

Fabrication of Geneva Wheel Based Auto Roll Punching Machine with IR Sensing

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Abstract: In conventional punching machines, the time required for job setting, marking, and punching operations is relatively high, leading to increased labor cost and reduced efficiency. To overcome these limitations, a Geneva mechanism-based automatic punching machine is proposed, which significantly reduces setup time, labor involvement, and maintenance requirements. This project focuses on the design and fabrication of an automated roll punching machine using the Geneva mechanism, specifically tailored for continuous punching on paper or fabric rolls.

The aim is to introduce low-cost automation in industrial applications, particularly in processes requiring repetitive punching tasks. The major components utilized in this system include a DC motor, cam arrangement, chain drive, Geneva wheel mechanism, and punching tool. The setup includes two rollers to move the paper or fabric sheet during operation. A DC motor drives the cam, which features a pin that periodically engages the Geneva wheel. The Geneva wheel, in turn, is connected to a chain drive system that moves the rollers, feeding the material for the punching operation.

An IR sensor is incorporated into the system to detect the presence of paper or fabric before each punch cycle. This addition prevents dry runs, ensuring that the punching tool only operates when material is properly in place, thus increasing operational reliability, reducing wear and tear, and avoiding damage to the punch. This prototype is suitable for mass production scenarios and represents a step toward intelligent automation in material handling and processing systems.

I. Introduction:

Automation and mechanical innovation play a critical role in enhancing productivity and precision in modern industrial processes. In the field of sheet metal operations, especially punching, automating the material feeding and punching process can significantly improve efficiency while reducing manual effort. The Geneva wheel mechanism, known for its ability to convert continuous rotary motion into intermittent rotary motion, finds effective application in indexing and timing-based systems.

The Geneva Wheel Based Auto-Roll Punching Machine with IR Sensing is a semi-automated system that utilizes the Geneva mechanism to precisely control the motion of the workpiece and synchronize it with the punching action. The inclusion of IR sensors ensures detection and positioning accuracy of the roll material, thus eliminating errors due to misalignment and enhancing the quality and repeatability of punched parts.

This project focuses on the design and fabrication of a punching setup using mechanical, pneumatic, and sensing principles to achieve a synchronized, cost-effective, and reliable punching system suitable for small-scale production lines or educational demonstrations.

Geneva Mechanism

The Geneva drive or Maltese cross is a gear mechanism that translates a continuous rotation into an intermittent rotary motion. The rotating drive wheel has a pin that reaches into a slot of the driven wheel advancing it by one step. The drive wheel also has a raised circular blocking disc that locks the driven wheel in position between steps.

The name derives from the device's earliest application in mechanical watches; Geneva in Switzerland being an important centre of watchmaking.

The Geneva drive is also commonly called a Maltese cross mechanism due to the visual resemblance when the driven wheel has four spokes. Since they can be made small and are able to withstand substantial mechanical stress, these mechanisms are frequently used in watches. Precision in indexing motion. This mechanism is chosen for its Simplicity in design, Ability to handle synchronized timing tasks, Low maintenance and mechanical reliability.

Types of Genevas

External Geneva Mechanism

The external Geneva mechanism is the most commonly used type. In this setup, the driving wheel is positioned outside the Geneva wheel, and it has a pin that engages with radial slots on the Geneva wheel. As the driving wheel rotates continuously, the pin enters one of the slots and rotates the Geneva wheel by a specific angle (like 90° for 4 slots). After completing the step, the Geneva wheel remains stationary until the pin comes around again. During the dwell phase, a raised portion on the driving wheel locks the Geneva wheel in place. This type is simple in construction and suitable for machines operating at low to medium speeds. It is commonly found in mechanical watches, punching machines, and film projectors.

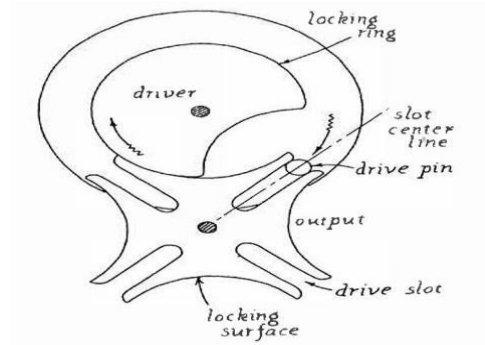


Fig1.14-Slot External Geneva

Detailed Examples of Sheet Metal Operations Using the Geneva Mechanism

Punching

- **Purpose:** To create holes or shapes through the sheet metal.
- **Process:** At one indexing position, a punching tool precisely punches holes at marked locations.
- **Application:** Creating ventilation holes in panels, mounting holes in brackets.

