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DESIGN AND ANALYSIS OF AN AUTOMATED PRESS TOOL USING ARDUINO

P Varun UG Student, Dept. of MECH, GMR Institute of Technology, Rajam
P Gowathmi UG Student, Dept. of MECH, GMR Institute of Technology, Rajam
P Yogeswararao UG Student, Dept. of MECH, GMR Institute of Technology, Rajam
GVSS Sharma Associate Professor, Mechanical Engineering Department, GMR Institute of Technology, Rajam

Abstract
The aim of this work is to design and develop an automated press tool machine using Arduino as the central control system. Press tool machines are essential in industrial applications for processes such as punching, blanking, notching, piercing and pressing materials with high precision and efficiency. Traditionally operated manual press tools are mostly done by workers, lack consistency, and are gone to human error. After adding automation with Arduino, this work seeks to overcome these errors by offering a more reliable, precise or accurate and repeatable operation. Here automated system utilizes an Arduino microcontroller to manage the entire operation cycle, including motor control, pressing mechanisms, and feedback from sensors. The press tool system is equipped with actuators such as stepper motors or servo motor, along with proximity and limit sensors to ensure safe and accurate movement during each cycle. This design gives improved efficiency, reduced manual workings, labour cost and enhanced safety features compared to conventional machines. The integration of Arduino enables flexibility in design modifications, ease of programming, and low-cost automation, making the machine suitable for small- to medium-scale industrial environments. When the design and Arduino coding is completed, stress analysis for the punch and die which is done on ANSYS software to check whether design is safe or not. Here the punch and die undergo repeated loads in press tool design. These parts undergoes for analysis to get better design of the punch and die for manufacturing.

Keywords
Press tool design, Arduino, Press Tool Automation, Stress analysis

Introduction

Now a days in modern industries are trying to decrease human number and want to increase product number for this automation is required. Using automation, In modern industrial applications, the demand for humans will decrease and errors also decreased. Press tool machines, commonly used for operations like piercing, notching, blanking, stamping, punching, and pressing are main operations in manufacturing sector. Traditionally operated manual press tools are mostly done by workers, lack consistency, and are gone to human error. After adding automation with Arduino, this work seeks to overcome these errors by offering a more reliable, precise or accurate and repeatable operation. Arduino is used to manage the entire working process of the system, including motor controls, pressing mechanisms, and information from the motors and sensors. The press tool system is attached with actuators such as stepper motors or servo motor, along with sensors to ensure safe and accurate movement during each operating cycle. Arduino is widely used in automation works due to its flexibility, ease of programming, and cost-effectiveness. By including or adding Arduino into the design of the press tool machine, the operation cycle including material detection, pressing force control, and movement precision can be fully done by automation. The proposed system aims to automate critical functions of a press machine, such as detecting material presence, controlling the press mechanism, and ensuring accurate operation through the use of sensors, actuators like stepped motors, and programmable logic. Actuators such as stepper motors or pneumatic cylinders will drive the press mechanism, while sensors like ultra sonic sensors or IR sensors ensure precision and safety.

Literature Review

In a world where technology and innovation rule, a team of brilliant engineers discovered groundbreaking research papers. These papers would change manufacturing and transportation forever. Their journey started with Paper [1] which showed how to design press tools that could do multiple tasks at once. This sparked their curiosity. Paper [2] revealed the importance of precision and efficiency using strong materials like D2 steel. Calculated forces and rigorous testing ensured high-quality metal components. Paper [3] amazed them with ANSYS simulations, minimizing deformation and stress. They saw potential for massive-scale efficient metal manufacturing. Papers [4] and [5] emphasized selecting the right materials, efficient task arrangement, and smarter design for enhanced quality and productivity. Paper [6] showcased press tools' impact on industries like automotive and aerospace. The team envisioned a future with efficient manufacturing transforming the world. Paper [7] revealed optimized press tool design and precise force control for improved metal forming efficiency. Streamlined production lines and reduced waste were within reach. Paper [8] inspired sustainability with versatile press systems transforming waste plastic into valuable resources. In transportation, Paper [9] proposed automated railway gate control and obstacle detection using infrared and ultrasonic sensors. Paper [10] presented AI-powered navigation tools for visually impaired individuals, enhancing safety and independence. Dwarakanath, an engineer who created an automatic railway gate using Arduino Paper [11]. Her innovation prevents accidents and saves lives. Meanwhile, her colleague, John, designed a device to help visually impaired friends navigate with streamline Paper [12]. Across town, a team developed an advanced obstacle detection system for railways, combining cameras, sensors, and AI Paper [13]. Others worked on similar projects, using ultrasonic sensors Paper [14] and deep learning Paper [15] to improve urban rail safety. In another part of town, innovators like Emily built Arduino-powered machines to streamline industry processes. She created an automated stamping machine Paper [16] and collaborated on a thin-film deposition system Paper [17] and an automated stacking crane Paper [18]. Sustainable agriculture also benefited from Arduino-based solar power Paper [19]. Hobbyists like Patel accessed affordable CNC technology Paper [20], and railway operators implemented real-time obstacle detection Paper [21]. Inspired, the engineers combined their knowledge to create innovative solutions positively impacting their community. Their journey began – harnessing technology for a safer, more efficient, and sustainable world.

