Palestine Polytechnic University

College of Engineering and Technology

Mechanical Engineering Department

Graduation Project

Cold Forming Packaging Machine for Drug Tablets

BY

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BY

Medicine packaging Machine by Cold Forming

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According to the project supervisor and according to the agreement of the Testing Committee Members, this project is submitted to the Department of Mechanical Engineering at College of Engineering and Technology in partial fulfillments of the requirements of (B.SC) degree.

Supervisors Signature

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Department Head Signature

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Project Concept

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1.1 Overview

The manufacturing process is one of the important sciences in the world. It is the study of the material and what the industry need. The manufacturing process is important in many different ways in industry for example

1) Shaping material into different sizes
2) Improving the properties of the materials.
3) Producing accurate product dimension.

The manufacturing process includes many types of processes. In this project, the cold forming process is used. Some materials cannot be formed at normal ambient temperatures, such as indium, and some alloys are not amenable to form on heat .This project is working on the formation and packaging template medicine by cold forming.

1.2 Problem Definition

Manufacturing the medicine in Palestine depends on imported machines from abroad which increase the cost of investment. Also, the political situation which is represented by many obstacles and challenges makes that more difficult.

1.3 Project Goal

The objective of this project is to design and manufacturing a machine that is able to perform cold formation of aluminum foil which will be used in the packaging (such as medicine).

1.4 Project Importance

The importance of the project is presented by four main objectives that will improve the process:-

1) **Human Safety**: This machine will reduce human interaction with the process which will keep workers safe. Process of formation through the hydraulic system depends on high-pressure which is proven to be extremely dangerous and harmful.

2) **High Efficiency and Accuracy:** these templates of high dimension accuracy and low error rate are needed to reach the perfect forming.

3) **Production Rate:** The production process will be adjusted by controlling the speed of the hydraulic system.

4) **Cost:** the aim is to lower the production cost and enhance production rate which will in return decrease product price and benefit both manufacturer and customers.

1.5 Methodology

The project will adopt a mechatronics system which is an integration between multidisciplinary sciences (   ). Figure1.1 illustrates the synergistic integration of three engineering fields.

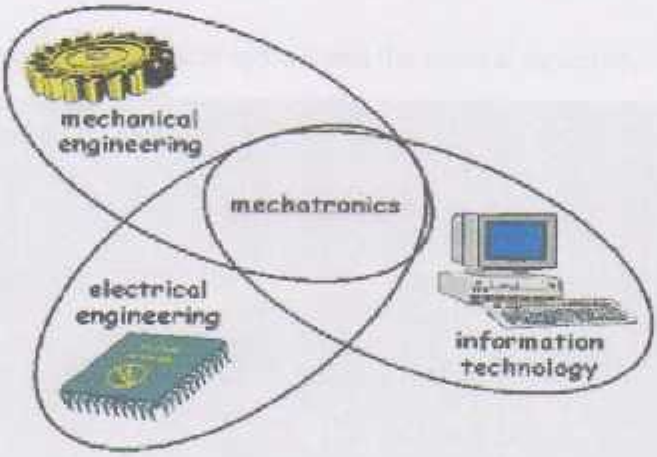


Figure: 1.1 Mechatronics system

The main idea is clear through Figure 1.2 which illustrates the machine operation principle.

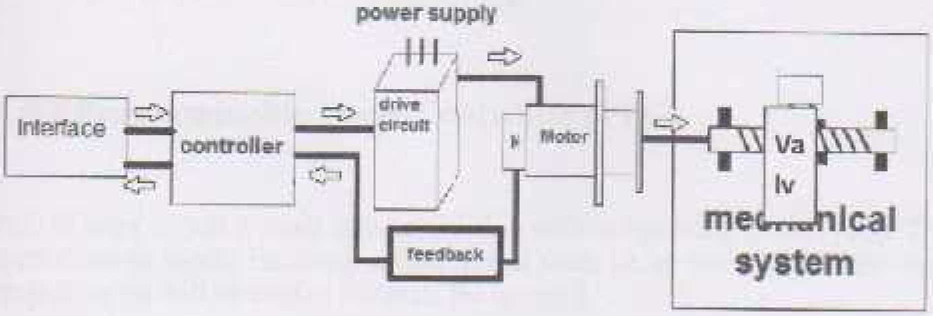


Figure 1.2 Machine operation principles

1.5.1 Mechanical system

Figure 3.1 illustrate the mechanical system and the general structure.

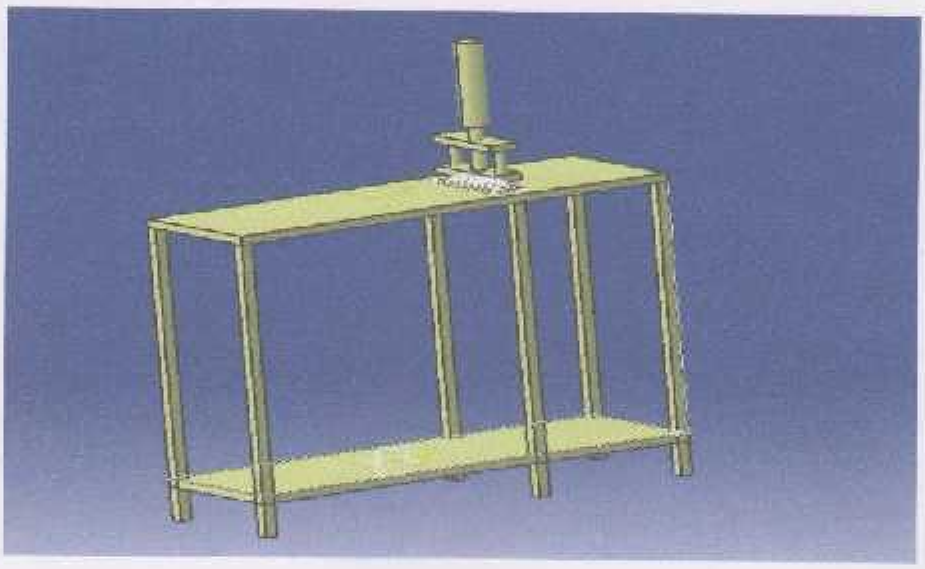


Figure 1.3 Mechanical system

Figure 1.5 illustrates the mechanical system. The template is divided into two parts; the first one is installed on the piston and the second one is placed on the table. When the piston rushes, the template rushes with the piston. When the first part moves towards the second part the aluminum foil are forming.

1.5.2 Programmable Logic Controller (PLC)

PLC is more or less a small computer with a built-in operating system (OS). This OS is highly specialized to handle incoming events in real time, i.e. at the time of their occurrence, in this project the plc will be used to automate the system ( ).

1.5.3 Drive Circuit

PLC or microcontroller is low power, it cannot give an enough current to drive the motor so that, power circuit will be used to drive motor's to increase power.

1.5.4 Electrical Motor

Electrical motors will be used to drive the hydraulic system; in this project the Dc motor and AC motor will be used.

1.5.5 Sensors

Sensors will be used as a feedback to the control system.

1) **A Rotary Encoder** (Shaft Encoder): is an electro-mechanical device that converts the angular position or motion of a shaft or axle to an analog or digital code ( ).
2) **Flow Sensor:** a flow sensor is a device for sensing the rate of fluid flow to control the speed ( ).
3) **Pressure sensor :** a pressure sensor is a device for sensing the pressure in the system to be sure the user is safe ( ) .

1.6 Project Schedule

Table 1-1: Time table for the first semester time (week)

Process	Week															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Selected the project																
Collection of the needed data																
Mechanical and electrical modeling																
Writing document																

Table 1-2: Time table for the second semester time (week)

Activity	Week															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Software Design																
Hardware Design																
Hardware Testing																
System Testing																
Documentation																

1.7 cost estimation and budget breakdown

This section lists the overall cost of the project , the cost includes the hardware cost, and the human resources budget .

Hardware cost: includes the cost of the component that was used to implement the project. Table 1.3 Illustrates this cost

Table 1-3: Cost of Project

Component	Price
Hydraulic pump (Gear Pump)	100 JD
AC Motor	100 JD
Template (Aluminum)	200 JD
Piston	50 JD
Pressure Relief Valve	25 JD
Selector (Control valve)	150 JD
Electronic	100 JD
Structure	150 JD
Throttle	25 JD
Total cost	**900 JD**

CHAPTER TWO

Mechanical Design

2.1 Overview

2.2 Material Specification

2.3 Machine Parts

2.1 Overview

Automated machine will be designed for controlling the forming for some of material, especially aluminum foil that's used in medicine, In order to understand the principle of operation and to obtain general idea about the motion, first of all the machine parts and mechanisms will be explained through this chapter.

Each machine parts will be explained in the next section. Figure 2.1 illustrates the general design of machine.

