Palestine Polytechnic University

College of Engineering

Electrical Engineering Department

Graduation Project

Design a Machine for Diaper Forming

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الخليل – فلسطين

كلية الهندسة

دائرة الهندسة الكهربائية

إسم المشروع

Design a Machine for Diaper Forming

أسماء الطلبة

بلال وراسنة

ضياء عبايدة

عمر عياش

بناء على نظام كلية الهندسة وإشراف ومتابعة المشرف المباشر على المشروع وموافقة أعضاء اللجنة الممتحنة تم تقديم هذا مقدمة المشروع إلى دائرة الهندسة الكهربائية وذلك للوفاء بمتطلبات درجة البكالوريوس في الهندسة تخصص أتمتة صناعية .

توقيع المشرف

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توقيع اللجنة الممتحنة

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توقيع رئيس الدائرة

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إهداء الى

معلمنا الأول ومعلم الناس الخير

نبينا محمد صلى الله عليه وسلم

إلى من زرعوا فينا الطموح والمثابرة

أبائنا الأعزاء

إلى من سهرن الليالي

أمهاتنا الحبيبات

إلى من مهدوا لنا طريق العلم

أساتذتنا الأكارم

إلى من يستحق الشكر

مشرفنا الفاضل

إلى من ناضلوا من أجلنا

شهدائنا وأسرانا وجرحانا

Abstract:

An artificial machine used for the formation of diapers and automatic packaging, where the process of forming diapers stretching and flexing and then the collecting certain number of diapers to be then compressed and put them in special bags and then close these bags using thermal welding.

Most of the local factories working in the field of diapers production manually perform all up mention stages. Which requires the huge workforce, time consuming and effort. So we designed this machine to accelerate the process of production, save time and effort.

This machine forms diapers of multiple sizes, where the duration of the production time one minute to three minutes depends on the speed of feeding the row materials done by the worked.

This machine is controlled by a "PLC" technology which receiver signals from switches and sensors to control the operation of the machine.

The prototype part is conducted for two production stages compressing and package the diapers inside the bags and seal them by means of thermal welding. This process take around, 15 seconds depending on the speed of the worker.

The proposed machine allows three mods of operate manual, semi-automatic and automatic operates, where the proposed design has form operation stages: collection certain number of diapers in one set, compressing and finally filling the set in special bags and closing the bags using welding.

ملخص:

آلة صناعية تستخدم لتشكيل الحفاضات والتعبئة التلقائية ، حيث تتم عملية تشكيل الحفاضات ببسطها وثنيها ثم تجميع عدد معين من الحفاضات ثم يتم ضغطها ووضعها في أكياس خاصة ثم تغلق هذه الأكياس باستخدام اللحام الحراري.

معظم المصانع المحلية العاملة في مجال إنتاج حفاضات الأطفال تقوم بأداء جميع المراحل المذكورة. وهو ما يتطلب قوة عاملة ضخمة ، مضيعة للوقت والجهد، لذلك قمنا بتصميم هذه الآلة لتسريع عملية الإنتاج ، وتوفير الوقت والجهد.

تشكل هذه الآلة الحفاضات بأحجام متعددة ، حيث تعتمد مدة وقت الإنتاج من دقيقة واحدة إلى ثلاث دقائق تعتمد على سرعة تغذية مواد الصف التي يقوم بها العامل.

يتم التحكم في هذا الجهاز من خلال تقنية "PLC" التي تستقبل الإشارات من المفاتيح وأجهزة الاستشعار للتحكم في تشغيل الالة.

تم إجراء جزء النموذج الأولي لمرحلتي إنتاج الضغط وتغليف الحفاضات داخل الأكياس وختمها عن طريق اللحام الحراري، حيث تستغرق هذه العملية حوالي 15 ثانية اعتمادًا على سرعة العامل.

تسمح الالة المقترحة بثلاثة أوضاع من التشغيل اليدوي وشبه التلقائي والتشغيل التلقائي ، حيث يحتوي التصميم المقترح على مراحل التشغيل التالية : جمع عدد معين من الحفاضات في مجموعة واحد وضغطها وملئها أخيرًا في أكياس خاصة وإغلاقها الاكياس بواسطة اللحام الحراري.

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1.7 Estimated Project Cost.

1.8 Time Table.

1.1 Introduction:

Diaper production technologies rapidly evolve to meet the demand for more comfortable diapers. Disposable diapers are renowned for their world-leading quality and well-designed construction for maximum comfort.

Where companies compete to provide the market with high quality product and comfortable product by using state of the art technology.

1.2 General Background:

A disposable diaper consists of an absorbent pad sandwiched between two sheets of nonwoven fabric. The pad is specially designed to absorb and retain body fluids, and the nonwoven fabric gives the diaper a comfortable shape and helps prevent leakage.

These diapers are made by a multi-step process in which the absorbent pad is first vacuum- formed, then attached to a permeable top sheet and impermeable bottom sheet.

The components are sealed together by application of heat or ultrasonic vibrations.

Elastic fibers are attached to the sheets to gather the edges of the diaper into the proper shape so it fits snugly around a baby's legs and crotch.

When properly fitted, the disposable diaper will retain body fluids which pass through the permeable top sheet and are absorbed into the pad.

1.3 Project Overview

Design production has complicated process that combine folding, sewing, cutting, conveyor, and hemming sections which incorporates novel means for centering during folding, for regulating the overall width during sewing of a center fold and for conveying diaper segments in a novel manner while hemming [1], the whole production line for diaper product, as shown in fig 1.1.

Figure 1.1: Production line for diaper product.

This project aims at formation process.

1.4 Project Objectives:

Design and implementation of such machine aiming at:

1) Acceleration the productive to make the market need.

2) Increasing the product quality and competiveness rate.

3) Improve the productivity effect by producing the work and less error.

These aims can be achieved throughout:
- Design concept.
- Accurate flexing.
- Assembling.
- Compressing.
- Packaging.

1.5 Project Description:

The machine contain a dual bus conveyor that pulls the diaper into a pneumatic piston for bending and inserting the diaper into another dual pass conveyor pass the diaper to place it on a conveyor belt for assembly.

After that, it will take a certain number of diapers for compression and packing. All of these stages represent in picture as show in fig 1.2

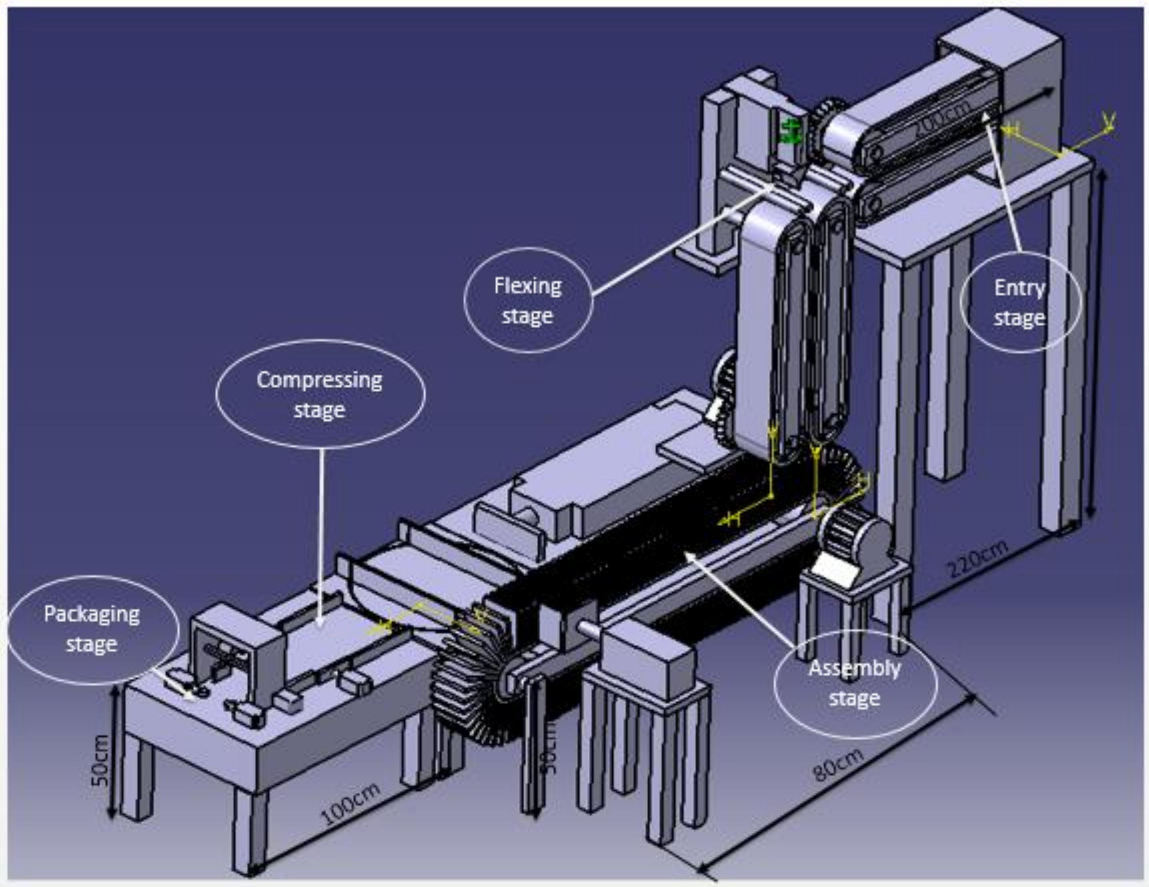


Figure 1.2: Production Line Stage

1.6 Functional Block Diagram:

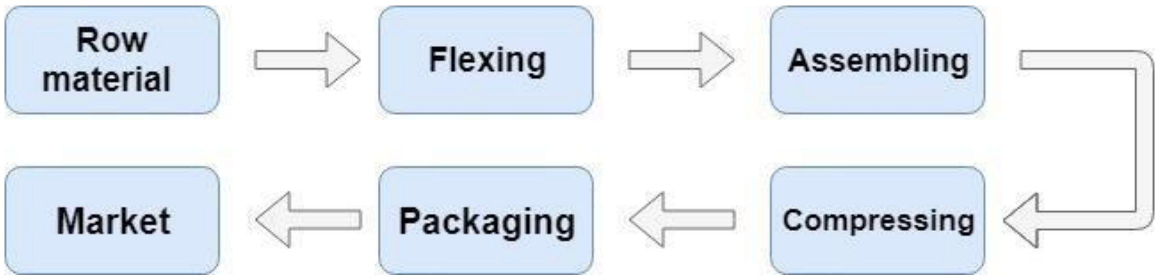


Figure 1.3: Machine stages.

1.7 Estimated project cost:

	Description	Price "NIS"
1.	Dual Conveyers	**5000**
2.	Schneider PLC, HMI and Variable Drive	**6700**
3.	Stepper Motor and Indication Motors	**4500**
4.	Pistons	**3000**
5.	Mechanical parts	**6000**
6.	Sensors, Switches and Relays	**1500**
7.	Electrical control panel, Wires and Cables	**700**
8.	Accessories	**3000**
9.	Technical and engineering work	**7000**
	Total Price	**37400**

1.8 Time Table:

Task month	9	10	11	12	1	2	3	4	5
Selecting group members and choose supervisor	■								
Choosing project	■								
Studying of project	■								
Writing an initial report explaining the project	■								
Detailed study		■							
Design of the machine on the CATIA program		■							
Select the controller and electrical elements		■							
Simulation of the project		■							
Writing the introduction of the project			■						
Complete the project chapter with supervisor feedback			■						
Submission the introduction				■					
Presentation and discussion				■					
Purchasing of mechanical and electrical parts						■	■	■	
Partially project implementation						■	■	■	
Programming the project						■	■	■	
Write project graduate with supervisor feedback									■

2

Chapter Two

Diaper Machine Forming

2.1 Introduction.

2.2 Machine Stages.

2.2.1 Flexing Stage.

2.2.2 Assembling Stage.

2.2.3 Compressing Stage.

2.2.4 Packaging and Transferring Stage.

2.1 Introduction:

This chapter, explain the general stages of forming diaper machine. Will explaining the development of forming diaper in a full automated system programmed with a PLC, which will allow the user to control the operation of the system.

2.2 Machine stages:

The proposed machine consist the following stages:

2.2.1 Stage one: flexing

The diaper comes up in the form of raw material with randomly shapes, where it inserted into a double belt conveyor through a nozzle, where a flat diaper is formed from and pressed (free of air), as shown in fig. 2.1.

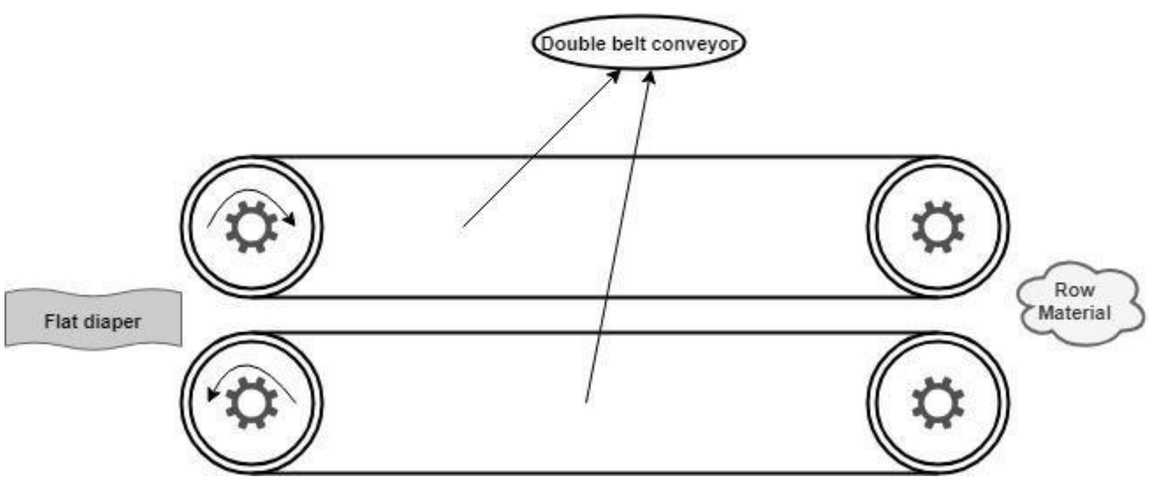


Figure 2.1: Flattening the diapers

Operation process:

1- The roll receives the flattened diaper.

