


Figure (3.2) : Top view of the conveyers

3.2 : vacuum and rotational system

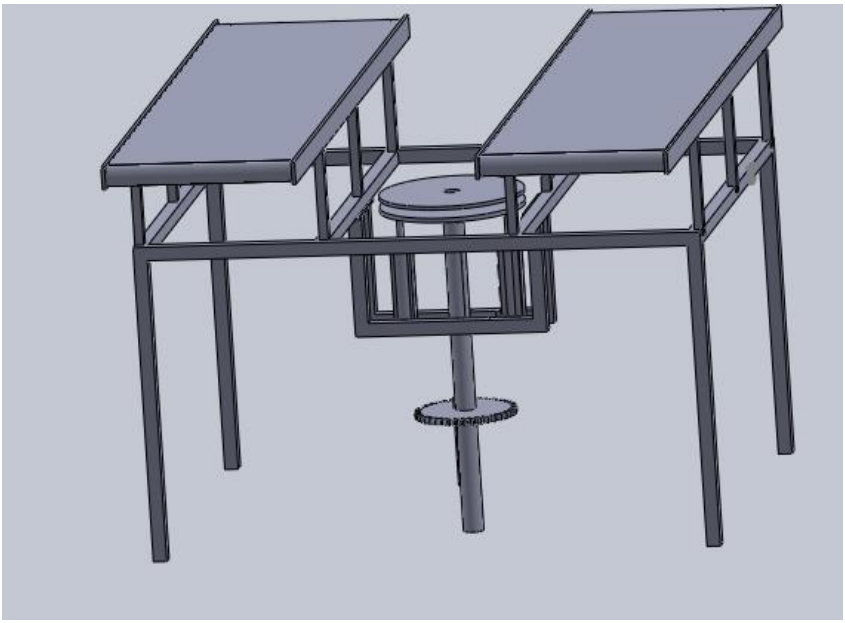
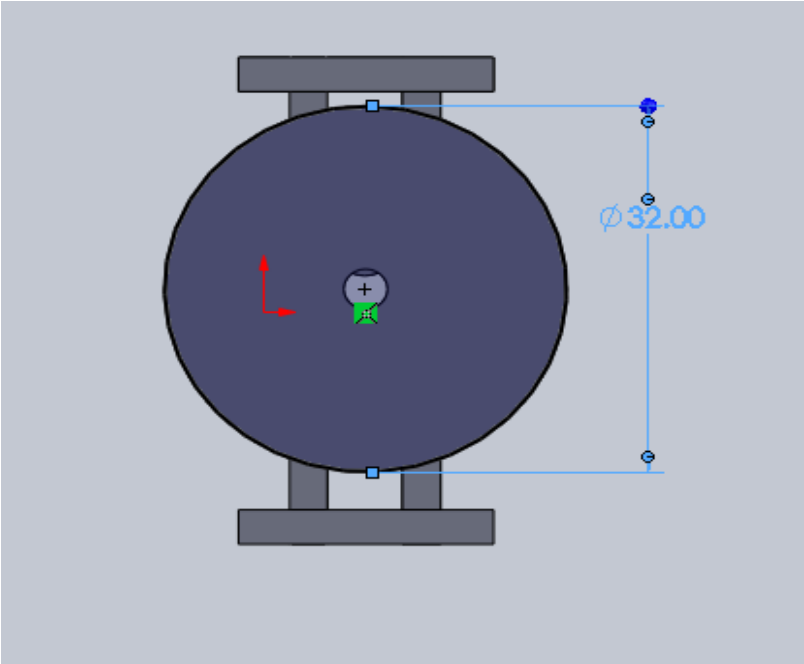
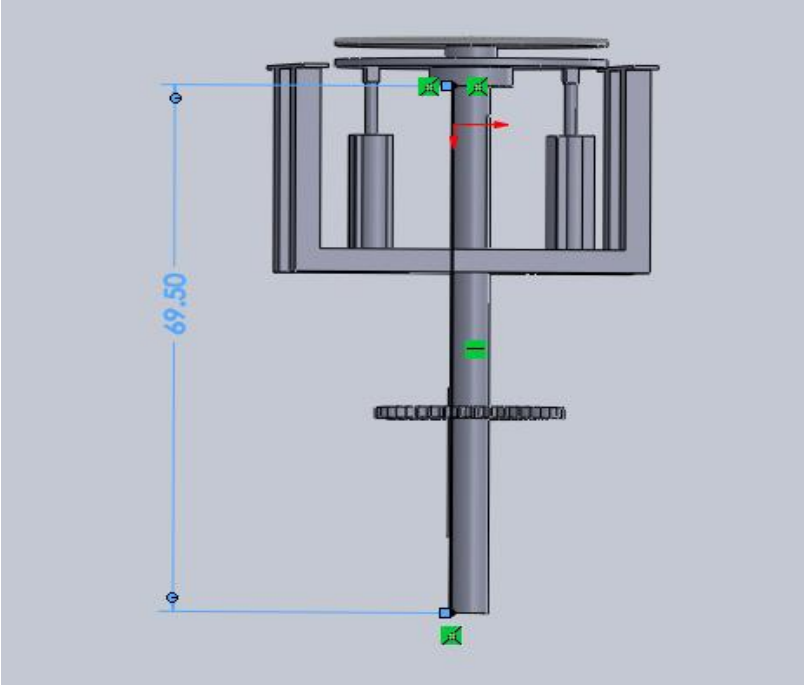


Figure (3.3) : Jack motor vacuum mechanical design

We have designed a shaft to allow the vacuum air to flow across the shaft and be able to hold the mattress from falling . Also we designed a suitable plate with suitable dimensions for most mattresses sizes. The mattress will stand over this plate and with the air crossing the shaft from the vacuum the mattress will stand still above it.



Figure(3.4) : Dimensions of top view of the mattress base



Figure(3.5) : Dimension of the shaft

3.3 :Arm system : This design is based on a pneumatic cylinder all we need is to install the cylinder as shown in the figure(3.6).

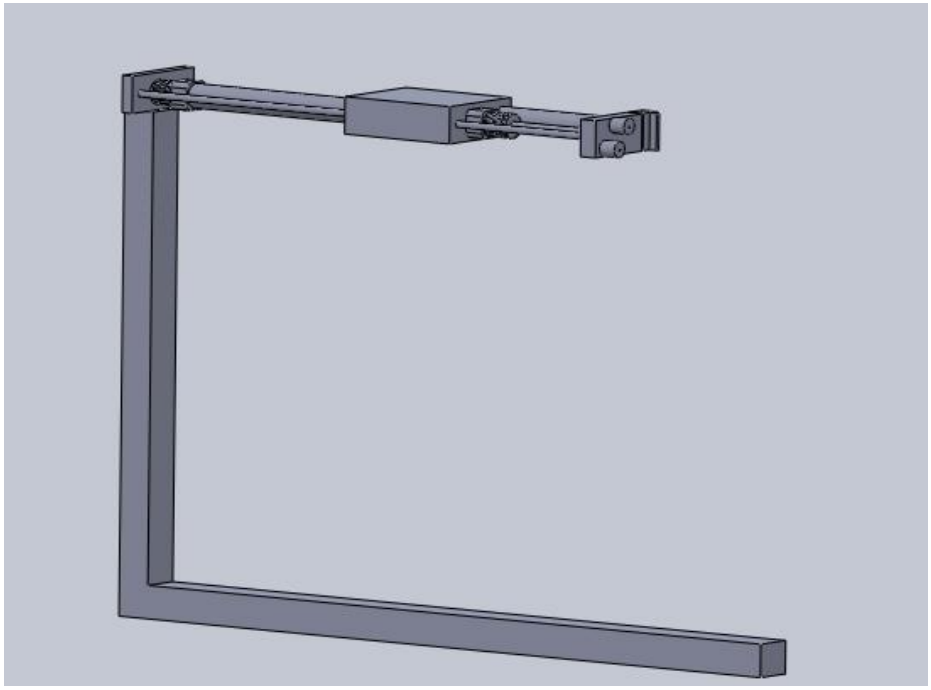


Figure (3.6) : Label adhesive arm mechanical design

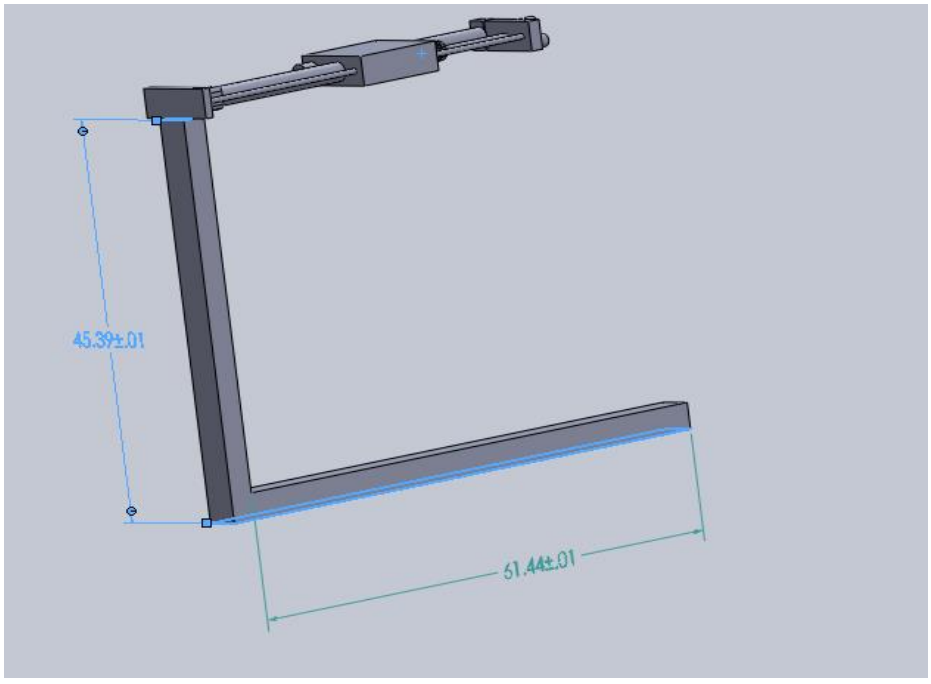


Figure (3.7) : Dimensions of label adhesive arm

3.4 : Mechanical connections:

3.4.1 : Screw we choose m12 grade 10.9

Figure(3.8) : Suitable screw

3.4.2 : Bearings

We chose four bearing two of them in a bigger form to support the main gear to make a smooth rotational movement (10 cm inner diameter) . The other two of them is to support the main shaft located on both sides of the shaft (4.5cm inner diameter) as shown in a figure.