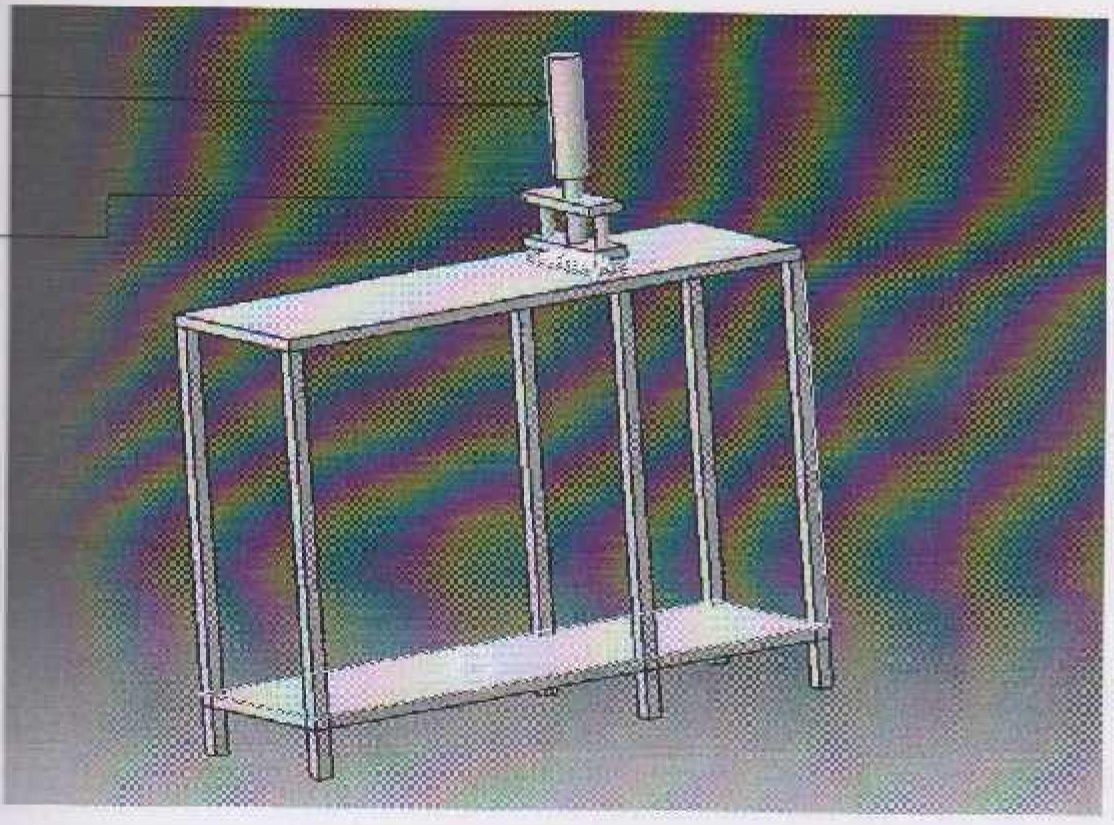


Figure 2.1 General figure of machine

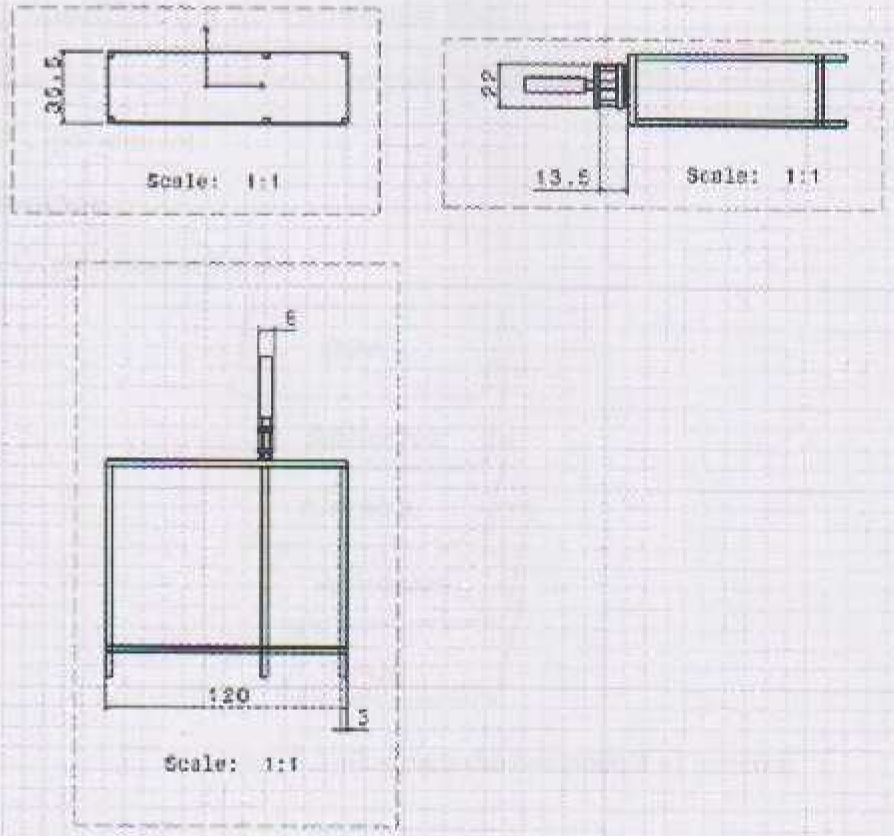


Figure 2.2 General figure of machine

2.2 Material Specification (Aluminum Foil)

Aluminum foil is the materials used in the medicine packaging and this material Characterized by the possibility of keeping the medicine for a long time after packaging and it divided into two parts, the first one exposed to the forming process in order to achieve the required shape and the second part exposed to heat and pressed to the first part close the tape this project will work with only the first part forming .Figure 2.1 illustrates the component of material

2.2.1 Specification of Aluminum Foil

The material used for medicine template is composed of three materials as

1) OPA (polyamide)

2) Aluminum

3) PVC (polyvinyl chloride)

Figure 2.3 illustrates the component of material

This aluminum foil composed from three materials, the aluminum is basic and .Is put adhesive on both sides of Aluminum and on the top part there will be polyamide, and the bottom there will be polyvinyl chloride.

2.2.2 Material Specification (Aluminum Foil)

Table 2-1: Illustrate the Specifications of Aluminum Foil

Material-Description	**Base**	**Thickness or Grammage**
OPA	Polyamide	25micrometer=28.8g/m2+10%
Adhesive	PU	3.5±.8g/m2
Primer	Eproxy resin	1.2±.2g/m2
Aluminum soft dull/bright	Alloy min 98.6%=AA8079	47µm=128.9g/m2±8%
Adhesive	PU	4.0±.8g/m2
PVC	Polyvinylchloride	60µm=78.6g/m2±10%
Total weight	243.0g/m2 (4.1m2/Kg) ±10%	
THICKNESS	(119.7-144.3 micrometer)	

WIDTH	143mm±1mm
Quantity	2800 rm 99 Kgs
Joints	NMT 2 joints/wheel marked with red mark
WHEEL LINNER DIMETER	149.00_ 151.00 MM

Table2-2: Test Data Table:

Test	Supplier test-method	Nominal value	Check of process Data -conformity
Polyamide thickness	Analytical balance	25.0 my (+/-)2.5 my	22.5-27.5 my
Alu- thickness	Afco-a	47 my (+/-) 3.8 my	43.2-50.8 my
Pvc thickness	Analytical balance	60.0 my (+/-) 6.0 my	54.0-66.0 my
Sealing- strength	Qm-pa 10.10.29	>8N/15mm	>8N/15mm

***my**: micron unit

2.3 Machine Parts

In this section the machine parts will be discussed.

2.3.1 Main Base

Main base has rectangle as illustrates in Figure 2.4, and hydraulic system will be installed on the vertical, besides cylinders will be installed animation, as well as the rule that contains the lower part of the template.

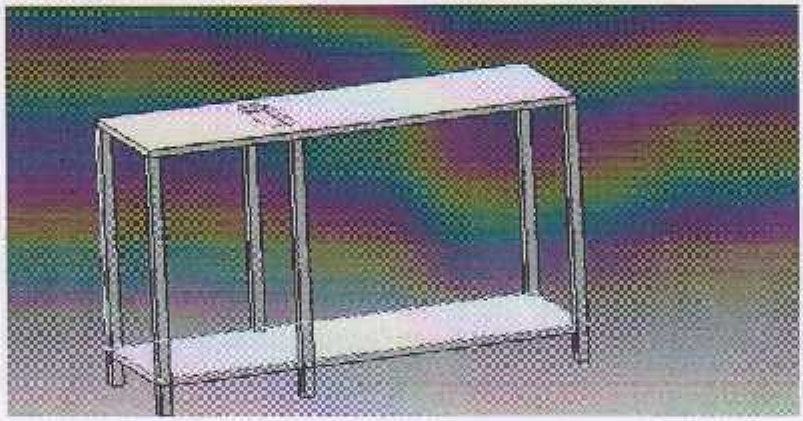


Figure 2.4 .The main base

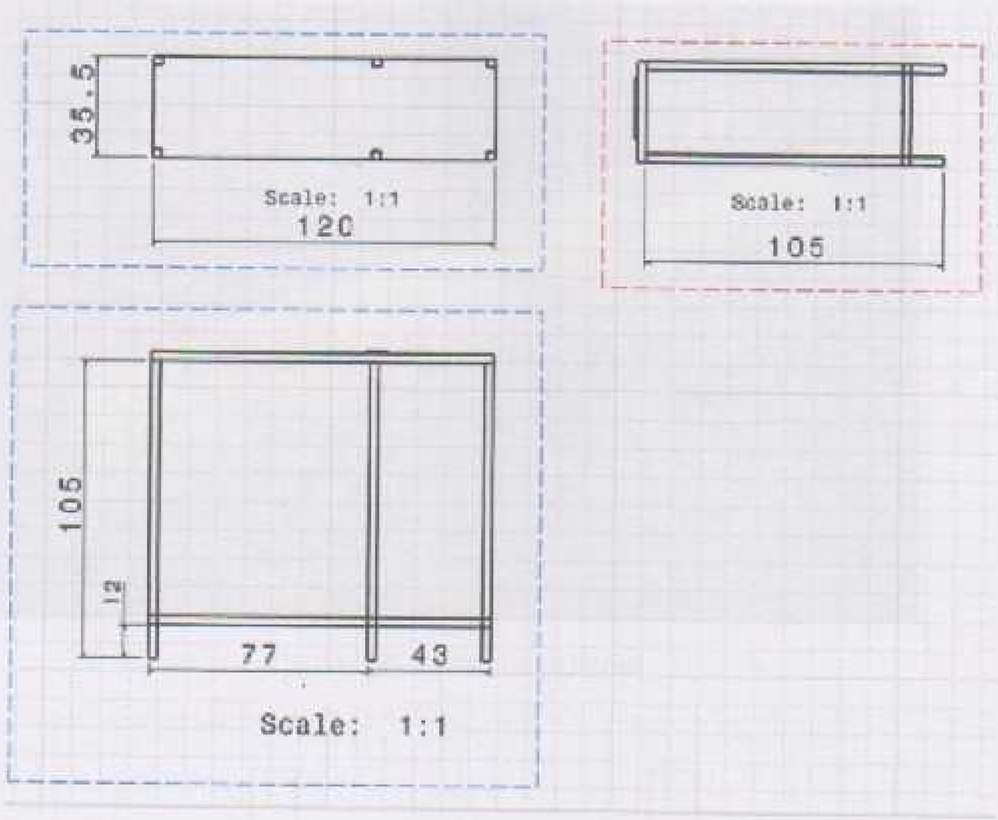


Figure 2.5.Tthe main base

And the main base consists of:

1) Guide
2) Stands
3) Template (Fix Part)

2.3.2 Forming Mechanism (piston)

The hydraulic system is responsible for the movement of the template and this movement is linear movement. That will control the speed of the piston to increase production quantity. Figure 2.5 illustrates the hydraulic cylinder and the diminution chosen based on the experimental test.

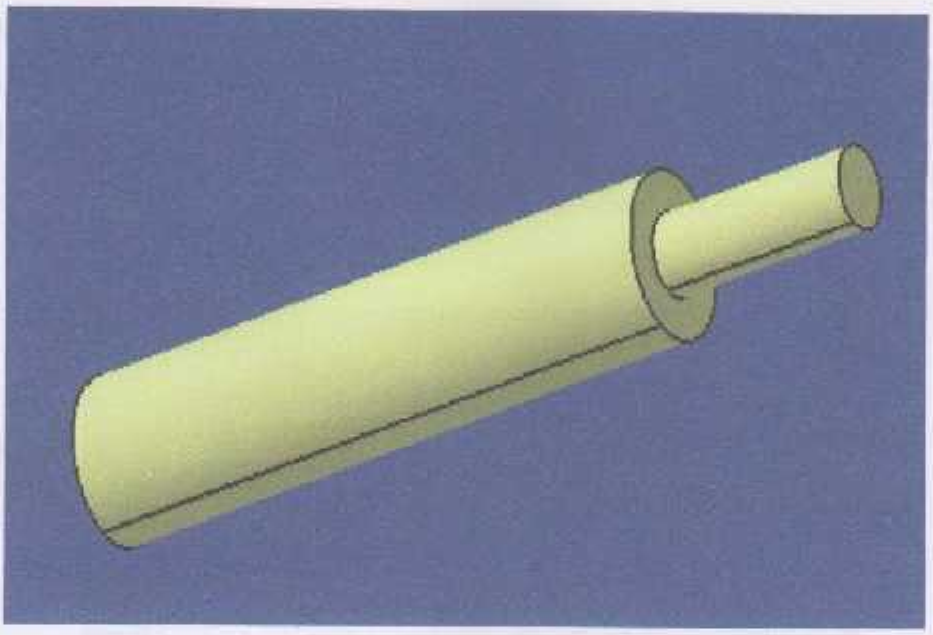


Figure 2.6 Hydraulic cylinder

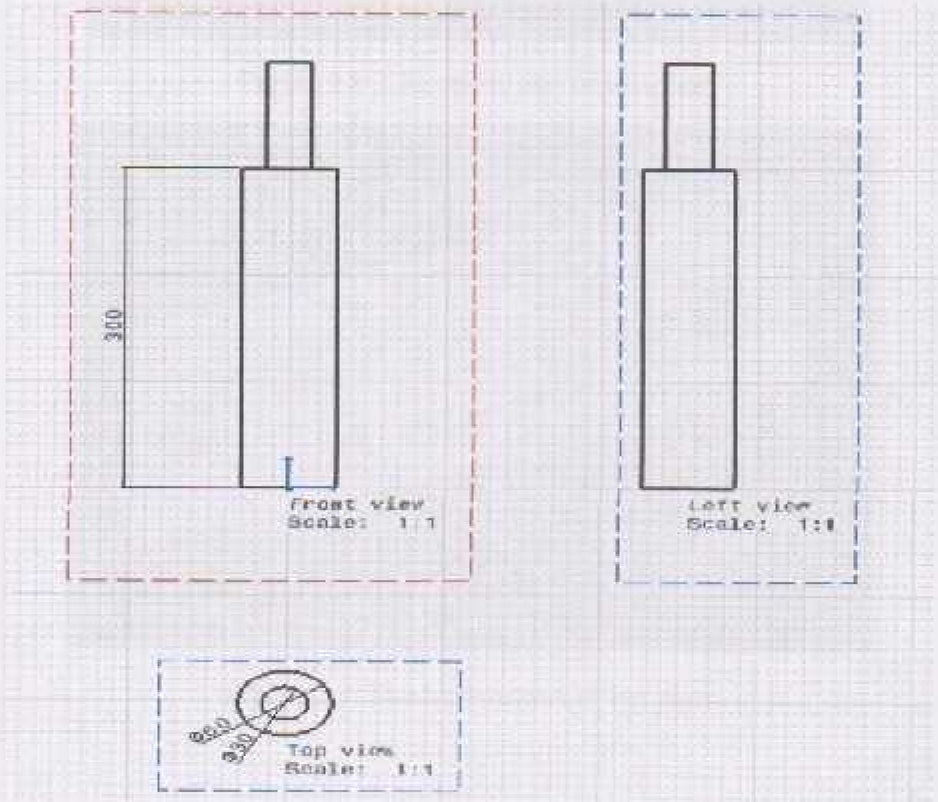


Figure 2.7 Hydraulic cylinders

2.3.3 Template Part

The template works so that when entering the part of Aluminum the piston will work to compress, the upper part of the template and the template will be installed on the piston, the template is made of aluminum In order to bear the pressure of piston. Illustrates the Figure 2.8 and Figure 2.9. And chosen the diminution based on tape width

