



**Palestine Polytechnic University**

**College of Engineering**

**Graduation Project Proposal**

**Design and Implementation of Automated Wood Edge Gluing Machine**

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## **Abstract**

The industry in our country faces many difficulties and challenges, and the constant need to develop the carpentry field in Palestine suffers mainly because of the use of traditional methods of cutting and pasting the side edges, as workers are exposed to a number of dangers that threatening their lives from the impact of adhesive materials and physical danger of the hands of workers

Also, the production is weak and the workers energy is wasted in work that can do with less time and effort and also higher accuracy.

Therefore, this project aims to propose a solution to this problem by designing automated machine using a programmable logic controller, through which the control circuit is designed for a machine.

Higher quality beside less time and effort compared to traditional machines and human elements, as well as greatly reducing risks, as the machine is fully automated and the human-machine interface is placed away from the moving elements of the machine to spare workers from dangers.

## نبذة مختصرة

تواجه الصناعة في بلادنا العديد من الصعوبات والتحديات، وتعاني من ضعف عملية التطوير المستمر في مختلف المجالات الصناعية في فلسطين وفي مجال التجارة بشكل رئيسي بسبب استخدام الأساليب التقليدية في قص ولصق الحواف الجانبية، حيث يتعرض العمال لعدد من الأخطار التي تهدد حياتهم من تأثير المواد اللاصقة والخطر الجسدي على أيدي العمال

كما أن الإنتاجية ضعيفة ويتم اهدار طاقة العمال في العمل الذي يمكن القيام به بأقل وقت وجهد وأيضًا بدقة أعلى.

لذلك، يهدف هذا المشروع إلى اقتراح حل لهذه المشكلة من خلال تصميم آلة مؤتمتة باستخدام وحدة تحكم منطقية قابلة للبرمجة، يتم من خلالها تصميم دائرة التحكم لآلة. بجودة أعلى بالإضافة إلى تقليل الوقت والجهد مقارنة بالآلات التقليدية والعناصر البشرية، بالإضافة إلى تقليل المخاطر بشكل كبير، حيث أن الآلة مؤتمتة بالكامل ويتم وضع واجهة الإنسان والآلة بعيدًا عن العناصر المتحركة للآلة لتجنب العمال من الأخطار.

## إهداء

إلى الأهل الأعزاء، إلى من بذل الغالي والنفيس لتكون كما نحن عليه .

إلى من ذقت معهم طعم المحبة والأخوة إلى أختي وزملائي.

إلى كل من علمني حرفاً أساتذتنا ومعلمينا العلماء.

إلى من ضاقت السطور ذكرهم إلى من كانوا قوت قلوبنا إلى أحبائنا وأصدقائنا الأعزاء.

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# **Chapter One: Introduction**

## **1.1 Overview**

This chapter represents a general description of the system, starting with background, objectives, the importance of the system, motivation, project schedule, and time planned budget.

## **1.2 Background**

Industrial automation came to facilitate people's lives and reduce the effort and money required to do daily and craft work with high accuracy and low error rates compared to the average human.

Carpentry shops in Palestine use traditional methods in their work, which consume a lot of time and effort, and their final product is less than that of modern carpentry that uses industrial techniques and automated devices.

This project is a design of automated machine for carpentry owners that sticks veneer on the edges of wood panels, as this machine saves money, increases production, saves time, and reduces risks to human labor.

## **1.3 Problem Statement.**

### **1.3.1 The General problems in an industrial and craft environment**

The Palestinian industrial sector is suffering a lot from Israeli occupation and the weak industrial infrastructure in Palestine, where the Israeli occupation works to Prevent insertion of necessary parts to automate industrial machines and monitor any development that occurs in the industrial sector, especially in the field of automation for fear of any development in the Palestinian industrial sector, work to prevent introduced these device and

besiege the development in the industrial field by not giving agencies from international companies to Palestinian engineers [1].

Which reduces their experience and another problem is the import of ready-made machines, compete and weaken the chances of locally manufactured machines, so that they will be at a lower price and higher quality due to the availability of the necessary materials without obstacles the introduction of imported and ready-made machines, which is one of the biggest problems because it works to reduce job opportunities for engineers.

Another important problem is the lack of awareness and experience among the Palestinian workforce, which exposes them to many dangers that affect their lives and luxuries due to direct exposure to the moving and sharp parts of machines and chemicals used in the industry.

### **1.3.2 Questionnaire Analysis**

A Questionnaire that took (10) samples from wood carpentry, some of which contain wood edge gluing machines, was designed to decide whether there is an importance to apply the project, and whether there is a real need for an automatic wood edge gluing machine. The analysis of the questionnaire result is displayed in the following charts.

Figure 1.1 indicates that people mostly agree that traditional gluing machines causes frequent machine failures with potential harmful consequences for workers.

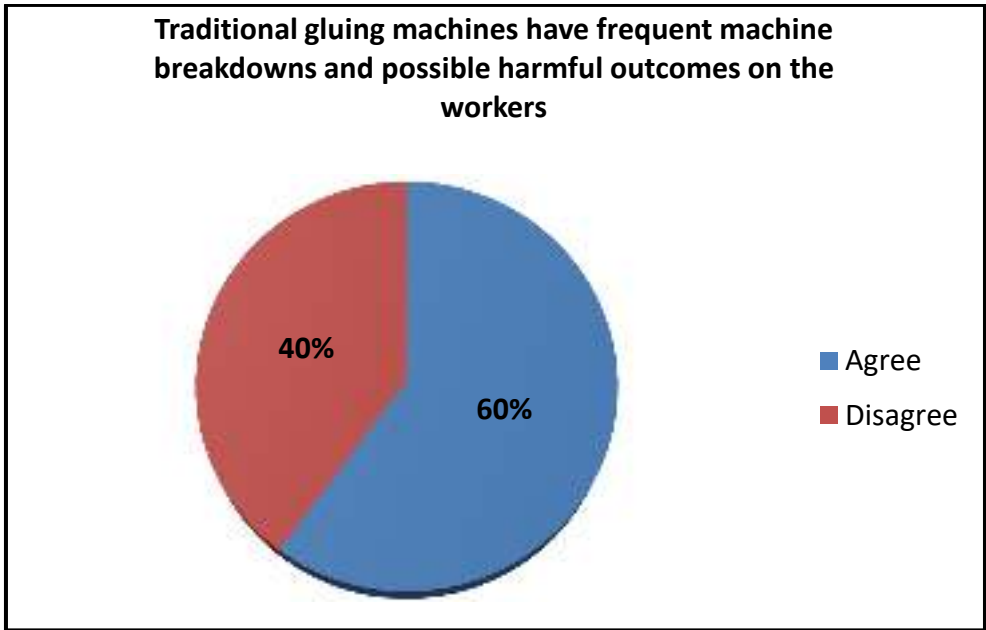


Figure 11.1: People's opinion about the harm of traditional gluing machines

Figure 1.2 also shows that 90% of carpentry shops uses traditional methods or traditional machines.