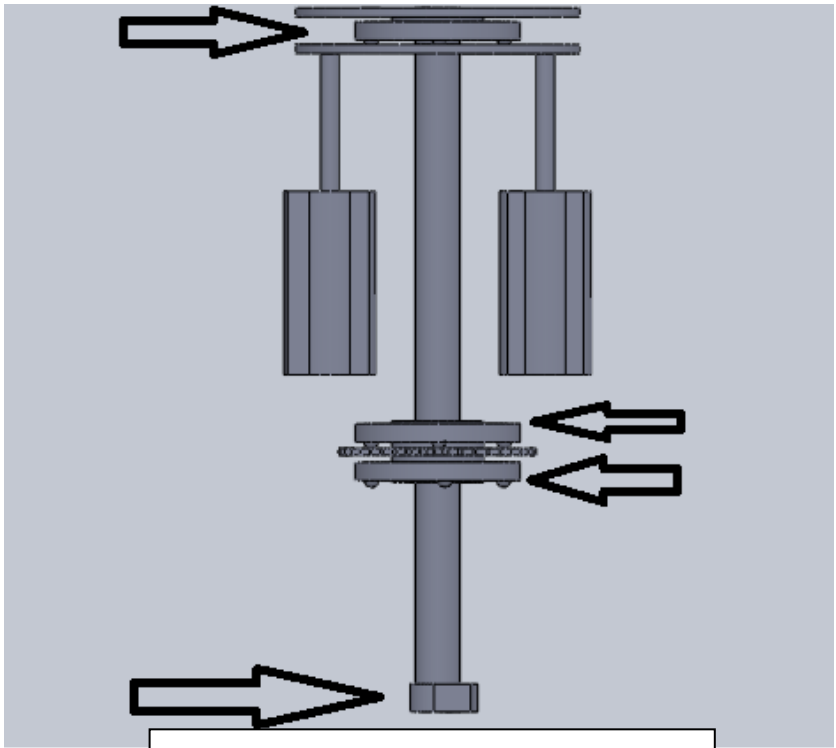


Figure (3.9) : Bearing position

3.4.3 : Timing chain drive

B10 to transfer the movement to the gear that rotates the jack that are holding the mattress.

Figure (3.10) : Suitable timing chain

3.5 Mechanical analysis

Stress acting on the table due to the masses on each pin and rod.

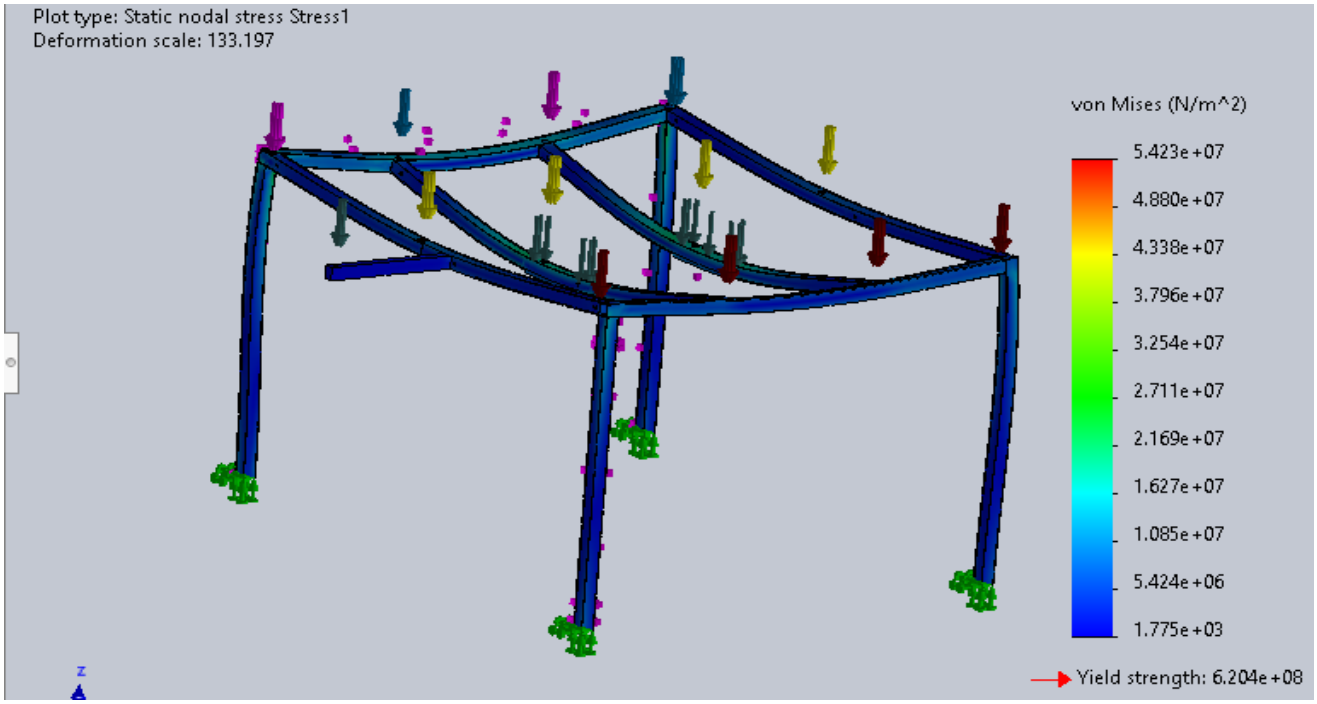


Figure (3.11) : Static stresses

Displacement

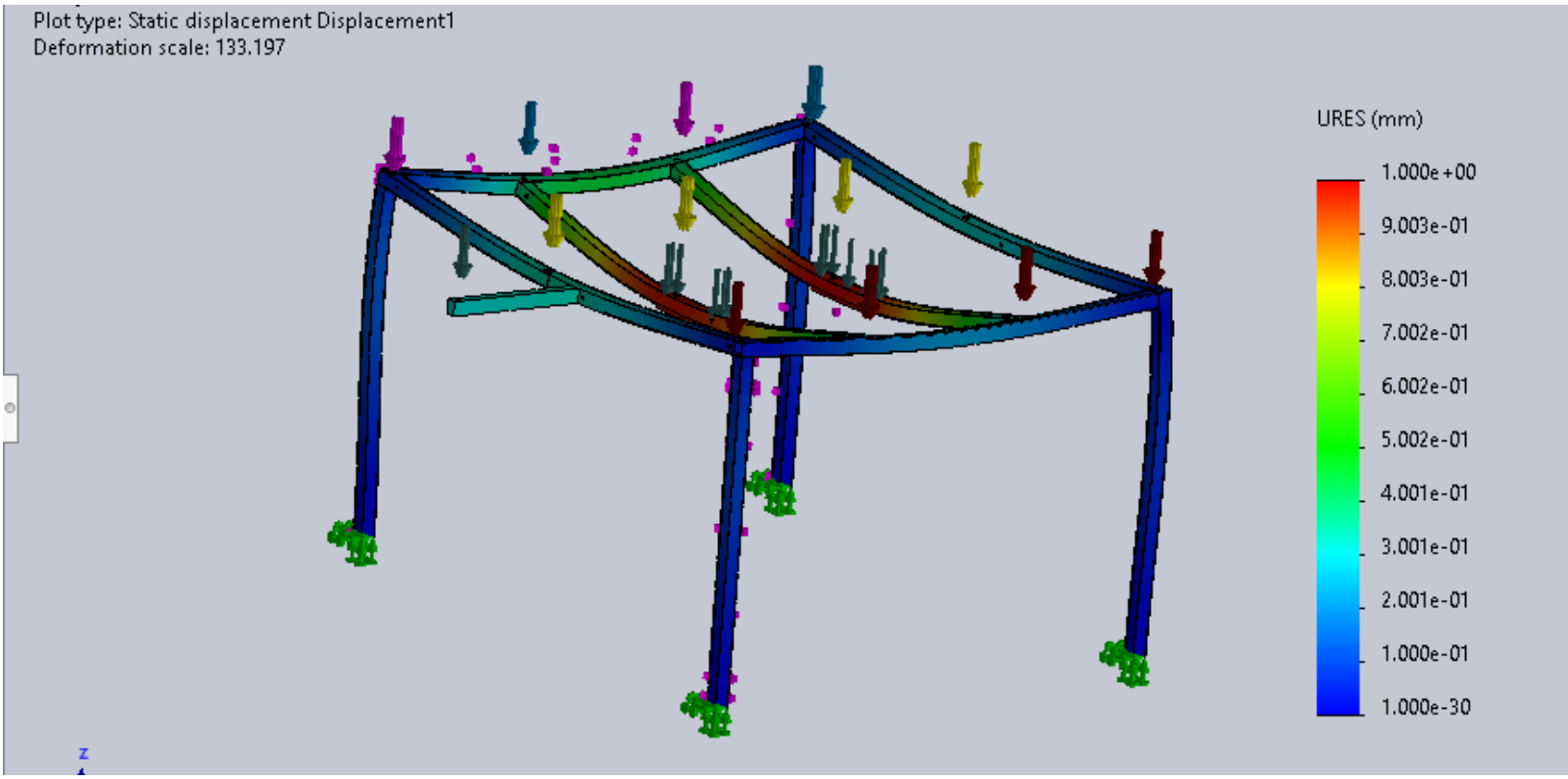


Figure (3.12) : Static displacement

Factor of safety (max von):