Research gap

The papers which we have done research are mainly focuses heavily on design aspects, cost estimation, and materials selection for blanking, Stamping, pressing, piercing and notching tools. However, there is a lack of discussion on newer manufacturing technologies such as additive manufacturing (3D printing) or automatic pressings for press tool components, which could reduce production and coming to the other some of the research papers discussed about automation of gates they have mainly focused on the obstacle detection and human safety but they have not used it in the design and press tool sector. By combining, Design of pressing tools and automation can reduces time, wastage of material, and human work. so, from this papers we are making an automatic press tool by combining both designing of an press tool and automation using sensors, Arduinos, microcontrollers and actuators like stepped motors. It can reduce the human errors and human safety also increases.

Methodology

The first step in this work is to design of an press tool with according to the dimensions and required component designs. After that automation is to be adjusted with the design accordingly. when the machine is ready, the sheet has to be placed between the die and punch. After placing the sheet between the punch and die, there the sensors like ultrasonic sensors can recognize the object and it can passes the signals to the Arduino. Here the Arduino receives the signals from the sensor and passes the signals further to the actuators like stepped motor or servo motors and this motor is connected to the punch. There by when the motor starts rotating, the punch starts moving up and down and when the punch falls on the sheet and it gets into a required shape.

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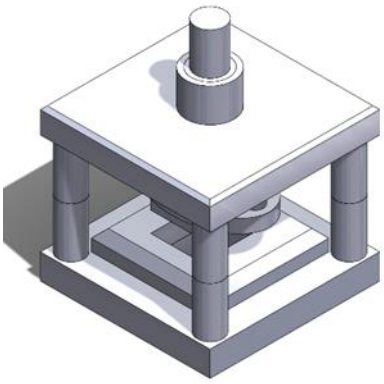