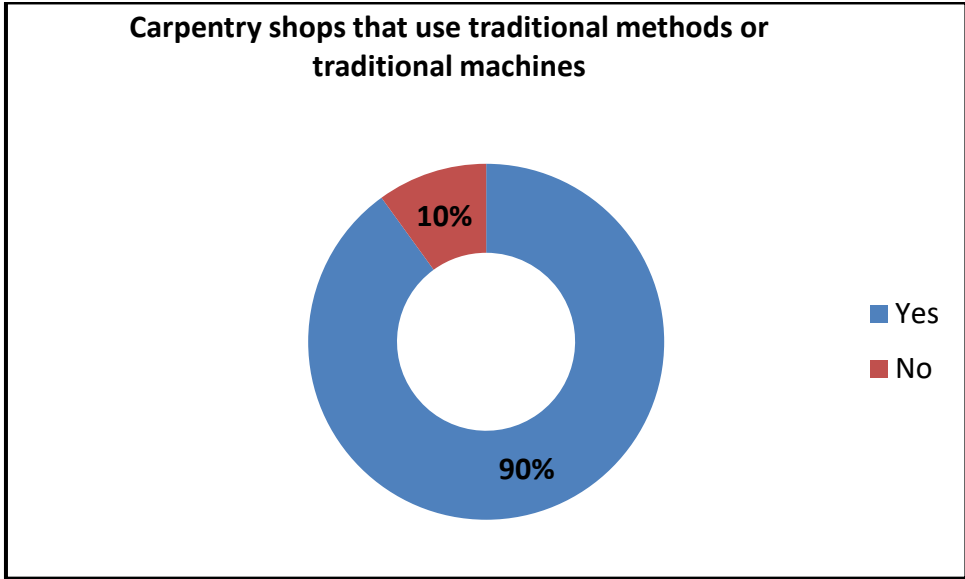


Figure12: Usage traditional machines

Most of the carpentry shops (70%) stated that they are ready to buy the machine and the remaining percentage declare the possibility of buying the machine if the cost is acceptable and the experience is appropriate and this indicated by Figure 1.13.

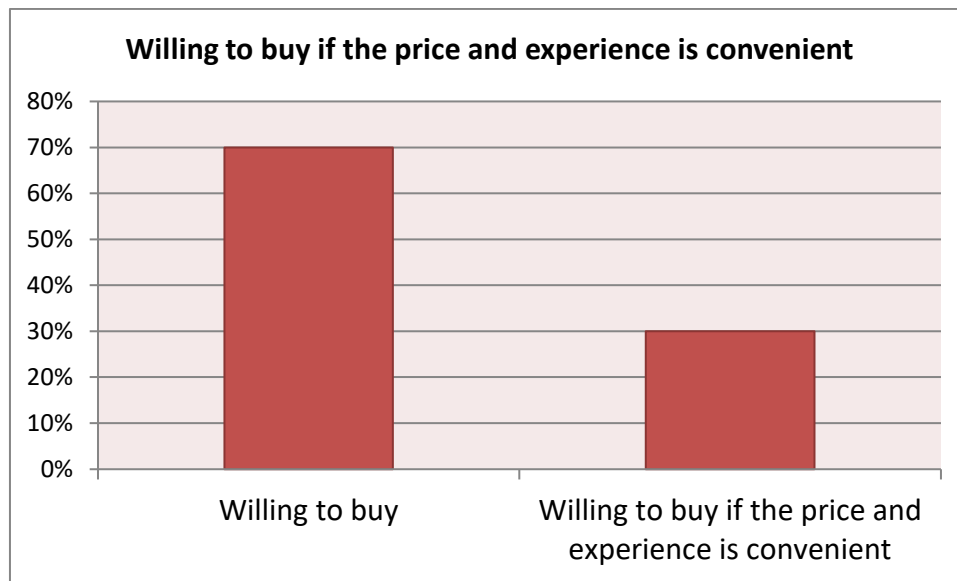


Figure 1.13: The percentage of the people that want to buy the machine

## 1.4 Objectives

The aim of this project is to design and implement a machine that sticks veneer on the edges of wood panels by using automatic methods, that meet the needs with of local market to be in compliance with the safety standards for industrial production processes.

## 1.5 Importance

The industrial sector, including the wood field, is one of the important sectors for any country and an important part of the national economy, and all ministries in developed countries are keen to develop Industrial sectors and the development of modern machines that help increase productivity in this sector and improve the quality of the final product that is presented to the consumer.

According to quality requirement stated by ministry of Standardization and Quality with respect to wood industry, The Ministry of standardization and Quality want that the final product provided to the consumer in her country is within the highest standards [2].

This project also aims to save the time needed to produce the final commodity and also save the time and effort needed by the labor force, as the machine performs the difficult and tiring work on the workers and thus helps to reduce the final costs of the product, raise the quality, reduce potential risks to the workers and increase safety. It facilitates the process of controlling and monitoring the worker of the production process

## **1.6 Motivation**

This project came to help in the advancement of the wood sector, where the local market suffers from a shortage of these machines due to the difficulty of introducing materials and parts used in the manufacture and automation of the project. The automated machine works to reduce wasted time resulting from machines and labor and reduce costs to obtain a product at the lowest costs for the consumer and with high efficiency. Also, through this project, we can avoid the risks that workers are exposed to when dealing with the machine and moving parts or because of the dangerous chemicals used in the paste.

## **1.7 Literature review**

Industrial automation is the use of control devices such as computers, mechanical devices, etc. to control industrial processes and machines by removing as much labor interference as possible and replacing hazardous assembly processes with automated ones. Industrial automation is closely related to control engineering. Automation is a broad term that applies to any machinery. Moving on their own, compared to manual systems, automation systems provide superior performance in terms of accuracy, power and speed of operation [3].

Control systems are an essential part of an automation system. Various types of closed-loop control technologies ensure process variables to follow set points. In addition to this basic function, the automation system uses many other functions such as: plant start and stop control, plant system performance monitoring, equipment scheduling, etc. In addition,

the automated system needs special hardware and software dedicated to implementing control and monitoring systems, and in recent years a number of these products have been developed from different vendors offering their own specialized software and hardware products [4].

Abu Alfie Company for Carpentry Machines and General Trade - Palestine - Tulkarem imports and manufactures parts for wood hollow gluing machines. These machines are fully automated and take into account safety standards and good productivity, but some review of the carpenters' opinions shows that the most important problems of this machine are: It is expensive as the cost of the machine It reaches from 4 to 5 times the machine proposed by the project. Another problem is the large size of the machine, and since many carpenters mean small space, the machine proposed by the project takes into account the issue of space, as many carpenters were impressed by its size and saw it suitable for their carpentry [5].

Crazek wood machines, which are also machines found in Palestine and used by carpenters, but their problem is also the high price, large size and the difficulty of maintaining them except by a specialized staff from the machine manufacturer, and this is what makes many carpenters refrain from buying the machine. [6].

## 1.8 Project outline

Planned tasks distributed on the first and the seconds semester are shown In Table (1.1).