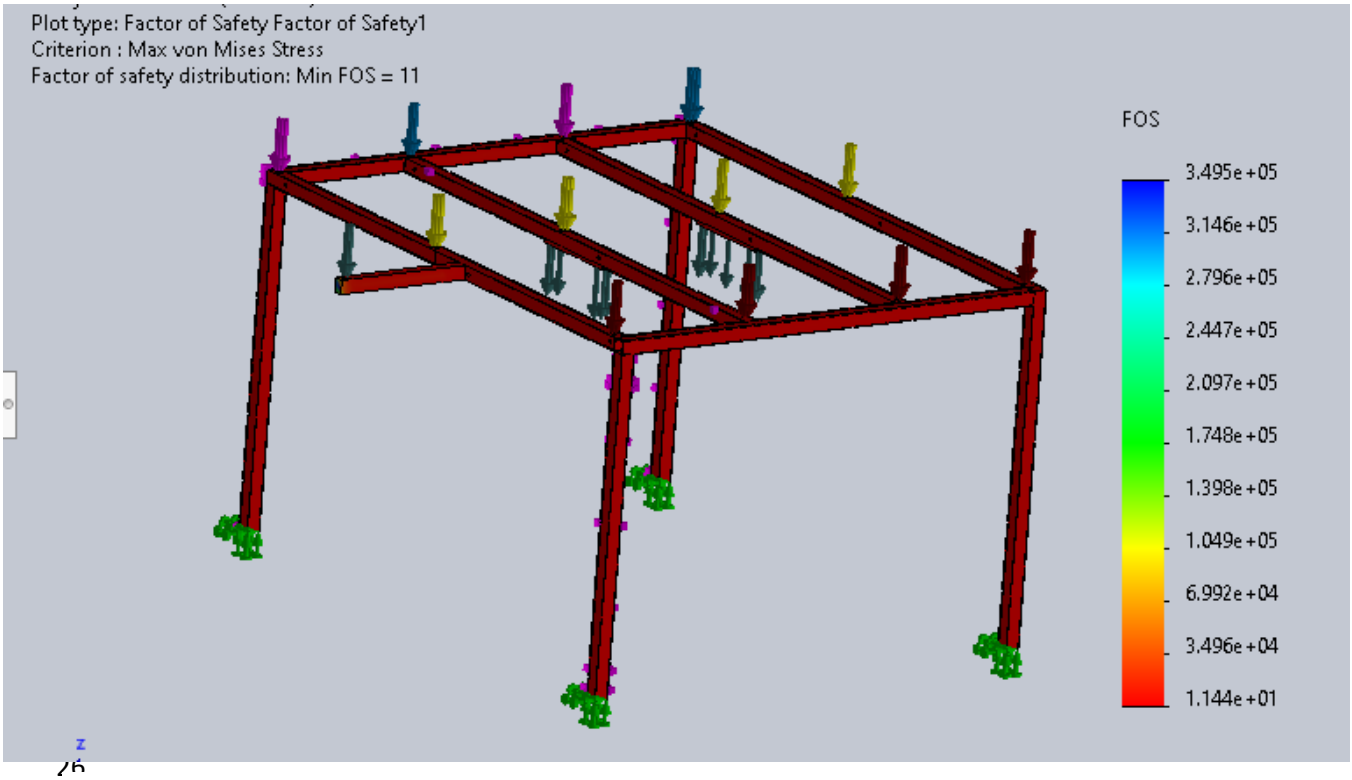


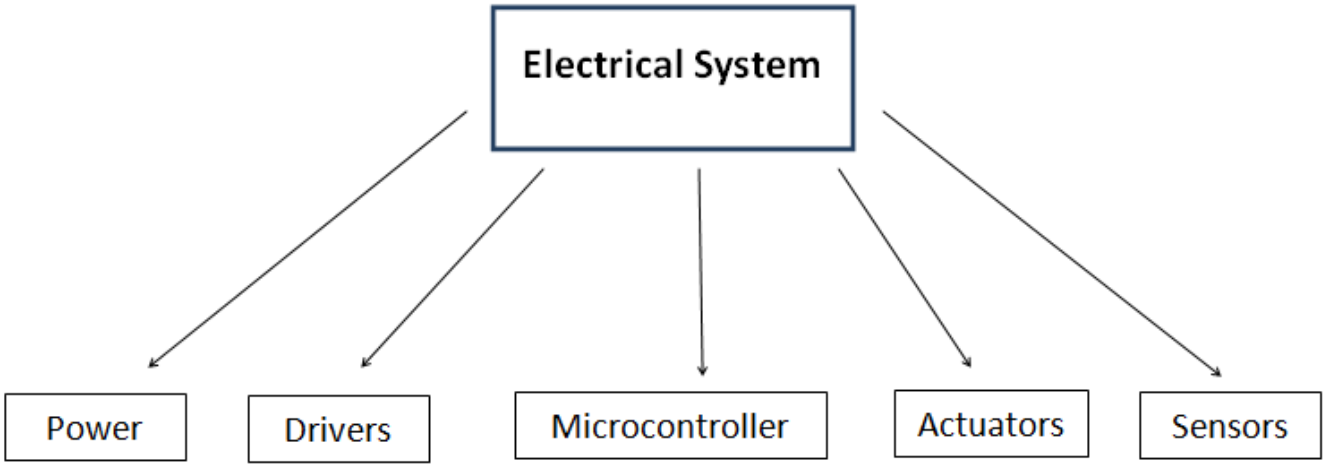
Figure (3.13) : Factor of safety

Chapter 4 : Electrical System

Electrical systems are groups of electrical components connected with each other to carry out some operation[1]. In our project the electrical system consists of :

-Power : The source of electricity for the machine is from the factory 3phase. Some electrical components work at 1phase , 3 phase and 24 DC power supply.

We used the power supply that gives twenty four voltage direct current for the inverter ,sensors, solenoid valves and contactors.



-Drivers: We used inverter to control two motors at the same time for the two conveyers we have in the machine .

Our inverter is made by Delta company which gives 1phase input and 3 phase output for the conveyors.

We also used two contactors in this machine . This was to control motor of the vacuum pump that rotates mattresses. Both contactors are 24DC voltage , 3phase.

Actuators: in this machine there is different types of actuators: electrical, mechanical, hydraulic and pneumatic. There are four motors :

-

Two motors for conveyers.

-Motor that rotate mattresses.

-Motor for the vacuum pump.

Also there are five pneumatic actuators in this project :

-Two pneumatic cylinders to lift the mattress before rotating.

- Three pneumatic cylinders for controlling the arm of Adhesive tape.

Sensors

In this project we used five roller limit switches. Which are all a digital sensors. The roller limit switches has three terminals .

1 - First limit switch will give a signal whenever a mattress enters the system . Which will gives a signal to the conveyers to start and move the mattress.

2 - Second limit switch will give a signal when the mattress is on top the jack vacuum system . Which will give a signal to the jack to lift the mattress and vacuum to hold the mattress from falling off. It also gives a signal to the cylinder on the arm to move and stick the adhesive on the mattress.

3 -Third limit switch will give a signal when the adhesive is attached to the mattress . Which will give a signal to the cylinder on the arm to get away from the mattress . It also gives a signal to the rotating motor on the jack vacuum system to start rotating.

4 -Fourth limit switch will give a signal when the rotating motor rotates 360 degrees . Which will give a signal to the arm to move forward the mattress again activating the third limit switch again . This will give a signal to the cylinder that holds the blade to cut the adhesive while still attached to the vacuum cylinder.

Then the system will wait for another mattress to enter.

Microcontroller

we have chosen programmable logic controller (PLC) type delta Because it have a suitable number of inputs and outputs . We Also chose it because of its cheap price . We usedWPLsoft2.50 as a program to write our ladder on.

Figure (4.1) : Delta PLC

This PLC contains of seventeen outputs and seventeen inputs. It have a power supply of 24 DC voltage. It is connected with 1 phase. PLC delta gives 24 V DC voltage for the inputs . So we used24DC voltage sensors. Outputs on the PLC we can connect any different voltages like 5 V,24 V,220 V because there is common that collect every three outputs with each other.

-Y0,Y1,Y2 ,Y3 on C0.

-,Y4,Y5 ,Y6,Y7 on C1.

- Y10,Y11, Y12,Y13 on C2.

- Y14,Y15,Y16,Y17 on C3.

Inputs and outputs

This table illustrates all inputs and outputs for PLC or machine . in addition the tasks for each other. In this machine there five inputs and 11 outputs.