Piercing

- **Purpose:** Similar to punching but generally for smaller, precise holes or slots without removing the blank.
- **Process:** A piercing tool creates slits, slots, or small openings.
- **Application:** Ventilation slots in enclosures, alignment holes.

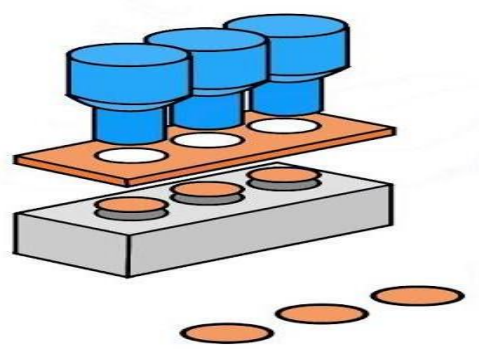


Fig1.4: Punching & Piercing

Blanking

- **Purpose:** To cut out a flat shape (blank) from a sheet.
- **Process:** The sheet is fed to a blanking die at a station where the Geneva wheel halts momentarily; the die cuts the complete shape out of the sheet.
- **Application:** Manufacturing of washers, covers, base plates.

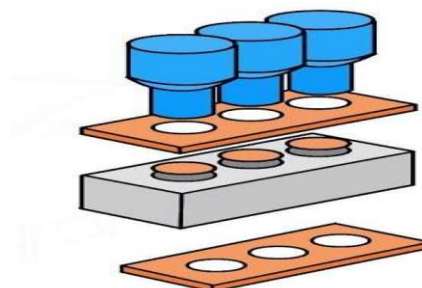


Fig 1.5: Blanking

Notching

- **Purpose:** To remove a small section from the sheet's edge or corners.
- **Process:** Special notching tools cut out corners or slots during each Geneva stop.
- **Application:** Preparing sheet edges for bending or assembly.

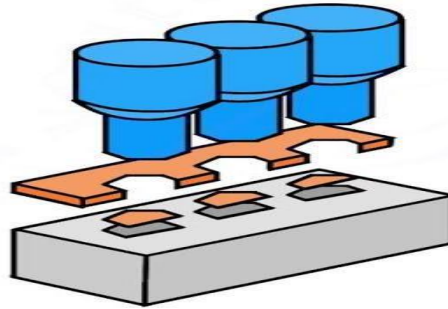


Fig1.6: Notching

Embossing

- **Purpose:** To create raised or recessed features on the sheet's surface.
- **Process:** At the embossing station, dies press into the sheet to form the desired surface texture or logo.
- **Application:** Decorative panels, nameplates, textured surfaces for grip.

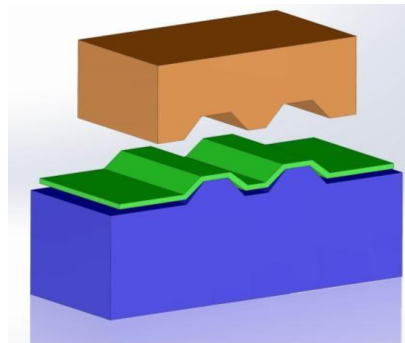


Fig 1.7: Embossing

Lancing

- **Purpose:** To cut and simultaneously form a tab or tongue from the sheet without removing material.
- **Process:** A lancing die slices and lifts a portion of the sheet to form louvers or ventilation openings.
- **Application:** Electrical cabinets, HVAC panels.

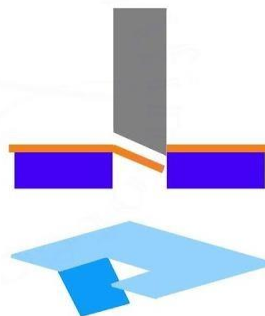


Fig 1.8: Lancing

II. Literature Survey Summary

Innovation in the field of automatic punching machines demands a deep study of existing mechanisms, materials, and technologies. This helps in understanding different motion conversion techniques, precision control methods, automation enhancements, and safety mechanisms. The following are the list of relevant published, patented, and unpublished research around the world.

The Geneva mechanism is widely utilized in applications requiring intermittent motion, making it an ideal choice for automatic punching machines. The mechanism transforms continuous rotary motion into intermittent rotary motion, allowing precise control over the indexing of material in automated systems.

R. S. Khurmi and J. K. Gupta (2005) in their work *Theory of Machines* discuss the basic working principles and design considerations of the Geneva mechanism. The intermittent nature of motion provided by this mechanism is especially beneficial in automation processes like punching, indexing tables, and film projectors.