2- The sensor calibrated the diaper in such away to be ready for next operation.

3- The piston pushdown the flat diaper between double belt conveyors causing diaper flexing in specific cells, as shown in fig. 2.2.

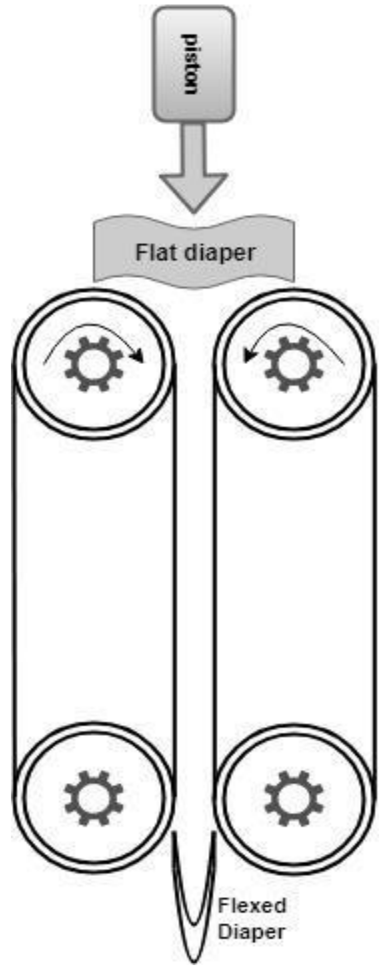


Figure 2.2: Flexing process

2.2.2 Stage two: Assembling stage:

After the flexion process, the diapers are arranged on the conveyor belt with having specified cells where the diaper push in, as shown in fig. 2.3.

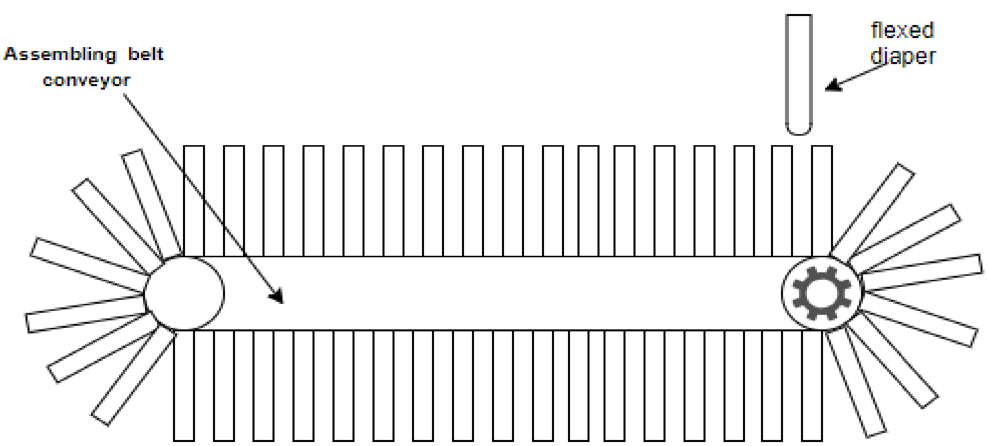


Figure 2.3: Assembling process

After the process of transferring, the diapers are sent from the conveyor to rotary trolley works to reverse the diapers direction, then the piston transfer the diapers from rotary trolley to the pressure diapers parts , as shown fig. 2.4.a & 2.4.b.

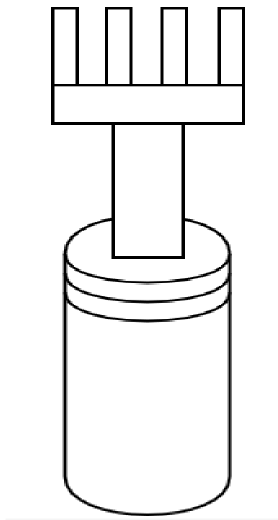


Figure 2.4.a: Transmitter process.

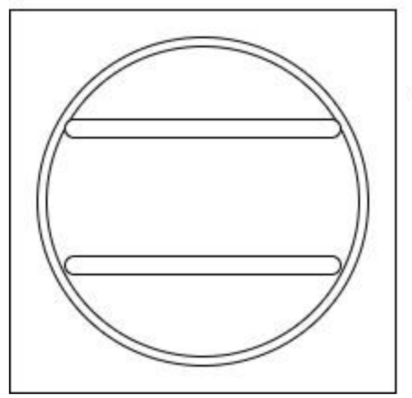


Figure 2.4.b: Rotation car

Stage three: Compressing stage:

In this section, the diapers are inserted after the formation process to the pressure pistons. When the diapers reach their position, they push the pistons and press the diapers to transfer them to the next operation, as shown in fig. 2.5.

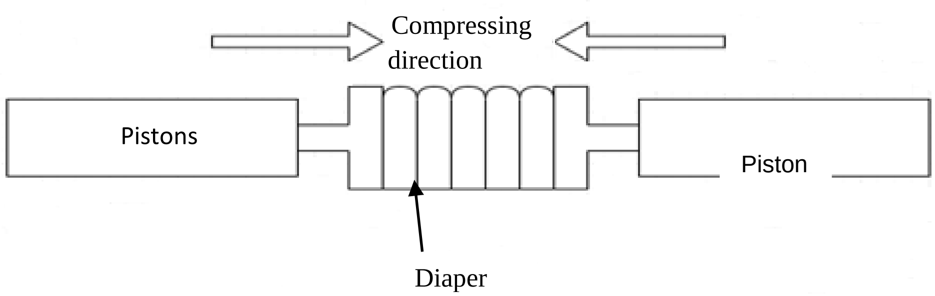


Figure 2.5: Pressure diapers

2.2.3 Stage four: Packaging and Transferring Stage:

In this sage, after compressing the diapers, the piston open the bags to transfer the diapers inside bags, then the piston works to push the diapers into bags then the piston stacked the bags , as shown in fig 2.6:

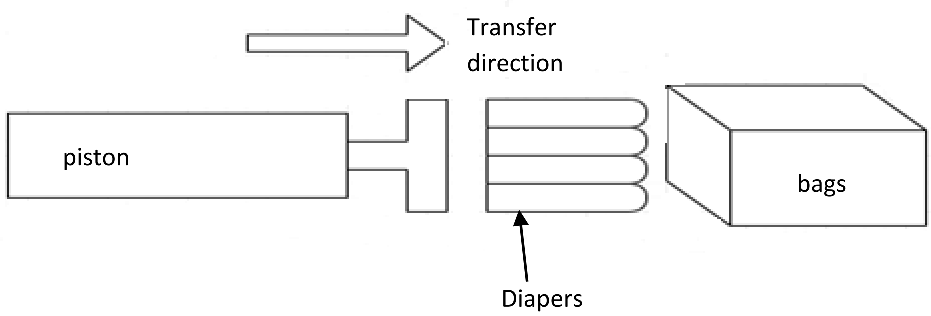


Figure 2.6: Packaging and transfer diapers in bags.

3

Chapter Three

Mechanical Design

3.1 Introduction:

This chapter will include the 3D Design for all the machine stages shown on fig 1.2, using Catia software. The proposed production sequence illustrate the mechanism operation stages starting with entry the row material of diaper, and ending with complete and finalize diaper Product ready for marketing.

The obtained diapers sizing are illustrated in table 3.2

Table 3.1: Diapers sizing

Name		Dimension		Number of diapers per packet
		Length	Width	
Size 1		15 cm	10 cm	40
Size 2		17 cm	10 cm	34
Size 3		20 cm	12 cm	32
Size 4		21 cm	12 cm	30
Size 5		23 cm	13 cm	28
Size 6		24 cm	14 cm	26
Old Diapers size	**L**	28 cm	15 cm	13
	XL	30 cm	17 cm	12

These stages are as follow:

3.2 Flexing Stage:

Flexing stage contains 4 element:

1- **Metal guard box**: used for protection the worker from eventual hazard as shown in fig 3.1.

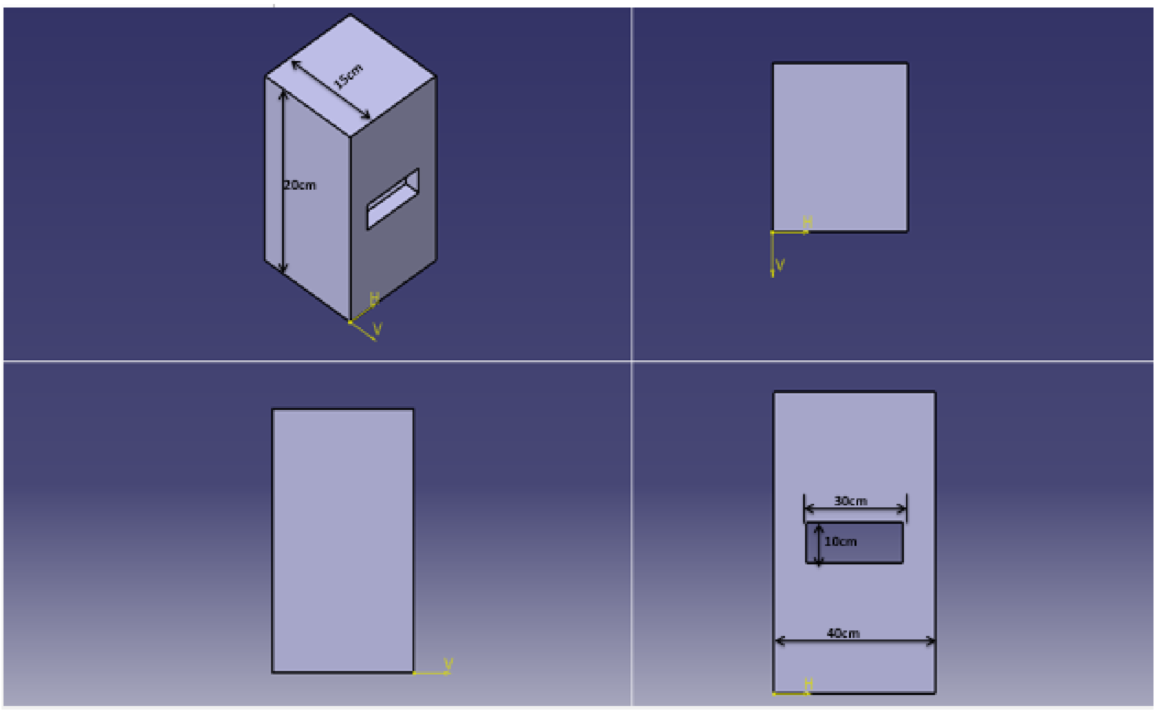


Figure 3.1: Metal guard box

2- **Double belt conveyor (horizontally):** as shown in fig 3.2.

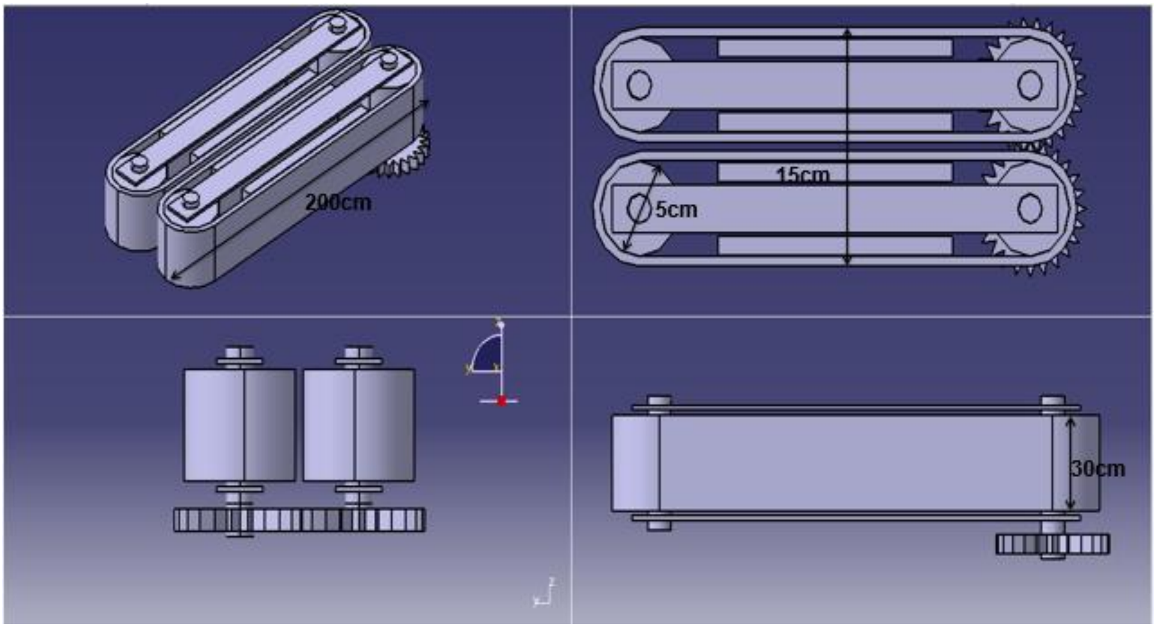


Figure 3.2: Double belt conveyor

Belt speed depends on rotational speed of motor [3]:

$$V = \frac{D}{T} \quad (3.1)$$

$$\omega = \frac{\Theta}{T} \quad (3.2)$$

$$V = r \times \omega \quad (3.3)$$

Where V: belt speed (m/s), r: Radius of pulley (m), ω: motor speed (rpm), T: time (s).