The name of the electrical peace	State	Task	Variable on PLC
Inputs			
First roller limit switch "receive sensor"	Digital input	To start operating the machine by detecting the mattresses.	Ls1 =X0
Second roller limit switch	Digital input	To stop the conveyer and lift the mattress	Ls2=X1
Third roller limit switch	Digital input	Determining the start and end of the rotation of the motor.	Ls3=X2
Fourth roller limit switch	Digital input	On the arm to stick the adhesive on the mattress and cut it when the	Ls4=X3

			rotation finishes	
Outputs				
Inverter "Variable Frequency Drives (VFD)"		Digital output	Inverters offer speed or torque control of electric motors.	Y0,Y1,Y2,Y3 C0
First electric Solenoid VALVE 5/2		Digital output	For controlling the two cylinders to raise and lower the mattress	Sel1:Y14
electric Solenoid VALVE3/2		Digital output	Forward hand jack	Sel2:Y15
contactor		Digital output	Controlling the motor that rotate the mattress	K2:Y5
contactor		Digital output	Controlling the vacuum the will hold the adhesive	K3:Y6
Fifth electric Solenoid VALVE 5/2		Digital output	For the knife jack that must cut the adhesive tape.	Sel5:Y7
Seventh electric Solenoid VALVE3/2		Digital output	To return the arm jack	Sel7:Y11
first contactor for motor	Digital output	Controlling the vacuum that will hold the mattress from falling off while rotating	K1:Y13	

Valves scheme

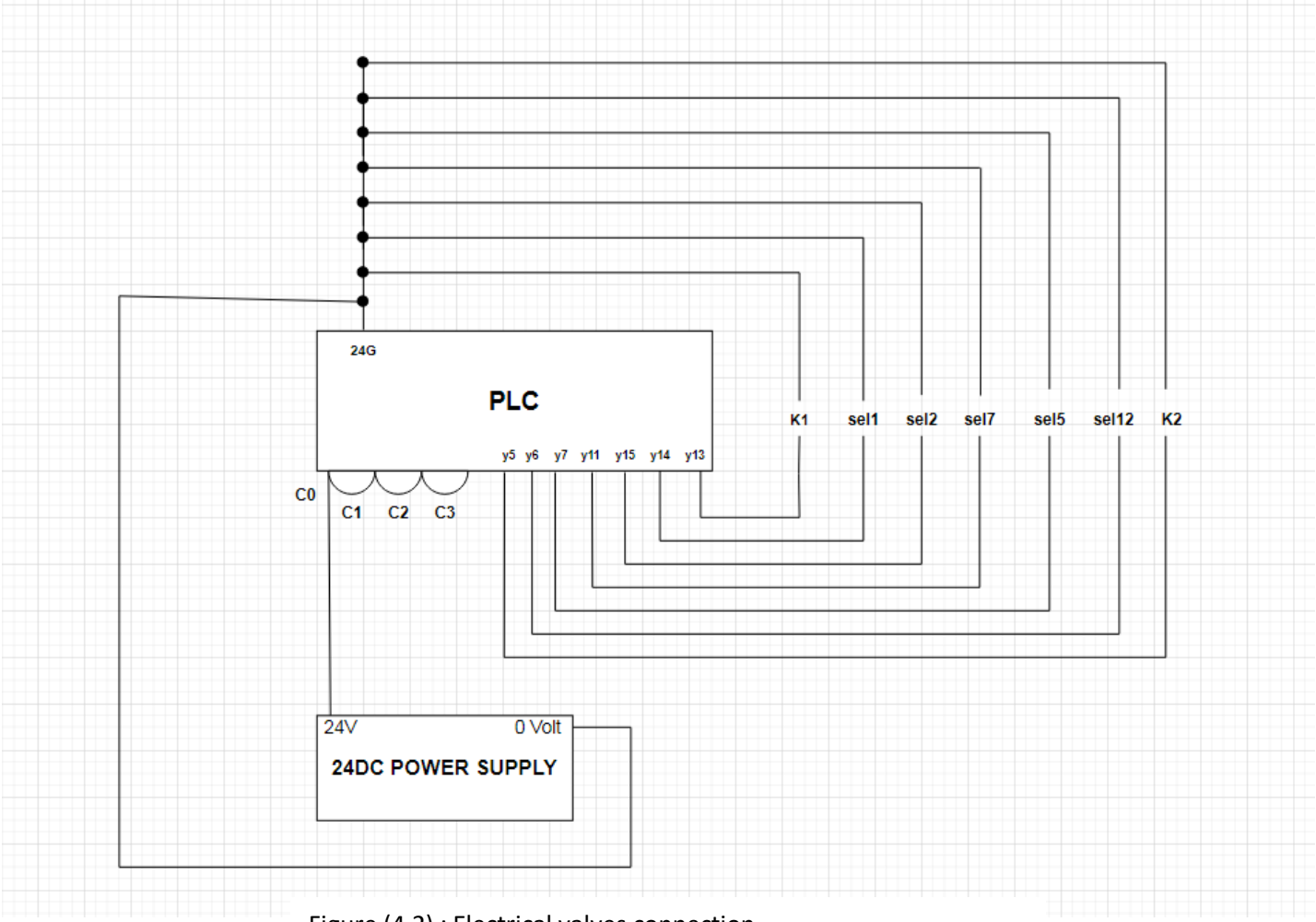


Figure (4.2) : Electrical valves connection

SFC scheme for PLC

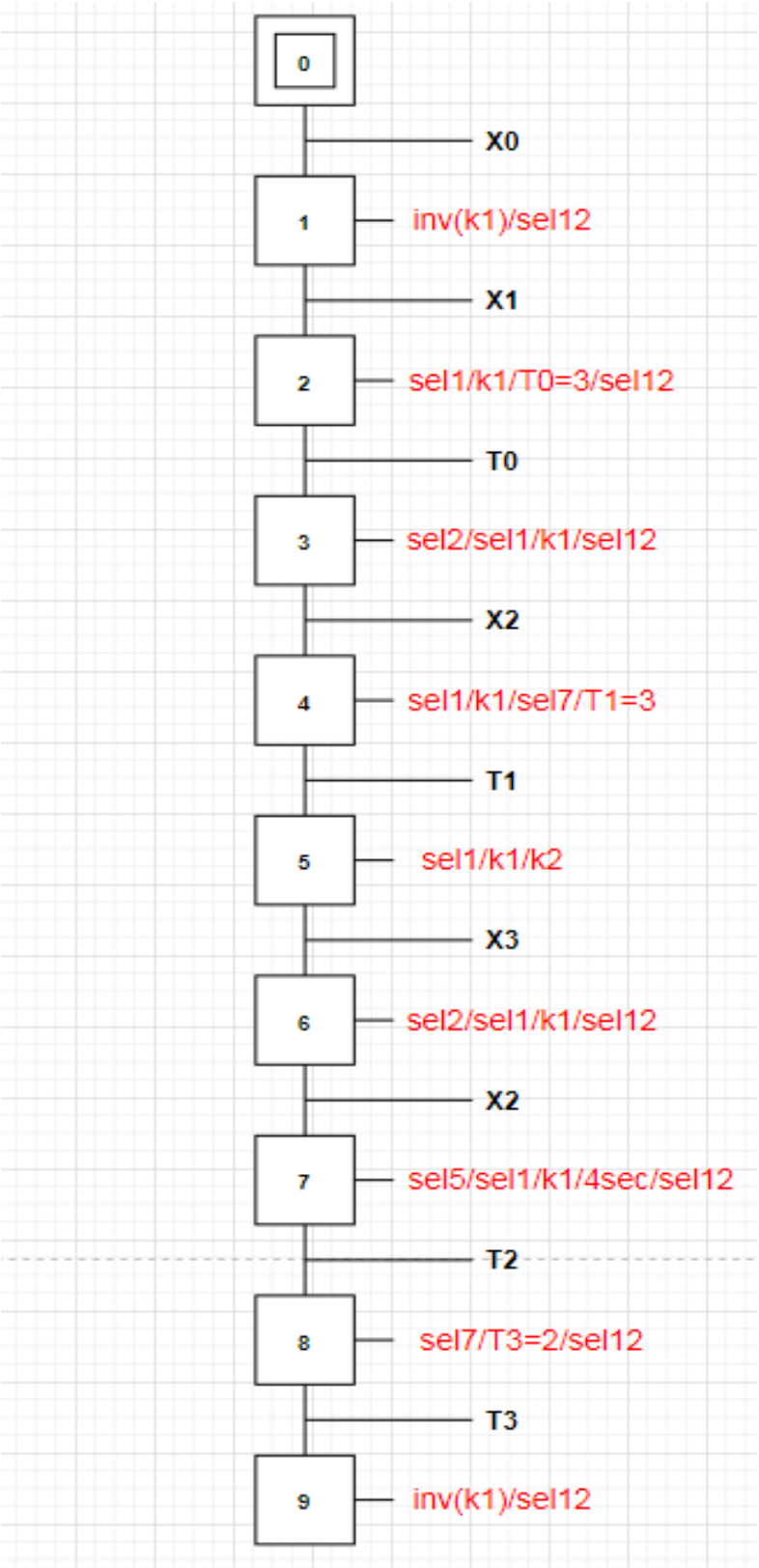


Figure (4.3) : SFC for the PLC program

Electrical panel design

A distribution board (also known as panel board, breaker panel or electric panel) is a component of any electricity supply system that divides an electrical power feed into subsidiary circuits . While providing a protective fuse or circuit breaker for each circuit in a common enclosure[2].

Electrical panel size

In this project we had an electrical panel one-door with a size of 60*70centimeter.

Switches on the panel door

On the front of the panel we have some switches that are connected to the PLC inputs and outputs.

-Start switch.

-Stop switch.

-Emergency push button.

Overview of the main Control panel components

-Central processing unit (CPU) which is PLC . It works as the brain of the control panel.

- Input and output cards.

- Gland plate. This plate is used to rearrange the wires in a suitable way in the panel without any intersections between the wires

-Power supplies :In this machine we chose 24 Volt DC power supply because all devices are powered by24 volt DC.

-Electrical circuit breakers : There is two phase breakers and three phase breakers.

-Contactors.

-Overloads.

-Inverter.

-Wires and cables.