**Table 1.1: Planned tasks**

# Of Task	Task description
T1	Project selection
T2	Identify the idea of the project
T3	Collect references from websites
T4	Select an initial design
T5	Conducting the needed adjustments and calibration on the design
T6	Select the mechanical parts
T7	Writing the thesis chapters

T8	Prepare the 1 <sup>st</sup> presentation (Introduction to project)
T9	Editing the thesis based on received committee revision
T10	Purchasing the sensors and microcontroller part
T11	Building project prototype
T12	Conducted the needed programming and coding
T13	Testing the smart system
T14	Calibration of testing prototype
T15	Completing the thesis structure
T16	Preparing the final presentation

## 1.9 Timeline

Table (1.2) illustrates the time Schedule for each task in the First semester.

**Table 1.2: Planned tasks in the first semester**

Task /week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
T1														
T2														
T3														
T4														
T5														
T6														
T7														
T8														

And In table (1.3) show illustrates the tasks in the second semester and how long it takes weekly for each task.

**Table 1.2: Planned tasks in the second semester**

Task /week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
T9	■	■	■	□	□	□	□	□	□	□	□	□	□	□
T10	□	□	■	■	■	□	□	□	□	□	□	□	□	□
T11	□	□	□	□	■	■	■	□	□	□	□	□	□	□
T12	□	□	□	□	□	■	■	■	□	□	□	□	□	□
T13	□	□	□	□	□	□	□	■	■	■	□	□	□	□
T14	□	□	□	□	□	□	□	□	□	■	■	■	□	□
T15	□	□	□	□	□	□	■	■	■	■	■	■	■	□
T16	□	□	□	□	■	■	■	■	■	■	■	■	■	■

### 1.10 Project Budget

The budget of the project, including printing costs, local study, survey and other costs are shown in table (1.4) which also shows the estimated cost of each one and whether it is available in Palestine or not.

**Table 1.3: Project Budget**

#	Name of part	available	Quantity	Cost
1	Project frame	yes	1	170\$
2	Induction motor (Roll moving)	yes	2	150\$
3	Limit switch	yes	4	50\$
4	Temperature sensor	yes	1	50\$
5	heater	yes	1	130\$
6	contactor	yes	3	70\$
7	PLC	yes	1	100\$

8	piston	yes	3	50\$
9	valve	yes	3	50\$
10	Gear box	yes	2	120\$
12	HMI Screen	yes	1	200\$
Total				<b>1210\$</b>

## Chapter 2: Conceptual Design

### 2.1 Overview

This chapter, is a description of the final product that the machine produce will be presented. The proposed view of the design, the main mechanical and electrical parts of the machine and the machine description will also get illustrated.

### 2.2 Description of the Product.

The final product that comes out of the machine is a piece of wood of a certain size that is covered with tape on its sides in the same color as the wood that enters the machine, as this tape is of great importance as it works to isolate the wooden edges from moisture and water factors and give a beautiful shape to the wood and remove Wood burrs resulting from shearing. The length of the plank of wood varies from one piece to another, depending on where it is used and the purpose of its use.

Figure 2.1 shows the final product that comes out of the machine, and tape has been added to its sides, where the machine has installed the appropriate tape for the type of wood board entered into it and in a color suitable for the wood board



Figure 2.1: The final product

### 2.3 The proposal view of the design

The external structure of the machine, which includes all electrical and mechanical parts, all parts of the system needed by the machine, the controls and the main panel, will be designed with measurements and specifications that differ slightly from the existing machine in the market and with suitable dimensions so that it is not too large and takes up a lot of space in the shops Carpentry or small in a way that is not commensurate with the wooden panels and in order to suit the workers in terms of safety first and secondly ease of use and in dealing with wooden panels and ensuring the quality of the product

The machine was designed using a design program, through which the final shape of the machine was imagined so that it is suitable for the task that you will perform. Figure 2.2 shows the design of the machine body using the AutoCAD program.

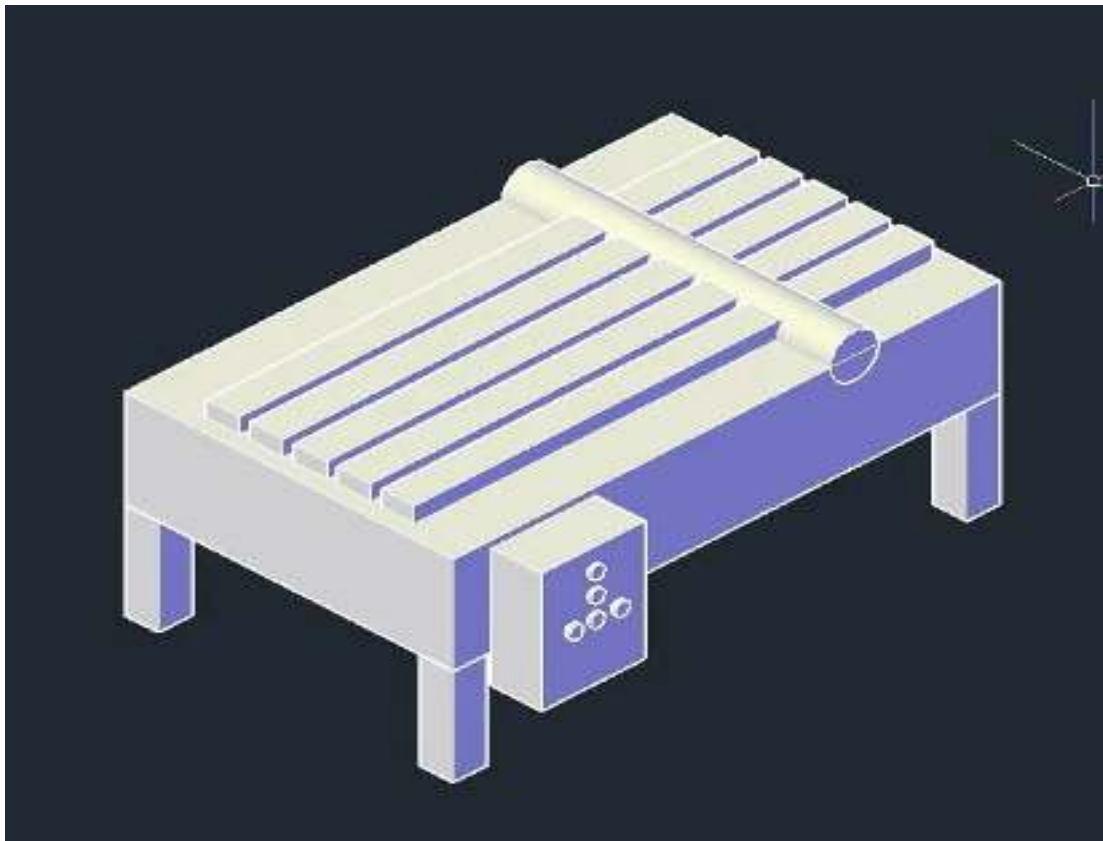


Figure 2. 2: The design of the machine body

Also shown in Figure 2.3 is the appropriate dimensions for the machine, such as the length, width, and height of the machine body.