The obtained result at various motor speed are illustrated in table 3.2

Table 3.2: The belt speed at roller diameter = 5cm.

Motor speed (rpm)	Belt speed (m/s)
200	0.52
400	1.04
600	1.57
800	2.09
1000	2.61

3- **Pneumatic cylinder:** is used to flex the diaper from middle as shown in fig 3.3.

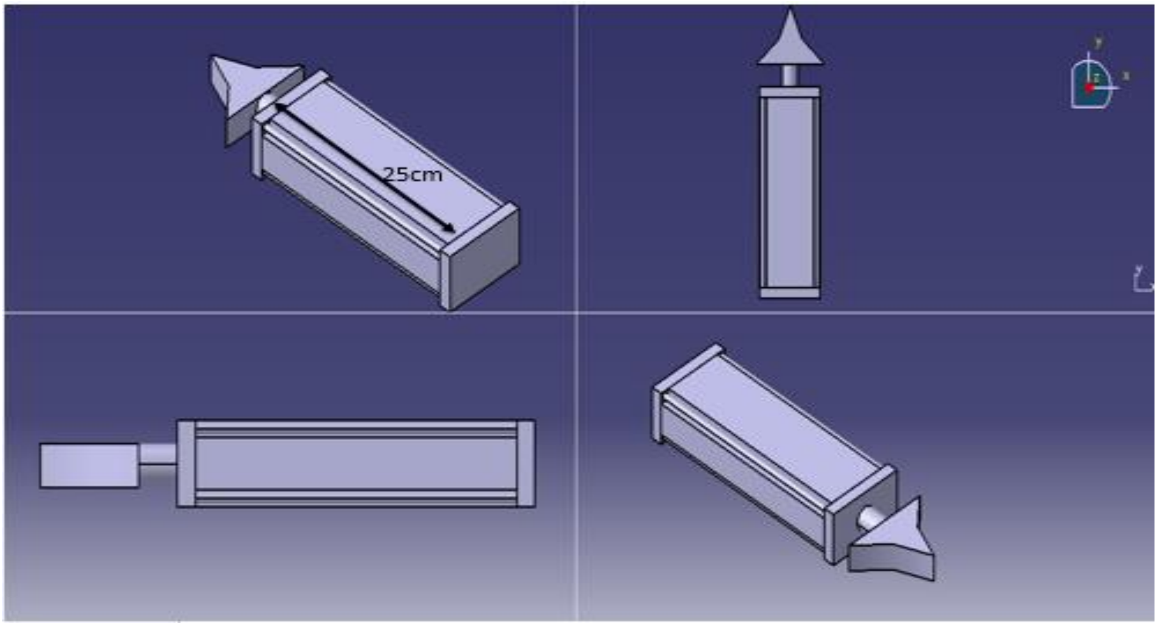


Figure 3.3: Flexing pneumatic cylinder

Cylinder calculation:

The diminution and area of flexing piston is calculated by the following equations:

$$F = P \times A \tag{3.4}$$

Where: F: Force (N)

P: Pressure = 0.3 N/mm^2

A: Cross section area of the piston rod (mm^2)

According to Newton second law, the force can be calculated as follow:

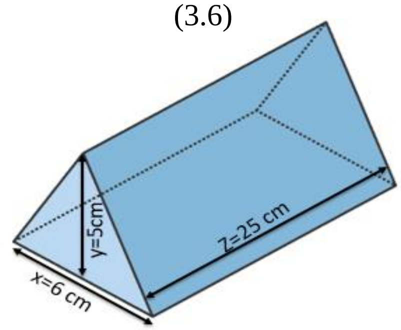
$$F = m \times g \tag{3.5}$$

Where m: Mass of prism (kg)

g: Acceleration of gravity (kg/m^2)

Mass of object can be calculated by the following equation:

$$m = \rho \times V \tag{3.6}$$



Where ρ: Plastic density = 900 kg/m^3

V: Volume of prism (m^3)

The volume of prism can be calculated by the following equation:

$$V = \frac{1}{2} \times x \times y \times z \tag{3.7}$$

Where: V = 0.000375 m^3

The prism mass equal 0.337 kg.

The push force equal 3.31 N.

The required piston rod area equal 11.03 mm^2.

The piston rod diameter can be calculated by the following equation:

$$A = \frac{\pi}{4} * d^2 \tag{3.8}$$

Where: d = 3.74 mm

According to ISO Cylinder (series C85) standard [2], the following specifications of flexing pneumatic cylinder are:

Bore size = 10 mm.

Rod size = 4 mm.

Cylinder stroke = 100 mm.

The piston speed can be calculate by the following equation:

$$V = d / t \quad (3.9)$$

Where V: piston speed (mm/s).

d: cylinder stroke (mm).

t: extended or retracted time (s).

The extended and retracted time of flexing piston should not exceeded 0.5 second so

$$t = 250ms.$$

$$V = 400\ mm/s$$

The required flow to achieve this speed can be calculated by the following equation

$$Q = V \times A \quad (3.10)$$

$$Q = 31.4\ cm^3/s$$

Where Q: The air compressed flow (cm^3/s).

V: Piston speed (mm/s).

A: Cylinder area (m^2).

4- Double belt conveyor (vertically): as shown in fig 3.4.

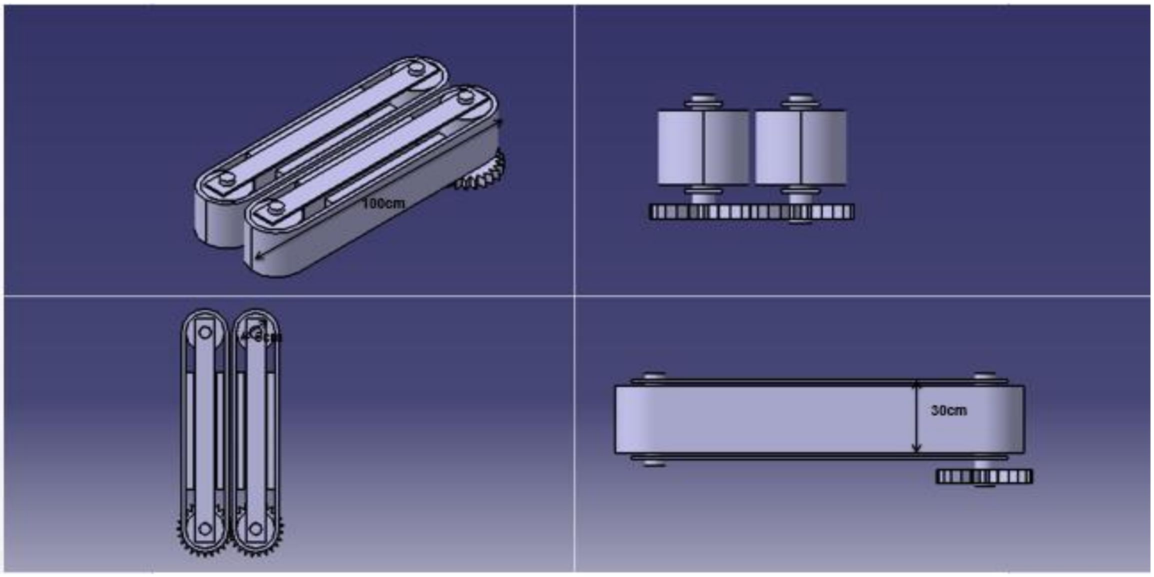


Figure 3.4: Double belt conveyor

Calculating the torque of the conveyor motor:

Table 3.2 represents the main mechanical properties of the conveyor belt and some mechanical coefficients

Table 3.3: Mechanical properties:

properties	Value
Steel density ($\boldsymbol{\rho_s}$)	8000 kg /m^3
Belt density	1200 kg/m^3
Belt thickness	0.01 m
Belt width	30 cm
Belt length	200 cm
The diameter of the pulley	5 cm
Fraction coefficient (μ)	0.35
Plastic density($\boldsymbol{\rho_p}$)	900 kg/m^3

The belt area = $lenght \times width$ (3.11)

= 0.6 m^2

The belt volume = $thickness \times area$ (3.12)

= 0.006 m^3.

The belt mass = $\rho_s \times v$ (3.13)

= 7.2 kg.

Where ρ_s: $Steel\ density$.

V: Belt volume.

Mass of pulley = $\rho_s \times area\ of\ pully\ \times length\ of\ pully$ (3.14)

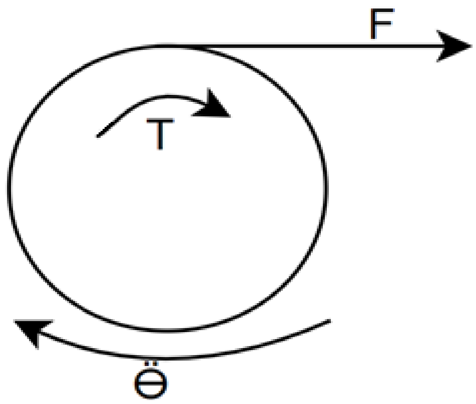
= 4.71 kg

Mass of diaper 0.1 kg.

The total mass obtained:

$m_{equivalent} = m_{belt} + 2\times m_{pulley} + m_{object}$ (3.15)

= 17.62 kg.



The belt motor torque found by substitution in Newton's low [3]:

$$\Sigma M_0 = J_0\ddot{\Theta} \tag{3.16}$$

$$T - F_f \times r - C_t\dot{\theta} = J_0\ddot{\theta}$$

Where F_f: Fraction force (N), T: Motor torque (N.m), r: Radius of pulley (m), C_t : Bearing coefficient factor, J_0 : Mass moment of inertia (kg.m^2), $\dot{\theta}$: Angular velocity (rad/s), $\ddot{\theta}$: Angular acceleration (rad/s^2).

$$\text{Fraction force} = m_{object} \times g \times \mu \tag{3.17}$$

$$= 0.343 \text{ N}$$

The moment of inertia [3] can be calculated:

$$J_0 = \frac{1}{2} m_{equivalent} \times r^2 \tag{3.18}$$

$$= 0.55 \text{ Kg/m}^2$$

The maximum motor speed in adjusted to 200 rpm, which in 0.52 m/s linear velocity.

$$\omega = \frac{speed}{r} = \frac{0.52}{0.025} = 20.8 \text{ rad/s.} \quad (3.19)$$

$$\ddot{\Theta} = \frac{\Delta\omega}{\Delta t} = \frac{\omega 2 - \omega 1}{t2 - t1} \quad (3.20)$$

$\ddot{\Theta}$ = 5 rad/s.

Where m: Mass (kg).

μ: Friction coefficient.

The value of the bearing frication (C_t) is taken from the table (3.3)

Table 3.4: Bearing fraction coefficient

Bearing Type	Coefficient of Friction (C_t)
Deep Groove Ball Bearing	**0.0015**
Angular Contact Bearing	0.002
Cylindrical Roller Bearing, Cage	0.001
Tapered Roller Bearing	0.002
Spherical Roller Bearing	0.002
Ball Thrust Bearing	0.0015
Tapered Roller Thrust Bearing	0.005

$$T = F_f \times r + C_t\dot{\theta} + J_0\ddot{\theta} \quad (3.16)$$

T = 2.75 N.m

The machine has two belt conveyor, where the total torque of these conveyors equal to 5.577 N.m.

3.3 Assembly Stage:

This stage Contain single modular belt with flap to safe the flexed diapers as shown in fig 3.5-a, 3.5-b.

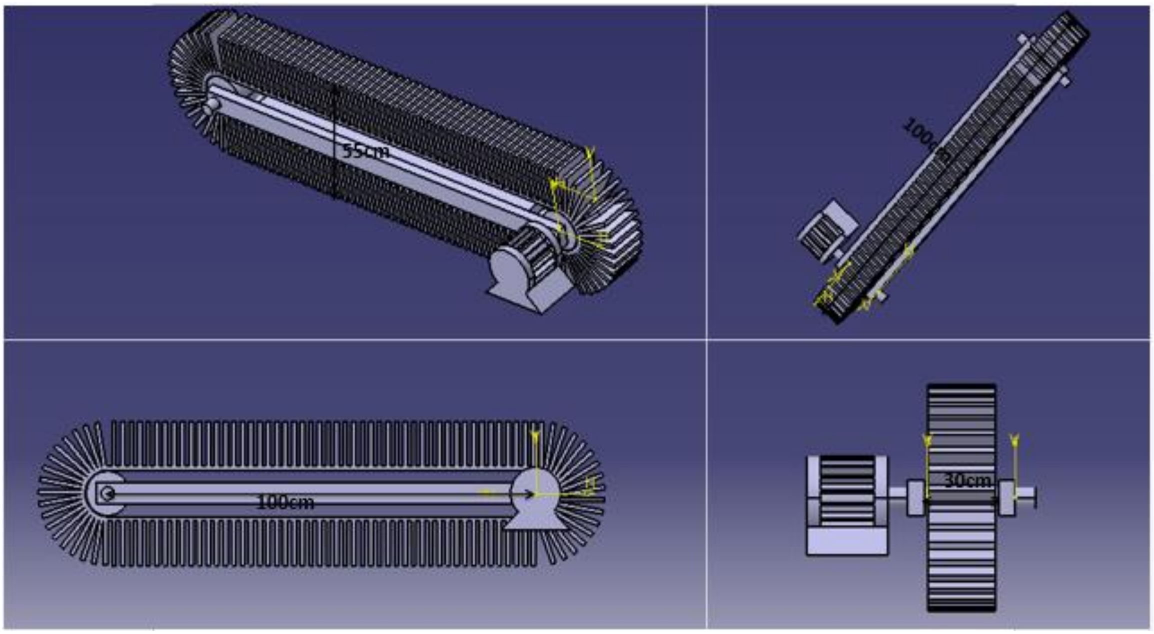
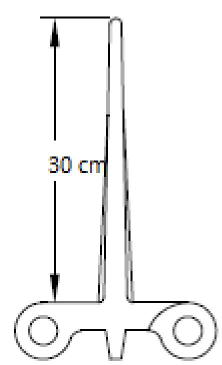


Figure 3.5-a: Assembly stage

Figure 3.5-b: Flap belt type

Calculating the torque of the assembly conveyor:



Mass of flap belt = 3.8 kg/m.