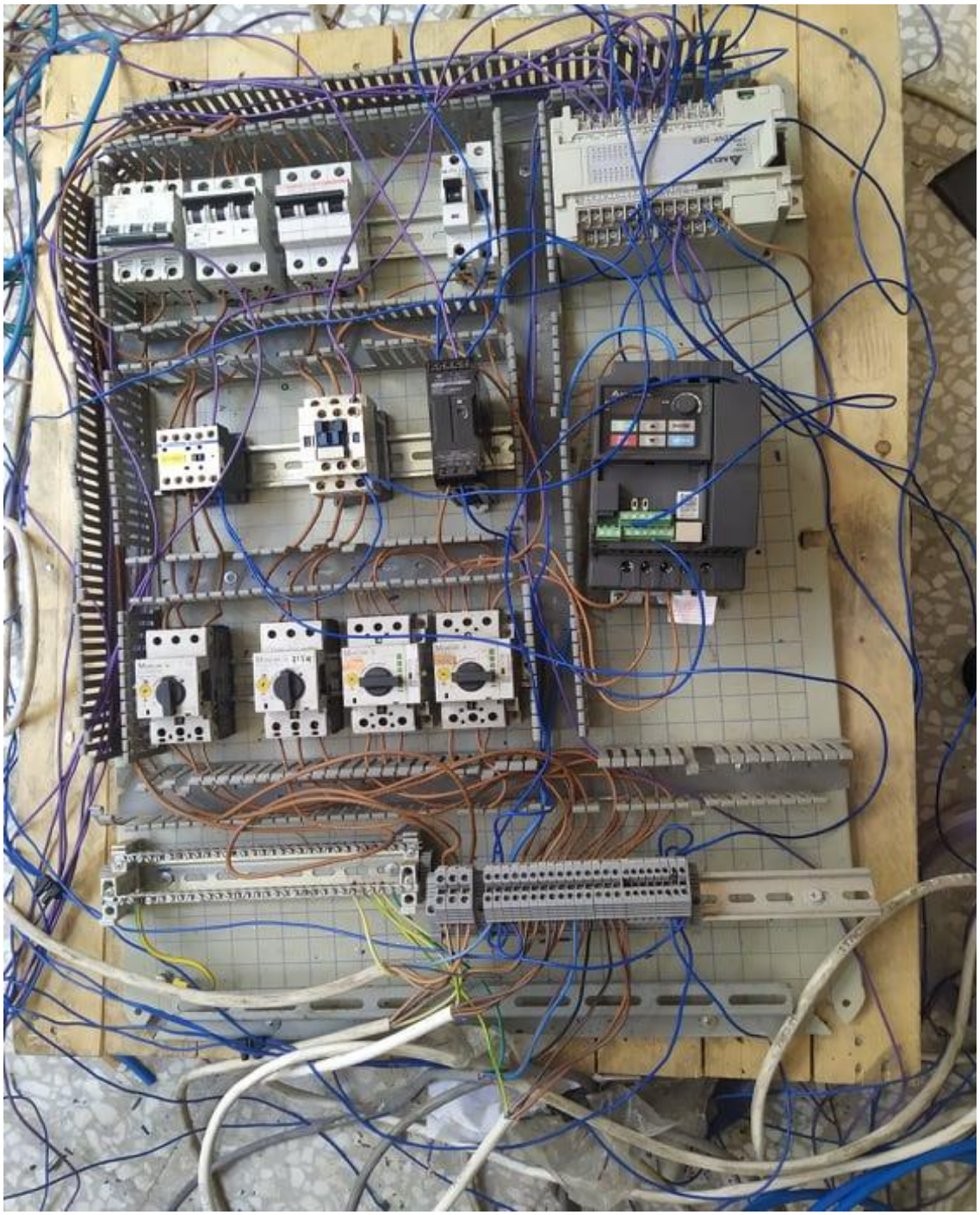
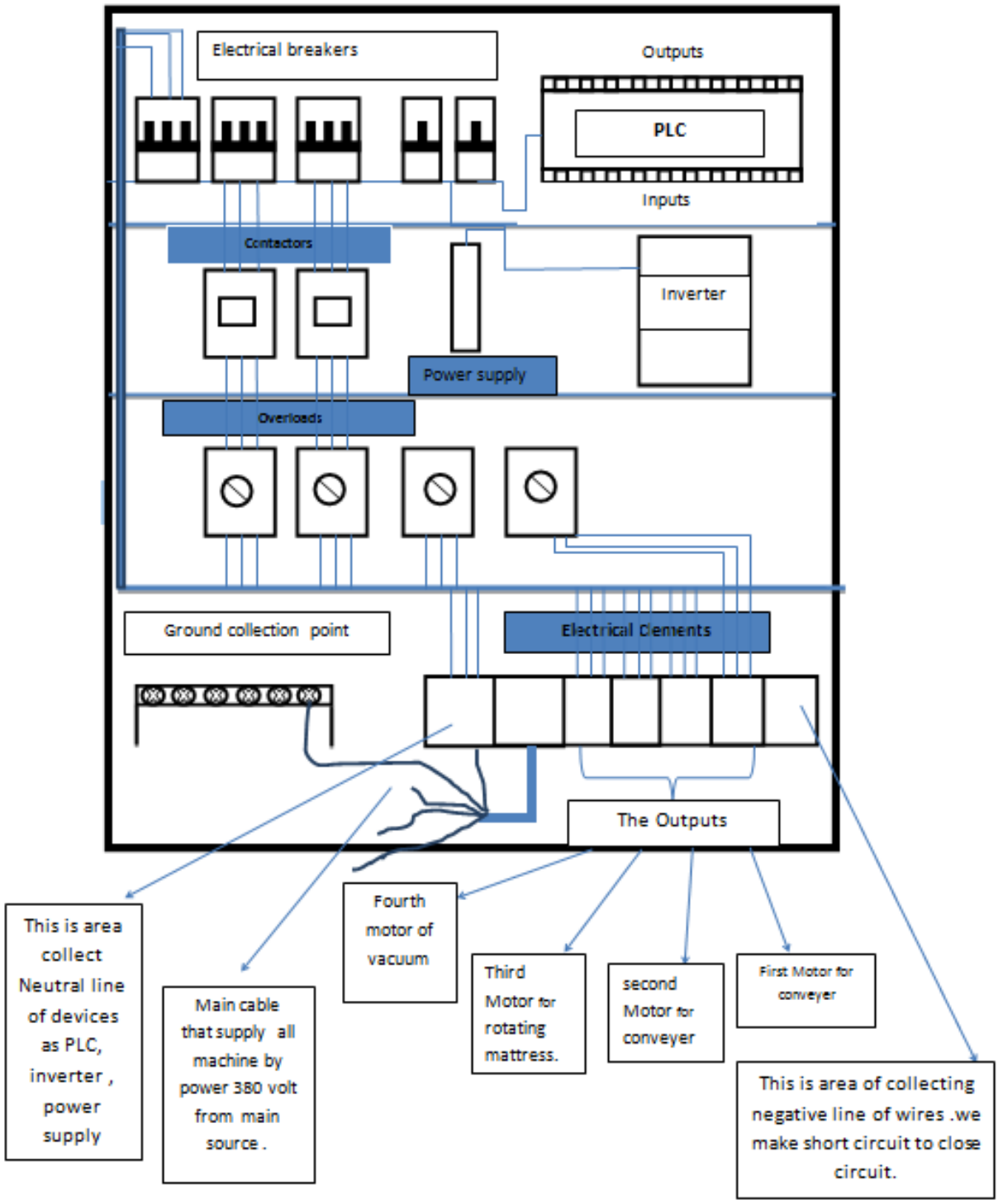


Figure (4.4) : Electrical panel

Panel diagram



There two of contactors the selection of them based on the available motors and power supply . So we chose normally open contactors with 24 DC volt .

There are four overloads .We selected them based on the current of motors for each other :

-The first and second motor is 0.73 A so overload around 0.6-1 A

-Third motor is 1.7 A so we chose a 1.3-1.9 A overload.

-Forth motor is 5.2 A so we chose a 3-9 A overload .

Chapter 5:Hydraulic system

5.1 : Pneumatic systems

Pneumatic systems is a branch of engineering that uses the gas or pressurized air .Pneumatic systems used in industry are commonly powered by compressed air or compressed inert gases[1].

Advantages of using pneumatic system in this project :

-Simple design.

-Flexibility.

-Suitable for industrial environment.

-Power-to-weight ratio. That means small components can handle large weight.

In this project we used pneumatic system in four stages which are :

-First is used to lift the mattress.

-Second is used to move the arm of label tape.