V.S. Kumbhare et al. (2016) in their paper *Design and Fabrication of Geneva Operated Auto Punching Machine*, emphasize the efficiency improvements in production lines due to the Geneva mechanism. They noted that the precise indexing reduces material wastage and increases productivity, making it suitable for repetitive punching operations.

R. Syam Sudhakar Rao et al. [1] presented a design for an auto-roll punching machine utilizing a Geneva mechanism. Their system integrates a DC motor, cam arrangement, chain drive, and punching tool. The Geneva wheel facilitates intermittent motion, enabling precise sheet feeding and punching operations. This design aims to reduce labor costs, maintenance, and operational time, making it suitable for mass production in sheet metal industries.

Ankit Raj and Bhaskar Singh [2] explored a smart punching and labelling machine employing a Geneva drive coupled with proximity sensors. Their machine automates positioning, punching, and labelling, enhancing throughput and minimizing human error. The study underscores the efficacy of integrating simple sensors to augment mechanical systems' intelligence.

Priya Sharma and Manish Kumar [3] investigated the application of Geneva wheel mechanisms in semi-automatic machines. Their research emphasizes how Geneva drives convert continuous rotary motion into intermittent motion with precise indexing, discussing various configurations and their impact on dwell time and cycle optimization.

Srinivasa Rao P. et al. [4] developed an automatic paper punching system integrated with IR sensors. The IR sensor detects material presence, triggering the punching operation automatically. This integration eliminates manual feed errors and improves process reliability, demonstrating cost-effective automation using basic IR technology.

Prof. A. S. Rathi et al. [5] reviewed mechanical-based automation systems for small-scale industries, focusing on low-cost Geneva mechanism applications in assembly lines and semi-automated production setups. Their findings highlight the Geneva mechanism's versatility in operations requiring precise, repeated indexing, such as drilling, punching, and labeling.

Conclusions from Literature Survey:

- **Geneva Mechanism Efficiency:** The Geneva wheel effectively converts continuous rotary motion into precise intermittent motion, optimizing indexing operations in punching machines.
- **Automation Integration:** Incorporating IR sensors enhances automation by enabling non-contact material detection, initiating punching cycles automatically, and improving process reliability.
- **Cost-Effective Solutions:** The amalgamation of mechanical systems like the Geneva mechanism with simple electronic components such as IR sensors offers a cost-effective solution for small and medium-sized enterprises.
- **Enhanced Productivity:** Automation reduces manual intervention, minimizes operator fatigue, and increases production rates, making it suitable for mass production scenarios.
- **Design Considerations:** Proper configuration of the Geneva wheel and integration with other components like cam drives and sensors are crucial for achieving desired performance and reliability.

Problem Definition

To overcome manual errors, fatigue, time delays, and inconsistent punching in traditional sheet punching methods by designing an automatic Geneva wheel-based punching machine integrated with IR sensing for accurate, sensor-driven operation and precise indexing.

Objective

- To design and fabricate an efficient automatic punching machine using the Geneva mechanism for intermittent motion.
- To implement IR sensing technology for accurate material detection and automatic activation of the punching unit.
- To achieve precise control over punching intervals and indexing, ensuring uniform spacing and enhanced productivity.
- To reduce labor involvement, improve operator safety, and increase repeatability in small-scale manufacturing units.

Scope of the Project

- Automates sheet feeding and punching process using Geneva wheel-based indexing system.

- Integration of IR sensor to detect material presence and activate punching action without manual intervention.
- Suitable for lightweight sheet punching in small workshops, packaging, or craft-based industries.
- Reduce human error and cycle time while increasing production quality and consistency.
- Serve as a cost-effective alternative to CNC or hydraulic punching systems for medium-precision tasks.