According to the equations (3.14), the pulley mass= 4.71 kg.

Total mass can be calculated as following

$$m_{equivalent} = m_{pulley} + m_{flap\ belt} + m_{diapers} \quad (3.21)$$

$$= 21\ kg.$$

The belt torque can be calculated as follow

$$T = J_0 \times \ddot{\theta} \quad (3.22)$$

According to the equation (3.18), the mass moment of inertia equal 0.00656 kg/m^2.

The length of the belts upper side equal to 1 m, the step distance between two cells equals to 0.025 m and the time for1q each step equals to 1s.

The angular step speed can be calculated by the following equation

$$\ddot{\theta} = \frac{a}{r} \quad (3.23)$$

Where $\ddot{\theta}$: angular step speed (rad\s).

a: acceleration ($m\backslash s^2$).

r: pulley radius (m).

The acceleration [3] can be calculated by the following equation

$$a = \frac{\Delta r}{4 \times (\Delta t)^2} \quad (3.24)$$

Where Δr: Step distance (m).

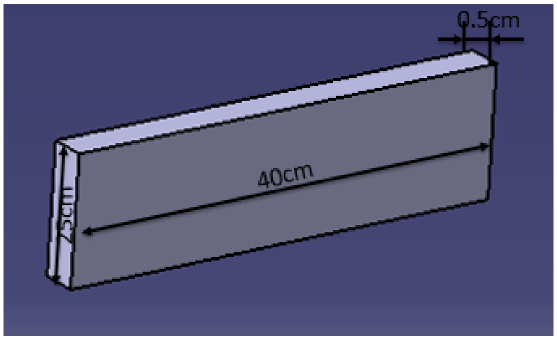
Δt: Step time (s).

$$a = 0.00625\ m\backslash s^2$$

$$\ddot{\theta} = 2.5\ rad\backslash s$$

$$T = 16.5\ N.m$$

The transfer piston calculations:



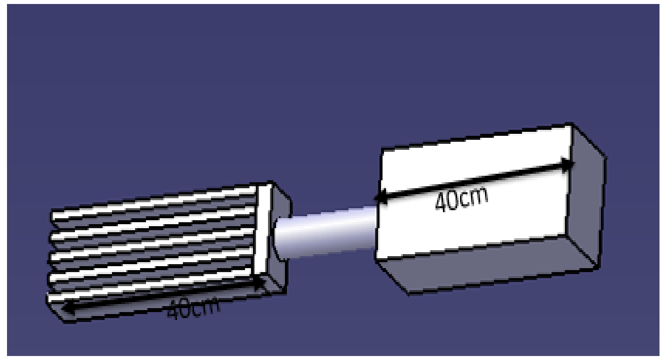


Figure 3.6: Transfer piston and cell

The following table contains the transfer piston specification.

Table 3.5: Transfer piston specification

Item	Value	According to equation
Mass of cell	0.45 kg	3.6
Number of cells	10 diapers	_____
The total push force	54 N	3.5
The rod area of piston	179.7 mm^2	3.4
The rod diameter of piston	15.13 mm	3.8

According to ISO Cylinder (series C85) standard [2], the following specifications of flexing pneumatic cylinder are:

Bore size = 40 mm.

Rod size = 16 mm.

Cylinder stroke = 400 mm.

The extended and retracted time of transfer piston should not exceeded 1 second.

According to the equation (3.9), the piston speed equal 0.80 m\s.

According to the equation (3.10), the required flow equal 1004.8 cm^3/s.

3.4 Compressing and packing Stage:

All the process in this stage depends on the Rotary trolley as shown in fig 3.6, And pneumatic cylinders as shown in fig 3.7.

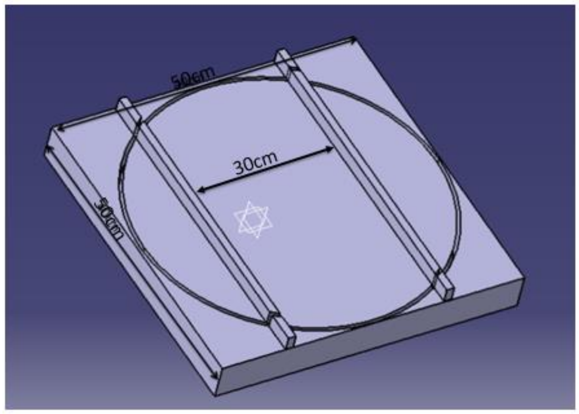


Figure 3.7: Rotary trolley

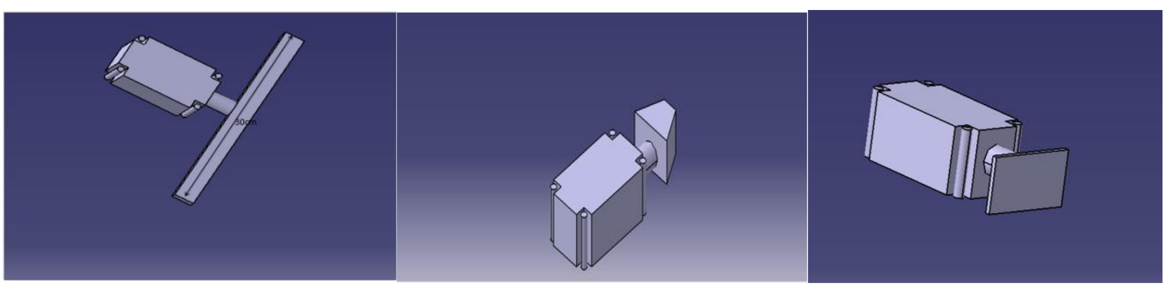


Figure 3.8: Pneumatic cylinders

Calculating the torque of the Rotary trolley:

Table 3.6: Rotary trolley toque calculations

Item	Value	According to equation
The mass of the Rotary trolley and diapers	6.65 kg	3.13
The mass moment of inertia	74.83 $N.m^2$	3.18
The rotation acceleration	0.05 m/s^2	3.24
The angular speed	0.38 rad\s	3.23
The required torque	28.43 N.m	3.22

Packaging piston calculation:

The mass of push diapers = number of diapers × mass of diaper (3.25)

= 1 kg.

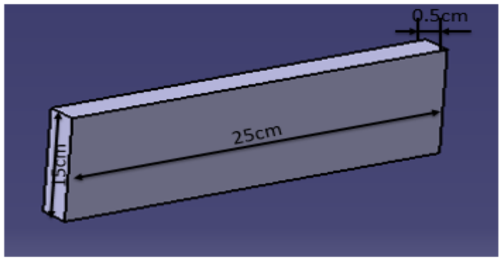


Figure 3.9: Piece mounted on the head of the piston

Table 3.7: Packaging piston specifications

Item	Value	According to equation
The mass of piece made by plastic material	0.168 kg	3.13
The push force	11.45 N	3.5
The Cross section area of the piston rod	38.2 mm^2	3.4
The piston rod diameter	6.97 mm	3.8

According to ISO Cylinder (series C96) standard [2], the following specifications of Packaging pneumatic cylinder are:

Bore size = 40 mm.

Rod size = 16 mm.

Cylinder stroke = 400 mm.

The extended and retracted time of transfer piston should not exceeded 2 second.

According to the equation (3.9), the piston speed equal 0.40 m\s.

According to the equation (3.10), the required flow equal 502.4 cm^3/s.

3.5 Accessories

Extra designed accessories are as follow:

Electrical Panel: This Panel contains electrical parts like contactors, MCB's, RCD, etc. As shown in Fig 3.9.

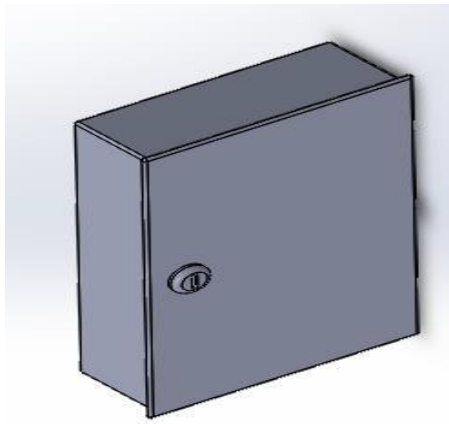


Figure 3.10: Electrical panel

HMI Screen: the used human machine inter face module aims at realize friendly communication between the machine and operation pre out such as calibration the mechanism speed ,size ,counter and monitoring the product progress as shown in fig 3.10.

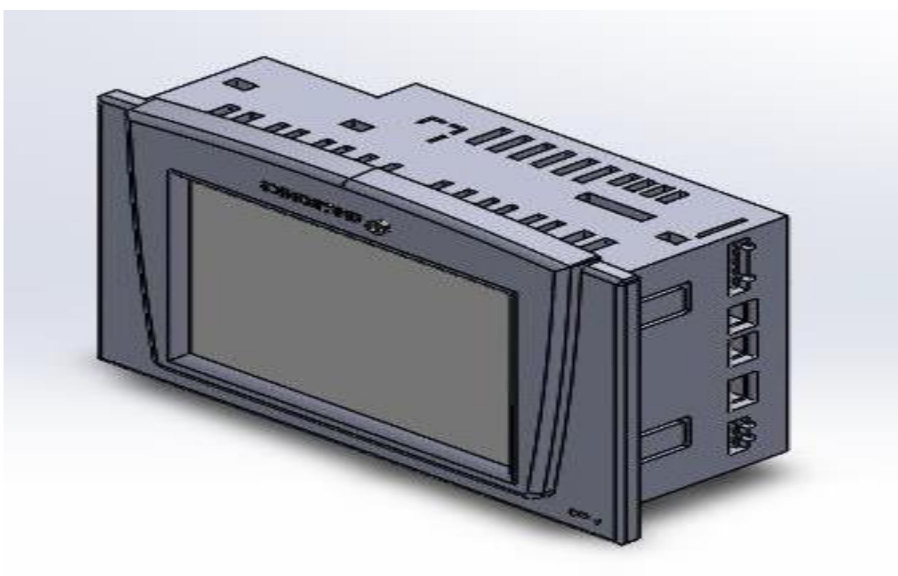


Figure 3.11: HMI Screen

3.6 Overall Machine assembly

Overall machine image in fig 1.2.

4

Chapter Four

Electrical Design

4.1 Introduction:

This chapter contains the electrical component specifications (motor, sensor, overload, etc.), power and control circuit which will be used in our project.

4.2 Motor calculations:

Referring to fig 3.12, there are four motors, three for conveyors belt and one for rotary trolley.

The conveyor torque is 55.077 N.m according to equation (3.16), where the rated induction motor torque is

$$T_n = sf \times T_{act} \quad (4.1)$$

The power of motor can be calculate by the following equation

$$P = T_n \times \omega \quad (4.2)$$

$$= 489.66 \text{ W.}$$

Where P: output power (kW).

T_n: rated torque (N.m).

T_{act}: required torque (N.m).

ω: speed (rad/s).

sf: safety factor =1.2.

Stepper motor calculation:

For assembly conveyor, according the equation (3.22), the actual torque is 16.5 N.m.

According to the equation (4.1), the rated torque is 19.8 N.m.

The step distance (d) is 0.025m within 1 second.

The Hybrid Stepper Motor (HSM) type is selected to drive the conveyor with high torque, needed for movement, standard HSM has 50 rotor teeth and rotate at 1.8 degree per step [4].

The required revaluation for specific distance can be calculated by the following equation

$$Rev = 2\pi \times r \quad (4.3)$$

Where Rev: number of revaluation = 360°.

r: pulley radius = 0.025m.

The number of revaluation for d= 0.025 is 0.16m.

step degree of 0.16 rev. equal 57.6°.

The number of steps to achieve 57.6° are 32 step.

According to JVL intelligent motor company [5], the high torque stepper motor MST432C213-X1AA9.0.

The speed of stepper motor can be calculated by the following equation

$$RPM = 60 \times (SPS / SPR) \quad (4.4)$$

Where RPM: stepper motor speed (rpm).

SPS: step per second.

SPR: step per revaluation = 32 step.