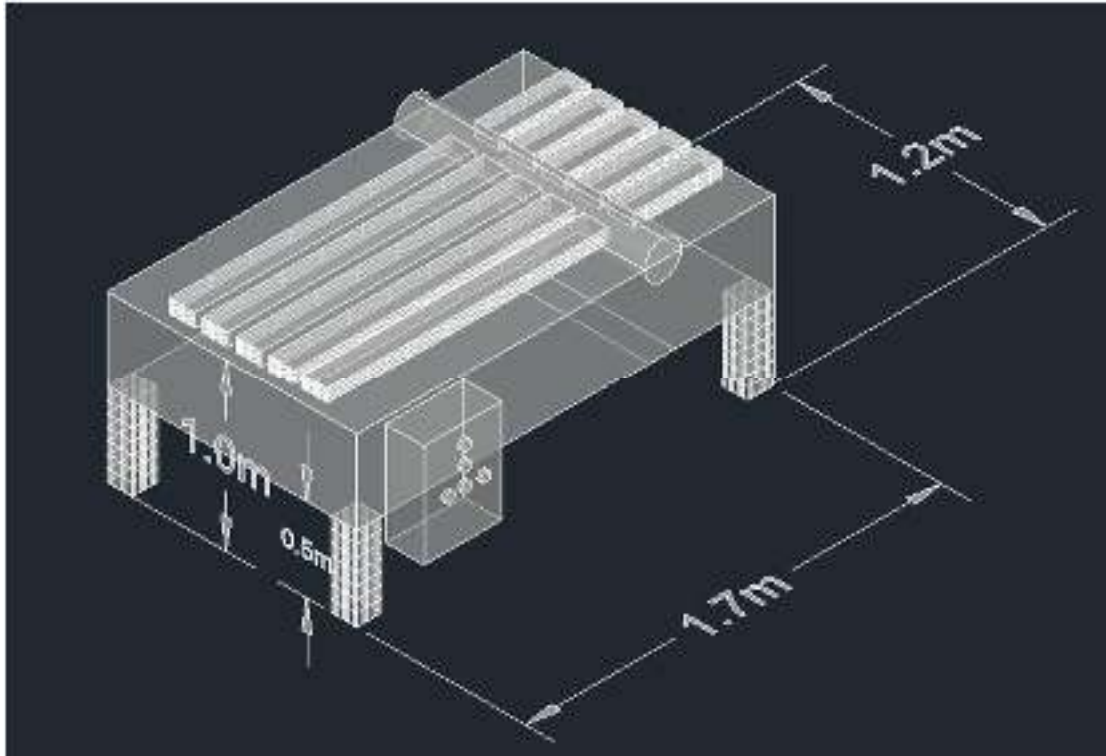


Figure 2. 3: The dimensions for the machine body

## 2.3 Mechanical and electrical devises of the machine

### 2.3.1 The Roll Motors and gearboxes

In synchronous AC motors, the rotor turns at exactly the same speed as the rotating magnetic field; in an induction motor, the rotor always turns at a lower speed than the field, making it an example of what's called an asynchronous AC motor. The theoretical speed of the rotor in an induction motor depends on the frequency of the AC supply and the number of coils that make up the stator and, with no load on the motor, comes close to the speed of the rotating magnetic field. In practice, the load on the motor (whatever it's driving) also plays a part— between the speed of “slip ” tending to slow the rotor down. The greater the load, the greater the rotating magnetic field and the actual speed of the rotor [7].

And the biggest advantage of AC induction motors is their sheer simplicity. They have only one moving part, the rotor, which makes them low-cost, quiet, long-lasting, and relatively trouble free. [8]

And in this project, to reduce the speed of the motor and increase the torque, so need to use a gearbox.

Gearboxes and speed reducers are enclosed mechanical speed reduction devices commonly used in today's automation control systems to dictate your motor's torque and accomplish other motion-related tasks and they allow you to increase torque while reducing the speed of your prime mover output shafts. The output shaft of a gearbox rotates at a slower rate than the input shaft. This produces a mechanical advantage, which increases torque. Conversely, gearbox can be set up to do the opposite, providing an increase in shaft speed with a reduction in torque. [10]

Motor is connected to the gearbox as shown in figure 2.7, which helps determine the appropriate torque and speed for the machine and the accounts will be clarified in the third chapter.



Figure 2.4: Motor with the gearbox

## 2.3.2 Pneumatic system

### 2.3.2.1 Cylinders

Pneumatic cylinders are mechanical devices that use the power of compressed air to produce a force in a reciprocating linear motion. The piston is a disc or cylinder, and its rod transfers the force it develops to the object to be moved.

In this project, there is a need for a cylinder that cuts the tape after the wood board comes out and the gluing process is completed.

Cylindrical structure we need was designed using SolidWorks and appears in Figure 2.8.

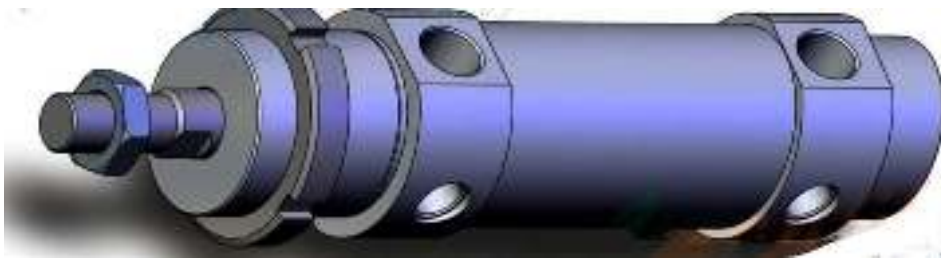


Figure 2.5: The cylindrical structure

the structure of the cylinder and its dimensions was explained, which will be clarified in the next chapter

### 2.3.2.2 Pneumatic valves

Pneumatic valves are one of the components responsible for controlling the pressure, rate, and amount of air as it moves through a pneumatic system [11].

Directional control valves, as shown in Figure 17, can be used to start, stop and change the airflow in the air system. The main function of the direction control valve is to control the direction of flow in pneumatic systems.

And it is also able to determine the path through which the air must flow in the circuit and we can use a directional control valve to direct the inlet flow to a specific outlet port. Directional control valves are classified according to some factors such as the inlet control element the structure, the number of ports, the number of positions, the mode of operation, and the center flow pattern. In the directional control valve, the internal control element will be a sliding reel, a spinning reel or a ball. build and design directional control valves make it suitable for various applications. [12]

Representing the valve 5/3 will be used which will enable to control the cylinder opening and closing as shown in Figure 2.10.

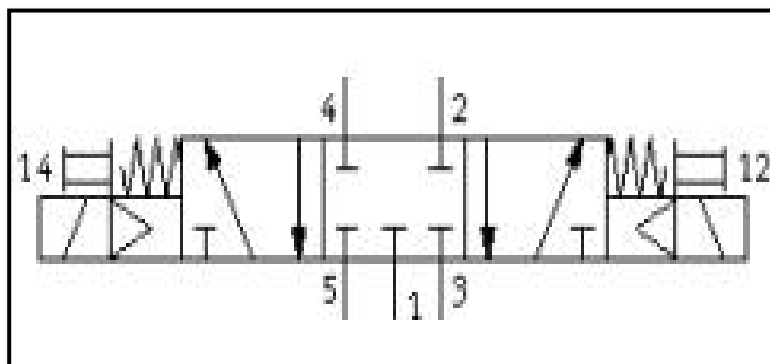


Figure 2.4: 5/3 valve.

