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AUTOMATIC PRODUCT SHRINK WRAP MACHINE

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Abstract- *The world of technology is always striving to unveil the latest inventions that transform human lives. Industrial technology has been adopting the automation by the time to reduce human effort. One of the great inventions in packaging sector is the shrink poly. Using shrink poly we have develop and designed a machine for packaging. Our aim is to develop and automate a product packaging system which will offer an easier and time saving facilities with minimum cost. This is a PLC based system that reduces the time of packaging and the dispensing process is way easier and faster than the typical human based packaging system. The Photo cell sensor counts the products coming through the conveyer belt and when it comes to the desired number the push arm pushes them to heat chamber through the wrapping section binding with a portion of plastic. And hot air blow shrinks the whole thing in the chamber and later it releases a complete packet. The software section is programmed using SIEMENS LOGO! 24RC soft comport version 7.0. The operation of the system has been displayed successfully as expected. Thus the project will benefits of the owners of small industries as during doing this project we kept in mind to make it cost effective.*

Keywords: Automation, Shrink poly, Shrink Wrap Packaging, Programmable Logic Control (PLC), SIEMENS LOGO!, Cost effective.

1. INTRODUCTION

Shrink wrap machine is a packaging machine that is used to package the products with plastic by being applied heat on it. Shrink wrap, also shrink film is a material made up of polymer plastic film. When heat is applied, it shrinks tightly over whatever it is covering. Heat can be applied with a hand held heat gun (electric or gas) or the product or film can pass through a heat tunnel on a conveyor.

The most commonly used shrink wrap is polyolefin. It is available in a variety of thicknesses, clarities, strengths and shrinks ratios. The two primary films can be either cross linked, or non-cross linked. Other shrink films include PVC, Polyethylene, Polypropylene, and several other compositions. Co extrusions and laminations are available for specific mechanical and barrier properties for shrink wrapping food. For example, five layers might be configuration as EP/EVA/co polyester/EVA/EP, where EP is ethylene-propylene and EVA is ethylene-vinyl acetate copolymer.

A shrink film can be made to shrink in one direction (unidirectional or mono-directional) or in both directions (bidirectional). Films are stretched when they are warm to orient the molecules from their initial random pattern. Cooling the film sets the film's characteristics until it is reheated: this causes it to shrink back toward its initial dimensions. Prior to orientation, the molecules of a sheet or tube are randomly intertwined like a bowl of spaghetti. The molecules are coiled and twisted and have no particular alignment. However when a draw force is imposed, the amorphous regions of the chains are straightened and aligned to the direction of orientation. By applying proper cooling, the molecules will be frozen in this state until sufficient heat energy is applied to allow the chains to shrink back. One can visualize this phenomenon by stretching a rubber band and dipping it into liquid nitrogen so as to freeze in the stretched state. The band will remain in this state as long as it is kept at sufficiently cold temperatures. However, when enough heat energy is applied, the rubber band will shrink back to its original relaxed state. Orientation on a commercial scale can be achieved using either of two processes: a Tenterframe or a bubble process. Tenterframe technology is used to produce a variety of "heat-set" products, with biaxial (BOPP) being the most common (heat-setting is a process whereby a film is reheated in a constrained state such that the shrink properties are destroyed). The second commercial process is the bubble process, sometimes referred to as the tubular process. In this process, a primary tube is produced by either blowing or casting the tube onto an external or internal mandrel, respectively [1].

2. PLC OVERVIEW

A programmable logic controller is a solid state user programmable control system with functions to control

logic, sequencing, timing, arithmetic data manipulation & counting capabilities. It can be viewed as an industrial computer that has a central processor unit, memory, input output interface & a programming device. The central processing unit provides the intelligence of the controller. It accepts data, status information from various sensing devices like limit switches, proximity switches, executes the user control program stored in the memory & gives appropriate o/p commands to devices such as solenoid valves, switches etc. Input output interface is the communication link between field devices and the controllers. Through these interfaces the processor can sense and measure physical quantities regarding a machine or process, such as, proximity, position, motion, level, temperature, pressure, etc. the programmer unit provides the man machine interface. It is used to enter the application program which often uses a simple user-friendly logic [2].

2.1 Features of PLC:

1. Real time operation
2. Capable of work at hazardous environment.
3. User-friendly programming language and technique
4. Low cost.
5. Visual operation
6. High speed of operation.
7. Easier maintenance & trouble shooting.
8. Reliability.
9. Expandability and
10. More secured programming etc.