III. Methodology

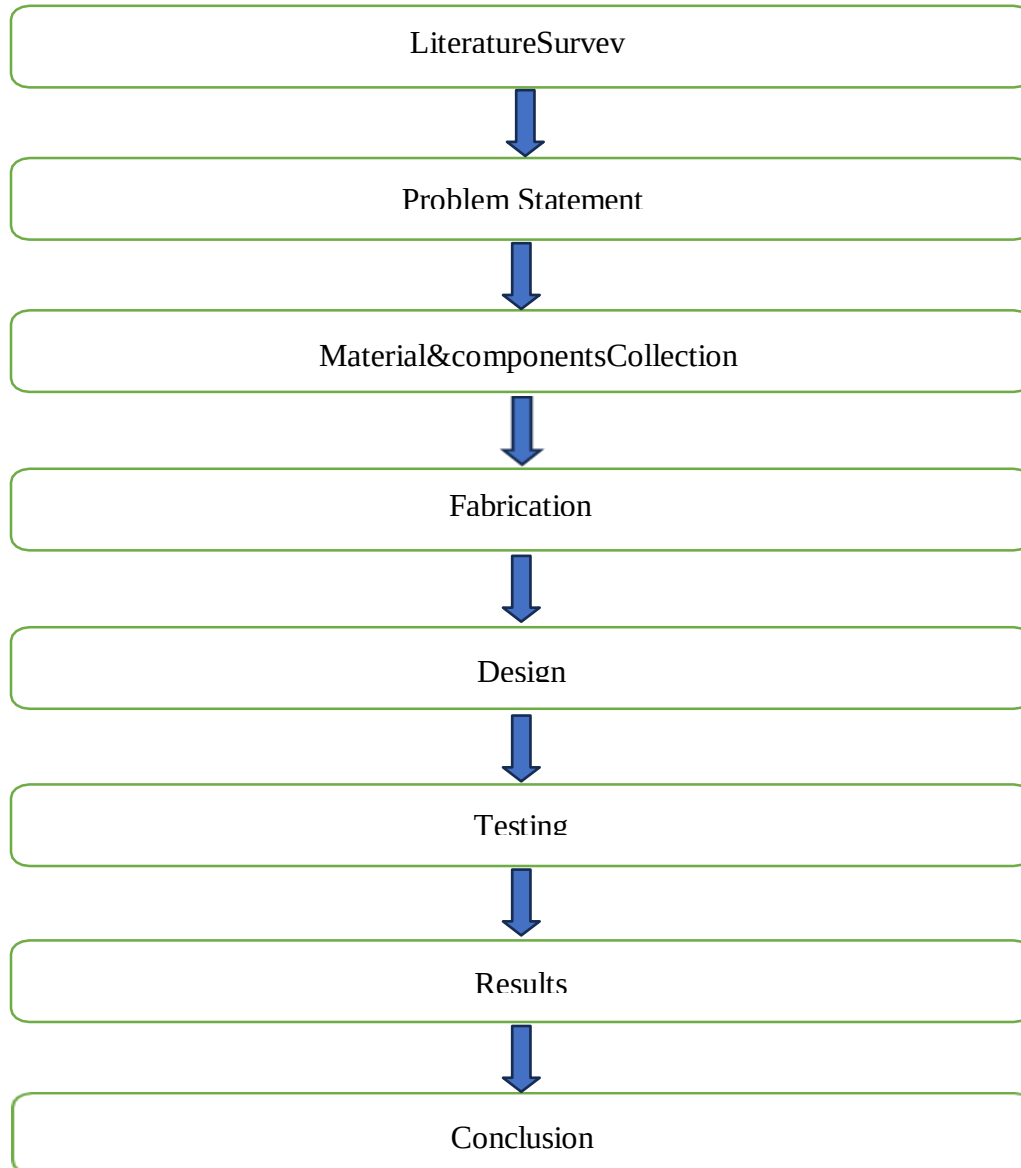


Table 5.2: Specification of Rechargeable battery

Specification	Details
Brand	SANCA
Model	RB1275BS
Battery Type	Sealed Lead-Acid (SLA) Rechargeable
Nominal Voltage	12V
Capacity	7.5 Ah
Charging Voltage (Cycle Use)	14.40V – 15.00V

Charging Voltage (Standby Use)	13.50V – 13.80V
Maximum Charging Current	2.35A



Fig5.4: Rechargeable lead-Acid Battery

Table5.3: Specifications of Chain & Sprocket

Specification	Details
Material (Chain)	Carbon Steel
Material (Sprocket)	Hardened Steel
Large Sprocket Diameter	180mm
Small Sprocket Diameter	80mm
No. of Teeth on Large Sprocket	44
No. of Teeth on Small Sprocket	24
No. of Links in Chain	30

Rollers

Introduction to Rollers:

Rollers are cylindrical components that facilitate smooth linear or rotational motion between contacting surfaces, typically with minimal friction. In an Autoroll punching machine, rollers play a critical role in feeding the sheet material or substrate into the punching zone in synchronization with the Geneva indexing mechanism.

Function of Rollers in Autoroll Punching System:

In a Geneva-based punching setup, rollers are responsible for the continuous or intermittent movement of the material being processed. The Geneva mechanism imparts an indexed motion, and the rollers must grip and guide the material precisely during the dwell and motion phases of the Geneva wheel.

