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Development of Semi-Automatic Operated Pneumatic Based Wire Stripping Machine

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ABSTRACT

In recent years, the trend in the business has been toward more automation. A growing number of variables, including improving accuracy and reducing human error, are driving this trend. An in-depth examination of the design and development of a pneumatically driven cable stripping machine for industrial mass production is provided in this dissertation, which includes an extensive bibliography. To cut the cable in large diameters in mass production, the industry now employs the traditional technique of employing a cable cutter, which takes longer and needs more manpower to cut the cable than other methods. The precision achieved by the traditional technique is low, and the procedure is time-consuming. In addition to providing a solution to the traditional way of solving issues, automation reduces costs and saves time while also increasing accuracy and reducing human mistakes. By using automation, we want to achieve low-cost stripping that is both quick and efficient, thereby reducing stripping time. The practical goal of an automated cable stripping machine is to remove the PVC from a cable at the necessary length and in the required number of pieces, according to the specifications. The stripping process in this system is accomplished via the use of pneumatic pressure and an Arduino. In our project, a solenoid valve is utilized to activate a pneumatic double-acting cylinder, which is controlled by an Arduino.

KEYWORDS: *Pneumatic, Cable Stripping, Automation*

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INTRODUCTION

It should be noted that waste reduction to zero can't currently be accomplished in many industrial processes and that only the second principle of the waste management hierarchy can be implemented in many organizations. While it is not difficult to recycle clean and homogenous trash, composite goods composed of various materials, such as "plastic combined with metals, rubber, paper, other types of plastics, and so on," may pose significant difficulties. In this scenario, waste separation, which is often multistage and expensive, must be included in the waste recovery process. Electric lines and cables are a good example of a composite product. Nonferrous metals such as copper and aluminum are the most valuable components of cable that must be recycled. The most difficult issue in the recovery of electric wire/cable trash is figuring out how to separate the plastic insulator from the metal conductor. Electric wires and cables were recycled in the past by simply burning them. After burning, the copper remained solid and could be collected. Although burning cables was a simple and effective technique, such thermal recycling is no longer permitted in many countries due to the emission of heavy metals, dust, and hazardous gases such as hydrogen chloride, dioxins, and other toxins into the environment. Furthermore, recovering just the metals without taking into account the insulating layer is not cost-effective. This is an ongoing effort. A pneumatic wire stripping machine may be used to recycle copper wires in large quantities for use in the manufacturing sector. Copper is an example of a material that is fully recyclable. Copper has a greater recycling rate than any other engineering metal, and it also does not deteriorate during processing. Scrap copper has a value that is about 85 to 95 percent that of freshly mined ore. Copper recycling has given rise to a slew of small-scale businesses today. Ashwin V. Desai et_al[1]

describe the project as the design of an automatic machine for manufacturing segments of heavy gauge insulated electrical wire with both ends stripped. Automatic Cable Stripper is machining that separates the core from coaxial cable for recycling use. The relevant information was analyzed to know the size of the cable and the speed of the motor that is used in the stripping process. The relationship is made for different sizes of cable and pulley height to injure various sizes of cable can be fed. In theory, the expected result was the Automatic Cable Stripper machine will strip and separate between core and coaxial cable automatically. Gao Xiaoxing et_al[2] introduced technology PLC control system and discussed the characteristics of relay control circuit, computer and SCM control technology than about the PLC control system design methods. For the use of Wire grinding and Wire stripping machine. In the wire grinding machine, the module is single and easier, with the principle of how it works. PLC obtains the status of sensors, data such as the diameter value to control the operation of the corresponding parts to form a closed loop between the PLC control system, the motor, and wire diameter grinding detectors to grind the wire into segments with different diameters. Finally, they concluded the PLC-based control system design of the stripping machine. For the manufacturing of recycled copper wires, industries rely on both human labor and big machinery. In this project, we designed a simple wire stripping machine that is pneumatically driven and would be cost-efficient while maintaining the same output rate.