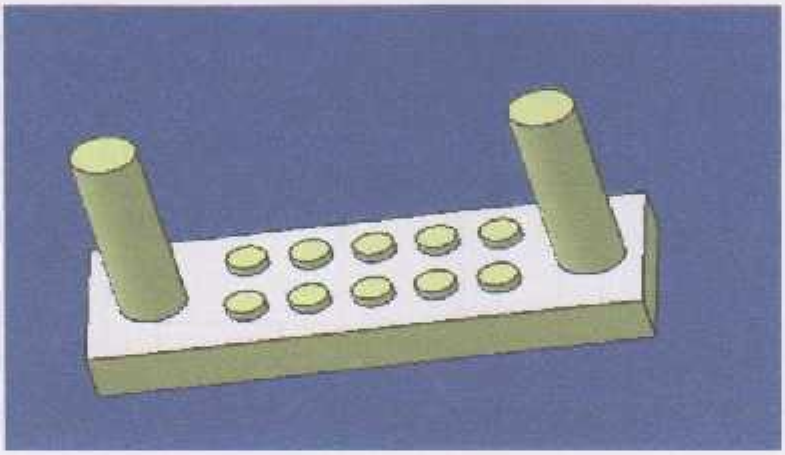


Figure 2.8 .The upper part of template

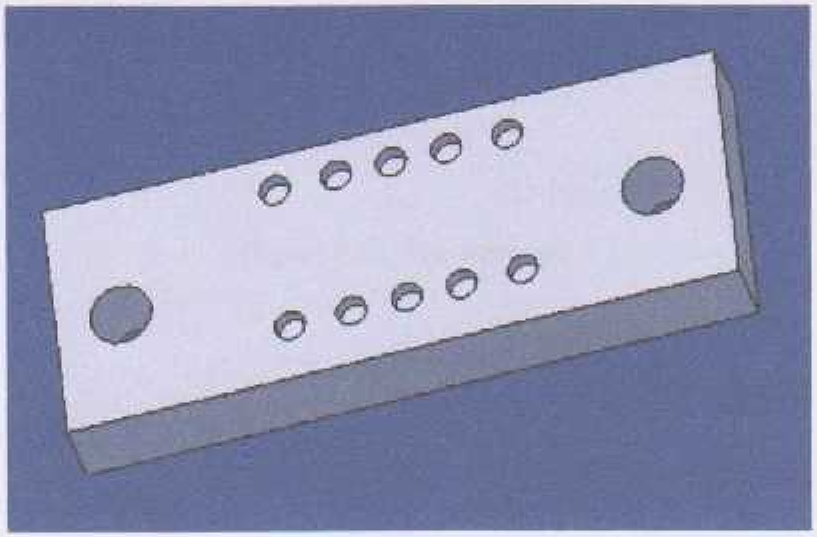


Figure 2.9 .The bottom part of template

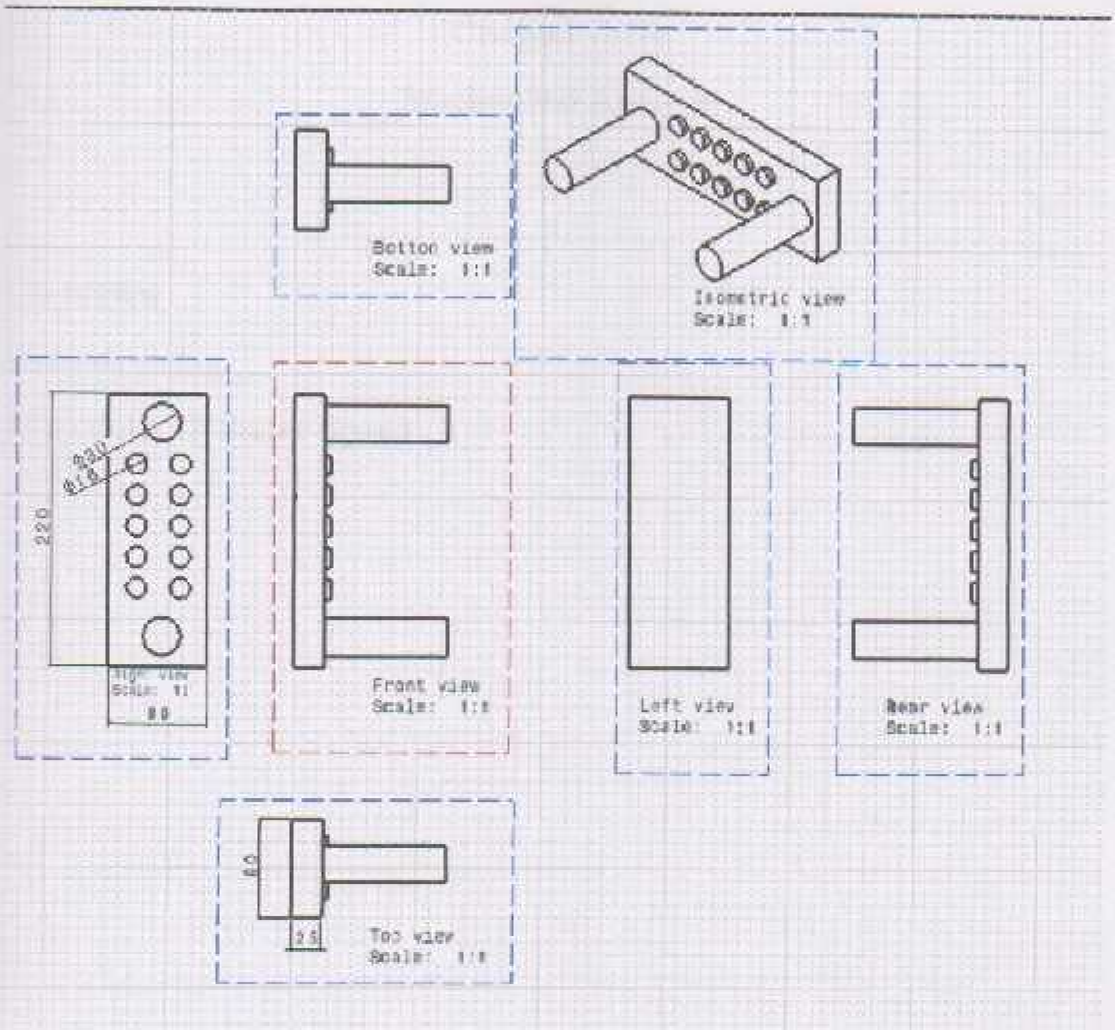


Figure 2.10 .The template

Chapter three

Mechanical Analysis

3.1 Overview

3.2 Deep drawing

3.3 Hydraulic Cylinder Speed

3.1 Overview

The template will be push by the force resulting from the compress piston so the template will be installed in the piston, through this chapter the force and material analysis will be explained.

3.2 Maximum Punch Force

To calculate the maximum punch force, first of all the punch force required to shear stress of the metal sheet is direct proportional to the length of cut sheet, the thickness, shearing strength, and in no friction condition, the result is equation 3.1

$$F_p = 0.7\sigma_u hL \qquad (3.1)$$

Where:

F_p is maximum punch force
σ_u is the ultimate: tensile strength
h is sheet thickness
L is total length of the sheared edge

3.3 Experimental Tests

In equation 3.1 the tensile strength for the aluminum foil is not available so that an experimental to test the material strength and find the required force is applied in hydraulic laboratory. Figure (3.1) illustrate the experimental,

Figure 3.1.The experimental

The value to be adjusted to the pressure forming process and this value is 8 bar or $8 \times 10^5\ pascal$.

$$F = P \times A \tag{3.2}$$

Where

F is the force piston

P is the pressure of piston

A is the area of piston

From pressure definition of equation 3.2 is $8 \times 10^5\ pascal$,and the area A=(7.06 $\times 10^{-4} m^2$ so the force is equal 565.2 N.

3.4 Hydraulic Cylinder Speed

The Speed of hydraulic cylinder rod based on two factors.

1. The size of the cylinder bore, which is the area inside the cylinder in which the piston moves.
2. The oil flow rate into the cylinder. Figure 3.3 illustrates the hydraulic system.

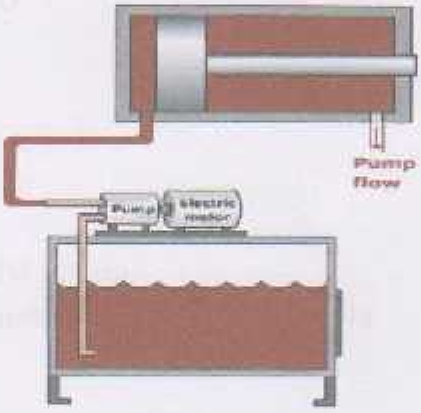


Figure 3.2 .The hydraulic systems

3.4.1 Calculation the Extension Speed of Cylinder

Three calculations are required to determine the extension rate of the cylinder

Calculation 1:

Find the flow rate of fluid

$$Q = V_D \times N \quad (3.5)$$

$Q = 20\ litter/min$
$v_D = 14 \times 10^{-3}\ m^3/rev$
N=1450 rpm

Q is flow rate
V_D is fixed displacement pump
N *is* Revaluation per mints

Calculation 2:

Find the bore size of the cylinder (also the piston area) using the following equation 3.6.

$$A_p = \frac{\pi D_p{}^2}{4} \quad (2.6)$$

$$A_p = 7.065 \times 10^{-4} \quad m^2$$

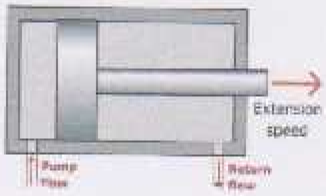
Where:

A_p is Piston area
π is 3.14
D_p is Diameter of the piston
4 is numerical constant used in the formula

Calculation 3:

Find the speed of piston at which the piston rod extends use equation 3.7.

$$V_E = \frac{231 * Q}{A_P} \qquad (3.7)$$



$$V_E = \frac{231 * 20}{7.065 \times 10^{-4}} = 6.5 \times 10^6$$

in^3/rev

231 is constant (for cubic inches in a gallon)

Q is Flow rate of the pressurized fluid (in gpm)

A_p is Piston area

3.4.2 Hydraulic Pressure

- the pressured, marked p, is created by direction a force on a fluid
- according to Pascal's low, pressure spread equally in every direction in a fluid
- Pressure in the fluid causes a force effecting at a right angle against surface as illustrated Figure 3.5.

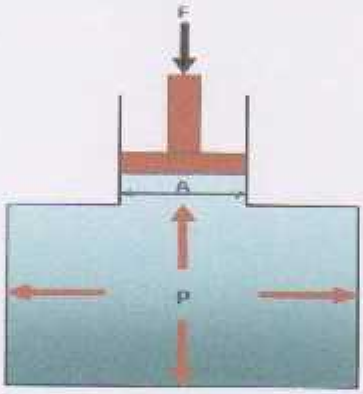


Figure 3.3. The effect of pressure

- the force is equal in every area unit
- Pressure is given in a force on area unit.