Key functions include:

- **Material Feeding:** Rollers feed the sheet or material into the punching zone at a controlled rate.
- **Synchronization:** They work in coordination with the Geneva indexing to ensure accurate timing between feed and punch.
- **Friction Control:** Proper roller material ensures adequate grip without damaging the substrate.

Types of Rollers Used:

- **Drive Rollers:** Connected to a motor or Geneva-driven mechanism to actively pull or push the material.
- **Idler Rollers:** Passive rollers that provide support and maintain tension on the material.



Fig. 5.7: Rollers

Table 5.4: Specifications of Rollers

Specifications	Details
Length of Upper Roller	215mm
Length of Lower Roller	215mm
Diameter of Upper Roller	38mm
Diameter of Lower Roller	150mm
Bearing Diameter in Upper Roller	31mm
Bearing Pin Length	250mm
Material of the Roller	Aluminum

Paper feeder

The paper feeder roller used in the Geneva wheel-based auto-roll punching machine with IR sensing is a completely stationary component. It is designed to support and guide the paper roll movement without itself rotating. When the machine is operational, the paper roll moves forward under the influence of a separate powered driver roller, while the feeder roller remains fixed in place. The movement of the paper across the stationary roller is smooth and controlled,

ensuring a stable feed into the punching section without direct mechanical interaction from the feeder itself.

An important feature of the paper feeder roller is the inclusion of tapered conical plastic guides at both edges. These conical guides are fixed firmly and play a critical role in maintaining the paper's central alignment. They prevent the paper from drifting sideways during its forward movement and protect against paper edge wrinkling or jamming. By physically limiting lateral motion, the conical guides ensure that the paper remains properly aligned throughout the entire operation, maintaining punching accuracy and consistency.



Fig. 5.8: Paper feeder



Fig. 5.9: Sliding Bearing & Plastic Knob

Table 5.5: Specifications of Sliding Bearing & Plastic Knob

Specification	Details
Bearing Diameter	30mm
Knob Length	160mm
Knob Head Diameter	30mm
Knob Diameter	15mm

Punching Machine

A punching machine is a mechanical device used to create holes or shapes in sheet metal or other materials by applying a large force with a punch tool onto a die. The basic working principle involves placing the material over the die and then forcing the punch through the material into the die opening, cutting out the desired shape.



Fig.5.10: Paper Punching Machine

Geneva Wheel

The **Geneva drive** or **Maltese cross** is a gear mechanism that translates a continuous rotation into an intermittent rotary motion. The rotating drive wheel has a pin that reaches into a slot of the driven wheel, advancing it by one step. The drive wheel also has a raised circular blocking disc that locks the driven wheel in position between steps.

The **four-slot Geneva wheel** in the punching machine is made of nylon and features four evenly spaced radial slots. Driven by a crank with a pin, powered by a 12V DC motor with a speed reduction gearbox, it rotates 90 degrees per slot engagement, pausing briefly between rotations to ensure precise, intermittent motion for synchronized paper feeding.

Uses of making the Geneva wheel with nylon:

- **Lightweight:** Nylon's low density reduces the wheel's weight, minimizing inertia and energy consumption during operation.
- **Durability:** Nylon's high strength and wear resistance ensure the wheel withstands repeated slot engagements without significant wear.
- **Low Friction:** Nylon's self-lubricating properties reduce friction with the crank pin, enhancing smooth operation and reducing maintenance.
- **Cost-Effective:** Nylon is economical compared to metals, lowering manufacturing costs for the wheel.
- **Corrosion Resistance:** Nylon resists corrosion, making it suitable for various fabrication environments without degrading.
- **Noise Reduction:** Nylon's damping properties reduce operational noise compared to metal, improving workplace conditions.

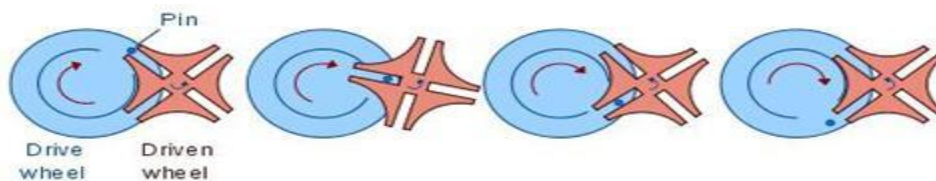


Table5.6: Specifications of 4-Slot Geneva Wheel

Specifications	Details
No. of Slots	4
DepthofEachSlot	100mm
Widthof theSlot	10mm
ArcRadiusofEachSlot	120mm
MaterialUsed	NYLON
SquareSide ofNylon Billet	260mm X 260mm
Thicknessof theNylonBillet	10mm