Fig.1: PLC (Siemens LOGO! 24RC) [4].

2.2 Central Processing Unit (CPU):

Central processing unit (CPU) is the main part of PLC which called brain of PLC controller. It can perform all processing function such as-program execution, peripheral & external device communications etc. It can also perform data handling execution and self-diagnostics.CPU consists of mainly three blocks. Such as –

1. Arithmetic Logic Unit(ALU)
2. Control Unit (CU)
3. Register.

2.3 PLC Memory:

The memory unit is the part of the programmable controller where process data from the input modules and control data from the output modules are stored. Following one or more than one can be used in CPU to carry the memory content of PLC.

1. ROM
2. PROM
3. RAM
4. EPROM
5. EEPROM

2.4 PLC Siemens LOGO!

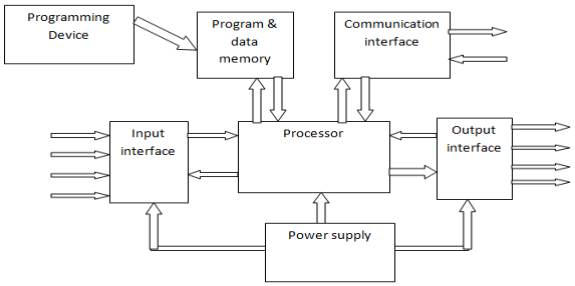


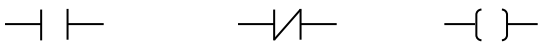
Fig.2: Architecture of PLC [3].

2.5 Technical Specifications

1. No. of Analogue Inputs: 0
2. No. of Digital Inputs:8
3. No. of Digital Outputs:3
4. Meter Display Type: LCD
5. IP / NEMA Rating:IP20
6. Approval Bodies: CSA / FM / IEC / UL / VDE
7. External Depth:55mm
8. External Length / Height:90mm
9. Mounting Type: DIN Rail
10. Operating Temperature Max:+55°C
11. Operating Temperature Min: 0°CSupplyVoltage:24V

2.6 Ladder Diagram

Ladder diagram is a graphical language which represents Boolean logic in PLC for input, output, flags, timer, counter and registers as parameters of Boolean equation. A ladder diagram consists of individual rungs each containing one output instruction and one or more than one serial/parallel combination of input or other type of contacts. A ladder mainly consists of contacts and coils. The standard representation of contact and coils (outputs) are as follows:



(a) Normally open contact (b) NC, Normally closed contact (c) Output contact

Fig.3: Symbols of Ladder Diagram.

3. PROJECT DESCRIPTION ANDDESIGN

The purpose of this machine is to wrap any products by using hot air blow in the heat chamber. When the products have been produced at the main production

section, comes to get packaged through conveyer belt. The main aim of this project is to produce a shrink wrapping machine. Shrink wrap machines are just one of the modern conveniences in the world because these machines allow the industries to package items without having any extra worker to do the particular job. In a production industries there have too many other important sections to operate by human effort. In such condition if a finishing section has given upon to a machine then it would not only save the production cost but it would save the time and enlarge the reliabilities as well. Business people want to make money in each time they breathe. So, with the implementation of this machine the dispensing process will be held for the whole day and no times limit. This machine is ready to serve 24 hours.

3.1 Project Requirement

We have used the following tools in our project:

1. Siemens Logo PLC-24
2. I/O Extension module DM8
3. Personal computer.
4. Communication cable PC to PLC (USB Port)
5. Push button switch.
6. Relay, (24V Dc)
7. Photocell sensor
8. Limit Sensor
9. Indication bulb /LED
10. DC Gear Motor
11. Connecting wire.

We have discussed here some of the equipment details bellow:

3.2 Photocell sensor:

These sensors use light sensitive elements to detect objects and are made up of an emitter (light source) and a receiver. It is used to count the products that are going to shrink wrap. Emitter and receiver are housed together and use the light reflected directly off the object for detection. In the use of these photocells, it is important to bear in mind the color and the type of surface of the object. With opaque surfaces, the sensing distance is affected by the color of the object. Light colors correspond to the maximum distances and vice versa. In the case of shiny objects, the effect of the surface is more important than the color. The sensing distance in the technical data is related to matte white paper.

Fig.4: Photocell Sensor.