To calculate the pressure of the piston we use equation 3.8.

$$P = \frac{F}{A} \tag{3.8}$$

Where:

- P is pressure $[N/m^2]$
- F is Force [N]
- A is Area $[m^2]$

But the value of pressure is equal 8×10^5 *pascal by test.*

Hydraulic power:

- Hydraulic power is a result flow and pressure.
- SI system power unit is KW.
- Imperial system power unit is hp.
- To calculate the power use equation 3.9.

$$P_{power} = p \times Q \tag{3.9}$$

$$P_{power} = 16 \text{ kw}$$

Chapter Four

Control Design

4.1 Overview

4.2 Overall Control Steps

4.3 System Modeling and Control

4.1 Overview

Control system is essential in a system to give desired motion and it can be tuned according to the need of application.

Control system is a collection of components to construct an accurate machine. There are two types of control systems, open-loop system and closed-loop system and all the components (physical system) can be represented by mathematical equation called transfer function.

Figure 4.1 illustrates a schematic diagram of a hydraulic control system

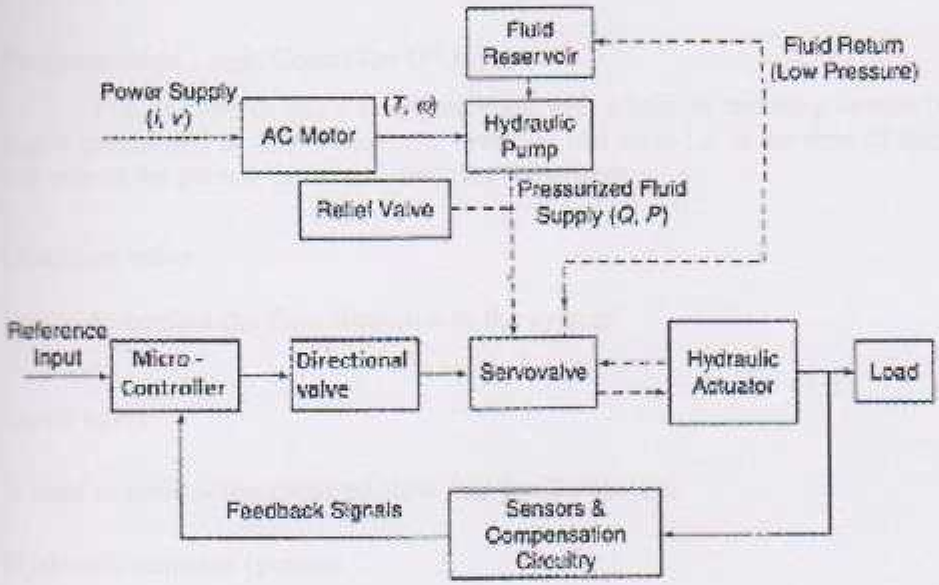


Figure 4.1 Schematic diagram of a hydraulic control system

System components include the following:

1) AC Motor

AC motor is an electric motor driven by an alternating current (AC) and this motor operating the pump.

2) Hydraulic pump

It will be used to convert the mechanical power into hydraulic power, and supply high pressure to the system

3) Fluid reservoir

The tank that contains oil. Its volume three times the needed oil for the system.

4) Pressure Relief Valves (PRV):

The pressure relief valve used to return the oil when the pressure of the system increase so it is safety valve

5) Programmable Logic Controller (PLC)

PLC is more or less a small computer with a built-in operating system (OS). This OS is highly specialized to handle incoming events in real time, i.e. at the time of their occurrence, in this project the plc will be used to automate the system.

6) Direction valve

It used to control the flow direction in the system

7) Servo valve

It used to control the required flow rate for the system.

8) Hydraulic actuator (piston)

Used to convert hydraulic power into mechanical power

9) Sensor and compensation circuit:

Sensors will be used to monitor and control the system parameter such as pressure, flow and speed, compensation circuit will be used to condition sensors signal if there is a noise.

4.2 Overall Control Steps

From the previous chapter the piston speed is direct proportional to oil flow rate that could be controlled by two ways

1) Control the flow by control the speed of the AC motor by using inverter.
2) By servo valve that contain a throttle and flow feedback that control the throttle area to adjust the flow rate and that what will be used in this project to control the flow rat

Figure 4.2 illustrates the block diagram of closed loop control system; the system will start from the input position (q) by the user. The input signal is handled by software installed on microcontroller that gives the command to the circuit until it achieves the required input.

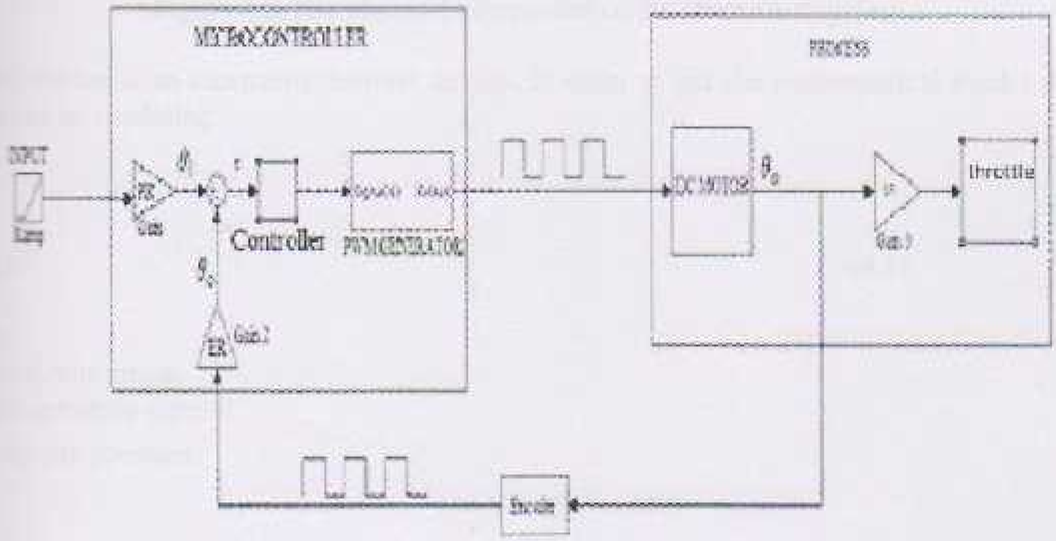


Figure 4.2 Block diagram of closed loop control system

4.3 System Modeling and Control

Control system design is based on a mathematical model for the system or process to be controlled.

Figure 4.3: illustrate the physical component of the controlled system that contain a servo DC motor and the throttle in order control the flow rate the DC motor will control the opening throttle area.

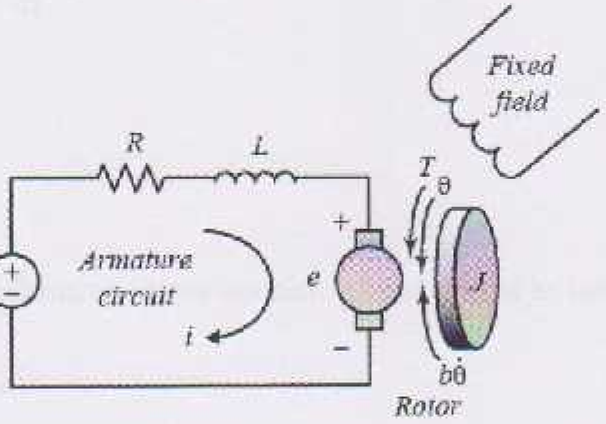


Figure 4.3.The physical component of the controlled system

The DC motor is an electromechanical device, in order to get the mathematical model the two sides must be modeling.

$$T = ki \qquad \textbf{(4.1)}$$

Where
T is the motor torque
i is the armature current
k is a torque constant

The generated voltage, e_a is relative to angular velocity by

$$e_a = k_e\omega_m \qquad (4.2)$$

From the Figure 4.3 we can derive the following equations for mechanical and electrical behavior by using Newton's 2nd law and Kirchhoff's voltage law.

$$j\frac{d^2\theta}{dt^2} + b\frac{d\theta}{dt} = ki \tag{4.4}$$

Where

j is the inertia
b is the damping

$$L\frac{di}{dt} + Ri = v - k\frac{d\theta}{dt} \tag{4.5}$$

L is inductance

R is the resistance

V is the voltage

Transfer Function

Using the Laplace transform, equations equation 4.4 and 4.5 can be written as:

$$(js^2 + bs)\theta(s) = kI(s) \tag{4.6}$$

$$L(s + R)I(s) = V(s) - Ks\theta(s) \tag{4.7}$$

$$I(s) = \frac{V(s) - ks\theta(s)}{R + Ls} \tag{4.8}$$

Substitute equation 4.8 in equation 4.6 to obtain:

$$js^2\theta(s) = bs\theta(s) = \frac{kV(s) - ks\theta(s)}{R + Ls} \tag{4.9}$$

$$\frac{\theta(s)}{V(s)} = \frac{K}{s(Js + b)(Ls + R) + K^2} \tag{4.10}$$

For the throttle could be modeling throw the following equation

$$Q = UbC_d\sqrt{\frac{2(P_S - P_2)}{\rho}} \tag{4.11}$$

Where:
Q is the Flow Rate
U is the Input displacement
b is the Land width

Cd is the discharge coefficient at each port
P_s is the supply pressure of the hydraulic fluid
P_2 is the pressure after the valve
ρ is the Density of the hydraulic fluid

$$Ub = \theta L \tag{4.12}$$

θ is the Angular displacement
L is the land of screw

Substitute equation 4.12 in equation 4.11 to obtain:

$$Q = \theta L C_d \sqrt{\frac{2(P_S - P_2)}{\rho}} \tag{4.13}$$

From equation 4.13 can express(θ):

$$\theta = \frac{Q}{LC_d\sqrt{\frac{2(P_S - P_2)}{\rho}}} \tag{4.14}$$

By Laplace transformer equation 4.14 will be:

$$Q(S) = LC_d\sqrt{\frac{2(P_S - P_2)}{\rho}}\,\theta(s) \tag{4.15}$$

And substitute equation 4.15 in equation 4.16 to obtain equation 4.17:

$$\theta(s) = \frac{K}{s(Js+b)(Ls+R)+K^2}\,V(s) \tag{4.16}$$

$$Q(S) = \frac{LC_d\sqrt{\frac{2(P_S - P_2)}{\rho}}K}{s(Js+b)(Ls+R)+K^2}V(s) \tag{4.17}$$

Now a transfer function can be obtained by write equation 4.18 as a ratio between the input ($Q(s)$) and the output ($V(s)$):

$$\frac{Q(s)}{V(s)} = \frac{LC_d\sqrt{\frac{2(P_S - P_2)}{\rho}}K}{s(Js+b)(Ls+R)+K^2} \tag{4.18}$$

Transfer function coefficient obtained from assumed parameter in Table 3, now MATLAB/Simulink could be used to study the response of the system, in order to decide which controller have to be used.