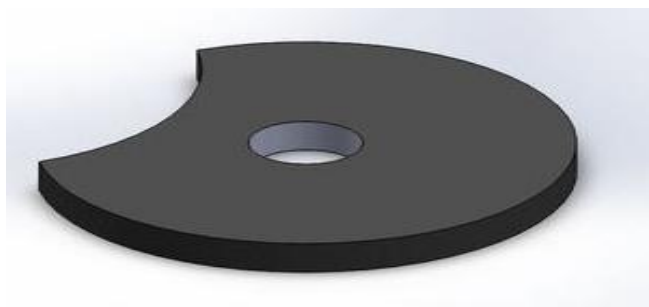


Fig.5.12: Crank Wheel

Table5.7: Specifications of Crank Wheel

Specifications	Details
DiameteroftheCrank Wheel	240mm
MaterialUsed	NYLON

I.R Sensor

Infrared (I.R) sensors are electronic devices that detect infrared radiation (heat) from objects. They are commonly used for motion detection, proximity sensing, and temperature measurement. IR sensors work by either emitting and detecting infrared light (active) or just detecting ambient infrared radiation (passive). They're widely used in remote controls, security systems, obstacle-avoiding robots, and thermal imaging.

IR sensors are super handy for detecting objects, motion, or line tracking. Here are a few common uses:

- **Obstacle avoidance:** In robotics, IR sensors detect nearby objects so the robot can avoid collisions.
- **Line-following robots:** Sensors detect contrast (like a black line on a white surface) to help the robot follow a path.
- **Automated doors:** IR sensors detect when someone is nearby to trigger the door.
- **Security systems:** Used in motion detectors to sense movement and trigger alarms.
- **Speed detection:** In DIY speed measurement systems, they track when an object passes two points.

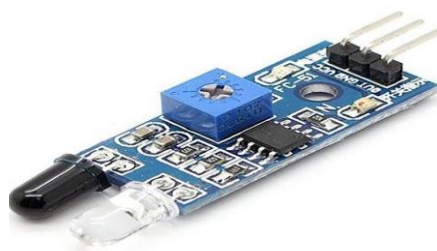


Fig. 5.14: I.R Sensor

ARDUINO UNO ATmega328P

Features

- High Performance, Low Power AVR® 8-Bit Microcontroller
- Advanced RISC Architecture
 1. 131 Powerful Instructions – Most Single Clock Cycle Execution
 2. 32x 8 General Purpose Working Registers
 3. Fully Static Operation
 4. Up to 20 MIPs Throughput at 20 MHz
 5. On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory Segments
 - a. 4/8/16/32 Kbytes of In-System Self-Programmable Flash program memory
 - b. (ATmega48PA/88PA/168PA/328P)
 - c. 256/512/512/1 Kbytes EEPROM (ATmega48PA/88PA/168PA/328P)

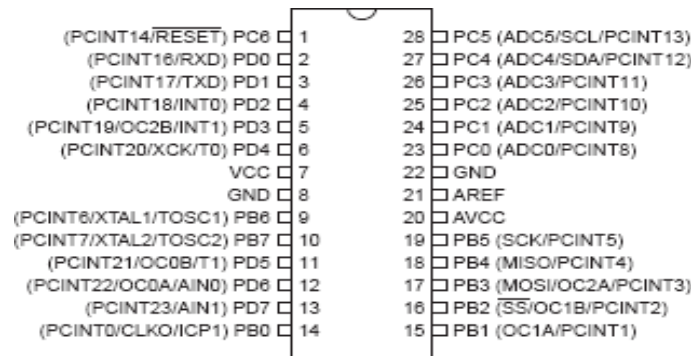


Fig.5.15: PDIP

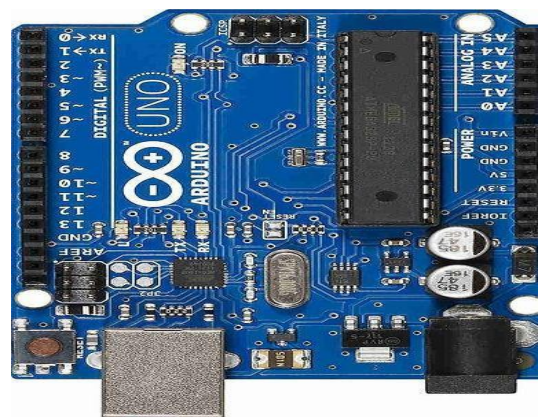


Fig.5.16: ARDUINO UNO ATmega328P

Relay (Single-Channel 5v)

Relays are electrically operated switches used in many electronic and electrical projects to control high-voltage or high-current devices with a low-power signal. They work using an electromagnet that, when energized, pulls a switch to open or close a circuit. Relays are commonly used to:

- Turn on/off lights, motors, or appliances
- Isolate control circuits from high-power loads
- Interface microcontrollers (like Arduino) with AC or high-current DC device

Regulated Power Supply (R.P.S)

A Regulated Power Supply (RPS) module is designed to convert **230V** AC mains power into a stable **5V** DC output, commonly used in electronic circuits.