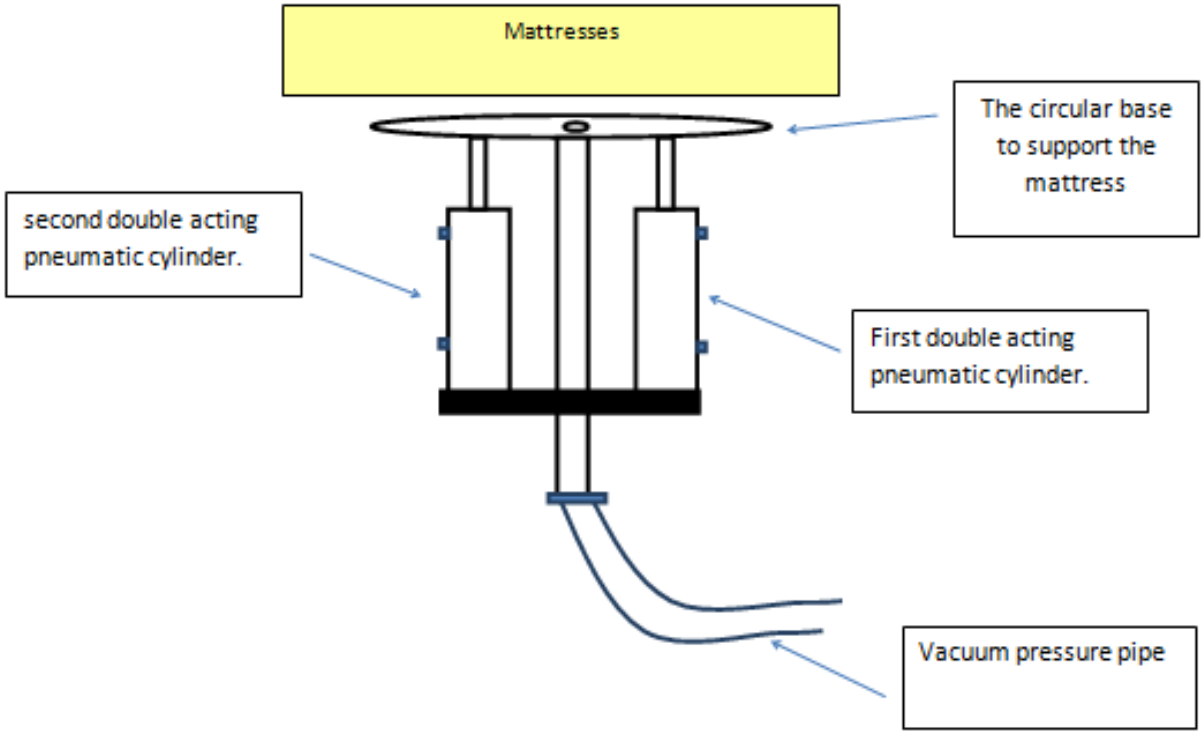
-Third is used to cut the label tape after finishing the taping process.

-Fourth is to apply vacuum pressure to fix the tape on the arm .

5.1.1Pneumatic system of part that responsible for rising the mattress

In this system we needed a way to lift the mattress from the level of the conveyor surface so that it is calibrated accurately with the height of the arm to prepare it for rotation. We need a simple and strong reliable system that can carry the mattress and the iron rotational base. So the idea was to use two pneumatic double cylinders to solve this problem.

So in this part we used two double acting pneumatic cylinders with the same size ,



type, pressure and stroke . The stroke length is how far the piston travels in the cylinder[2].

Specifications :

-Size : 10x22 centimeters.

-Pressure: 8 bar.

-Stroke: 17 centimeters

Connection diagram

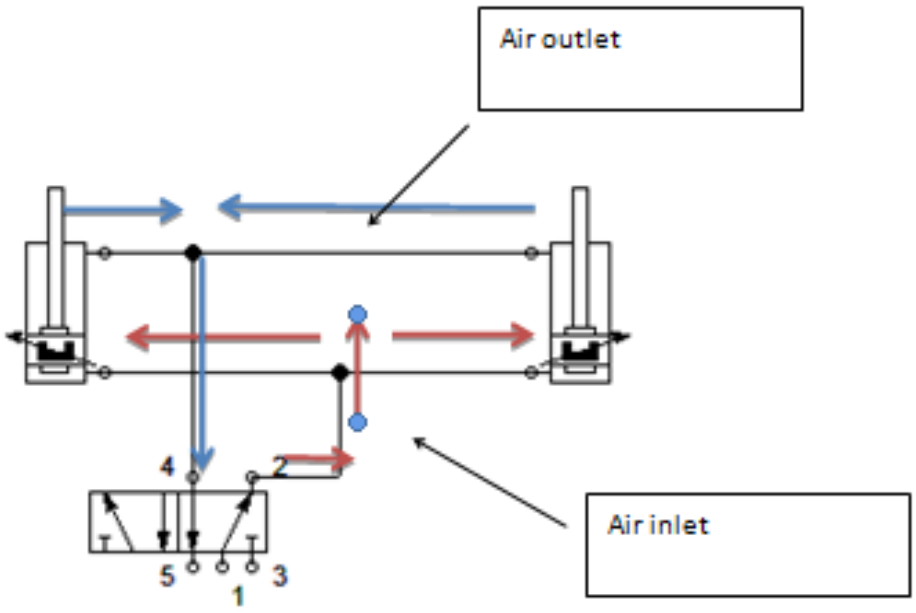


Figure (5.1) : Double acting cylinder

The two cylinders must move together almost at the same time . So we added one valve for them . it is 5/2 solenoid directional valve . We connected each cap-end for cylinders together by Tee connector and connect each rod-end for cylinders together by the tee connector. The first Tee connector with first direction of valve “1 to 2” to and second tee connector with second direction of valve “4 to 5” to expand and retract cylinders at the same time .

The main power of this system is coming from the compressed air that is supplied by a compressor the directional control valve is directing the flow of the compressed air in two different directions to rise and lower the mattresses these two double acting cylinders have an air chamber on each side of them to move the piston back and forth one of the directions expands the cylinders to rise mattresses and the other direction retracts the cylinders to them first position .

Figure (5.2) : 5/2 valve

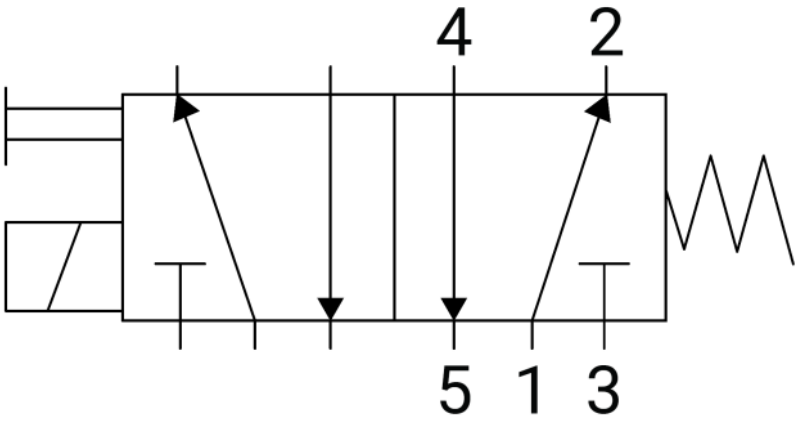


Figure (5.3) : T shape air distributer

The selection of cylinders was based on the amount of load and force that the cylinder bears, so we calculated the amount of force applied to the air cylinders based on the weight of the mattress and the weight of the iron base.

-Stroke of cylinders = 17 centimeters.

-Weight of mattresses = 4 kilograms.

-Weight of metal base= 38 kilograms.

-Piston diameter = 8 centimeters.

-Rod diameter = 2.5 centimeters.

There are two methods to calculate the force output of the cylinders that extend and retract by manually or by software programs as FISTO program.

$$F_E = p.A_p$$

$$F_R = p.(A_p - A_R)$$

5.1.2Pneumatic system for the arm of adhesive tape

In order to apply the adhesive tape to the perimeter of the mattress. a reliable pneumatic system has been designed that consists of three main parts:

-Moving arm . This part simulates the idea of a real worker's arm because it moves in a linear motion back and forth to push the adhesive tape away from the mattress at the appropriate distance.

-Cutting Tool . Cut the adhesive tape with a blade after the operation.

-Vacuum part. This part is responsible for holding theadhesive tape and fixing it to the mattress in each cycle.

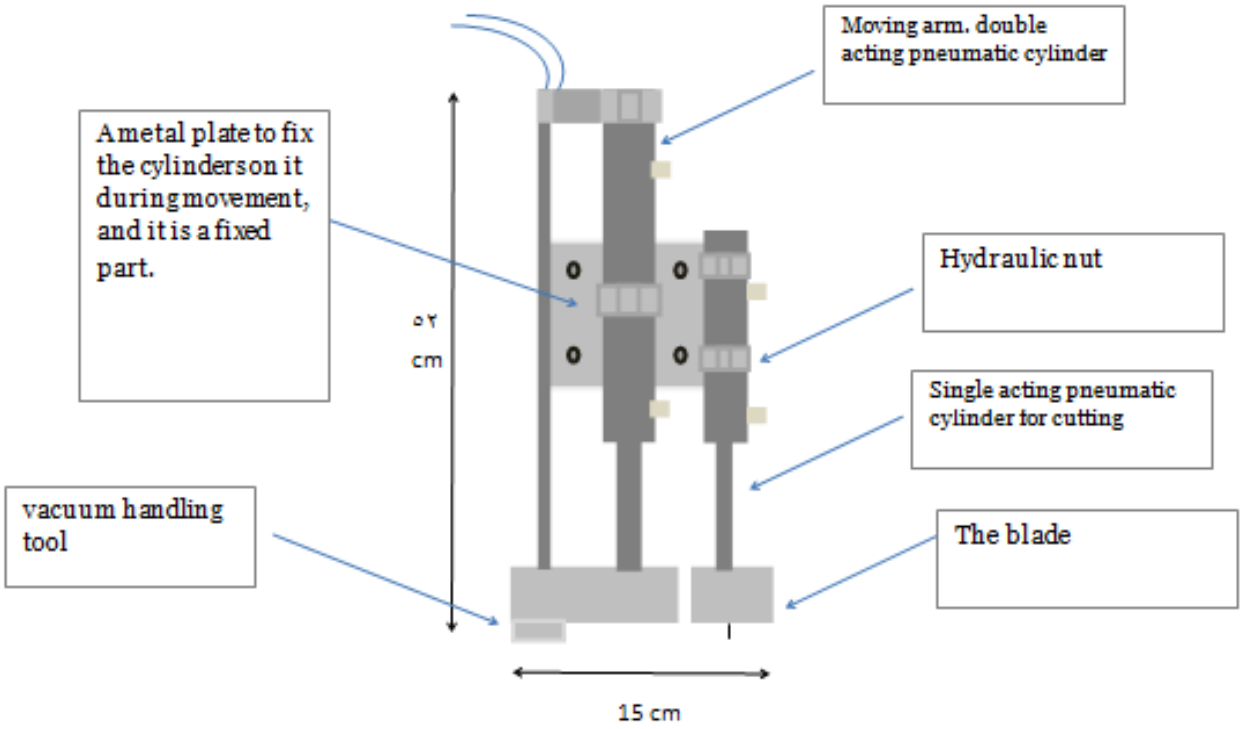


Figure (5.4) : Label adhesive arm

We used two pneumatic cylinders with the different specification .