Table 4-1: Assumed System Parameters

Parameters		Value	Unit
R	Resistance	28	Ohm
$K_\tau = K_b$		.443	--------
J	Inertia	0.9	$kg * m^2$
ρ	Density	0.880*10^3	Kg/m^3
l	Land	0.002	m
C_d	Discharge coefficient	0.877	--------
B	Damping	0.012	N.s /M
P	Pressure	8×10^5	Pascal
I	Inertia	1.169	mH

Figure 4.4 show the Simulink block of the uncontrolled system with 1ml as input

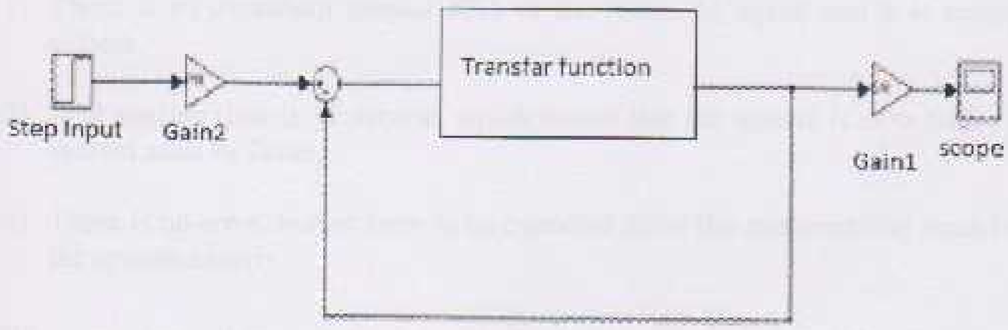


Figure 4.4 show the Simulink block of the uncontrolled system

The step response of the uncontrolled system shown in figure(4.5):

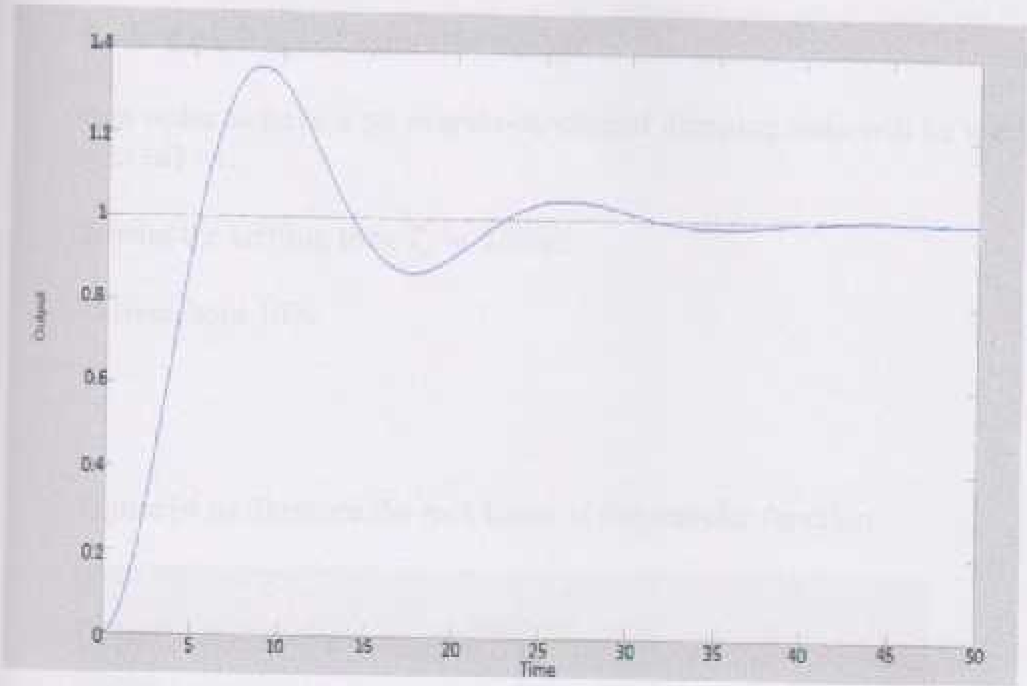


Figure 4.5 Step responses for uncontrolled system

Figure 3.4 indicates that

1) There is an overshoot around 30% of the reference signal and it is unaccepted in the system.

2) The settling time is 15 second, which means that the system is slow while the hydraulic system must be faster.

3) There is no error, but an error is be expected since the mathematical model not represent the system exactly.

A PID controller will be design to provide 0% study state error , and decrease the settling time to be 1.5sec, and decrease the overshoot.

4.4 PID controller design

From the criteria of controller design:

1-in order to have a no overshoot, critical damping ratio will be used which mean zeta (δ) =1.

2-from the settling time $T_s = 1.5sec$

3- overshoot 10%

Figure (4.6) illustrate the root locus of the transfer function

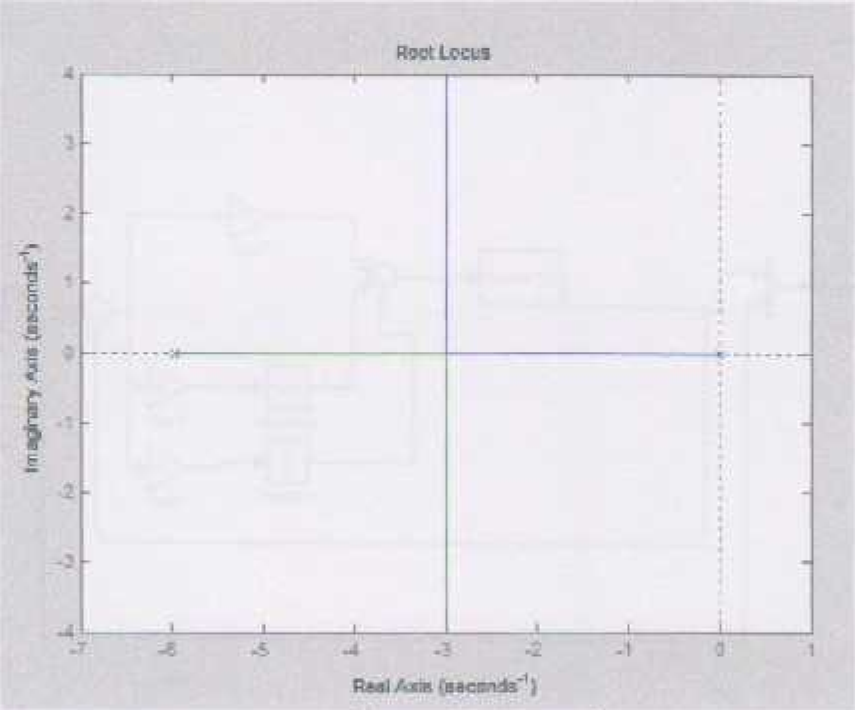


Figure (4.6) root locus

By using SISOTOOL in matlab we can design of PID controller just adding the data required and transfer function, after that can get the gain pf PID controller from equation(4.19).

$$G_{PID} = \frac{1.4e^{004}s^2 + 0.002502s + 130.8}{s} \qquad 4.19$$

From equation 4.19 the gain of PID is:

1) KD=$1.4e^{004}$
2) KP=0.002502
3) KI=130.8

Now we simulate the controlled system in order to ensure the required response is achieved. Figure (4.7) show the Simulink of controlled system and the response

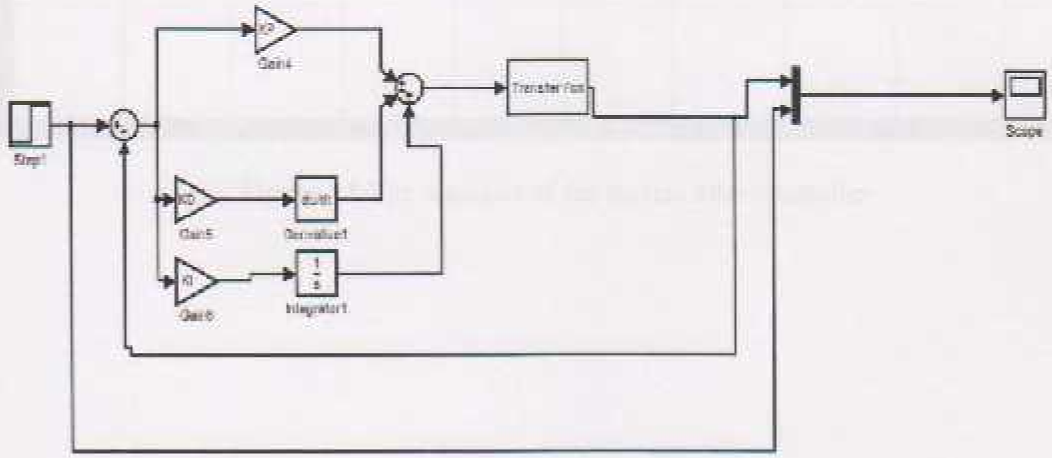


Figure 4.7.Simulink of PID controlled system

Figure 4.8 illustrate the response after simulation, and the result decreased the settling time to 1.5 sec, decreased the overshoot from 30% to 10%, and study state error 0%.

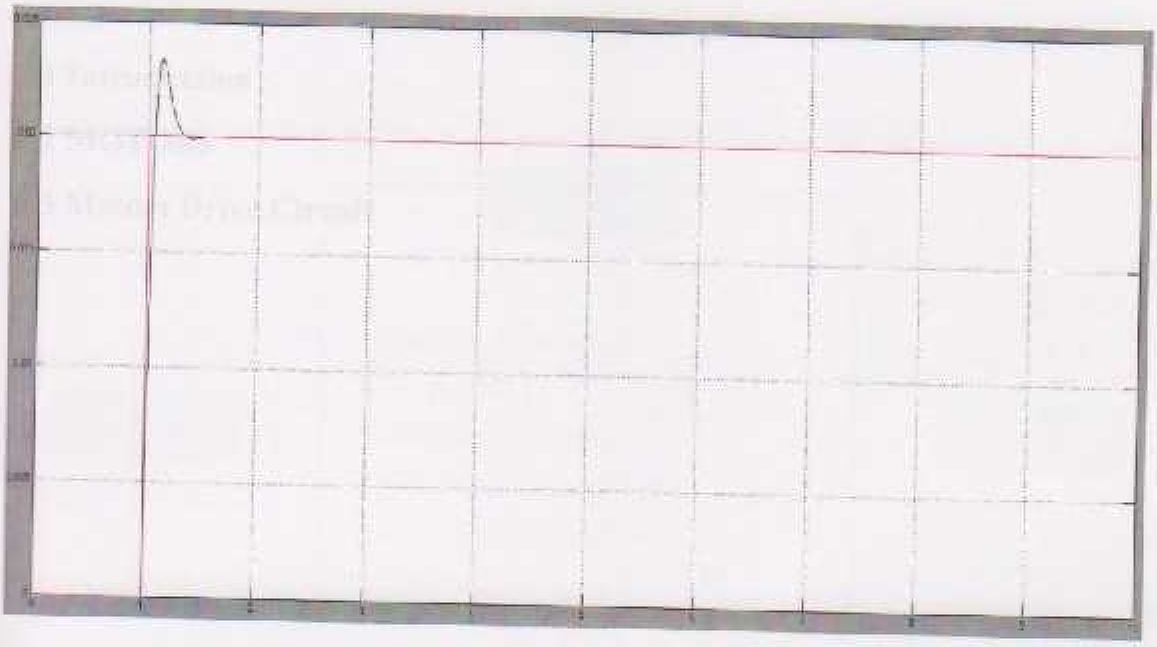


Figure 4.8.The response of the system after controller

Chapter Five

Electrical Design

5.1 Introduction

5.2 MOTORs

5.3 Motors Drive Circuit

5.1 Introduction

This chapter will discuss the process of designing the needed electrical parts to operate the system; these parts include the actuators which are electrical motors, the drive circuits, and the controller.

The block diagram shown in Figure 5.1 describes the elements that form the entire system generally.

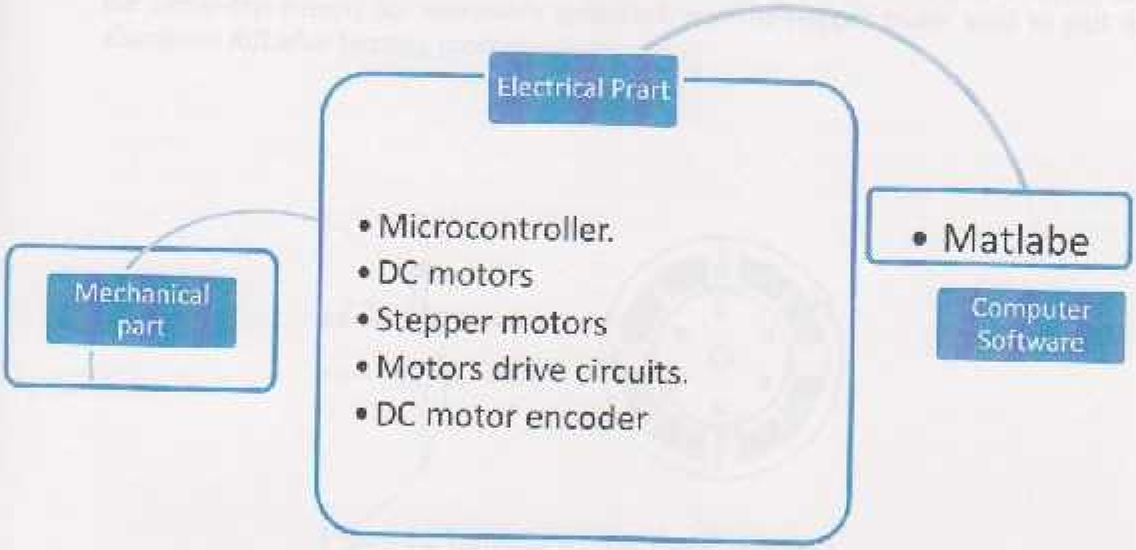


Figure 5.1 Basic Elements in the System

The electrical system includes two types of electrical motors, the first is stepper motors these motors are controlled by digital sequence generated by microcontroller and supplied to the motors throw drive circuits, and the second type is the DC motors which are controlled by the controller using pulse with modulation technique.

