Automatically Controlled Pneumatic Vice

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Abstract: *As for any mechanical operations clamping of workpiece is a primary need and conventional hand driven vice machine consumes a lot of time and labour work. So, it was tried to automate this machine which increases production rate. As we put workpiece in between the jaws, sensor activates Arduino to send electrical signal to relay. This activate the solenoid valve which further allows cylinder to clamp workpiece. Time period of operation is specified. As the operations gets finished, Arduino sends signal to retract the movable jaw through cylinder to make workpiece free.*

Keywords: Pneumatic Vice, Arduino.

Introduction

A huge range of mechanical engineering systems utilize the fluid force and power. This power of pressurised air or oil can be utilised in powered clamp operation, press and forging, and various types of assembly fasteners. In all these examples, the required mechanical forces are obtained from fluid energy. Systems acquiring this functioning from liquids fall under the category of hydraulic systems whereas systems that use air are called pneumatic systems. [1]

In pneumatics compressed air is used as the source of required potential energy, which it accumulates after getting compressed. **A. S. Aditya Polapragada, et.al** [2] worked upon a pneumatic auto feed punching and riveting machine. In their paper, they discussed the importance of the pneumatic press tool and stated that even the pressure as low as 6 bar was enough to operate the unit. **T. Suresh Kumar, et.al** [3] fabricated an automatic feed pneumatic vice. They automated their vice using a special microcontroller AT89C51 which is a very low power consuming but high-performance CMOS 8-bit microcomputer having 4K bytes of flash PEROM. The vice was adjusted via a pneumatically operated jack. **Mr. Sunil Kumar Jena, et.al** [1] published a paper on fabrication of low-cost pneumatic vice. The unit was specifically designed to work between the pressure range of 60 psi to 120 psi. The unit was used for drilling purpose especially the ones requiring long stroke length.

Principle of Operation

The principle of operation of pneumatic system is more or less similar to that of the hydraulic systems. The pressure energy of the air is increased by compressing it i.e. by converting the mechanical energy of the prime mover, motor, into pressure energy. The storage, transmission, and control of energy is facilitated by this transformation. [4]

There are electronics components like Arduino which is basically a microcontroller, it will be used to make this operation automatic. An IR sensor senses the presence of the workpiece

between the two movable jaws. It will send a signal to the Arduino which will take the decision to either close the jaws or open them. Arduino will send a signal to the relay. This relay works as a switch. Relay will be connected to the pneumatic valve, which is a solenoid valve. As the workpiece is put between the jaws of the vice, it will extend the movable jaw to clamp it.

After the operation is performed on the workpiece, the Arduino will send signal to retract the movable to its dead-end position.

Components

- **Compressor**

The function of a compressor is to convert the mechanical energy into pressure energy. Interested characteristics of a compressor here are delivery capacity and compression ratio.

- **Double acting Cylinders**

A double acting cylinder produces propelling force as well as retracting force, as both the sides of the piston are subjected to air pressure alternately. Retraction thrust is relatively small due to small effective area of the piston.

- **Control valves**

These valves are helpful not only in controlling the volume of the compressed air but also in changing the direction of the flow as well. The valves are characterised on the basis of the ports they have, the switching positions, its normal and method of operation. General nomenclature used for these valves is in terms of the number of pots and switching position, e.g. 5/2, 3/2, 2/2 etc.