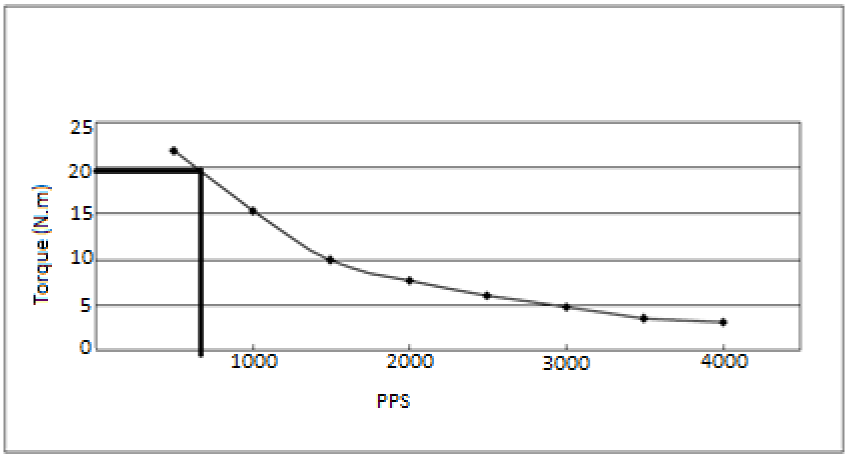


Figure 4.1: Torque/speed performance for MST43x

Form a fig (4.1), the SPS= 700 pules per second.

According to the equation (4.4), the speed of stepper motor = 1312.5 rpm.

Rotary motor specification:

Table 4.1: Rotary motor specification

Item	Value	According to equation
Required torque	28.43 N.m.	3.22
Angular speed	0.38 rad\s.	3.23
Rated torque	34.16 N.m.	4.1
Output power	53.2 Watt.	4.2

Table 4.2: Data sheet of motors [6]

Function	Motor type	Power (kw)	Voltage (v)	Speed (rpm)	Current (A)	Driver
Entry motor	Induction motor	0.49	380 V_{ac}	700	2.2	Frequency converter
Flexing motor	Induction motor	0.49	380 V_{ac}	700	2.2	Frequency converter
Assembly motor	Stepper motor	0.72	80 V_{dc}	1312	1.25	Micro step driver
Rotary Trolley motor	Induction motor	0.37	380	900	1.73	Frequency converter

4.3 Pneumatic cylinder specification:

There are eight pneumatic cylinder, the diminution of flexing piston that obtain by the equations (3.4), (3.5), (3.6), (3.7), (3.8), (3.9), (3.10).

Table 4.3: Specifications for pneumatic cylinders

Function	Action	Diminution* (mm)			Compressor		
		d_B	d_R	S_L	Type	pressure	Flow
Flexing piston	Double acting	10	4	100	Recuperating	0.3 N/mm^2	31.4 cm^3/s
Transfer piston	Double acting	40	16	400	Recuperating	0.3 N/mm^2	1004.8 cm^3/s
Packaging piston	Double acting	40	16	400	Recuperating	0.3 N/mm^2	504.2 cm^3/s
Compressing piston	Single acting	12	6	50	Recuperating	0.3 N/mm^2	20 cm^3/s
Other pistons	Single acting	12	6	50	Recuperating	0.3 N/mm^2	20 cm^3/s

* d_B: Bore diameter, d_R: Rod diameter, S_L: Strok lenght

4.4 Protection calculation:

The proposed machine has the following protection element

- Circuit breaker:

A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by excess current.

There are two type of circuit breakers , first circuit breaker three phase for a power circuit as shown in fig 4.2, and Second circuit breaker one phase for control circuit as shown in fig 4.3.

Figure 4.2: Three phase circuit breaker

Figure 4.3: One phase circuit breaker

Capability of Miniature Circuit Breaker [7] (MCB) = 1.25× rated current (I_n) (4.5)

- Over load:

To protection the motor we used overload switches and it defined as overload relays are intended to protect motors against excessive heating due to long time motor over currents up to and including locked motor currents.

There are four over loads for each motor as shown in fig 4.4.

Figure 4.4: Over load

Capability of overload= rated current (I_n) (4.6)

Table 4.4: Sizing of protection element

Name	Overload size	MCB size
Motor	7.72A	16A
Solenoid	------	10A
Control element	------	10A

4.5 Control element:

Switches:

The emergence switch are used to stop the machine immediately when something wrong happened with the machine as shown in the fig 4.5.a. The start pushbutton switch are used to turn on the process as shown in the fig 4.5.b.

The limit switch is a switch operated by the motion of a machine part or presence of an object. They are used for controlling machinery as part of a control system as shown in fig 4.5.c.

Figure 4.5.a:Emergence switch Figure 4.5.b:Start pushbutton switch Figure 4.5.c:Limit switch

Relay:

A relay is an eclectically controlled switch used for switching a power circuit with lower current ratings as shown in fig 4.6.

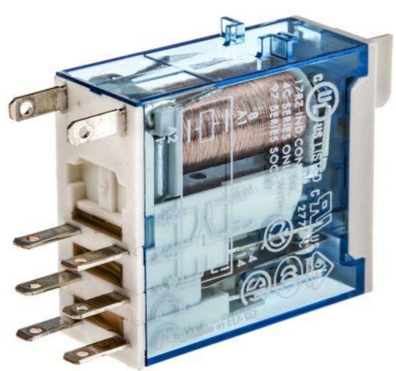


Figure 4.6: Relay

There are eight relays used with frequency converter for control of motors.

Frequency converter:

Frequency converter is an electronic or electromechanical device that converts alternating current (AC) of one frequency to alternating current of another frequency as shown in fig 4.7.

Figure 4.7: Frequency converter.

Micro step driver:

A stepper drive is the driver circuit that controls how the stepper motor operates. Stepper drives work by sending current through various phases in pulses to the stepper motor. Micro stepping delivers very fine motion resolutions, the drive uses current regulation to prevent torque oscillations.

Micro stepping is achieved by using pulse-width modulated (PWM) voltage to control current to the motor windings.

Figure 4.8: Digital stepper drive.

Directional Control Valves:

Directional control valve are component which change open or close flow paths in pneumatic system, they are used to control the direction of motion of power component and manner in which this stop. As shown in fig 4.9.

Figure 4.9: Directional valve

Compressor :

Compressors supply the air flow for all equipment in a system as shown fig 4.10.

Figure 4.10: Air compressor

4.6 Block Diagram:

4.7 Control Circuit:

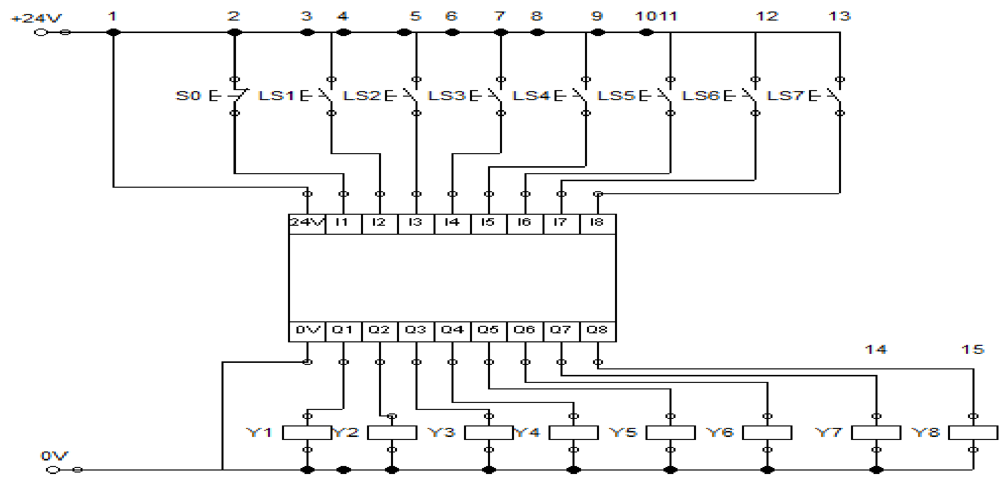


Figure 4.11.a: PLC Connection module 1

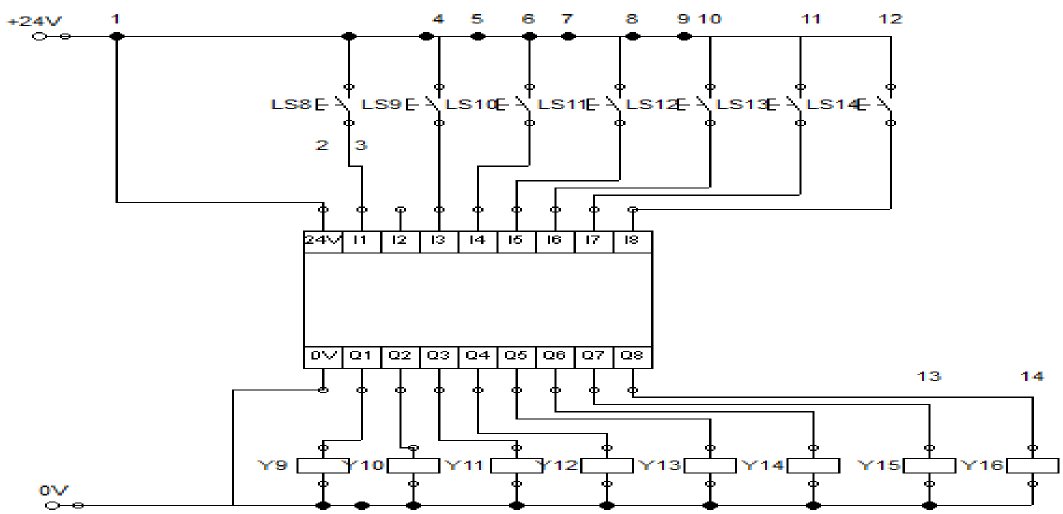


Figure 4.11.b: PLC Connection module 2

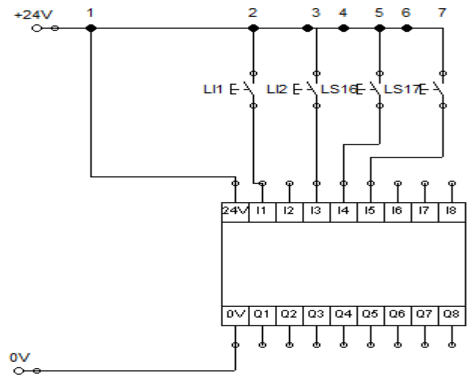


Figure 4.11.c: PLC Connection module 3

4.8 PLC Input-Output table:

Table 4.5: Input/output parameter

Symbol	function	address
Input		
Start	Start switch	X0
Stop	Stop switch	X1
Em	emergency	X2
Ls1	Limit switch 1	X3
Ls2	Limit switch 2	X4
Ls3	Limit switch 3	X5
Ls4	Limit switch 4	X6
Ls5	Limit switch 5	X7
Ls6	Limit switch 6	X8
Ls7	Limit switch 7	X9
Ls8	Limit switch 8	X10
Ls9	Limit switch 9	X11
Ls10	Limit switch 10	X12
Ls11	Limit switch 11	X13
Ls12	Limit switch 12	X14
Ls13	Limit switch 13	X15
Ls14	Limit switch 14	X16
Ls15	Limit switch 15	X17
Ls16	Limit switch 16	X18
Ls17	Limit switch 17	X19
Li1	Light sensor 1	X20
Li2	Light sensor 2	X21

Output		
Y1	pneumatic selector valve 1	Y4
Y2	pneumatic selector valve 2	Y5
Y3	pneumatic selector valve 3	Y6
Y4	pneumatic selector valve 4	Y7
Y5	pneumatic selector valve 5	Y8
Y6	pneumatic selector valve 6	Y9
Y7	pneumatic selector valve 7	Y10
Y8	pneumatic selector valve 8	Y11
Y9	pneumatic selector valve 9	Y12
Y10	pneumatic selector valve 10	Y13
Y11	pneumatic selector valve 11	Y14
Y12	pneumatic selector valve 12	Y15
Y13	pneumatic selector valve 13	Y16
Y14	pneumatic selector valve 14	Y17
Y15	pneumatic selector valve 15	Y18
Y16	pneumatic selector valve 16	Y19