The designing of stepper motors drive circuit will be discussed in this chapter.

5.2 MOTORs

The system includes one unipolar stepper motors and one DC motor to provide the needed motion, and one Ac motor to drive the pump.

5.2.1 Stepper Motor

Unipolar stepping motors are composed of two windings, each with a center tap as shown in Figure 5.2. The center taps are brought outside the motor as two separate wires. As a result, unipolar motors have 6 wires, and driven by tied the 4 coils to power supply and the center tap wire(s) are alternately grounded, and the stepper motor used to pull the aluminum foil after forming process.

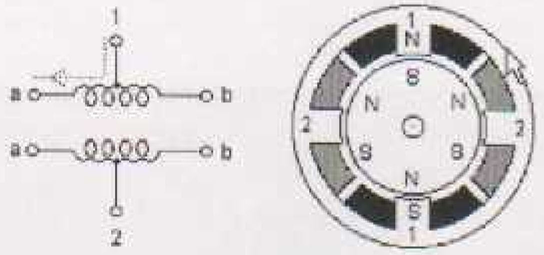


Figure 5.2 Unipolar stepper motor windings

5.2.2 Dc Motor

This project work to controlling for speed of the system by controlling the flow of the oil, and in order to controlling the flow used dc motor installed on the spigot, and make position control for this system form during this can control for the speed.

5.2.3 Ac Motor

This project work by hydraulic system, and this system need the Ac motor to drive the pump, when the Ac motor run the pump run .

5.3 Motors Drive Circuit

Since the motor need a power that microcontroller can't deliver it, a power circuit will be used that increase the power of the control signal.

5.3.1 Designing of Motors Drive Circuit

Since the motors used in the systems are unipolar stepper motors with 4 poles, it is now required to design a drive circuit that transfer the digital signal produced by the Microcontroller and supply the motor with the required power as it donated in the motors datasheets.

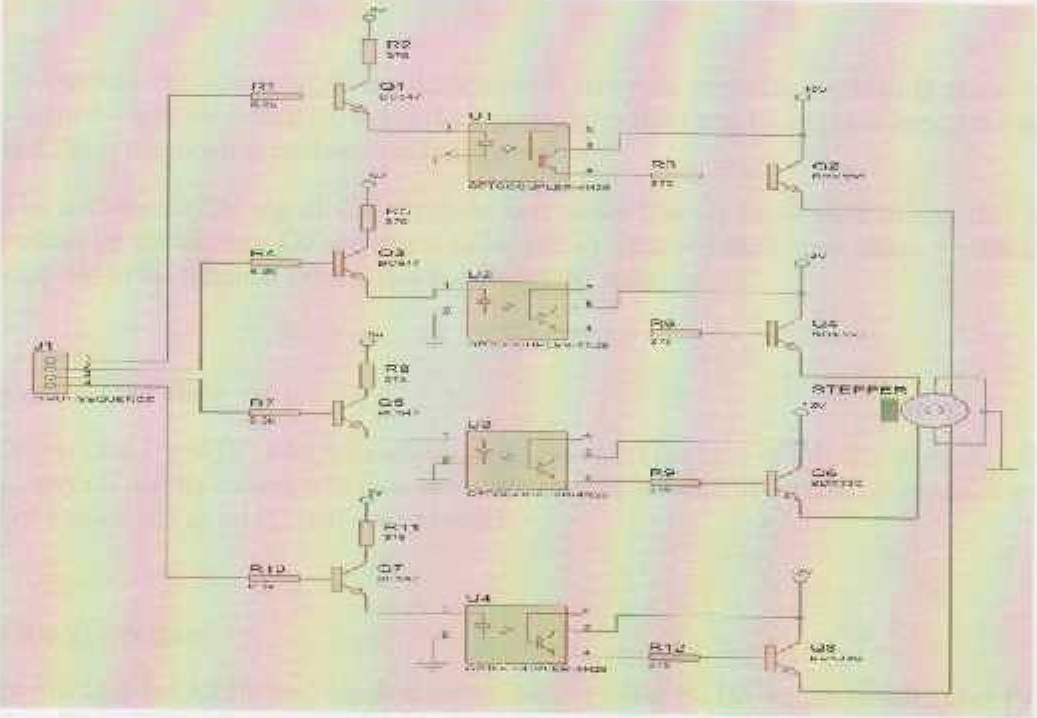


Figure 5.3: Motor Drive circuit

Figure 5.3 show the drive circuit, the motor poles are power from power transistors, and for isolation purpose the power transistor biased by an Optocoupler to isolate the power connection between the Microcontroller and the power transistors.

The Optocoupler is biased by a transistor which receives the digital signal from the Microcontroller.

Thus in our calculation we will design one pole drive circuit which will be applied for all the other poles.

5.3.2 Circuit Operation Principle

As we mentioned earlier in this chapter the digital sequence which control the motor rotation is produced by the microcontroller, this sequence is formed by four digital bits (0 0 0 1) since a four poles unipolar stepper motor will be used, 4 bits are shifted on the input of the motor drive circuit to generate the rotation.

To describe the operation of the drive circuit ,one pole connection which is shown in Figure 4.4 will be discussed. D0 is the signal comes from one bit of the microcontroller, and Zm is the motor impedance representation.

The microcontroller signal (D0) include two states 0 or 1, the 0 state means that no voltage on the terminal D0 and this is called (OFF) state, and the 1 state means 5 volts are supplied to the terminal D0 and this is called (ON) state.

Case 1: OFF state

In this case D0=0 [V] which means no input current at the base of Q1, this will make Q1 to stay off and no current will flow throw the emitter, because of that the optocoupler will not turn on and so on Q2 will not be biased.

Case 2: ON state

In this case the ARDUINO supplies digital logic 1 to the bit D0, which means D0=5 [V], *thus D0 will bias Q1 as will show by the calculations latest in this chapter, and Q1 will* turn on the optocoupler which will bias Q2.

Q2 is a power transistor that will supply the power to the motor terminals in order to activate the pole that is connected to the emitter.

So the stepper driver is work like switch that convert the small power signal generated by the microcontroller to high power signal with specific values of voltage and current that can activate the desired motor pole.

5.3.3 Relay

The hydraulic system can controlling by selector, and this selector installed two coil work on 220 volte and this project will be controlling by microcontroller, and the microcontroller get 5 volte output so must be used relay and transistor to drive this coils. Figure 5.4 illustrates circuit for controlling an Ac or other high - current device from a microcontroller by using relay.

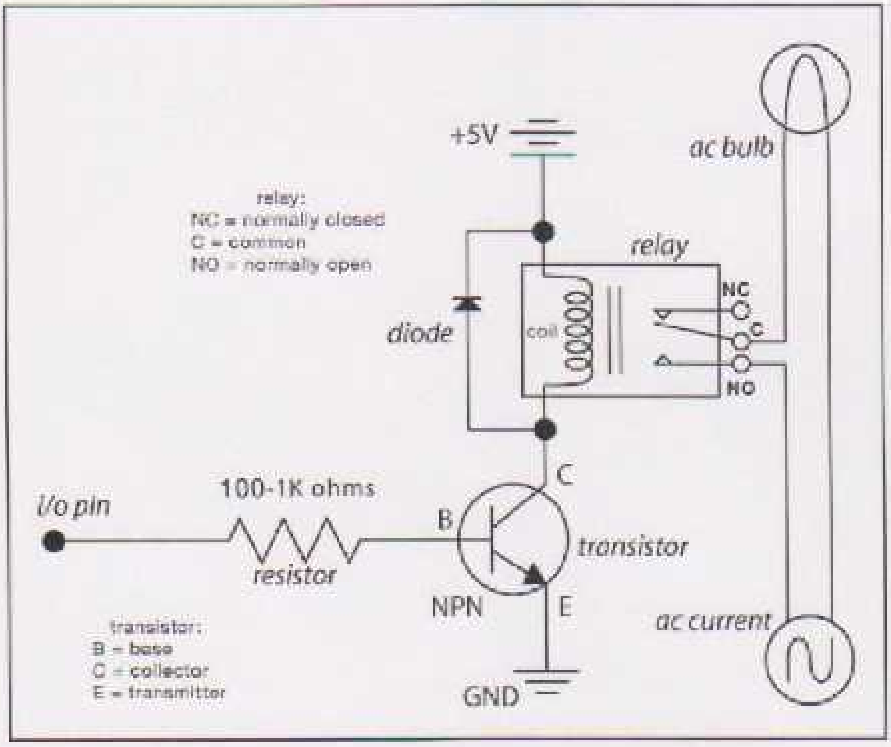


Figure 5.4 Drive Circuit for Relay

Chapter six

Experimentations and Results

6.1 Introductions

6.2 Mechanical parts

6.3 Response testing of the control system

6.4 Conclusion:

6.5 Recommendations

6.1 Introduction

This chapter demonstrates the results that are obtained from the experiments in order to verify the theoretical results reached in control design chapter. The mechanical, electrical, and control designs are to be applied in this practical side. Then the practical results and modifications that refer to the theoretical results are discussed.

6.2 Machine parts

Figure 6.1 illustrates the general structure of the machine

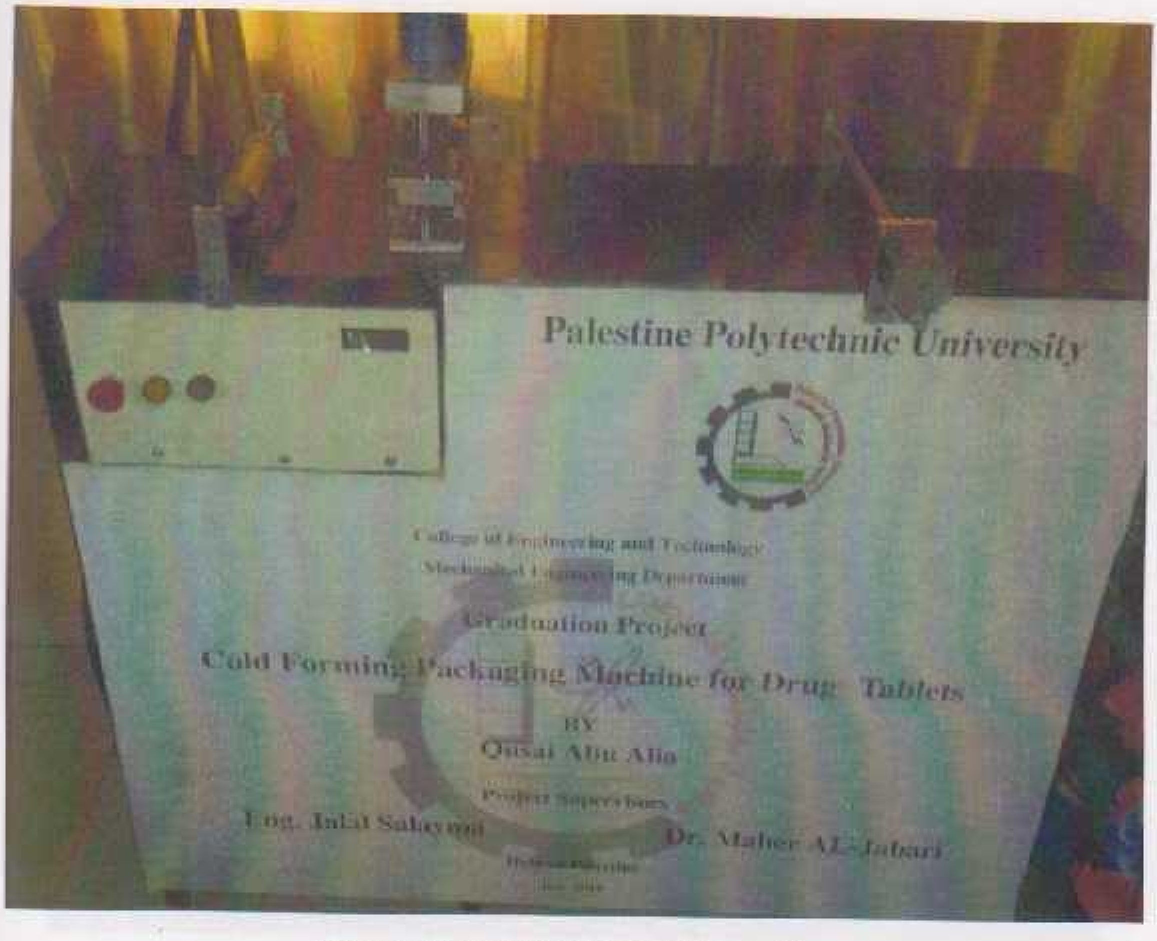


Figure 6.1. General structure of the machine

Figure 6.2 illustrates the stepper motor. This motor works to pull the aluminum foil after the forming process.