Problem Description

Observations have been made that manual stripping of the cable takes more time and produces less accuracy, and that skilled labor is required to strip the PVC from the cable in question. This method is unsuitable for large-scale production of any kind.

Objectives

A pneumatic wire stripping machine was designed and developed, and it was shown in operation.

- To work quickly and efficiently in order to minimize stripping time.
- To make the machine as basic and portable as possible.
- To strip the necessary length of wire to provide the required spacing between conductor and cable.
- To decrease the cost by modifying the design and the amount of human labor.

MATERIALS AND METHODS

A. Electronic Control Unit

Here the 555 IC has been used as a multivibrator. The output of IC 555 is fed to the input pin (pin no 14) of CD 4017 continues counting. The output of the IC becomes available at pin Nos. 3, 2, and 4. The output pulse of anyone output pin triggers (Puts ON) the TRIAC and the current starts flowing across the load connected. This process continues on other pins at different time intervals and the cycle continues. The frequency interval (Time) of the cycle can be adjusted by the pre-set look connected to pin 6 of 555 Timer IC.

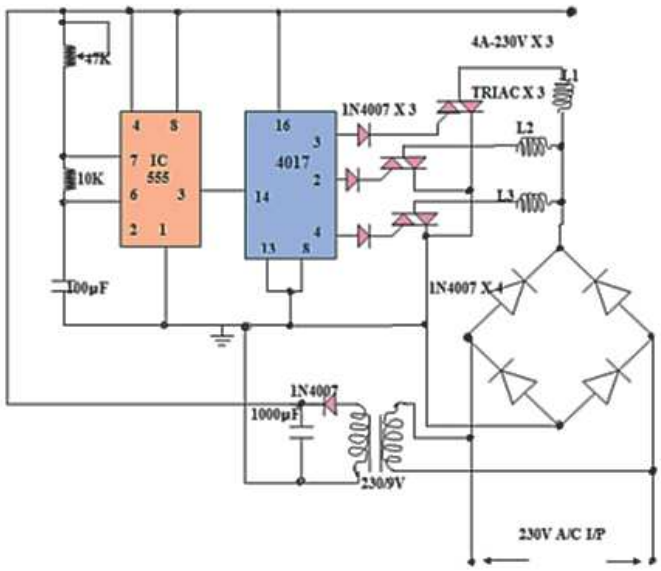

Fig.1 Circuit Diagram for ECU

B. Pneumatic Cylinder

In this project, we are using three pneumatic cylinders for clamping the wire, cutting the wire, and stripping the wire. The specification for the cylinder used for clamping and cutting the wire is shown in Table.1 and Fig.1 shows that the clamping cylinder

Table 1 Clamping, Cutting Cylinder Specification

Description	Specification
Bore	16mm
Stroke Length	30 mm
Fluid	Air
Max. Opearting Pressure	0.7 Mpa
Cushion	Rubber Bumper

Fig.2 Clamping Cylinder Fig.3 Cutting Cylinder

The specification for stripping the wire is shown in Table.2 and the Fig.4 shows that the stripping cylinder.

Table. 2 Stripping Cylinder Specification

Description	Specification
Bore	160mm
Stroke Length	32 mm
Fluid	Air
Max. Opearting Pressure	10 Bar
Cushion	Rubber Bumper

Fig. 5 Stripping Cylinder

Pneumatic cylinder calculation

$T \alpha f^{0.75} D^{1.8}$

$T = C f^{0.75} D^{1.8}$

Where,
C = Constant
D = Diameter in mm
f = Feed (mm/rev) =10 mm/rev=0.01m/rev

In bench type drilling machine normally upto 20 mm diameter drills can be used.

Therefore Torque produced (T)
= 0.11 x 0.25 0.75 x 20 1.8
= 8.5448 Newton-meter

We know that,
T = F x d
∴F = T/d
= 8.5448 / 0.01
F = 854.48 Newton

For C.I Cylinder
T = 0.07 x 0.4 0.75 x 20 1.8
= 7.735 Newton Meter
F = 773.5 Newton

Where,
$F = P \times \Pi d^2/4$
$3562.5 = P \times (\Pi \times 60^2)/ (4)$
$\therefore P = (3599.2 \times 4) / (\Pi \times 60^2)/4$
= 1.27296 Newton/mm²
= 0.12923 / Kg/ mm.