Fig1: Design of an press tool

Circuit diagram

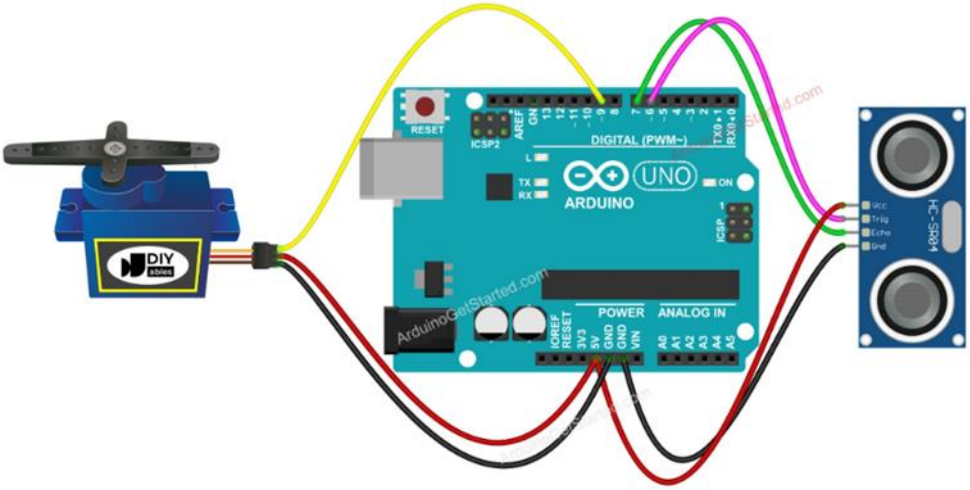

Fig2: connections of Sensor, Arduino and Servo motor

Arduino code

```
#include <Servo.h>
Servo myServo; // Create a Servo object
// Ultrasonic sensor pins
const int trigPin = 9;
const int echoPin = 8;
// Distance threshold in centimeters
const int distanceThreshold = 10;
void setup() {
  // Set up the servo and ultrasonic sensor
  myServo.attach(3); // Attach the servo to pin 3
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
// Initialize serial communication (optional for debugging)
Serial.begin(9600);
// Set servo to initial position
  myServo.write(0); // Start at 0 degrees
}
void loop() {
// Measure distance
long duration, distance;
```

```
// Trigger the ultrasonic pulse
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
// Calculate the distance in cm
  duration = pulseIn(echoPin, HIGH);
  distance = duration * 0.034 / 2;
// Print distance to the serial monitor (optional for debugging)
  Serial.print("Distance: ");
  Serial.print(distance);
  Serial.println(" cm");
// If an object is detected within 10 cm
  if (distance > 0 && distance <= distanceThreshold)
{// Rotate servo to 180 degrees
    myServo.write(180);
  } else {
 // Return servo to 0 degrees
    myServo.write(0);  }
  delay(100); // Small delay to stabilize readings
}
```

Arduino code implementation

For the operation of automated press tool, the code which is written in Arduino IDE software is uploaded to the Arduino board. After that check, the servo motor is connected to pin 3, and sensor's trigger and echo pins are connected to pins 9 and 8. The distance threshold is kept to 10 centimetres in the code. When the power is supplied, the servo motor will rotate to its initial position. If any object comes within the set threshold distance, the servo motor rotates to 180 degrees which leads to punching operation. The system will check the distance and accordingly it adjusts the servo motor. Connecting to this, the analysis the punch and die is done to get efficient design output.

Clamp Tool

For making clamp, shear force has to be calculated using the formula which is used to cut the material and using shear force we can calculate stripping force. Stripping force helps to release the material. Clearence is also calculated for precise punch and die alignment.

A. Shear force

Shear force = $L \times T \times \tau$

$=120 \times 3 \times 82.7$

=29772 N

1N =0.1019716213 Kg

=3035.899 Kg

L=Length of cut in mm

T=Sheet thickness in mm

τ =Shear strength in N/mm^2

B. Stripping force

Stripping force=20% of shear force

$=(20 \div 100) \times 3035.899$

=607.179 Kg

C. Press force

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Press force=Shear force + stripping force
=3035.899 + 607.179
=3643.078 Kg
=3.643 Tons

D. Clearence

Clearence=$0.005 \times t \times \sqrt{fs}$
=$0.005 \times 3 \times \sqrt{82.7}$
=0.14mm/side
fs=Shear force in Kg/mm^2

Punch and Die analysis

When the designing, modelling and Arduino coding is completed, the press tool has to be analysed using ANSYS software to ensure that the design safe. Punch and die are the parts which have repeated movement for the press operation. Here we are using structural steel material for the punch and die. It is very important to do analysis to prevent errors before manufacturing the tool. So if the parts are analysed initially we can get efficient design of the parts. There by if any errors are there on during the working of analysis we can change accordingly which decreases time consumption and material wastage. Hence based on the results of the analysis we can manufacture the products.

A. Die analysis

Die is to be analysed in ANSYS software. In this firstly, we have to done boundary conditions and suitable material has to be applied with the die. The figures which are kept below gives the information about stress distribution of die with applied load conditions. In the below Fig4. The orange and blue colour indicates the maximum and minimum stress distribution area.