3.3 Limit Sensor:

Its a mechanical type of sensor. When the sensing part of the sensor touched by any object, it ust switch the output Normaly open (N/O) to Normaly close (N/C). It is been used to limit the forward and backword movement of Push arm and the Cutter.

Fig.5: Limit Sensor

3.4 Plastic Used For Wrapping

Basically the plastic that we have used in order to wrap the products, are transparent and temperature is highly effective on it. A limited air blow on the plastic paper for a particular time may easily shrinks the plastic paper and helps to seal the product.

Fig.6: Plastic paper to wrap the product [1].

3.5 Block Diagram of Shrink Wrap Machine System

The total system is based on PLC system. And a portion of the system is depends on the mechanical equipment. The whole experiment starts with the power supply and goes to DID, PLC and DM8 respectively. In total four DC motors have been used in the whole system in order to run the conveyor belts, push arm, and cutter. The motors are rated in 24 volts and got internal gears to control it by itself. Overall the total system is control by the PLC. Two pair of Limit switches have been installed in push arm and the cutter that give the pulse (1,0) and mechanically it switches them forward and reverse.

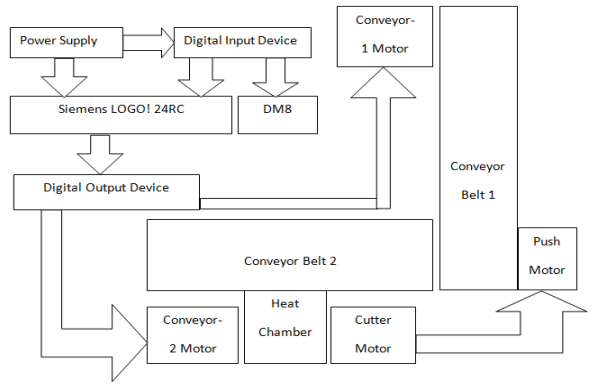


Fig.7: Block Diagram of Shrink wrap machine System.

3.6 Circuit Diagram

The following figure shows the internal circuit diagram of the electric panel consisting the PLC, DM8 and the power supply. S1 to S8 are the inputs of PLC where the Q series is the output. P1 and P2 are the power inputs.

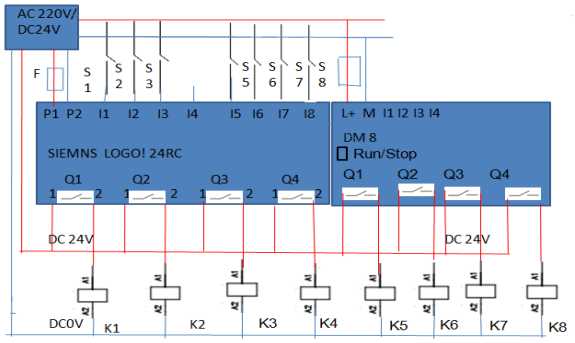


Fig.8: Circuit Diagram of Shrink wrap machine System.

Here is the motors diagram. We have four DC motors used in the project.

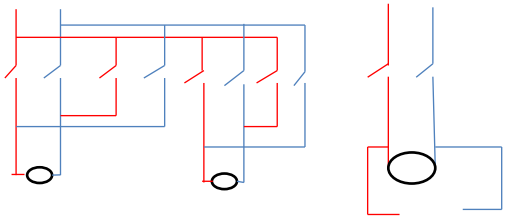


Fig.9: Circuit Diagram (Motor circuit).

3.7 Circuit Details

Here we use eight inputs including one ON, one OFF switch, four limit switches and a photocell sensor. We also use eight outputs. One for conveyor belt-1(Q1), one for conveyor belt-2 (Q7), Push arm (Forward) (Q2),Push arm (Backward) (Q3), Cutter (Forward) (Q4), Cutter (Backward) (Q5), Air heater (Q6) and Sealer Heater (Q8). At fast devices power supply this device are processing AC to DC converter. This devices input terminal L=220V Ac N=0V Ac and output terminal L+ =24V DC M=0V DC. A PLC & extension analogue input module power terminal (P1, P2/L+, M) P1/L+ =24V DC and P2/M=0V DC are connected. As we press the start button the conveyor belt-1 starts to run as well as with the system. Then the photocell starts to detect the product and gives inputs to the counter as (I3) inputs. As the counter counts for the conveyor belt stops and the push arm starts to move forward till the limit switch (I5) is touched. As the limit switch (I5) touched the push arm starts to move backward. Its moves backward till the limit switch (I6) touched. During this, product passes through the wrapping process. Now cutter moves forward till it touch the limit switch (I7). When the cutter moves down it cuts the wrapping plastic and seal it using heat. As soon as cutter cuts the plastic, conveyor belt-2 get on for 3 sec then it stops. The product gets into the heat chamber. Meanwhile the cutter backs to its previous position. The products Waits in heat chamber for 10 seconds and then conveyor again get on for another 10 seconds. As soon as the conveyor belt stops conveyor 1 get on operation. Then the process keeps going on.