Calculation of cylinder thickness
Thickness of the cylinder (t) = $pd/2 f_1$

Where,
f_1 = Circumferential stress of hoop-stress and is also called maximum allowable stress
= 1000 kg/cm²
= 10 Kg/mm²
= 98.1 Newton/mm²

p = Intensity of internal pressure
= 1.2599 N/mm²

d = Diameter of the shell
= 60 mm

∴Thickness of the cylinder (t)
= 1.2599 x (60/2) x 98.1
= 0.3853 mm

Thickness of the cylinder take as = 1 mm.

C. Arduino Mega Controller

The Arduino Mega 2560 Controller is used to control the movements in the solenoid valve to change the direction of flow to the cylinder. Fig.6 shows the Arduino Mega 2560 board and Table.3 shows the Arduino specification.

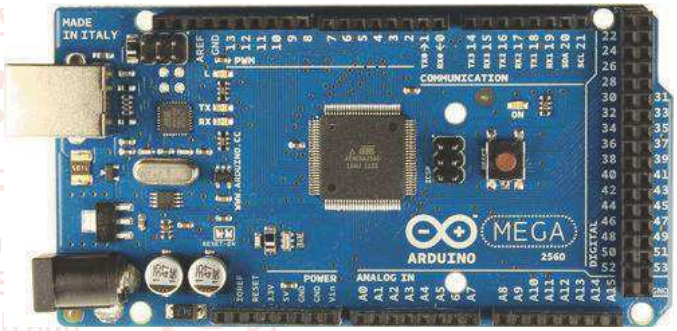

Fig. 6 Arduino Mega 2560 Controller

Table.3 Arduino Mega 2560 Controller Specification

Description	Specification
Operating Voltage	5V
Input Voltage	7-12V
Input Voltage Limit	6-20V
Digital I/O Pins	54
Analog Input Pins	16

Arduino Programming

```
int input;

void setup() {
pinMode(2, OUTPUT);
pinMode(3, OUTPUT);
pinMode(4, OUTPUT);
}

void loop() {
while(Serial.available()>0){
input=Serial.read();
if (input=='Z')
digitalWrite(2,HIGH);
delay(1000);
digitalWrite(3,HIGH);
delay(1000);
```

```
digitalWrite(4,HIGH);
delay(1000);
digitalWrite(2,LOW);
delay(1000);
digitalWrite(3,LOW);
delay(1000);
digitalWrite(4,LOW);
delay(1000);
}
}
```

WORKING PRINCIPLE

Starting with the mentioned configuration, the connections to the pneumatic cylinders are made using PU tubes (Polyurethane Tubes) from the air compressor, which serves as the source of air supply. The Arduino Micro-controller is comprised of a Step-down Transformer for reducing 18 the 230V alternating current power source to 12V, as well as other components. For the Arduino microcontroller to function properly, the input voltage must be reduced from 12V to 5V.

Two relays control the two 5/2 Direction Control valves (for turning them on and off), and a capacitor is used to ensure that the Arduino Micro-control unit operates continuously without interruption. The Arduino microcontroller and its whole arrangement are linked to the Electric board, which serves as the power source. The wire stripping machine is now capable of performing four operations. The initial 5/2 Direction Control Valve is activated by the signal received from the Micro-Controller during the first operation of the system. In this stage of the process, the cylinders equipped with vices and cutting blades begin to operate.

The first cylinder secures the wire that has to be stripped while the second cylinder shears the wire's sleeve. An additional 5/2 Direction Control Valve is powered by the micro-controller in the second operation, and this activates the Pneumatic cylinder with guide shafts, which also pulls the cylinder out of the mounting bracket. As a consequence, the sleeve that was sheared off during the first operation is removed/pulled away from the wire roll in the second operation (balance wire to be stripped). Fig. 7 shows the overall layout of the machine.