### 2.3.3 The Control Units

#### 2.3.3.1 The PLC

A programmable logic controller (PLC) is a control system using electronic operations. It's an easy of storing procedures, handy extending principles, functions of sequential/position control, timed. counting and input/output control are widely applied to the field of industrial automation control.

Delta's DVP series programmable logic controllers offer high-speed, stable and highly reliable applications in all kinds of industrial automation machines. In addition to fast logic operation, bountiful instructions and multiple function cards, the cost-effective DVP-PLC also supports various communication protocols, connecting Delta's AC motor drive, servo, human-machine interface and temperature controller through the industrial network into a complete, and the plc.

A delta-type plc will be used, which suits this project in terms of the number of entrances and exits more than others and figure 2.11 show the plc that will be placed inside the control panel. [13]

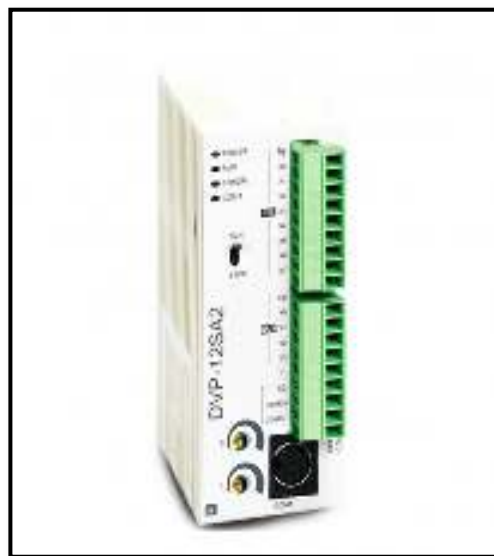


Figure 2.5: The delta's DVP PLC.

### 2.3.3.2 The HMI

A Human-Machine Interface (HMI) is a user interface or dashboard that connects a person to a machine, system, or device. While the term can technically be applied to any

screen that allows a user to interact with a device, HMI is most commonly used in the context of an industrial process. [14]

In industrial settings, HMIs can be used to Visually display data, Track production time, trends, and tags, Oversee KPIs and Monitor machine inputs and outputs. And this is what is needed to be done in this project, as it depends on the screen to show the results of the work, what has been finished and what has not been finished yet we also use it to control the work from turning on and off the machine. A delta HMI project was chosen for this project because it is suitable for the machine, is quick to respond and has a good cost as shown in Figure 2.12.



Figure 2.6: Delta HMI DOP. [15]

#### 2.3.3.3 The Limit Switch.

limit switch, is a switch operated by the motion of a machine part object. It is used for controlling machinery as part of a control system, as a safety interlocks, or to count objects passing a point. A limit or presence of a switch is an electromechanical device that consists of an actuator mechanically linked to a set of contacts. When an object comes into contact with the actuator, the device operates the contacts to make or break an electrical connection.

The limit switch is used in the project to determine the presence of the wood board and also the end of the process and the exit of the board from the machine.

limit switch and the external appearance are shown in Figure 2.13.



Figure 2.7: Limit switch

#### 2.3.3.4 Push-button,

Push-button switch is used to turn on and off the control circuit, and it is a kind of control switch appliance that is widely used. It is used in electrical automatic control circuits to manually send control signals to control contactors, relays, electromagnetic starters and so on.

A push-button switch is a small, sealed mechanism that completes an electric circuit when you press on it. When it's on, a small metal spring inside makes contact with two wires, allowing electricity to flow. When it's off, the spring retracts, contact is interrupted, and the current won't flow. [16]

The machine is turned on and off by the Push-buttons, and Figure 2.14 shows the shape of the Push-button switches. [17]



Figure 2.8: The Push-button switch

### **2.3.3.5 emergency stop button**

Emergency stop button, also known as an E-Stop, is a fail-safe control switch that provides safety both for the machinery and for the person using the machinery. The purpose of the emergency push button is to stop the machinery quickly when there is a risk of injury or the workflow requires stopping.

Emergency stop buttons are wired in series with the control circuit of machinery equipment. When pushing the mushroom head of emergency stop button will break the circuit of machinery equipment and removes power supply from the that keeps the circuit energized.

Shape of the emergency stop button is shown in figure 2.14.



Figure 2.9: Emergency Stop Button.

### **2.3.4 Heating system**

#### **2.3.4.1 Cartridge Heater**

Electric heating is a process in which electrical energy is converted to heat energy. Common applications include space heating, cooking, water heating and industrial processes. An electric heater is an electrical device that converts an electric current into heat. [18]

Electric heating is a process in which electrical energy is converted to heat, The heating element inside every electric heater is an electrical resistor, and works on the principle of Joule heating: an electric current passing through a resistor will convert that electrical energy into heat energy. [19]

The heater is used in this project in order to heat the glue on the tape to prepare the tape and place it on the edge of the wood board. Figure 2.15 shows the cartridge heater used in the project. [20]

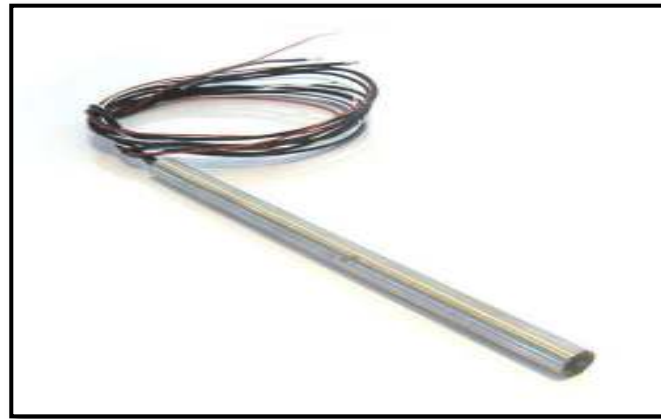


Figure 2.10: The cartridge heater

#### 2.3.4.2 Thermostat

Thermostat is a regulating device component that senses the temperature of a physical system and performs actions so that the system's temperature is maintained near a desired setpoint, it is used in any device or system that heats or cools to a set point temperature. A thermostat operates as a "closed loop" control device, as it seeks to reduce the error between the desired and measured temperatures. Sometimes a thermostat combines both the sensing and control action elements of a controlled system, such as in an automotive thermostat. Thermostat is used in this project to determine the appropriate temperature for heating. Figure 2.16 shows the used thermostat. [21]



Figure 2.11: Thermostat.

### 2.3.5 Protection devices

To protect the machine, protection devices must be used, which will be soon. thoroughly explained

#### 2.3.5.1 Circuit Breaker

Circuit breaker essentially consists of fixed and moving contacts. These contacts are touching each other and carrying the current under normal conditions when the circuit is closed. When the circuit breaker is closed, the current carrying contacts, called the electrodes, engaged each other under the pressure of a spring. During the normal operating condition, the arms of the circuit breaker can be opened or closed for a switching and maintenance of the system. To open the circuit breaker, only a pressure is required to be applied to a trigger. [22]

In the control board, 20-amp circuit breaker was used on the grounds that had two motors in common, a heater and sensors, Figure 2.17 shows the circuit breaker used.