For the first that will move the arm:

-Type : Double acting cylinder.

- Size : 2.3 centimeter.

-Pressure: 10 bar maximum.

-Stroke: 27 centimeters .

For pneumatic cylinder used for cutting :

-Size :2.3 centimeter.

-Type : Double acting cylinder

-Pressure: 10 bar maximum.

-Stroke: 12cm .

Connection of pneumatic for the arm valves

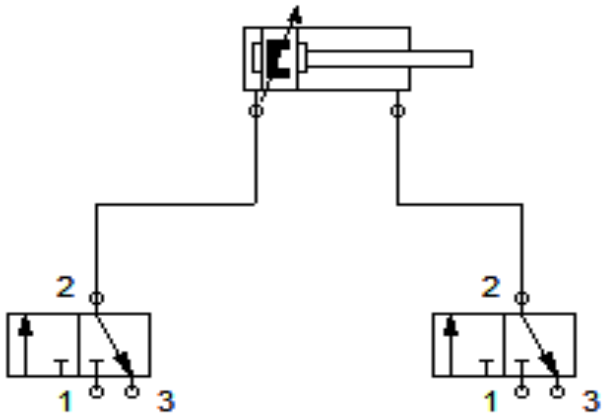


Figure (5.5) : diagram for double acting cylinder (arm cylinder).

There is a limit switch on the moving cylinder whose function is to take a signal from the mattress and give it to programmable logic controller

(PLC) . Then the cylinder must move until it touches the mattress to stick the adhesive tape in the mattress. Air enters from first valve to expand cylinder when cylinders reach at the mattress the limit switch give signal for PLC and the cylinder must stop and return to first position. So the air out from second valve .

To calibrate the position pneumatic cylinder We use two of 3/2 solenoid one directional control valves .

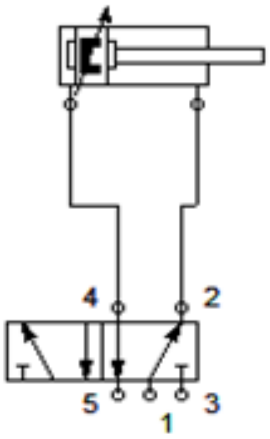


Figure (5.6) : Diagram for blade cylinder

The main power of this system is coming from the compressed air that is supplied by a compressor the directional control valve is directing the flow of the compressed air in two different directions to cut the adhesive tape .This double acting cylinder has an air chamber on each side of it to move the piston back and forth one of the directions expands the cylinder to cut by blade and the other direction retracts the cylinder to the first position .

5.2Vacuum part

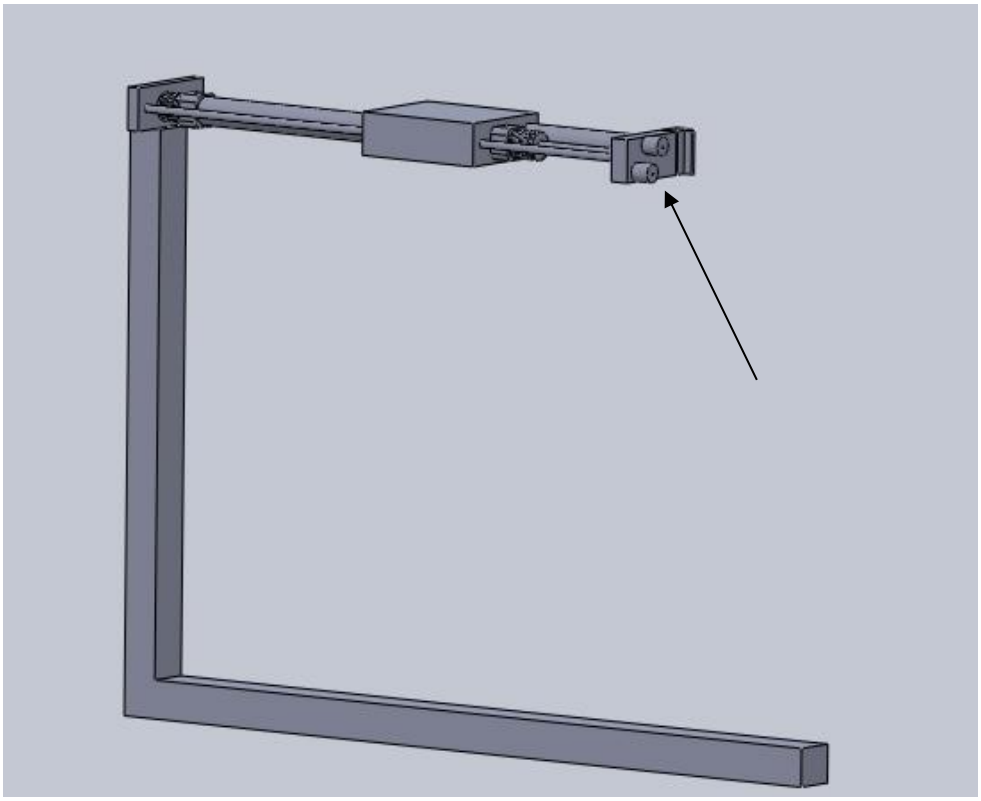
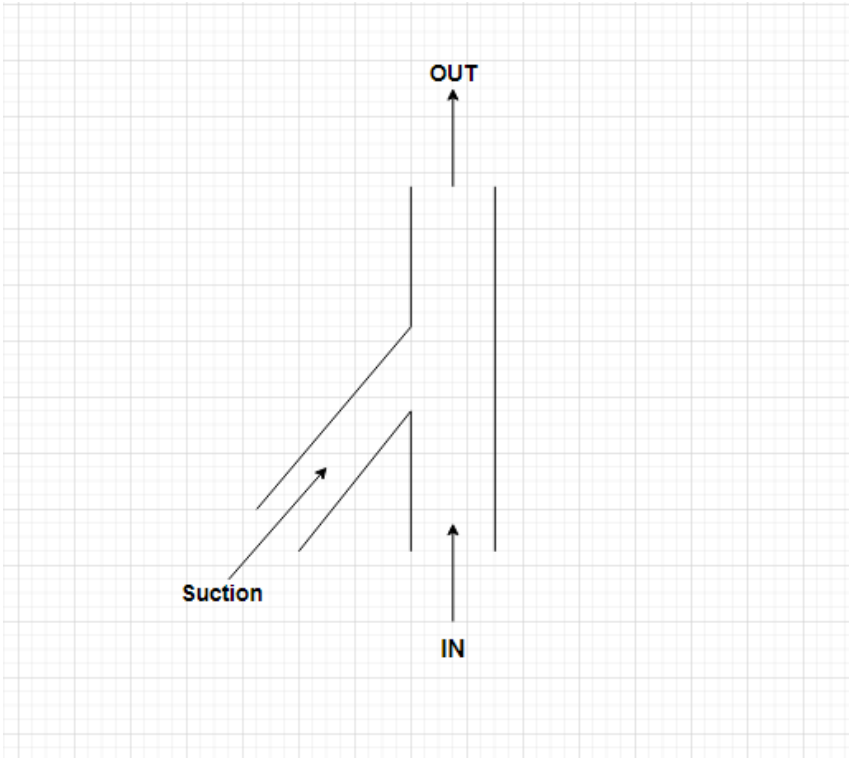


Figure (5.7) : label adhesive vacuum

This part function is to make an airflow throw a specific path and due to this airflow it will make an inverse air suction . This inverse air suction will hold the adhesive tape from falling of the arm when taping and cutting it . This part made our project from being just one cycle system to continuously working system (infinite cycles) by Venturi model .



Chapter 6: Selection of motors

The procedure to select the optimal motor for these applications.

1-First step is to determine the mechanism .

2-Then we check the required specifications.

3-Then we calculate the load.

4-Then we select the motor type.

5-Then we calculate the required calculations .

There are two methods of selecting a motor . It can be manually or by software.

1-Conveyer motor

For this application we chose AC induction motor to move the conveyor with timing belt drive to achieve the following :

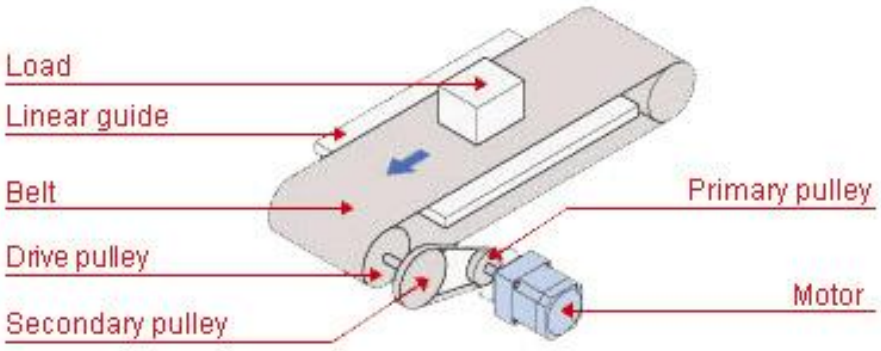
-High torque carrying capacity.