The first 5/2 Direction Control valve was switched off during the third operation, which cut off the air supply to the pneumatic cylinder. The pneumatic cylinders 1 and 2 return to their original positions, as do the Vice/Holder and the Wirecutter, which are likewise returned to their former locations. Fig. 8 shows the cutting cylinder and the clamping cylinder of the stripping machine. In the previous procedure, the 2nd 5/2 Direction Control Valve was also turned off, which cut off the air supply to the 3rd cylinder and returned the cylinder to its original position with the assistance of the Guide shaft.

All four procedures were completed in less than three seconds. This time length is set into the Microcontroller, and it may be adjusted to meet our specific working requirements. These four procedures will now be repeated until the power is turned off completely.

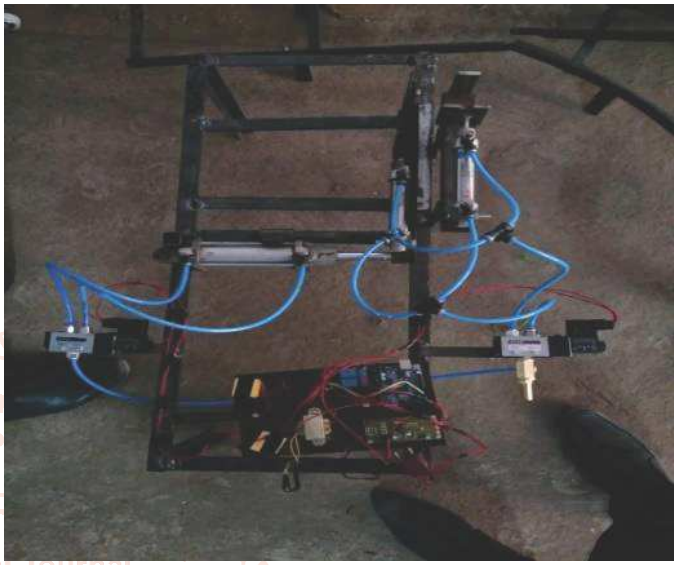

Fig. 7 Overall layout of the stripping machine

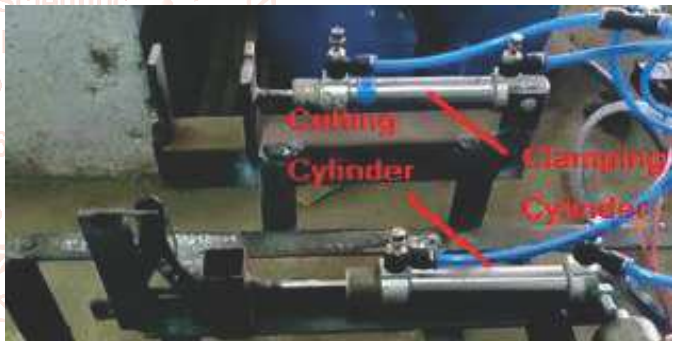

Fig. 8 Clamping and the Cutting Cylinder

Result and Conclusion

Results are taken from both the manual and semi automated processes for various parameters are measured like cutting force, cutting speed. In which the time taken for both the cases are same while increasing the cutting force. The result comparision of semi-automatic vs manual stripping are shown in Table.4.

From this, we conclude that using the semi automated stripping machine will reduce the overall timing for stripping is to be reduced. The cutting speed for the single wire takes around 1 sec, and for the manual process, it takes 1.25 sec. For per 3 wire cable it takes around 3 sec and 3.75 sec for the manual. Hence it is proved that the stripping process is more simple as compared to the manual method.

Table.4 Result comparison of Semi-Automatic vs Manual

Description	Semi-Automatic	Manual
Wire Diameter	1sq.mm	1 sq.mm
Cutting force	1.272 N/mm2	1.909 N/mm2
Cutting speed	1 sec	1.25sec
Cylinder movement speed for each operation	1sec	NA
Solenoid Valve Response time	50ms	NA
Overall Time taken for per 3 core cables	3 sec	3.75sec

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