REGULATED POWER SUPPLY

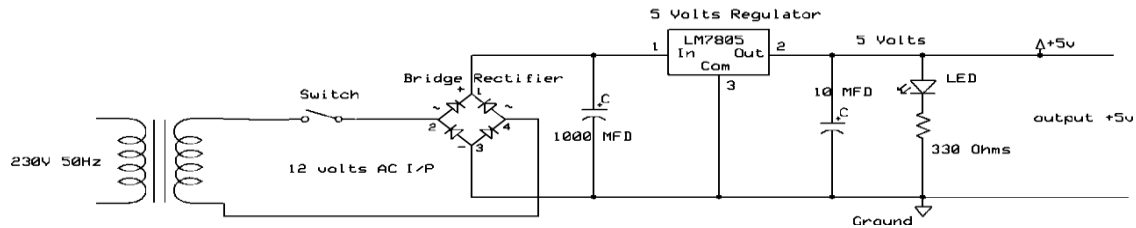


Fig5.18: Circuit Diagram of Regulated Power Supply with Led Connection

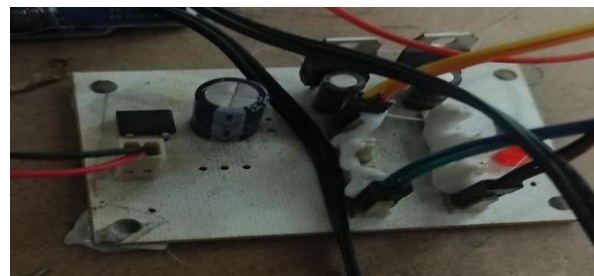


Fig5.19: 5v regulated powersupply using 7805 with transformer and Bridge Rectifier

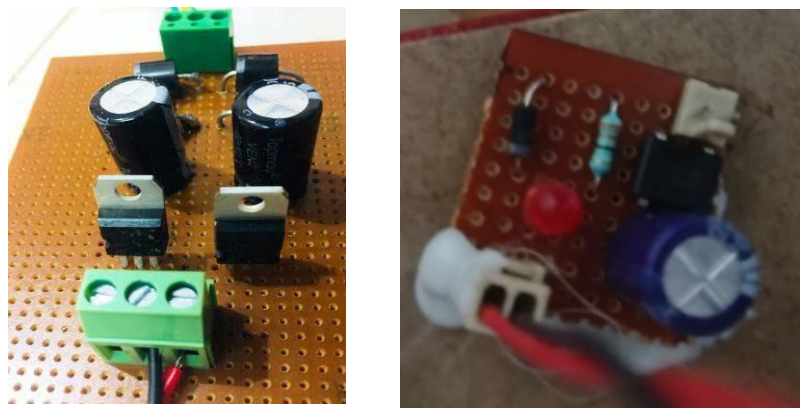


Fig5.20: 12V AC To 12VDC CONVERSION CIRCUIT BUILT ON PERFBOARD



Fig.6.1 Mild Steel Support Frame



Fig. 6.2 Rollers

Design and Fabrication

The 4-slot nylon Geneva wheel with four equally spaced slots and Crank Wheel are designed in CATIA to achieve intermittent rotation, driven by a crank wheel with a pin engaging the slots. The crank wheel was designed to match the Geneva wheel's geometry, ensuring smooth engagement. Both components were modelled with precise tolerances to minimize backlash and ensure reliable motion. The chain and sprockets system was selected to transmit power from the crank wheel to the rollers, with sprocket sizes chosen to achieve the desired gear ratio.