4.9 Power Circuit:

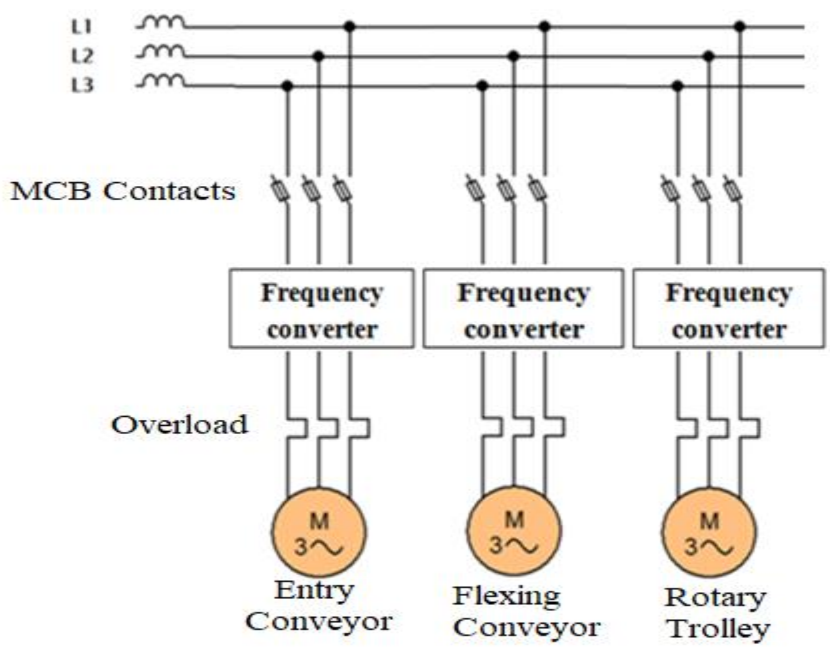


Figure 4.12: Power circuit

4.10 Pneumatic Circuit:

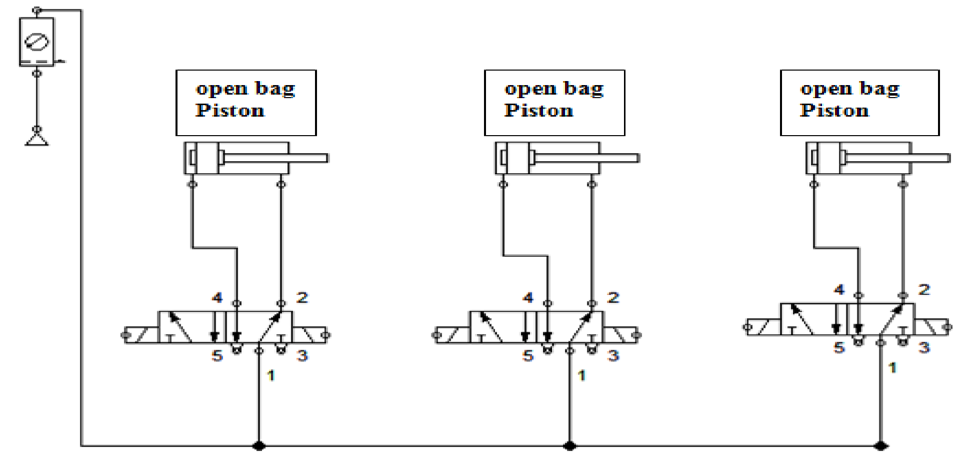


Figure 4.13.a: Pneumatic circuit1

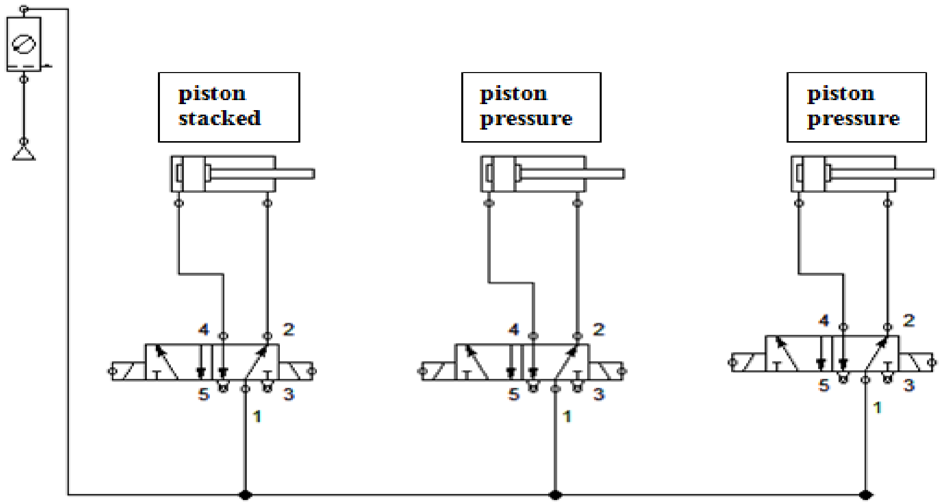


Figure 4.13.b: Pneumatic circuit 2

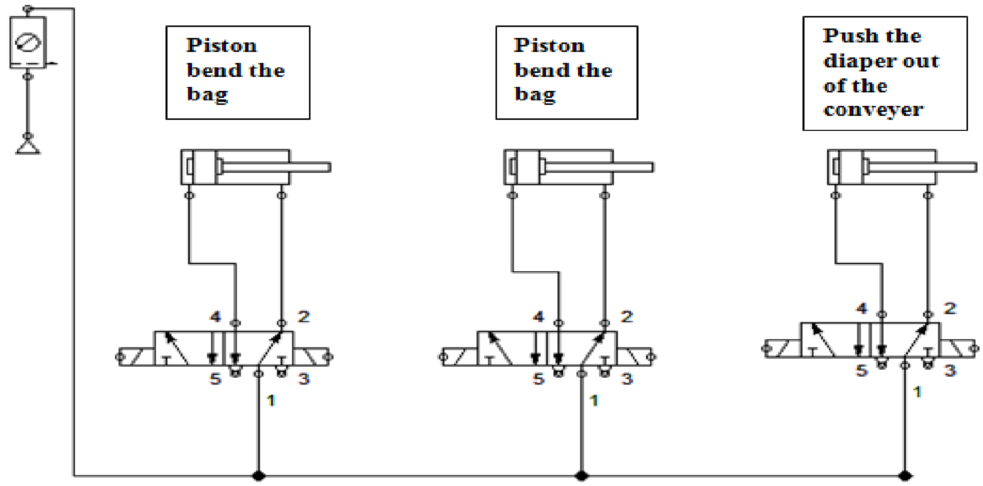


Figure 4.13.c: Pneumatic circuit 3

4.11 List of Elements:

Table 4.6: Electrical element

Element	Specification			
	Type	Power	Driver	
Motors	Indication	3 kw	Frequency converter	
	Indication	3 kw	Frequency converter	
	Indication	0.37 kw	Frequency converter	
	Stepper	0.72 kw	Micro step driver	
	Type	**Diameter rod**	**length**	**Directional Control Valves**
Pneumatic Cylinder	Double acting	4 mm	100 mm	3/2 way-valve
	Double acting	16 mm	400 mm	5/3 way-valve
	Double acting	16 mm	400 mm	5/3 way-valve
	Double acting	6 mm	50 mm	5/3 way-valve
	Double acting	6 mm	50 mm	3/2 way-valve
Control	**Specification**			**Number**
Sensors	light sensor			1
	approximate sensor			1
	NTC temperature sensor			1
	limit switch			22
PLC	modular delta PLC			1
HMI	delta type (10")			1
Relay	24 V coil			10
Contactor	24 V coil			3
Transformer	220/24 V			1
protection element	MCCB (32 A)			1
	MCB (16A,10A)			3,5
	over load adjustable (10 A)			3
	Earth leakage (32 A)			1
Switches	push button switch			2
	emergency button			4
	selector switch			1
Heat element	Enclosure Heating Element 100 watt			1
Wire cutting	diameter 3"			1

5

Chapter Five

Implementation Prototype

5.1 Introduction:

This chapter describes a complete design for the proposed machine for **one diaper size** in order to reduce the cost that can be covered by project team.

5.2 Complete Machine Design for One Size:

5.2.1 Mechanical elements:

1. Cylinders :

We have seven cylinders with the following specifications:

Table 5.1: Cylinder specification

Name of cylinder	Type of cylinder	No. of cylinder	Dimension	
			Length	Rod Diameter
Compressing cylinder	Double acting	1	70 cm	1.5 cm
Packaging cylinder	Double acting	1	100 cm	1.5 cm
Opening packet cylinder	Double acting	1	35 cm	1 cm
Flexing packet cylinder	Double acting	2	35 cm	1 cm
Welding packet cylinder	Double acting	3	50 cm	1 cm

2. **Compressor :**

Compressors supply the air flow for all equipment in a system as shown fig 5.1

Figure 5.1: Air compressor

3. **Thermal welding :**

A heating element converts electrical energy into heat through the process of heating. Electric current passing through the element encounters resistance, resulting in heating of the element, this process is dependent of the direction of current flow.

5.2.2 Electrical elements:

1. **Directional Control Valves :**

DCVs allow air flow into different paths from one or more sources. DCVs will usually consist of a spool inside a cylinder which is mechanically or electrically actuated. The position of the spool restricts or permits flow, thus it controls the air flow.as shown in fig 5.2

Figure 5.2: Directional valve

2. Relay :

Many relays use an electromagnet to mechanically operate a switch, Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal.as shown in fig 5.3.

Figure 5.3: Relay

3. Temperature sensor :

Use to measure the temperature of the thermal welding part.as shown in fig 5.4

Figure 5.4: Temperature sensor

4. Temperature controller :

Intelligent temperature controller with PID control use to adjust the temperature on set value.as shown in fig 5.5.

Figure 5.5: Temperature controller

5. Timer :

Use to control of welding duration, as shown in fig 5.6

Figure 5.6: Timer

5.2.3 Mechanical design:

The 3D Design for the practical design. As shown in fig 5.7.

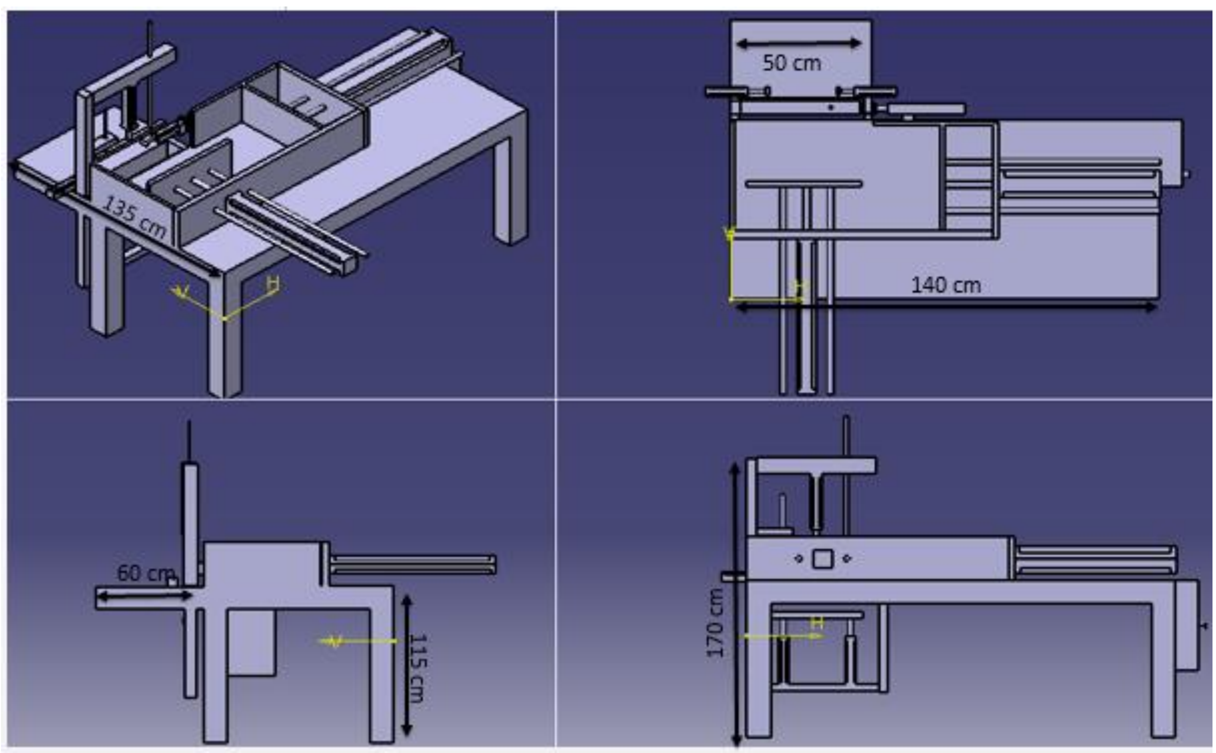


Figure 5.7: 3D design machine

The practical design of the overall prototype machine. As shown in fig 5.8.

Figure 5.8: Prototype machine

For more images kindly, refer to appendix D.

5.2.4 Electrical Circuits:

The electrical wiring and connection of the prototype machine

Control circuit:

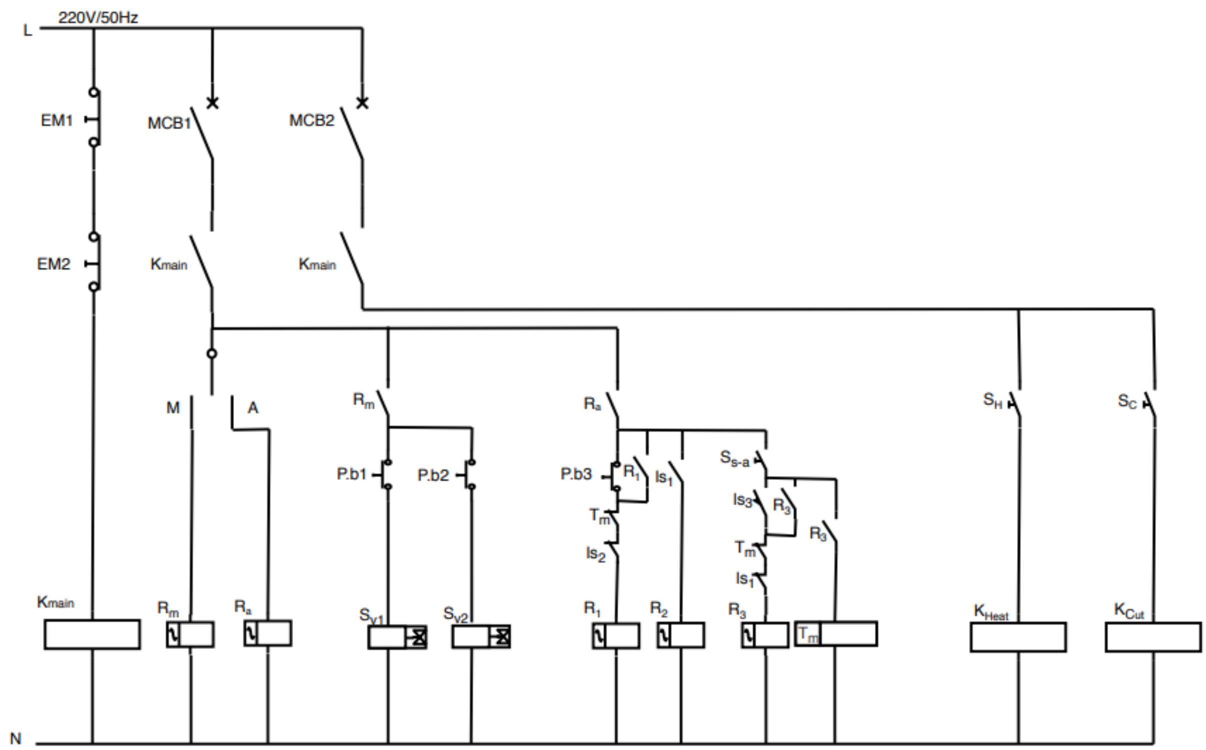


Figure 5.9: Control connection

Power circuit:

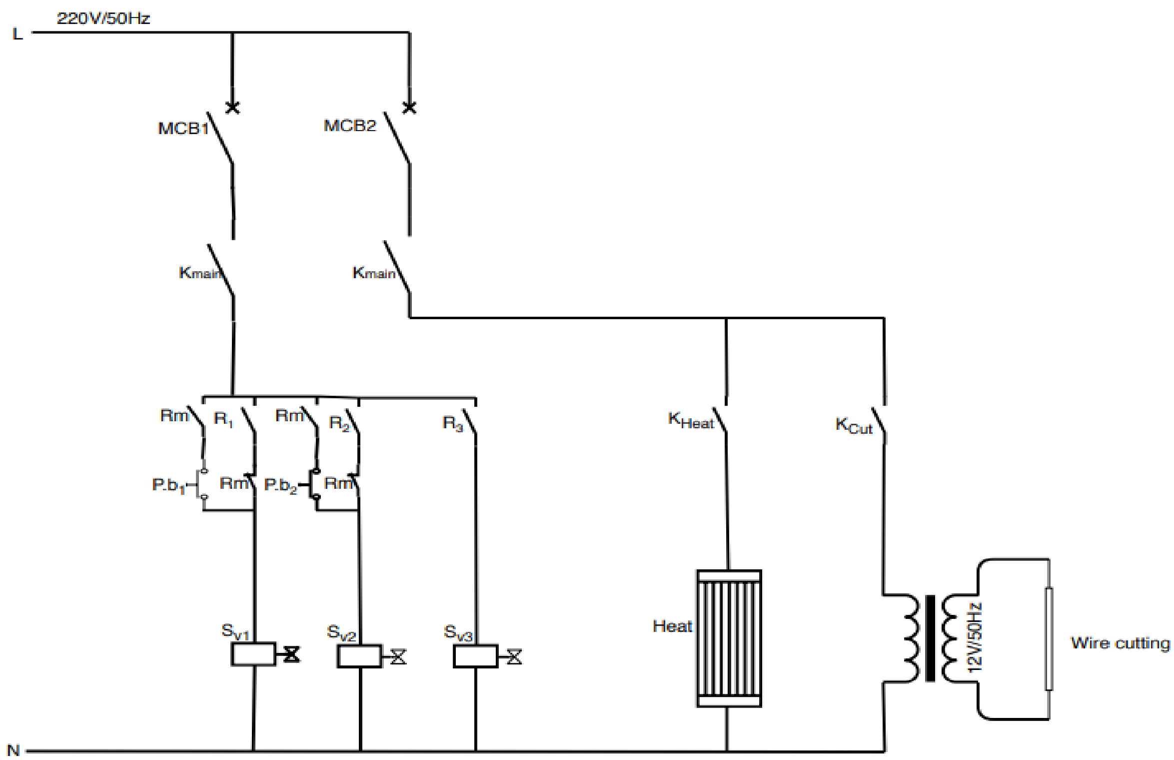


Figure 5.10: Power connection

Symbol table:

Table 5.2: Symbol table

Symbol	Abbreviation
EM1,EM2	Emergency buttons
k_{main}	Main contactor
MCB1,MCB2	Miniature circuit barker
M,A	Manual, automatic mode
R_a, R_m	Automatic relay, manual relay
Pb1,Pb2,Pb3	Pushbutton's
S_{v1},S_{v2},S_{v3}	Selector control valve for compress, push-diaper, welding.
Ls1	Limit switch for compress stage
Ls2	Limit switch for packaging stage
Ls3	Limit switch for welding stage
R1	Relay for control selector valve (1)
R2	Relay for control selector valve (2)
R3	Relay for control selector valve (3)
T_m	Timer for automatic operation
S_{s-a}	Selector switch for semi-automatic mode
S_H	Selector switch for heat process
S_C	Selector switch for cut process
K_{Heat}	Contactor for heat operation
K_{Cut}	Contactor for cut operation

5.6 Result, Conclusion and Recommendation:

- **Result:**

1. We conduct complete machine design for various sizes of diapers.
2. The design machine can be operated manual, Semi-automatic, full automatic for packaging, compressing and welding the bags.
3. Prototyping module is practically implemented for compressing, packaging as well as welding.

- **Conclusion:**

1. The proposed design is completely realized.
2. A porotype for one size is practically implement.
3. There were huge difficulties to faced us with respect to financing all the machine modules.

- **Recommendation:**

1. Provide financial support for complete machine implantation**.**
2. Asking the university to provide work space, educational tool and finance.
3. Better integration with the local industrial is highly appreciated.

References:

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Appendix A

Motor specification:

IE2

ELECTRICAL CHARACTERISTICS - AESV2E / AESU2E

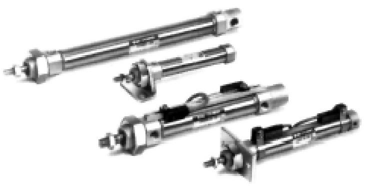
TEFC, CLASS F, 40°C AMBIENT TEMP., IEC DESIGN N CONTINUOUS DUTY, S.F. 1.0 400V/50HZ

OUTPUT		FULL LOAD	FRAME NO.	EFFICIENCY				POWER FACTOR				CURRENT		TORQUE				ROTOR GD2	APPROX. WEIGHT
HP	kW	rpm		FULL LOAD (%)	3/4 LOAD (%)	2/4 LOAD (%)	1/4 LOAD (%)	FULL LOAD (%)	3/4 LOAD (%)	2/4 LOAD (%)	1/4 LOAD (%)	FULL LOAD (A)	LOCKED ROTOR (A)	FULL LOAD N•m	LOCKED ROTOR %FLT	PULL UP %FLT	BREAK DOWN %FLT	kg-m2	kg
0.5	0.37	915	80M	65.5	63.8	57.9	40.5	65.0	55.5	44.0	31.0	1.25	5	3.856	230	215	260	0.009	17.5
0.75	0.55	1425	80M	78.1	78.0	75.1	64.1	72.5	62.0	47.5	30.0	1.40	8	3.680	290	260	305	0.010	17.5
		900	80M	68.5	68.8	64.9	50.2	67.0	57.0	44.0	29.0	1.73	7	5.827	225	220	250	0.012	19.5
1	0.75	2850	80M	77.4	78.0	76.3	64.3	85.5	78.5	66.0	44.5	1.64	9	2.509	215	180	280	0.005	17.0
		1415	80M	79.6	79.5	76.9	66.3	73.5	63.5	49.5	31.0	1.85	11	5.054	300	330	325	0.013	20.5
		935	90S	75.9	76.4	73.9	63.8	69.5	60.0	46.5	29.5	2.05	10	7.649	210	185	260	0.019	25.5
		695	100L	71.8	71.0	68.0	54.0	65.0	56.0	43.5	28.0	2.32	10	10.29	210	175	235	0.046	37.5
1.5	1.1	2875	80M	79.6	80.0	78.3	68.5	85.5	79.0	67.0	45.0	2.33	17	3.648	255	200	305	0.007	19.5
		1445	90S	81.4	81.4	78.9	69.8	76.0	67.0	53.0	33.5	2.57	19	7.259	270	205	325	0.017	25.0
		930	90L	78.1	78.8	76.9	68.2	71.5	62.0	48.5	30.5	2.84	14	11.28	215	190	260	0.026	30.0
2	1.5	2880	90S	81.3	81.8	80.3	73.5	86.5	80.5	69.0	48.0	3.08	24	4.966	260	245	325	0.011	24.5
		1435	90L	82.8	83.7	82.6	75.7	81.0	73.0	59.5	38.0	3.23	23	9.967	250	180	300	0.022	28.0
		950	100L	79.8	80.5	78.8	68.5	70.5	61.5	48.5	30.0	3.85	19	15.06	170	140	240	0.048	39.0
		700	112M	76.8	77.0	75.5	63.0	66.0	57.0	45.0	28.0	4.27	18	20.43	200	150	225	0.071	49.5
3	2.2	2875	90L	83.2	84.3	83.4	77.9	87.5	82.0	70.5	48.5	4.36	35	7.297	285	240	335	0.014	28.0
		1450	100L	84.3	85.0	84.1	76.1	81.5	74.0	61.0	39.0	4.62	33	14.47	210	170	300	0.041	37.0
		950	112M	81.8	82.4	81.1	72.6	75.0	66.5	53.0	33.5	5.18	34	22.08	280	255	300	0.071	49.0
		710	132S	79.4	82.0	79.5	69.0	64.5	55.0	42.0	25.0	6.20	31	29.55	240	235	300	0.138	65.5
4	3	2895	100L	84.6	85.9	85.7	80.4	88.0	83.0	73.0	50.0	5.82	49	9.88	245	225	310	0.022	37.6
		1445	100L	85.5	85.9	84.8	77.3	82.0	75.0	62.5	40.0	6.18	44	19.80	210	170	300	0.050	40.0
		960	132S	83.3	84.1	83.2	76.8	78.0	71.0	58.0	37.0	6.66	37	29.80	190	165	300	0.103	61.0
		700	132M	81.3	83.0	81.5	72.0	69.0	59.5	46.0	28.0	7.72	37	40.87	215	210	270	0.162	71.0
5.5	4	2880	112M	85.8	86.9	86.6	81.4	91.0	88.0	81.0	61.5	7.39	63	13.24	235	240	335	0.042	49.0
		1450	112M	86.6	87.6	87.5	83.2	85.0	80.5	71.0	48.0	7.84	58	26.30	220	200	300	0.083	54.0
		960	132M	84.6	85.6	85.1	79.3	79.0	72.5	60.0	38.5	8.64	53	39.73	210	180	300	0.131	69.0
		715	160M	83.0	84.0	82.0	73.5	71.5	63.0	51.0	31.0	9.73	55	53.34	185	160	270	0.343	110
7.5	5.5	2925	132S	87.0	87.2	86.2	81.0	86.0	82.5	74.5	55.5	10.6	82	17.93	240	180	300	0.063	68.0
		1455	132S	87.7	88.7	88.6	84.5	85.5	80.5	70.0	47.0	10.6	81	36.04	255	210	305	0.123	72.0
		960	132M	86.0	86.9	86.5	81.2	79.5	72.5	60.5	38.5	11.6	78	54.63	230	195	300	0.188	81.0
		715	160M	84.5	84.0	82.5	74.0	71.0	63.0	51.0	31.0	13.2	70	73.35	185	160	265	0.343	111

Appendix B

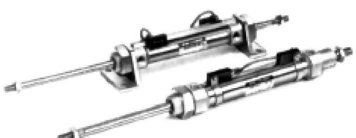
Cylinder specification :

Series C85



Rubber bumper/Single rod

Air cushion/Single rod

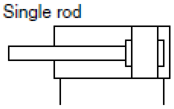


Rubber bumper/Double rod

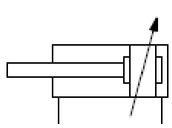
Air cushion/Double rod

Non-rotating rod

Double acting, Single rod

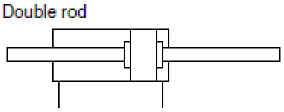


Rubber bumper

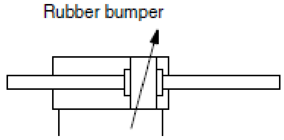


Air cushion

Double acting, Double rod



Rubber bumper



Air cushion

Specifications

Bore size (mm)		8	10	12	16	20	25
Piston rod dia. (mm)		4	4	6	6	8	10
Piston rod thread		M4 x 0.7	M4 x 0.7	M6 x 1	M6 x 1	M8 x 1.25	M10 x 1.25
Port size		M5 x 0.8	M5 x 0.8	M5 x 0.8	M5 x 0.8	G 1/8	G 1/8
Action		Double acting, Single/Double rod					
Fluid		Air					
Proof pressure		1.5 MPa					
Max. operating pressure		1.0 MPa					
Min. operating pressure		0.1 MPa	0.08 MPa	0.05 MPa			
Ambient and fluid temperature		–20 to 80°C (Built-in magnet: –10 to 60°C)					
Cushion		Rubber bumper (Non-rotating: Rubber bumper only), Air cushion (Except ø8)					
Lubrication		Not required. Use turbine oil Class 1 ISO VG32, if lubricated.					
Rod boot	**Nylon tarpaulin**	—				Max. ambient temperature 60°C	
	Heat resistant tarpaulin	—				Max. ambient temperature 110°C*	
Piston speed		50 to 1500 mm/s					
Allowable kinetic energy	**Rubber bumper**	0.02 J	0.03 J	0.04 J	0.09 J	0.27 J	0.4 J
	Air cushion	—	0.17 J	0.19 J	0.4 J	0.66 J	0.97 J
Non-rotating accuracy		±1.5°	±1.5°	±1°	±1°	±0.7°	±0.7°
Stroke length tolerance		$^{+1.0}_{0}$ mm				$^{+1.4}_{0}$ mm	

* Maximum ambient temperature of rod boots only

Weights

(g)

Bore size (mm)			8	10	12	16	20	25
Double acting	Basic weight		45	49	96	109	183 (203)	258 (286)
Double rod	Additional weight per 10 mm of stroke		3	3.2	6.2	7.2	11.8	18.4
Mounting bracket		C85L□A	20		40		95	
		C85L□B	55		105		210	
		C85F□	12		25		90	
		C85T□	20		50		75	
		C85C□	20		40		85	
Accessories	Single knuckle joint	KJ□D	17		25		45	70
	Double knuckle joint	GKM□-□	10		20		50	100
	Floating joint	JA□-□-□	10		20		50	70

Calculation: Example) **C85N10-50, C85F10**

( ): In the case of air cushion

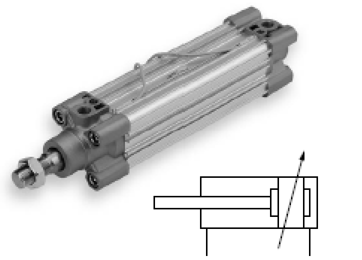
- •Basic weight ·················· 49 (ø10) g
- •Additional weight ··········· 3.2/10 mm stroke
- •Cylinder stroke ·············· 50 mm stroke
- •Mounting bracket ·········· 12 g

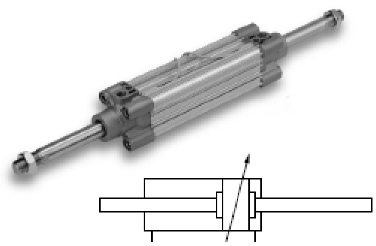
49 + 3.2 x 50/10 = 65 g 65 + 12 = 77 g

⚠ Caution

Be sure to read before handling.