- **Arduino**

The Arduino Uno is an ATmega328 based microcontroller board. It has multiple components such as analog inputs, digital input and/or output pins (out of which 6 can be utilized as PWM outputs), an ICSP header, reset button, a crystal oscillator, a power jack. [5]

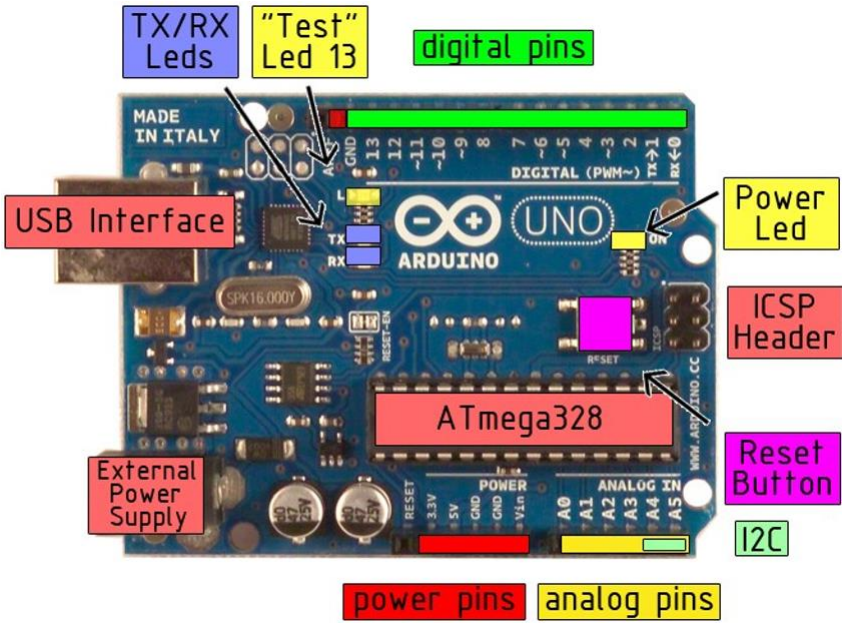

Figure 1: Arduino

- **IR Sensors**

An infrared sensor works by detecting light of a particular wavelength in the Infrared (IR) spectrum. It consists of an emitter, detector and associated circuitry. [9] The emitter is simply Infrared Light emitting diode (IR-LED) and IR photodiode based detector, which is highly sensitive to IR light of the wavelength as radiated by the IR LED., the magnitude the output voltage changes proportionally to the light impinging on the photodiode. [6]

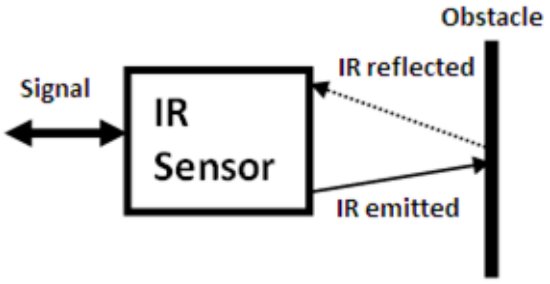

Figure 2: IR Sensor

- **Relay**

A relay is a switch that operates on electricity. There may be two sets of relays classed as "Normally Open / make contacts", or "Normally Closed / break contacts".