3.8 Flow Chart

Here we go the flow chart of the total system of the project.

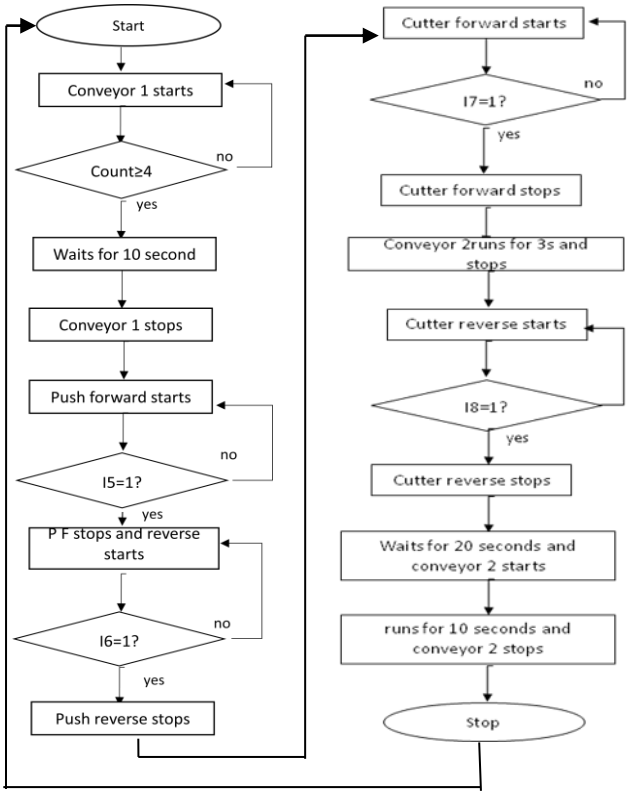


Fig.10: Flow chart of Shrink wrap machine System.

The whole system is automated and runs in a continuous loop.

3.9 The Designed Prototype

Final outcome of the Designed Prototype shown in Fig.11

3.10 Rating of Total System

PLC: LOGO! TD device directly connectable to all OBA5 basic modules. Display with adjustable permanent backlight (on-board and/or TD).
New integrated PWM functions.

4 analogue inputs (0-10V) – instead of 2
4 (5 kHz) fast counter inputs – instead of 2 (2 kHz)
Analogue output 0-20 mA or 4 – 20mA
10 different onboard languages (GE, EN, FR, IT, ES, CN, JAP, TR, RUS, and NL)

DC motors : 24V 500mA
Cutter (Heater) : 90W
Air heater : 1000W
Photocell : OMRON (E3JK-DS30M1)
12 to 24V DC, 3A 250VAC.
Relay : OMRON (MY4NJ)
220/240V AC

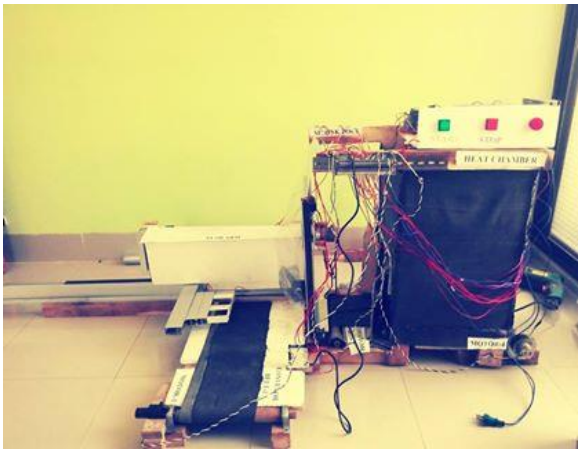


Fig.11: The Prototype

4. RESULT AND DISCUSSION

In the project we have introduced an Automatic Shrink Wrap Machine operation by Siemens LOGO! PLC. We have successfully completed the project in the demo. The program had been designed by LOGO Soft Comfort V7.0. All sort of condition have fulfilled successfully. This particular system has several advantages alike if we can get in into market by manufacturing industrially it may keep a notable impact in different spare of commercials.
As we have designed this machine to reduce the human effort and makes it cost effective it shows a brilliant success
Result could be divided into two part

1. Comparing with the Human labored manual system.
2. Comparing with the typical Packaging machine in heavy and manufacturing Industry.