Figure 2.12: The 20A circuit breaker.

Also, 10 ampere control circuit breakers were used, and Figure 2.18 shows this breaker



Figure 2.13: The 10A circuit breaker.

### 2.3.1.2 Over load

When the motor draws excess current, it is referred to as an overload. This may cause overheating of the motor and damage the windings of the motor. Because of this, it is important to protect the motor, motor branch circuit, and motor branch circuit components from overload conditions. Overload relays, as shown in figure 19, protect the motor, motor branch circuit, and motor branch circuit components from excessive heat from the overload condition. Overload relays are part of the motor starter (assembly of contactor plus overload relay). [22]

They protect the motor by monitoring the current flowing in the circuit. If the current rises above a certain limit over a certain period of time, then the overload relay will trip, operating an auxiliary contact which interrupts the motor control circuit, de-energizing the contactor. This leads to the removal of the power to the motor. Without power, the motor and motor circuit components do not overheat and become damaged. The overload relay can be reset manually, and some overload relays will reset automatically after a certain period of time. After which, the motor can be restarted. [23]



Figure 2.14: The Siemens Over load.

## Chapter 3: Working Steps and Calculations

### 3.1 Machine working steps

- At the beginning and after the worker enters the number of wood panels on which the process will be carried out, and the process begins by pressing the start button.
- After that, the Heater begins to work until it reaches a certain degree suitable for melting the glue on the tape with the presence of the wooden board on the machine that activates the limit switch. When these two conditions are met, roll motor 1,
- Which in turn automatically inserts the wooden board into the machine and after 3 seconds the roll motor 2 works, which compresses the melted tape on the glue with the wooden piece and sticks with it well, so the final product is ready.
- After every board is done, the number of operations that took place in the machine appears on the screen so that the worker knows the number of parts and the remaining and completed parts.

#### 3.1.1 Production Process

Figure 3.1 shows Production process chart

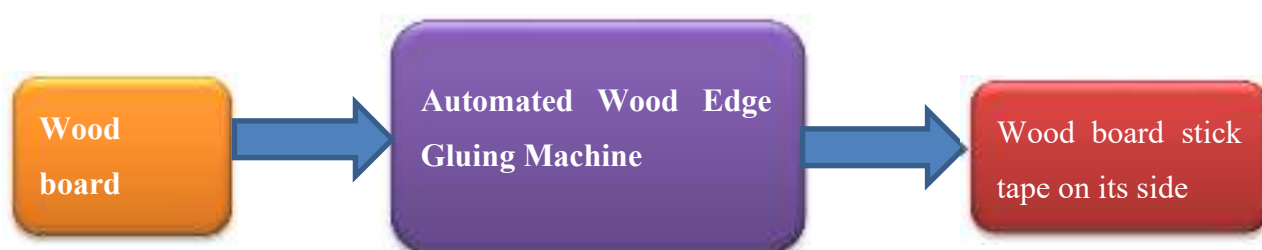


Figure 3.1: Production process chart



## 3.2 Power and Control circuit

### 3.2.1 Power circuit

It is the part responsible for delivering the electric current from the electricity source to the load (the load is the part to be controlled, such as the two motors and heater in project). It pulls the entire load current according to its size.

And we can see the electric power circuit in Figure 3.4.

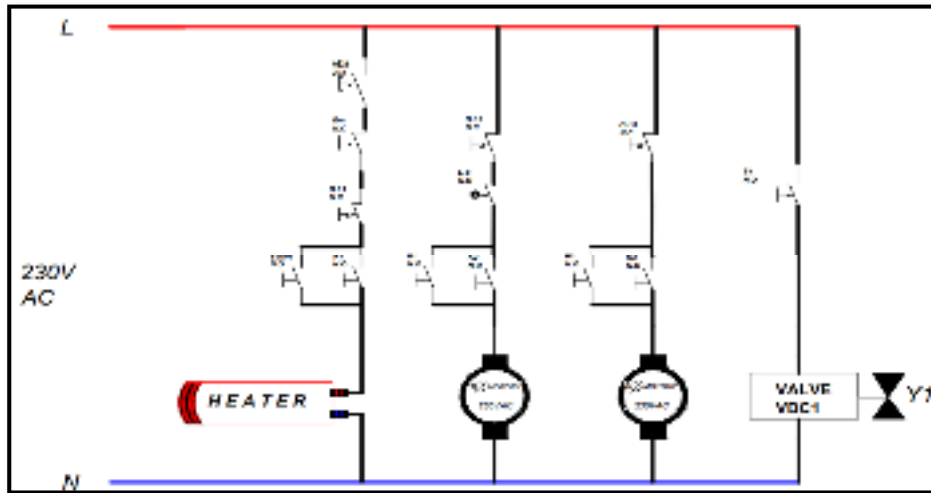


Figure 3.3: Power circuit

### 3.2.2 Control circuit

It is the part responsible for delivering the electric current to the circuit components, which are contactors and overloads, in order to perform the load control tasks in the desired manner, and it usually consumes a little current compared to the current consumed in the power circuit as shown in Figure 3.5

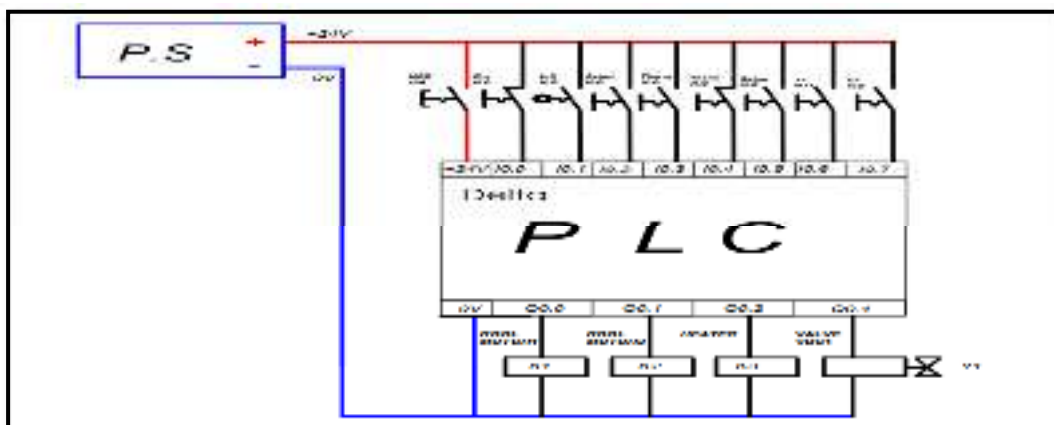


Figure 3.4: Control circuit

### 3.3 The Tables of inputs and outputs

#### 3.3.1 Inputs and Outputs of PLC

Table 3.1 displays the inputs of the PLC, the name of the input and its type.