Pneumatic Vice Circuit Diagram

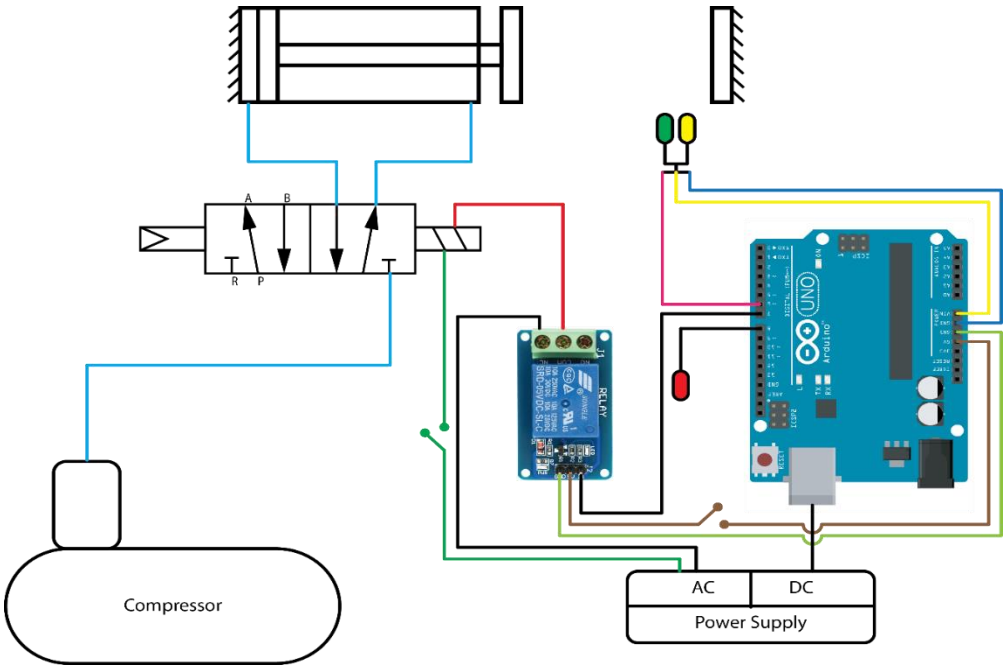

Figure 1: Pneumatic vice circuit diagram

Pneumatic Vice 3D Model

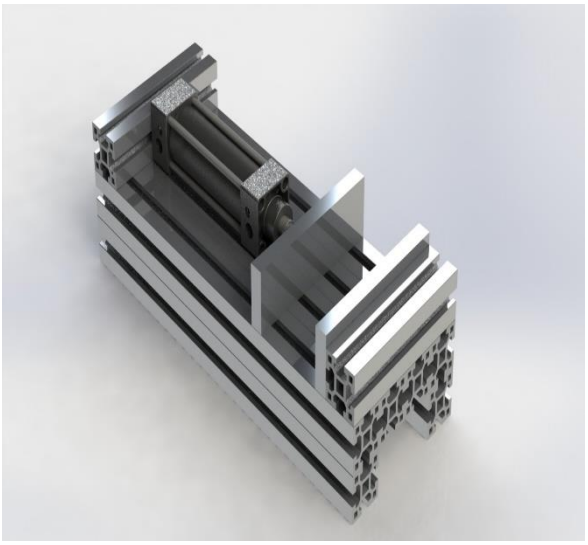

Figure 43: Pneumatic vice render 1

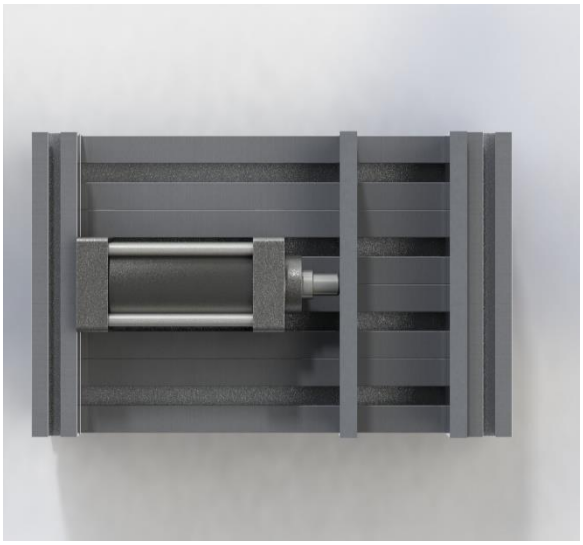

Figure 52: Pneumatic vice render 2

Theory

The fluid (compressed air) exerts a pressure P (Pascal) on the face, having cross sectional area A m^2, of the piston and then the force produced can be calculated as [7]

$$\mathbf{F = P \times A} \quad \mathbf{N}$$

It is assumed here that the pressure on the other side of the piston is negligible as well as the cross-sectional area of the rod is also negligible in comparison to piston.