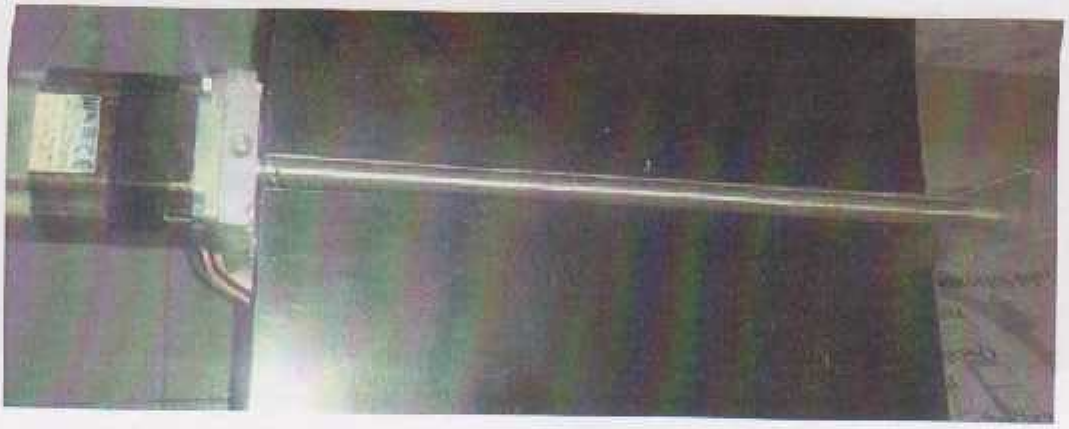


Figure 6.2.The cylinder that work to pull the aluminum foil by stepper motor

Figure 6.3 illustrates the template. This template is divided into two parts; the first one is the upper part (the one installed on the piston) and the second part which is installed on the table.

The first part moves towards the second part by guide. The guide represents the center between the two parts which helps to reach the balance between the parts. Also, the guide is mode of chrome and the template is made from Aluminum.

Before the forming process, the aluminum foil must be installed from four sides to get the perfect forming , but in this project the material installed from two sides only.

Figure 6.3. The template that works on the formation of aluminum foil

Figure 6.4.illustrates the cylinder that installed the aluminum foil before forming process

Figure 6.4 the cylinder that installed the aluminum

Figure 6.5 illustrates the control panel of the machine. From this panel, the workers can run the machine and stop by the emergency, and display the number of tapes on the LCD screen.

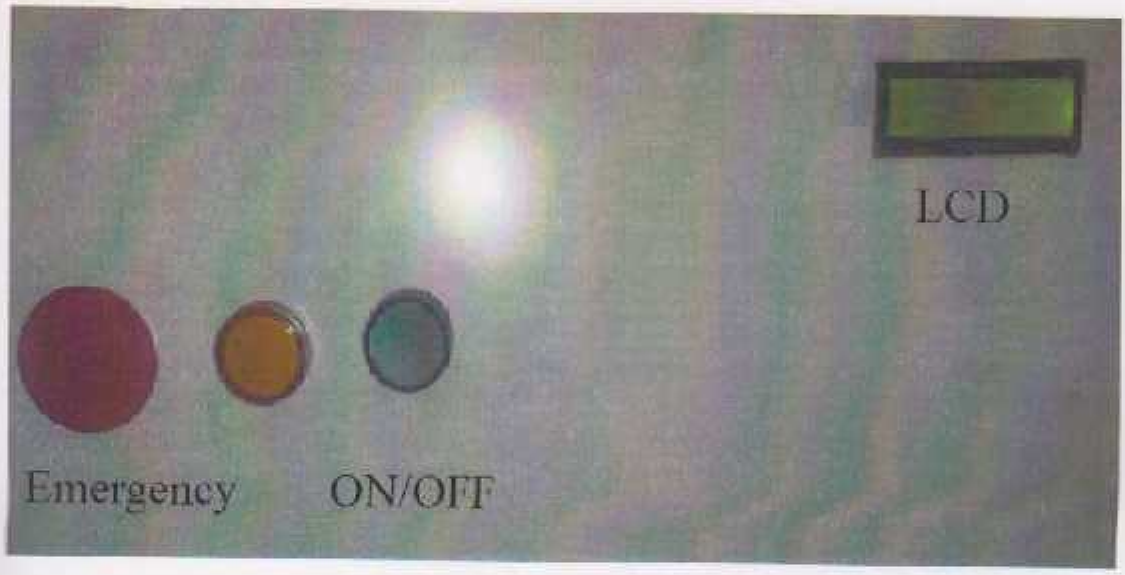


Figure 6.5 Control panel of the machine

Figure 6.6 illustrates the hydraulic pump that is important to pump oil to the piston for moving the template. When the Ac motor runs the pump which is installed on the shaft of the Ac motor, the oil goes through the pipes to the piston.

Figure 6.6: Hydraulic pump unit

Figure 6.7 illustrates the pressure relief valve. When the pressure increases in the machine, this valve works to get the oil back to the tank. So this valve is one of the most important parts as it has the main role to protect workers.

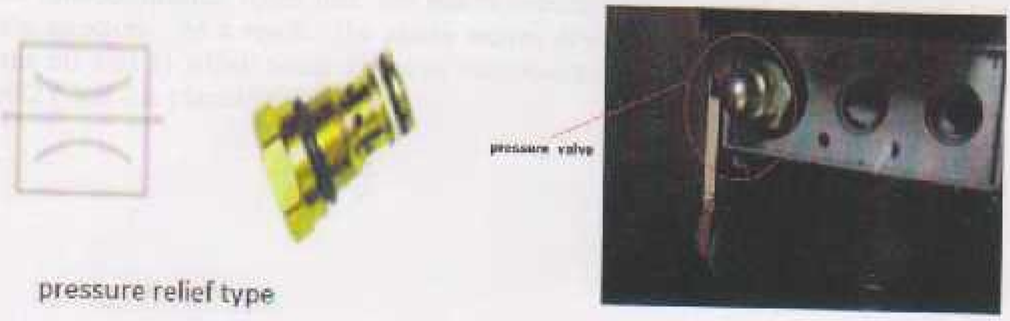


Figure 6.7 illustrates the pressure relief valve

Figure 6.8 illustrates the electrical panel which is responsible for the operation of the machine. This panel includes of the driver that works to run the stepper motor. Also, the panel includes of the microcontroller which is called arduino and this microcontroller work to control the machine.

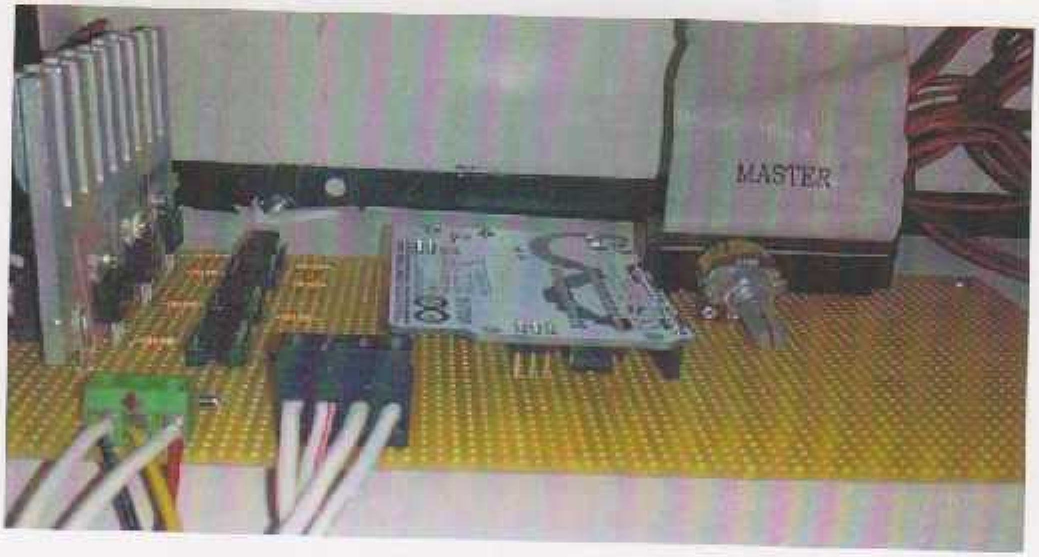


Figure 6.8. The electrical panel responsible for the operation of the machine

Figure 6.9 illustrates the limit switch that works to feedback the microcontroller. When the template rises, it reaches limit switch 1 (in this stage, it turns off coil 2), this limit switch sends signal to the microcontroller. After that, the microcontroller sends signal to coil 1 (coil 1 is placed on the selector). As a result, the piston moves down to reach limit switch 2 (in this stage, it turns off coil 1) which sends signal to microcontroller and the microcontroller sends signal to coil 2 (coil 2 is placed on selector).

Figure 6.9.The feedback of the microcontroller and called limit switch

Figure 6.10 illustrates the control valve that works to determine the direction of the oil. When the signal reaches the coils, the selector works.

Figure 6.10. Solenoid and Modular Valves

6.3 Response testing of the control system

The real hardware which is used to simulate and evaluate the performance of the proposed controller that applied on the throttle mechanisms as shown in figure 6.11

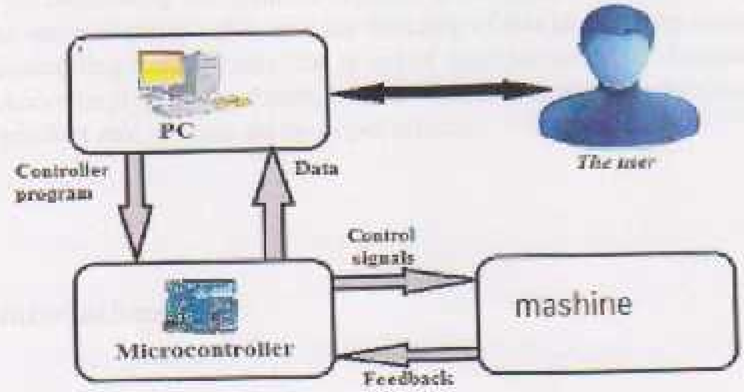


Figure 6.11.The interface between user and machine system

Controller applied to the norm of error to control the flow of oil in the hydraulic system. The purpose of this controller is to improve the speed of the system in order to increase the product rate.

From the previous controller, the response for system is good and has approximately negligible steady state error and there is no overshoot and the settling time is also acceptable .

6.4 Conclusion:

The project achieves its goal and it gives a feature to control for the speed of the machine, and keeps the workers safe. Also, the project could be used in the pharmaceutical factories. As mentioned before, complicated machines exist in pharmaceutical factories; however this machine can offer the same functions with low manufacturing cost.