**Table 3.1: The inputs of the PLC**

I0.0	Emergency Stop	Normally Close
I0.1	Limit Switch	Normally Open
I0.2	S_start	Normally Open
I0.3	Thermistor	Normally Open
I0.4	Thermistor	Normally Close
I0.5	S_stop	Normally Close
I0.6	S1	Normally Open
I0.7	S2	Normally Open

The following Table 3.2 displays the outputs of the PLC, the name of the output and its type.

**Table 3. 2: The outputs of the PLC**

Q0.0	Contactora 1	Roll Motor 1
Q0.1	Contactora 2	Roll Motor 2
Q0.2	Contactora 1	Heater
Q0.3	5/3 Valve	Cylinder

### 3.3.2 The Quantity Table

Table 3.4 shows the quantity required for the project and the name of each part.

**Table 3.3: The Quantity Table**

#	Name of part	Quantity
1	Over load	2
2	Induction motor (Roll moving)	2
3	Limit switch	2
4	Temperature sensor	2
5	Heater	1
6	Contactactor	3
7	Delta PLC	1
8	Cylinder	2
9	Valve	2
10	Gear box	2
11	Contactactor	3
12	HMI Screen	1
13	Push buttons	5

## **Chapter 4: Safety Through Automation**

### **4.1 Automation Increases Safety**

Over the past 30 years, there have been only 27 robot-related and automation workplace deaths according to OSHA incident reports. That is a relatively low number compared to the 4,585 overall fatalities recorded by the U.S. Bureau of Labor Statistics during this time period. Of course, an ideal work environment wouldn't have any accidents. While we haven't quite reached this goal, automation seems to be a step in the right direction[24].

Automation has become increasingly popular amongst companies for its cost-cutting benefits. While increased efficiency is an important feature, the argument for implementing these systems is only heightened by the safety measures it provides. These include:

- ❖ Functional Operations/Process: Automation reduces the risk of injury at the operational level by removing workers from dangerous work procedures.
- ❖ Functional Operations/Process: Automation reduces the risk of injury at the operational level by removing workers from dangerous work procedures.
- ❖ Functional Operations/Process: Automation reduces the risk of injury at the operational level by removing workers from dangerous work procedures.

### **4.2 Benefits of Safety**

- **Happier Workers:** While automation is taking care of the physical work, employees have more time to take care of projects that require higher-end thinking. Removing workers from a dangerous environment also shows that the company views them as an important asset whose well-being is an important matter.
- **Reduced Costs:** On average, businesses spend about \$170 billion a year on injury and illness according to the U.S. Department of Labor's Occupational Safety and Health Administration. The U.S. Department of Labor's Occupational Safety and

Health Administration also states that companies can reduce these costs by 20%-40% by simply improving safety procedures.

- **Increased Efficiency:** Automation typically works at a faster pace, provides consistent quality, and minimizes waste. Although you may have to pay a hefty price upfront, the cost of maintenance is much lower than continuing to pay for current procedures.
- **Increased Competitive Advantage:** Automation increases productivity through safety and efficiency which gives companies a competitive edge.

#### **4.2 Design a Safe Industrial Environment**

The increase in industrial automation (IA), and particularly the use of industrial machines, is increasing the chance of an unexpected interaction between a human operator and a piece of other mobile equipment or moving machine. The onus is on designers to implement appropriate and often overlapping safety precautions to avoid consequences ranging from interruptions in production to injury or even death.

While safety is paramount, designers must still design and keep an eye on both initial costs and total cost of ownership.

Numerous national and international safety standards apply to different types of industrial machinery, safety equipment, and production processes. Among these are:

- ANSI/RIA 15.06 (Robot and Robot System Safety).
- ISO 13856-1:2013 (Safety of machinery: Pressure sensitive protective devices).
- ISO 13849-1 (Safety of machinery: Safety related parts of control systems).
- ANSI B11.19-2003 (Safeguarding Equipment and Protecting Employees from Amputations).
- CSA Z432-16 (Safeguarding of Machinery).

After the initial analysis, the next stage is to develop a Hazard Control Hierarchy that ranks these measures in order of effectiveness and preference for each risk. ISO 12100:2010 (Safety of machinery – General principles for design) is the primary standard addressing the concept and methodology of tiered risk reduction.

The preferred solution is to eliminate the risk completely or substitute a safer alternative that minimizes the opportunity for unexpected human-machine interactions (Figure 4.1). An example is installing an automated material and sticking system to replace a manual loading operation [25].

Preference	Protective Measure	Examples	Influence on Risk Factors	Classification
<p>Most Preferred</p> <p>Least Preferred</p>	Elimination or Substitution	<ul style="list-style-type: none"> <li>Eliminate pinch points (increase clearance)</li> <li>Intrinsically safe (energy containment)</li> <li>Automated material handling (robots, conveyors, etc.)</li> <li>Redesign the process to eliminate or reduce human interaction</li> <li>Reduce energy</li> <li>Substitute less hazardous chemicals</li> </ul>	<ul style="list-style-type: none"> <li>Impact on overall risk (elimination) by affecting severity and probability of harm</li> <li>May affect severity of harm, frequency of exposure to the hazard under consideration, and/or the possibility of avoiding or limiting harm depending on which method of substitution is applied</li> </ul>	Design Out
	Guards and Safeguarding Devices	<ul style="list-style-type: none"> <li>Barriers</li> <li>Interlocks</li> <li>Presence sensing devices (light curtains, safety mats, area scanners, etc.)</li> <li>Two-hand control and two-hand trip devices</li> </ul>	<ul style="list-style-type: none"> <li>Greatest impact on the probability of harm (occurrence of hazardous event under certain circumstances)</li> <li>Minimal if any impact on severity of harm</li> </ul>	Engineering Controls
	Awareness Devices	<ul style="list-style-type: none"> <li>Lights, beacons, and strobes</li> <li>Computer warnings</li> <li>Signs and labels</li> <li>Beeper, horns, and sirens</li> </ul>	<ul style="list-style-type: none"> <li>Potential impact on the probability of harm (avoidance)</li> <li>No impact on severity of harm</li> </ul>	Administrative Controls
	Training and Procedures	<ul style="list-style-type: none"> <li>Safe work procedures</li> <li>Safety equipment inspections</li> <li>Training</li> <li>Lockout / Tagout / Tryout</li> </ul>	<ul style="list-style-type: none"> <li>Potential impact on the probability of harm (avoidance and/or exposure)</li> <li>No impact on severity of harm</li> </ul>	
	Personal Protective Equipment (PPE)	<ul style="list-style-type: none"> <li>Safety glasses and face shields</li> <li>Ear plugs</li> <li>Gloves</li> <li>Protective footwear</li> <li>Respirators</li> </ul>	<ul style="list-style-type: none"> <li>Potential impact on the probability of harm (avoidance)</li> <li>No impact on severity of harm</li> </ul>	

*Adapted from ANSI B11.0-2010 and ANSI/PMMI B155.1-2013*

Figure 14.1: Hazard control hierarchy ranks protective measures.