Calculation

- **Problem**

To estimate torque and the thrust force while drilling a solid block of mild steel with a normal twist drill. Given

$$\mathrm{D} = 20 \text{ mm}$$

$$\mathrm{rpm} = 240$$

$$\tau_{s_{\text{work material}}} = 400 \text{ N/mm}^2$$

$$\text{Feed} = 0.25 \text{ mm/revolution}$$

- **Solution**

The geometrical and mechanical parameters, other than those given, have to be suitably chosen from standard data table,

$$2\beta = 118°$$

$$\psi = 30°$$

The effective rake angle at the middle of each cutting lip is

$$\alpha \approx \tan^{-1}\left[\frac{(2(D/4)/D)\ \tan 30°}{\sin 59°}\right] \approx\ 18°$$

The uncut thickness is

$$t_1 = (f/2)\ \sin\beta = 0.125\ \sin 59°\,\text{mm} = 0.11\ \text{mm}$$

width of cut per cutting lip is

$$w \approx (D/2)\ /\sin\beta\ \approx\ 10/\sin 59°\,\text{mm}\ \approx 11.67\ \text{mm}$$

Assuming a suitable value of friction angle λ and a suitable shear angle relationship.

Taking $\mu \approx 0.6$, we find the friction angle $\lambda = 31°$

By, Lee's & Shaffer's relation

$$\Phi + \lambda - \alpha = 45°$$ Where, Φ is shear angle

$$\Phi = 45° + 18° - 31° = 32°$$

F_c and F_T are given by

$$F_c \approx \frac{0.125 \times 11.67 \times 400 \times \cos(31° - 18°)}{\sin 32° \times 0.707}\text{N} \approx 1517\ \text{N}$$

$$F_T = \frac{0.125 \times 11.67 \times 400 \times \sin(31° - 18°)}{\sin 32° \times 0.707}\text{N} \approx 350\ \text{N}$$

$$M \approx \frac{0.6 \times 157 \times 20}{1000}\text{Nm} \approx 18.2\ \text{Nm}$$

$$F \approx 5 \times 350 \times \sin 59°\ \text{N} \approx\ 1500\ \text{N}$$

Conclusion

This paper deals with fabrication of automatically controlled pneumatic vice machine. The pneumatic system can be found in almost all industries/field. Some of the industrial applications are punching, clamping, milling, drilling, filing operations etc. It can be concluded

that it can be used in small scale industries considering time to be a most important factor. This machine can be used for low load application with better machining operation capability.

References

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Appendix

Programming

The Arduino Uno is programmed with the help of Arduino software. The microcontroller board is programmed using Arduino development environment (based on Processing) and Arduino programming language (based on Wiring).

This below written code is installed in the used Arduino:

[code]

```
// digital pin 6 has a pushbutton attached to it. Give it a name:
int IR_Sensor = 6;
// digital pin 7 has a pushbutton attached to it. Give it a name:
int Relay = 7;
// digital pin 8 has a pushbutton attached to it. Give it a name:
int LED_Red = 8;
/* the setup function runs once when you press reset or power the board */
void setup()
{
// initialize digital pin IR_Sensor as an input.
        pinMode(IR_Sensor,INPUT);
// initialize digital pin Relay as an output.
        pinMode(Relay,OUTPUT);
```

```
// initialize digital pin LED_Red as an output.
        pinMode(led_red,OUTPUT);
}
// the loop function runs over and over again forever
void loop()
{
        int sensor_value = digitalRead(ir_sensor);
        if(sensor_value == HIGH)
        {
// turn the Relay on (HIGH is the voltage level)
                digitalWrite(Relay,HIGH);
// turn the LED_Red on (HIGH is the voltage level)
                digitalWrite(LED_Red,HIGH);
// wait for a second
delay(5000);
// turn the Relay off by making the voltage LOW
                digitalWrite(Relay,LOW);
// turn the LED_Red off by making the voltage LOW
                        digitalWrite(LED_Red,LOW);
                delay(5000);
// wait for a second
        }
Else
        {
                digitalWrite(Relay,LOW);
                digitalWrite(LED_Red,LOW);
        }
}
[/code]
```