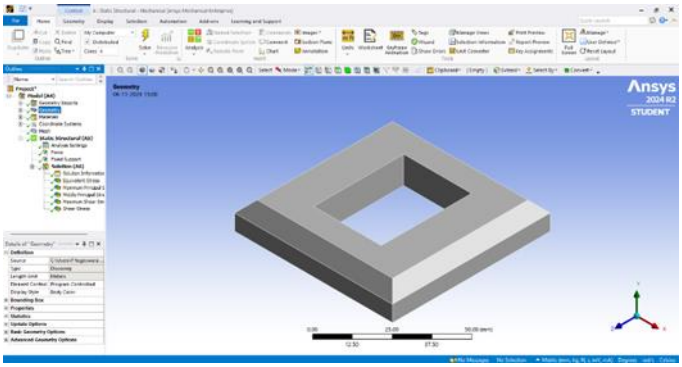

Fig 3: 3D model of die

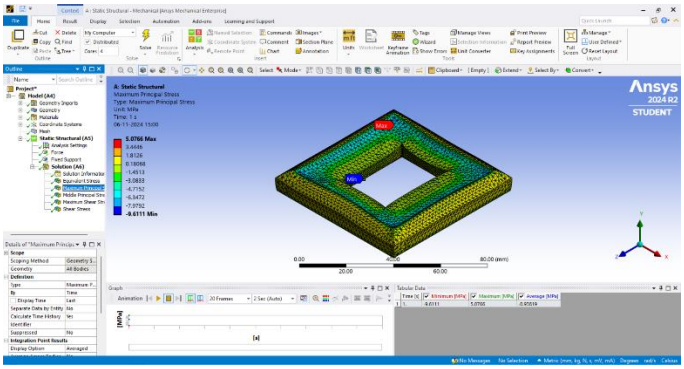

Fig 4: Maximum and minimum stress analysis of die

B. Punch analysis

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Punch is to be analysed in ANSYS software. In this firstly, we have to done boundary conditions and suitable material has to be applied with the die. The figures which are kept below gives the information about stress distribution of die with applied load conditions. In the below Fig6. The orange and blue colour indicates the maximum and minimum stress distribution area which is tabulated in Table 1.

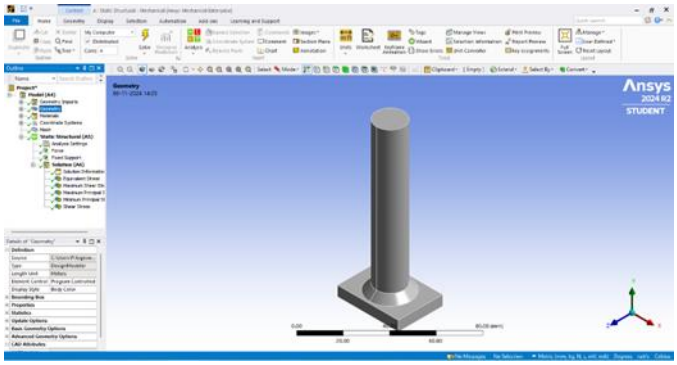

Fig 5: 3D Model of Punch

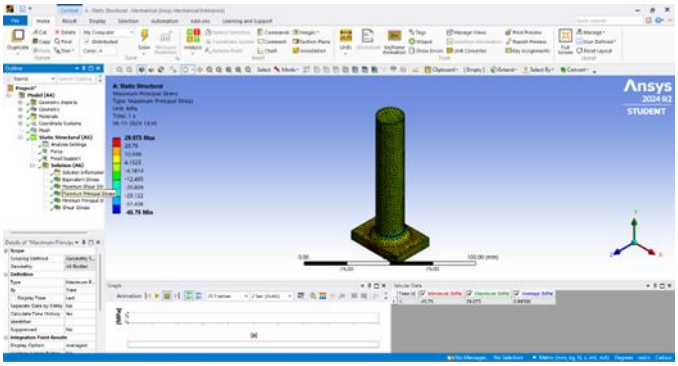

Fig 6: Maximum and minimum stress analysis of punch

Table 1: Maximum principle stress of punch and die

SI NO	TYPE	VALUE	UNITS
1	Punch	29.073	N/mm^2
2	Die	5.0766	N/mm^2

Results and discussions

The total press force which is considered to 3.643 tonnes. From the design calculations, shear force required for cutting is 3035.899 kg and stripping force is 607.179 Kg. From the Analysis software, when the load is applied on the punch and die, the maximum stress induced for punch and die is 29.073 N/mm^2 and 5.076 N/mm^2. The use of analysis software for simulation ensures the design is useful or not before manufacturing the tool. By performing simulations it gives the issues in the design there by we can change and decreases the material wastage and production time. Using Arduino, we can increase the productivity, efficient working of the tool and safety.

Conclusions

At the outset, automated press tool work is successfully combined using CAD design in 2d and 3D model, stress analysis using ANSYS, and Arduino-based control systems. This integration resulted in a manufacturing solution that is both efficient and accurate. Through ANSYS simulation, we validated the structural integrity of our design and optimized its performance. The Arduino-based control system ensured precise control and automation of the press tool. The use of sensors enables real-time feedback for accurate control of the press operation, ensuring precision in positioning, force application, and safety measures. The incorporation of safety features like emergency stops and overload protection is

essential for ensuring reliable and secure operation, which is critical for industrial environments. By designing the press tool in 3D model, the design will be more accurate and reduces the errors and time will also decreased compared to traditional methods. Designing an automatic press tool using Arduino offers an efficient, customizable, and cost-effective solution for industrial applications.

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