The majority of the forming machines in pharmaceutical factories use the cam to move the template. This mechanism and this rotated cam from the shaft of the motor generate the friction between the shaft of motor and cam, so the life cycle of this cam is short. However, in this project the template moves by piston that works by hydraulic system and generates no friction in this mechanism.

The best way for controlling the hydraulic system is the servo valve. However, this project uses mechanism the same of servo valve, and the function of this mechanism controls the flow rate of oil. Through controlling the flow rate, the speed of machine could be changed according to the product rate. Accordingly, in the project, it is obvious that through controlling the speed of the machine, the product rate reaches 40 tapes per minute.

6.5 Recommendations

- This project is the first part from packaging machine, and the machine consists of four parts. The first one is called forming and the second is called filling and the third is sealing and the last one is cutting. So this machine is important as it represents a primarily model in which future development could take place.
- Some sensors could be added to show the pressure, flow and temperature and can add camera to know if the entire gap formed or not. Also, it is important to know if this gap filling drug or not.
- The material must installed from four sides to get the perfect forming. In this project the material is installed from two sides only, and after experimental test, it shows if the forming is perfect or not, so the material must be installed from all sides.
- Besides the fact that this machine is very expensive, it is imported from outside Palestine, as the import cost is approximately 500,000 euros. Therefore, if this machine is manufactured in Palestine, the cost will be 2000 JD.
- It is recommended to have new factories that encourage the national industry in which they will adopt the idea of some machines manufactured in Palestine.

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Appendix A

The codes of arduino

Code 1 for limit switch and LCD

```
#include <LiquidCrystal.h>

LiquidCrystal lcd(0, 1, 5, 4, 3, 2);
int counter = 0; //variable that will store the count

const int buttonPin1 = 6;
const int buttonPin2 = 7;    // the number of the pushbutton pin

// the number of the pushbutton pin
const int ledPin1 =  8;
const int ledPin2 =  9;      // the number of the LED pin
boolean PB1p=0;
boolean PB2p=0;
int i=0;
// the number of the LED pin

// variables will change:
int buttonState1 = 0;        // variable for reading the pushbutton status
int buttonState2 = 0;        // variable for reading the pushbutton status

const int fw =  13;
const int fw1 =  12;
const int re =  11;
const int re1 =  10;// the number of the LED pin
      // interval at which to blink (milliseconds)

void setup() {
 // initialize the LED pin as an output:
 pinMode(ledPin1, OUTPUT);
 pinMode(ledPin2, OUTPUT);

 // initialize the pushbutton pin as an input:
 pinMode(buttonPin1, INPUT);
```

```
pinMode(buttonPin2, INPUT);
 lcd.begin(16, 2); //set up the LCD's number of columns and rows:
  lcd.setCursor(0,0);
  lcd.print("temlate number ");


   pinMode(fw, OUTPUT);
 pinMode(fw1, OUTPUT);
 pinMode(re, OUTPUT);
 pinMode(re1, OUTPUT);
}

void loop(){
 lcd.setCursor(0, 0);
  lcd.print("temlate Number ");
  lcd.setCursor(0, 1);
  lcd.print(counter); //print it on serial monitor
  PB1p= buttonState1;
  PB2p=buttonState2;

  buttonState1 = digitalRead(buttonPin1); //read the increment button state
  buttonState2 = digitalRead(buttonPin2); //read the decrement button state

 if (buttonState1 == HIGH)
   {
     digitalWrite(ledPin2, LOW);
     digitalWrite(ledPin1, HIGH);
     delay(500);
   // Motor motion//

  for(int hold=0;hold<=50;hold++)
 {
   digitalWrite(10, HIGH);

delay(5);
   digitalWrite(10, LOW);
  digitalWrite(11, HIGH);

delay(5);
   digitalWrite(11, LOW);
   digitalWrite(12, HIGH);

delay(5);
   digitalWrite(12, LOW);
  digitalWrite(13, HIGH);
```

```
 delay(5);
    digitalWrite(13, LOW);
 }

    }

   else if (buttonState2 == HIGH)
    {
    digitalWrite(ledPin1, LOW);
    digitalWrite(ledPin2, HIGH);
     delay(50);

   }

  if(PB1p==LOW &  PB2p==LOW & buttonState2==HIGH)
 {
 counter++;

 }

 delay(200);

}
```

Code 2 for dc_ motor

```
#include <Encoder.h>

Encoder myEnc(2, 3);
const int CCWdir=4;
const int CWdir=5;
const int  OUT=10;

double u,r,c,ep,epp,Ip,up,upp,e;
//u Input for motor
//e Error
//c Feedback
//r input desired angle

double Kp=0.001;
double Ki=0.05;
```

```
double Kd=0.01;
double Ts=0.01;

double A=(Kp+((Ki*Ts)/2)+((2*Kd)/Ts));
double B=((Ki*Ts)-((4*Kd)/Ts));
double C=(-Kp+(Ki*Ts)/2+(2*Kd)/Ts);
double D=1;

int count=0;
void setup()
{


 pinMode(12,INPUT);
 attachInterrupt(0, blink, CHANGE);

 attachInterrupt(1, blink1, CHANGE);
 pinMode(9,OUTPUT);
 Serial.begin(9600);
 u=0;
 e=0;
 c=0;
 r=0;
 ep=0;
 epp=0;
 up=0;
 upp=0;
pinMode(CCWdir,OUTPUT);
pinMode(CWdir,OUTPUT);
pinMode(OUT,OUTPUT);
Serial.begin(9600);

}
long oldPosition = -999;

void loop()
{
 long oldPosition = -999;
 long newPosition = myEnc.read();
 c=analogRead(0);
 c = int(c/100);
  e=r-c;

 if(oldPosition<c)
  {
```

```
    digitalWrite(CCWdir,HIGH);
    digitalWrite(CWdir,LOW);
   }
   else
   if(newPosition>c)
  {
   digitalWrite(CCWdir,LOW);
   digitalWrite(CWdir,HIGH);
  }
  else
  if(oldPosition==c);
  {
    digitalWrite(CCWdir,LOW);
    digitalWrite(CWdir,LOW);
  }
 u=A*e+B*ep+C*epp+D*upp;

 epp=ep;
 ep=e;
 upp=up;
 up=u;

 if (newPosition != oldPosition) {
   oldPosition = newPosition;
   Serial.println(newPosition);

}

void blink()
{



 Serial.print("count=");
 Serial.print(count);
 Serial.print("  ");

if(count==c)
  {
   digitalWrite(CCWdir,LOW);
   digitalWrite(CWdir,LOW);
  }

   else
   if(count>c)
  {
```

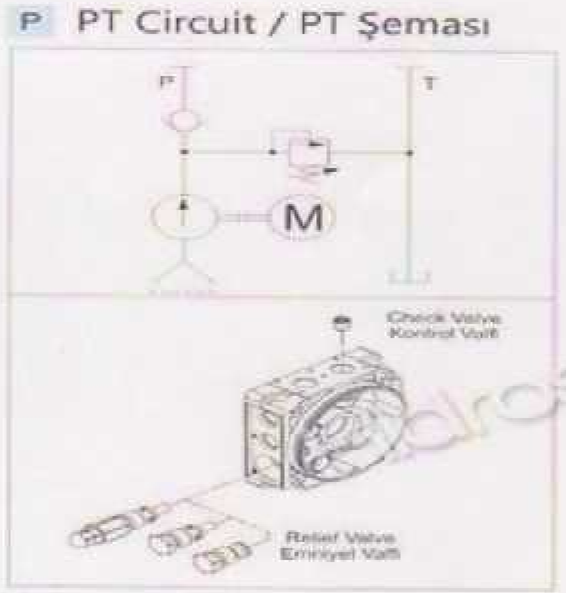
```
  digitalWrite(CCWdir,LOW);
  digitalWrite(CWdir,HIGH);
  count++;
 }
 else
 if(count<c)
 {
   digitalWrite(CCWdir,HIGH);
   digitalWrite(CWdir,LOW);
   count--;
  }

}


}
```

Appendix B

Hydraulic pump unit

AC Motor

Code	Phase	Power (KW)	Voltage(V)
A20	1	0.75	220 v



Pump

Displacement: 0.25...2 cm³

Outlet pressure: up 200 bar

Speed: 750 ...3500 rev/min

Fluid temp.: -20 ... +80 °C

Working liquid: hydraulic oils

Viscosity: 16 ... 200 mm²/s

Degree of filtration: 15-25µm

VI 10 11 12 Reservoir / Tank

10 11 Capacity of Reservoir(Lt) / Tank Kapasitesi(Lt)

[illegible]	01	02	04	06	08	10	12	16	20	20	25
[illegible]	1	2	4	6	8	10	12	16	20	20	25

12 Type of Mounting / Montaj Tipi

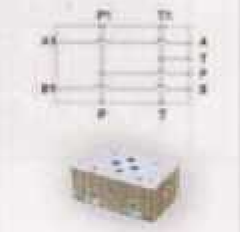
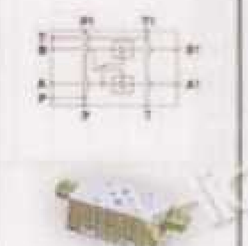
H: Horizontal / Yatay
V: Vertical / Dikey
S: Square / Kare

Horizontal Mounting / Yatay Montajlı

Vertical Mounting / Dikey Montajlı

Hydro-pack

15 Sub Circuit of Solenoid Valve

A03	A05
	

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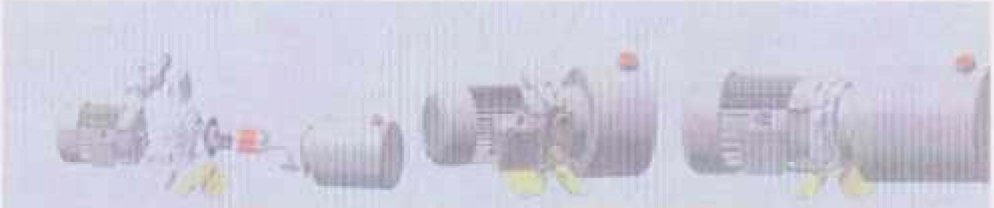
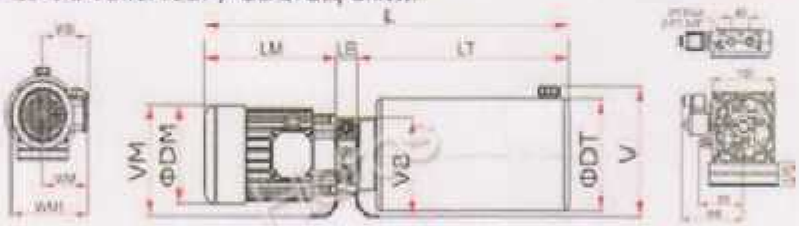


Dimension Table / Boyut Tablosu

General Power Pack / Genel Güç Ünitesi



	DIM / Motor	WB	WM	WM1	DM	VM	LM	LB	LT 1L	LT 2L	LT 4L	LT 6L	LT 8L	LT 10L	LT 12L	L (LM+LB+LT) 1L	2L	4L	6L	8L	10L	12L	1-2L	4-12L	1-2L	4-12L	VB
AC	0.37		105	175	140	170	220									400	470	430	490	550	600	640					
AC	0.55		112	190	155	185	240									420	490	450	510	570	620	660					
AC	0.75		112	190	155	185	247									420	490	450	510	570	620	660					
AC	1.1		127	215	175	195	265									445	515	475	535	595	[illegible]	685					
AC	1.5		127	215	175	195	288									475	545	505	565	[illegible]	[illegible]	715					
AC	2.2	133	148	245	193	205	320	40	140	231	170	230	290	355	420	500	[illegible]	[illegible]	[illegible]	[illegible]	700	740	124	200	196	232	175
AC	3.0		148	245	193	205	315									525	[illegible]	[illegible]	598	655	705	745					
AC	4.0		164	164	317	220	330									530	580	560	620	680	730	770					
DC	0.8		99	139	80	145	133.5									343	413	373	433	493	543	583					
DC	1.5		118	175	115	163	160									344	414	374	434	494	544	584					
DC	2.0		118	175	115	163	165									344	414	374	434	494	544	584					
DC	3.0		118	175	115	163	192									392	442	422	482	542	592	632					