-No slipping between the belt and pulleys.

-Low noise and vibration.

-Lubrication not required.

This application needs a 3-phase motor to operate at this industrial machine .



Fig(6.1) : Conveyer layout

Speed of conveyer motor

This project needs to move the four-kilogram mattress at a rate of five seconds on a one and half-meter-long conveyor.

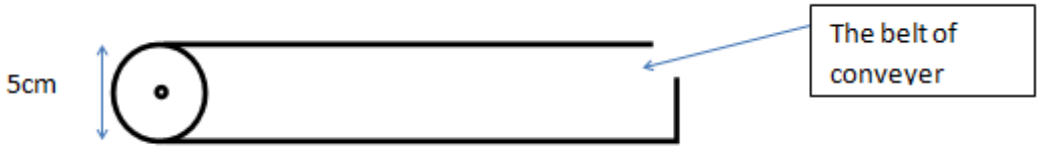
-The mass of mattress =4kgm.

-The time=5s.

-The distance =1.5m .

The velocity of conveyer =$\frac{distance}{time} = 0.3\ m/s.$

By back to the design of the conveyer we found that the drive pulley of the conveyer has diameter of five centimeters . By this information we can calculate the distance that the motor can move the mattress in one recycle .



The distance per one recycle = the perimeter of drive pulley of conveyer that we can calculate by $the\ diameter\ of\ the\ pulley * pi = 0.157\ meter$. We also need to convert this unit of velocity to revolution per minute.

$$0.3\frac{meter}{second} * 60\frac{second}{minute} * \frac{one\ recycle}{0.157\ meter} = 115\ rpm.$$

This application needs a motor that has a speed of at least 115 rpm.

Torque of conveyer motor

In this part we relied on the software program in calculating the necessary torque for the motor through a website. We entered the parameters and got the result.

Required parameters:

Total mass of belt and load =32 kilogram .

External force = zero.

Friction coefficient of sliding surface =0.5.

Roller diameter =0.05 meter.

Roller mass= 2 kilogram .

Belt and roller efficiency = 0.4.

Belt speed=0.157 m/s

Motor power supply = 230 V ,three phase.

Operating time =8hours/day.

The result is required torque with a value of 500 N.m.

So we selected this suitable motor that has these specifications:

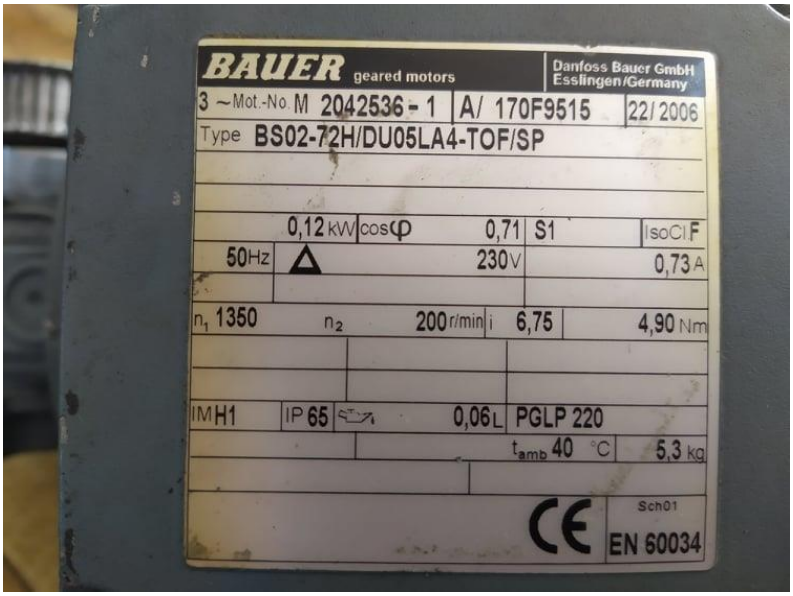


Figure (6.2) : Conveyer motor plate

2-The motor that rotates the mattress

This application needs a system that rotates the mattress just for one cycle at the finishing processes of applying the adhesive tape on all sides of the mattress.

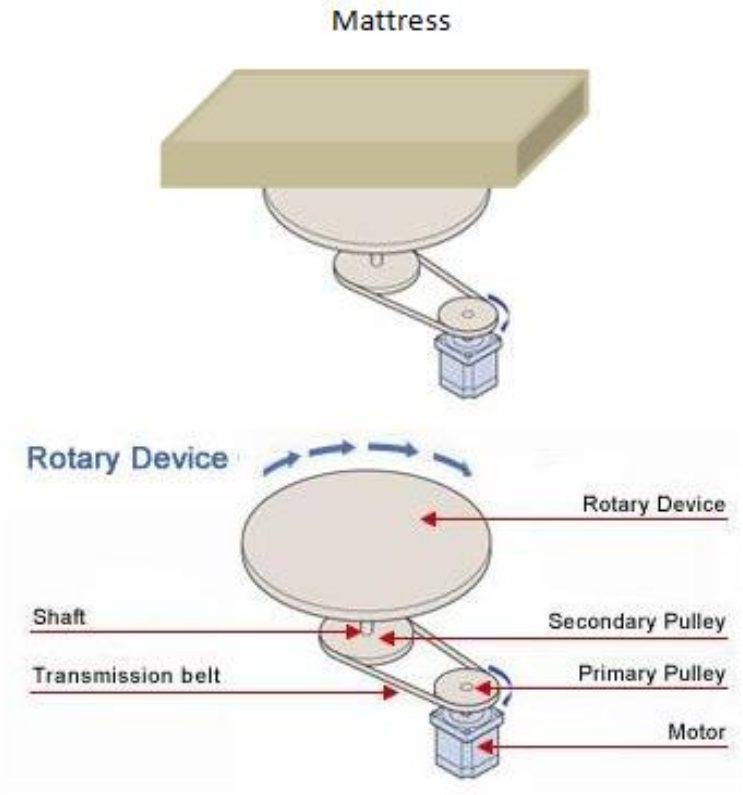


Figure (6.3) : Base working principle

As shown in the figure for this motor we used timing chain drive. It is a metal part. It has holes or gaps on it due to which it takes a grip on pulley gears. It is suitable if you want a part which will not fail or needs to be replaced earlier.

Figure (6.4) : Chain drive

We need to rotate the mattress for five seconds during a one cycle (12 rpm) . That means we can calculate the angular velocity for this .

-The total mass of load =4kgm.

-Time=5s.

-Inner diameter of the shaft =3.5 centimeter.

-Outer diameter of the shaft =4.5 centimeter.

The distance per one recycle = the perimeter of drive shaft that we can calculate by $the\ diameter\ of\ shaft * pi = 0.142\ meter$. We need to convert this unit of velocity to recycle per minute .

So in general we must use motor with high torque and low speed with high reduction ratio .

In this part we relied on the software program in calculating the optimal motor selection . We entered the parameters and got the result.

Sizing Results

Load Inertia	J_L	=	2.7944e-2	[kg·m ^{2}]
Required Speed	V_m	=	252	[r/min]
Required Torque	T	=	1665	[N·m]
Acceleration Torque	T_a	=	2.458	[N·m]
Load Torque	T_L	=	1107	[N·m]
Required Stopping Accuracy	Δθ	=	0	[deg]
Other Requirement(s)				

Figure (6.5) : Sizing results

As shown in the figure this is the group of the results that we got . We found suitable motor has the following specifications:

Figure (6.6) : Rotating motor plate

This motor has 860 rpm so we use gears to reduce its velocity . Primary gear has nine tooth and secondary gear has forty tooth.

$velocity2 = velocity1\ \frac{N2}{N1}$.

By this the velocity will become around 170 rpm. This value is suitable for this application .

The torque equal $\frac{power}{angular\ velocty}$. Which give a torque of1444 N.m .

So this motor is suitable .

3-Vacuum motor

The main motor generates air suction to hold the mattress on the base and prevent it from slipping during the spinning phase. We reached by experience to optimal vacuum motor that gives ideal and suitable vacuum pressure . Which will not make any rupture for the plastic cover of the mattress. We selected this optimal motor pump which has 300 mbar vacuum pressure.

Figure (6.7) : Vacuum motor plate

Chapter 7 : Conclusion

In this project we converted the full manual taping process into full automatic one by designing a lot of systems and subsystems to get this job done . This was first just an idea which has become a reality and working as planned . Surely we faced a lot of problems and experienced a lot of new things before getting this project done as we want it to be . to get this job done we designed and built a hall machine by designing all its parts . We extended an existing conveyer to made it suitable for our mattress to move on . Then we designed a jack vacuum system that will lift and hold the mattress while taping it . In this system we used two bearing parts and connect them with a rod to rotate the rod while he is lifting the mattress . We also connected the rod with a motor by a chain to give the rod the suitable torque . This system worked perfectly as planned . Then we designed the adhesive arm where we faced some problems building it in the beginning . Firstly we designed two arms one of them will hold the tape from falling to make it continuously process and the other arm is for cutting the label when finishing the taping process . This system didn't work as planned because we needed a lot of cylinders to get it work perfectly . This caused heavy weight on the arm making low accuracy taping process . So we chose to reduce the number of cylinders by designing a cylinder with a vacuum in it to hold the tape instead of the cylinder we used earlier . Also we connected a blade to the same cylinder which made us get rid of another cylinder . This system also faced some

kind of problems at the beginning like the high speed of the cylinder when it extract to stick the tape on the mattress which will not allow the adhesive to stick to the mattress . In this situation we used a regulator to control the speed of the cylinder . After solving this problem the adhesive arm worked perfectly . The conclusion that even we faced a lot of problems building our project we ended building it as we wanted it to be.

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