Table 1: Comparison between Human labor manual system and Automatic Product Shrink Wrap Machine.

Terms	**Human labored manual system**	**Automatic Product Shrink Wrap Machine**
Time	Human labor and manual operation takes approximately five minutes to shrink wrap a product.	Our designed machine takes only one and a half minutes. That is almost three times faster than the human labor.
Cost	The cost of the human labor is high as we look at the production rate. So the packaging cost is high.	The packaging cost to shrink wrap a product is much more less than the cost in Human labored manual system because there is no cost of human labor and the electricity cost is minimum, like 0.896$ per day (66.48tk/day)

Table 2: Comparison between Packaging machine in heavy and manufacturing Industry and Automatic Product Shrink Wrap Machine.

Packaging machine in heavy and manufacturing Industry.	**Automatic Product Shrink Wrap Machine**
The packaging machines used in the heavy manufacturing industries are high speed as 50-60 package per minute and high efficient and also comes with a higher price is about 20,000 $ (Twenty thousand Dollar) or 15,00000/- Tk (Fifteen Hundred Thousand Taka) . So the local market suppliers can't afford it. [5]	Our designed machine can deliver 5 products per minute. It's little slower as comparing with the Packaging machine in heavy and manufacturing Industry, But it's perfect for the local and micro businessmen and it goanna cost around 20,000 Tk (Twenty Thousand) for the machine. That's gives us better benefit.

So, it is perfect for the small manufacturing companies, the local businessman and the farmers to pack their products and supplies.

4.1 Power consumption

We designed this machine by using four motors with same power rating but none of these motor runs together. There is only one Motor runs at a time.

Table 3: Total Power consumption of Automatic Product Shrink Wrap Machine

Component	**Power in Watt (W)**
DC Motor	12w
Air Heater	1000w
Heat Sealer (Cutter)	100w
Total	**1112W or 1.12 kw**

4.2 Cost of power consumption

Power consumption of the machine is 1.12 kWh. And if the cost of the per unit electricity is 0.1$ (7.42tk) (For small industries), then the cost per hour is only [6]

Tootal cost ={0.1$ (7.42tk)*1.12}
= 0.112 $/hr (8.31 tk /hr)

If the working period is 8 hours per day, then

Total cost ={0.112$/hr (8.31tk/hr)*8)} $/day
=0.896$/day (66.48tk/day)

4.3 Discussion

It was already mentioned on the abstract that this particular system is being used in the heavy industries. While we were planning for some new idea that can add a new dimension in our small commercial alike fruit market, bakeries, dispensaries so on. While the program was designed we made it for four products that can easily be increased and decrease if necessary. In addition the timing of conveyor run can be controlled as needed. As the system is designed for small commercial, definitely the assemble cost will be under owners capability.

5. CONCLUSION AND FUTURE WORK

And finally our effort has seen an end. The prototype works pretty smoothly. It took couple of months to get the total structure in an idle shape. We have used woods for frame. If we had had some good financial help we could use Aluminum, Strain Less Steel and other light weight frame. Nevertheless ours one is quite strong in such condition.

Below are the suggestions of future research and work to improve the design of the Automatic Product Shrink Wrap Machine System:

1. Advanced PLC system can be used.
2. Mobility can be improved.
3. Cost can be reduced by manufacturing in industries.
4. Can bring it into open market.
5. The system can be designed for both high and low temperature products.
6. A database system can be included to keep a reading.

6. REFERENCES

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APPENDIX

PLC= PROGRAMMABLE LOGIC CONTROL
CPU= CENTRAL PROCESSING UNIT
RAM= RANDOM ACCESS MEMORY
I/O= INPUT/OUTPUT
R= RESET INPUT
S= SET
T= TIMER
CO= COUNTER
W= Watt.
KW= Kilo Watt.
mA= Mille Ampere
kHz= Kilohertz