Refer to page 105 for Safety Instructions and "Handling Precautions for SMC Products" (M-E03-3) for Actuator and Auto Switch Precautions.





Minimum Stroke for Auto Switch Mounting

Refer to "Minimum Stroke for Auto Switch Mounting" on page 54.

Made to Order

(For details, refer to pages 84 to 91.)

Symbol	Specifications
-XA□	Change of rod end shape
-XB6	Heat resistant cylinder (150°C)
-XC4	With heavy duty scraper
-XC7	Tie-rod, cushion valve, tie-rod nut, etc. made of stainless steel
-XC10	Dual stroke cylinder/Double rod type
-XC11	Dual stroke cylinder/Single rod type
-XC22	Fluororubber seal
-XC35	With coil scraper
-XC68	Made of stainless steel (with hard chrome plated piston rod)

Specifications

Bore size (mm)	32	40	50	63	80	100	125
Action	Double acting						
Fluid	Air						
Proof pressure	1.5 MPa						
Max. operating pressure	1.0 MPa						
Min. operating pressure	0.05 MPa						
Ambient and fluid temperature	Without auto switch: –20 to 70°C (No freezing) With auto switch : –10 to 60°C (No freezing)						
Lubrication	Not required (Non-lube)						
Operating piston speed	50 to 1000 mm/s						50 to 700 mm/s
Allowable stroke tolerance	Up to 250 st: $^{+1.0}_{0}$, 251 to 1000 st: $^{+1.4}_{0}$, 1001 to 1500 st: $^{+1.8}_{0}$, 1501 to 2000 st: $^{+2.2}_{0}$						
Cushion	Air cushion						
Port size	G 1/8	G 1/4	G 1/4	G 3/8	G 3/8	G 1/2	G 1/2
Mounting	Basic, Axial foot, Rod flange, Head flange, Single clevis, Double clevis, Center trunnion						

Standard Strokes

Bore size (mm)	Standard stroke (mm)	Max. stroke Note)
32	25, 50, 80, 100, 125, 160, 200, 250, 320, 400, 500	2000
40	25, 50, 80, 100, 125, 160, 200, 250, 320, 400, 500	2000
50	25, 50, 80, 100, 125, 160, 200, 250, 320, 400, 500, 600	2000
63	25, 50, 80, 100, 125, 160, 200, 250, 320, 400, 500, 600	2000
80	25, 50, 80, 100, 125, 160, 200, 250, 320, 400, 500, 600, 700, 800	2000
100	25, 50, 80, 100, 125, 160, 200, 250, 320, 400, 500, 600, 700, 800	2000
125	—	2000

Intermediate strokes are available.
Note) Please consult with SMC for longer strokes.

Accessories

Mounting		Basic	Foot	Rod flange	Head flange	Single clevis	Double clevis	Center trunnion
Standard	Rod end nut	●	●	●	●	●	●	●
	Clevis pin	—	—	—	—	—	●	—
Option	Piston rod ball joint	●	●	●	●	●	●	●
	Rod clevis	●	●	●	●	●	●	●
	Rod boot	●	●	●	●	●	●	●

* Do not use a piston rod ball joint (or floating joint) together with a single clevis with a ball joint (or clevis pivot bracket with a ball joint).

Appendix C

Stpper Motor specification :

Preliminary datasheet.

MST43x NEMA43 Stepper Motor up to 25Nm

JVL is one of the world leading companies in the field of integrated servo and stepper motors. JVL have developed and released a new integrated stepper motor MIS43 and the stepper motor used for this motor can now also be delivered without build in electronics as a high torque stepper motor called MST430 - MST432 up to 21Nm.

The motor is very useful in applications where motors must be very compact, have very high torque at low speed and without backlash as a normal gear would offer.

- Shortest length in the industry only 99 for 10 Nm
- Can be delivered with wire out or optional high current connectors
- Optional IP 55 or IP67
- Option for double shaft and single or absolute multiturn encoder
- 5,5Am or 9 Amp windings.
- Can be delivered with build on controller.

Flange size is 110x110 mm which corresponds to the NEMA43 standard and shaft diameter is 19.0 mm with key. Planetary gears that fit the motor directly can also be delivered.

It will also be possible to deliver the motor with build on driver and controller called integrated stepper motor. The integrated stepper motor can be delivered with 9Amp driver and PLC on board, RS485 and optional Profinet EtherCAT , Powerlink and wireless Bluetooth, ZigBee, WLAN, absolute multiturn encoder build into the motor.

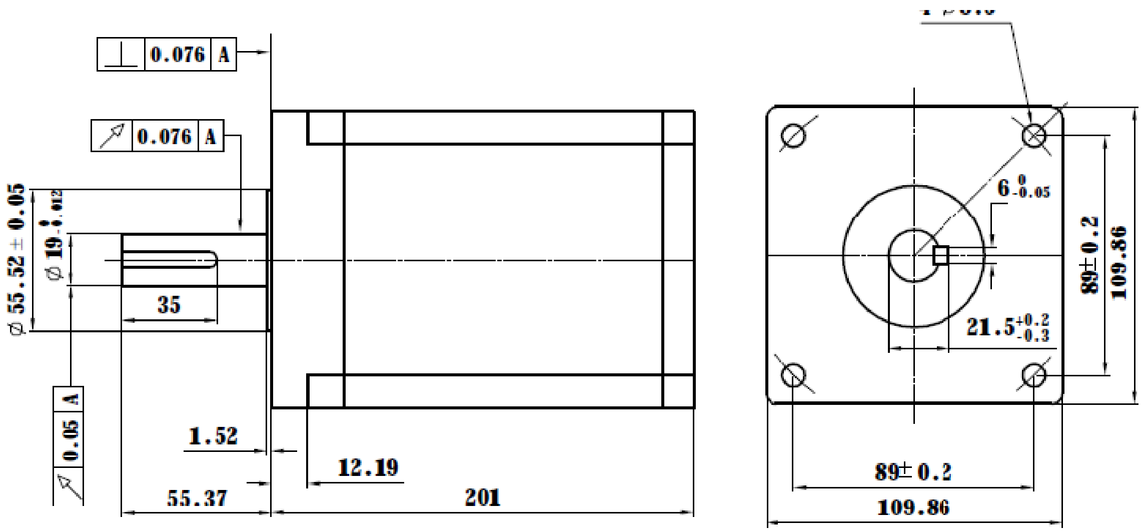
JVL can also deliver driver and controller for MST43x like SMD41 steppermotor driver og SMC85 stepper motor controller. Read more at www.jvl.dk

Technical data

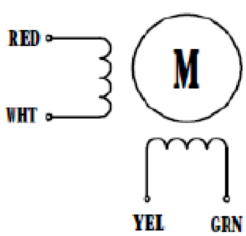
	MST430C213-X1AA9.0	MST431C213-X1AA9.0	MST432C213-X1AA9.0	
Holding Torque	10	21	25	Nm
Rotor moment of Inertia	5,5	10,9	16,2	Kgcm2
Weight	5,0	8,4	11,7	Kg

Current	9,0	9,0	9,0	Amp
Length (+-2mm)	99	150	210	mm
Detent torque	0,35	0,63	0,75	Nm +-10%
Resistance			0,53	Ohm +-10%
Inductance			*10*	*mH +-20%*
Max Radial force Fr with axial force 80N	*At 5mm max 640N, At 10mm max 425 N , At 15mm max 320N, At 20mm max 240N*			
Shaft Play	*Axial shaft play 0,075mm at load max 10N. Radial shaft play 0,025mm at load max 5N*			
Step angle	*1,8 degree +-5% (Non-Accumulating)*			
Temperature	*Ambient 0-40 degree or internal temperature sensor max 85% degree. Will depend in supple voltage and load.*			
Humidity	*Ambient humidity Max 85% (No condensation)*			
Insulation	*Insulation class B 130 degree Celsius [266'F]. Insulation resistance 100M ohm.*			

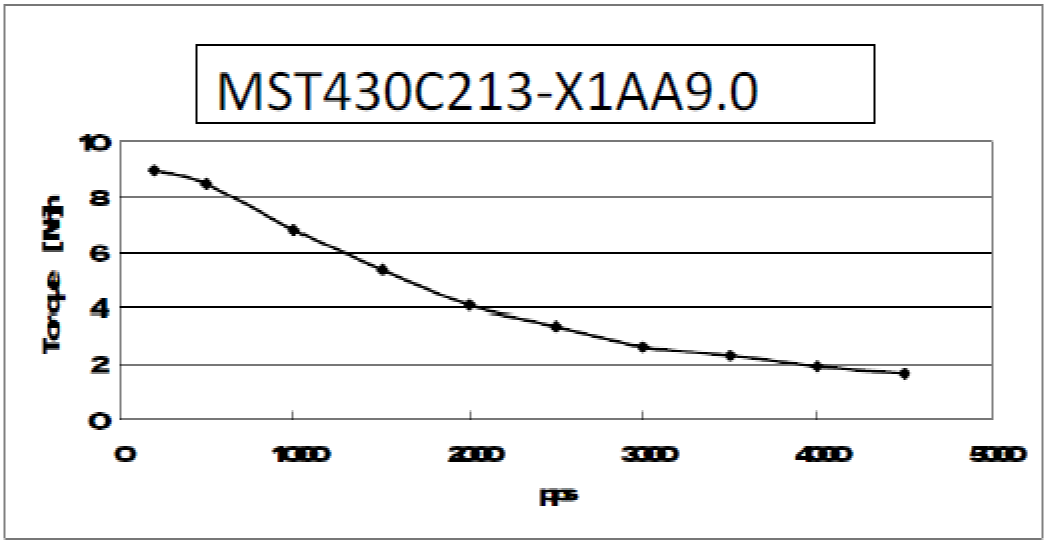
MST431 can only be delivered if orders above 25 pcs

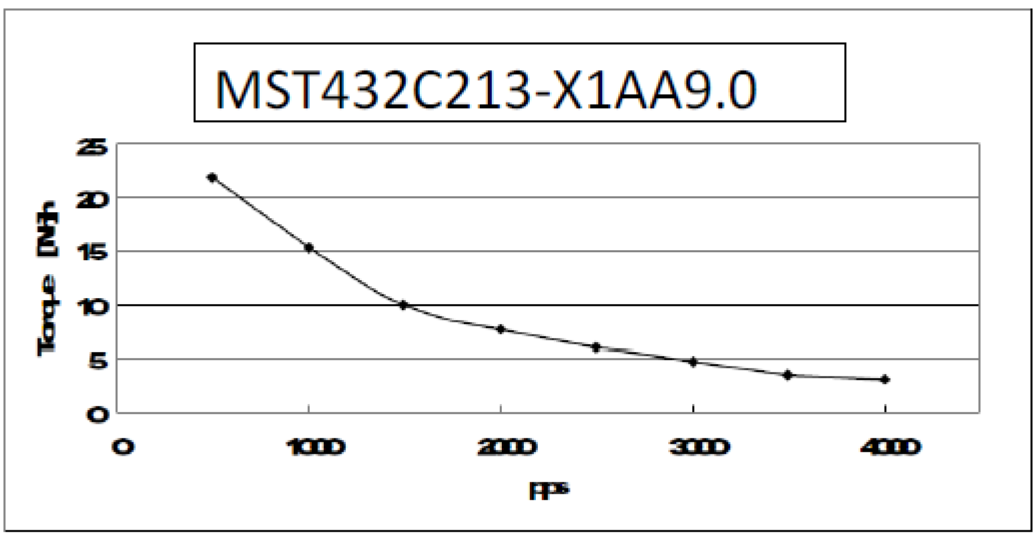


Wiring Diagram:



<u>Torque/ speed curve for MST43x. Speed shown as fullstep/sec and Voltage 80VDC.</u>





For further information, please contact:

JVL Industri Elektronik A/S, Blokken 42, 3460 Birkerød, Denmark. Tel. +45 4582 4440.

E-mail: sales@jvl.dk. Web: www.jvl.dk'

Appendix D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