## Chapter 5: System Implementation

### 5.1 Introduction

During the implementation stage, every single component has been tested individually and the results have recorded. This chapter will focus on the testing stage of the project systematically, and finally a summary for the testing scenarios.

### 5.2 Hardware System Implementation

This section talks about each component implementation.

- **Implementation of the project design (structure)**

The design of the machine was implemented and the profile plates were placed, where the durability factors and the strength of the metal structure of the machine were confirmed, which will bear all of the mechanical, pneumatic and electrical parts, in addition to the control panel.

Figure 5.1 shows the structure with the struts before the lamination, where the parts that will be fixed inside the machine body were added and then we laminated them with profile plates that isolate the electrical parts from water leakage factors and is also considered an additional protection factor from the approach of human hands to the moving elements in the machine.



Figure 15.1: Structure of project.

In Figure 5.2 machine appears after it is fully laminated



Figure 15.2: Machine body

- **Control panel**

After designing the control panel and locating it, the machine structure using CAD software as shown in Figure 5.3.

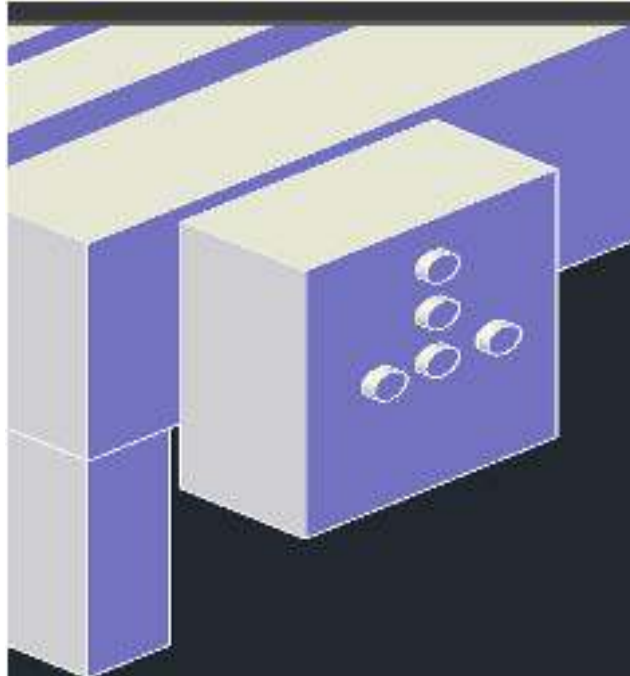


Figure 5.3: Control panel (design)

In Figure 5.4 the control panel (outward appearance) is shown.



Figure 5.4: Control panel (outward appearance)

It was implemented, assembled and added to the machine's structure, and its location was taken into account with a design so that it is easy to reach and the necessary maintenance work in the event of a malfunction

Figure 5.5 shows the control image during the assembly process and the addition of controls and protection to it.



Figure 5.5: Control panel (internal parts)

- **Actuators**

The mechanical, electrical and pneumatic actuators were added after calculating the loads, choosing the appropriate sizes, and installing them on the machine body from the motors responsible for moving the rolls.

And also the gear responsible for raising the torque and reducing speed and the heater responsible for heating the non-stick material during the operating process

Figure 5.6 shows motors and gearboxes.



Figure 5.6 motors and gearboxes.

Heater after installation is shown in Figure 5.7.



Figure 5.7: Heater after installation

Thermal wool maintains a high temperature, the more we maintain the temperature, the less the electric current is drawn and the longer the life of the heater, as shown in figure 5.8.



Figure 5.8: Thermal wool.

The pneumatic elements responsible for cutting the tape after exiting the plank are shown in Figure 5.9.



Figure 5.9: Pneumatic elements

### 5.3 Software System Implementation

The delta plc was programmed on WPLSoft Figure 5.9 shows the automatic code to run the machine on the program.



Figure 5.10: Automatic code.

Also in Figure 5.10, the Manuel code appears when checking the parts and doing maintenance



Figure 5.11: Manuel code.

A design for the HMI screen was made using the SIEMENS program, where through the screen the operation and monitoring of the machine is turn on or out.

In Figure 5.10 shown HMI screen.



Figure 5.12:HMI screen.

#### 5.4 Achievements

This machine can stick the edges of wood by adding a strip of tape using modern automation methods and also raise the safety factor for workers and raise productivity and quality compared to similar traditional machines

#### 5.5 Challenges

This section will describe the main challenges that faced the team during the implementation stage.

- The size of the machine, as the automated machines available in the market are large in size and not suitable for most local carpenters, so the focus was on that by design and when implementing the project.
- One of the problems we also face is raising the safety factor during the operation of the machine.
- The cost of the project was an important problem as the automated machines in the local market are considered very expensive compared to the available capabilities. The machine was designed and implemented at the lowest possible costs and provided the basic elements of automation.

## **5.6 Conclusion and Recommendations**

During this period there were many experiences the team gained, the results and the conclusions will be discussed.

- Working with a team is very important thing, also gives power and meaning to the project, also during work as a team, too many solutions will be given and this helps the team to face their problems and solve it, each one has his own idea and the suggested solutions was made from these ideas.
- Industrial automation is very important as it solves problems facing humans and facilitates human life.
- In the future, we could use:
  - Developing the machine to add a foldable arm for the long wooden panels.
  - Add rollers and a heater on the other side of the machine so that you do the process of gluing the edges on both sides at the same time.
  - An application similar to the idea of a screen (HMI) can be made to monitor and control the machine.

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## Appendices

### Appendix: Questionnaire



**الموضوع:** المساعدة في تعبئة استبيان لمشروع تخرج في تخصص الهندسة الكهربائية في جامعة بوليتكنك فلسطين متعلق بصنع آلة "الصاق" خشب محسنة.

عزيزي النجار،

ندعو  ان تكون جزءاً من مشروع تخرجنا وتساهم في مساعدتنا بتعبئة استبيان بسيط، يحتوي معلومات متعلقة بآلات لصق الخشب وكيفية تحسين النواقص فيها وسد حاجة سوق العمل من آلات محسنة والتأكد من وجود حاجة لتواجدها.

مع العلم ان الاستبيان لا يحتوي ولن ينشر أي معلومات شخصية.

شكراً جزيلاً على تعاونك!

فريق البحث:

أمير ابو اسنيته، محمود عبد ربه.

## التعليمات:

- الرجاء الاجابة على جميع الأسئلة الثلاثة بدون ترك أي منها فارغا.
- الرجاء عدم التردد في طرح الأسئلة عن أي سؤال غير واضح.

1	آلات اللصق التقليدية تتعرض لأعطال متكررة وقد تعرض العاملين بها لخطر محتمل؟	أ. أوافق ب. لا أوافق
2	هل تقوم باستخدام الطرق والآلات التقليدية في المنجرة الحالية؟	أ. نعم ب. لا
3	هل هناك احتمالية لشراء آلة لصق جديدة تقدم سهولة وأمان أكبر من آلات اللصق القديمة	أ. <input type="checkbox"/> نعم ب. هناك احتمالية في شراء الآلة الجديدة في حال كان اداءها وسعرها مناسبين ت. لا