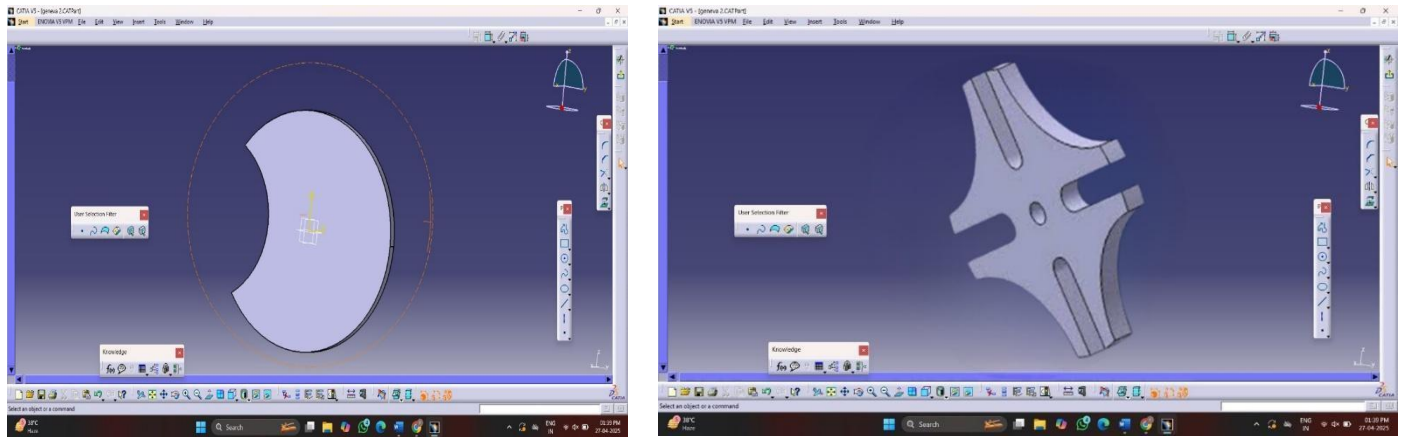


Fig.6.4 CATIA designs of Crank Wheel & Geneva Wheel

CNC Milling Operations for Precision Fabrication of Crank Wheel and Geneva Wheel"

CNC milling process coding- Geneva wheel

[BILLET X260 Y260 Z10]; G21 G17 G90 G94;

G00 Z5.0; G00 X0 Y0; M06 T1; M03 S3000;

G00 X120 Y0; G01 Z-10.0 F200;

G03 X0 Y120 R120 F300; G00 Z5.0;

G00 X0 Y0; G00 X0 Y120;

G01 Z-10.0 F200;

G03 X-120 Y0 R120 F300; G00 Z5.0;

G00 X0 Y0; G00 X-120 Y0;

G01 Z-10.0 F200;

G03 X0 Y-120 R120 F300; G00 Z5.0;

G00 X0 Y0; G00 X0 Y-120;

G01 Z-10.0 F200;

G03 X120 Y0 R120 F300; G00 Z5.0;

G00 X0 Y0; M05;

M30;

CNCmillingprocesscoding-Crankwheel

[BILLET X260 Y260 Z10];

G02X0Y90I90J0F500; G21;

G00 Z50.0;

G17;

M09;

G90;

M05;

T1 M06;

M30;

M03S8000; M08;

G00 Z5.0; G00X0Y120;

G01 Z-5.0 F200;

G02X0Y-120I0J0F500; G00 Z5.0;

G00 X90 Y0; G01Z-5.0F200;

G02X0Y-90I-90J0F500; G00 Z5.0;

G00 X-90 Y0; G01Z-5.0F200;

G02X0Y90I90J0F500; G00 Z5.0;

G00 X0 Y120; G01Z-10.0F200;

G02X0Y-120I0J0F500; G00 Z5.0;

G00 X90 Y0;G01Z-10.0F200;

G02X0Y-90I-90J0F500; G00 Z5.0;

G00 X-90 Y0; G01Z-10.0F200;

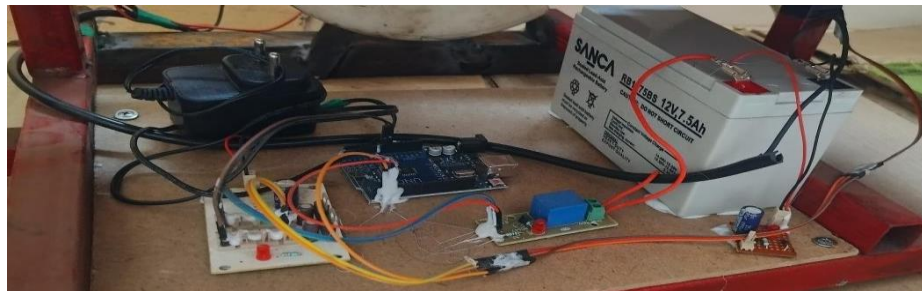


Fig.6.6Electrical&ElectronicsCircuitsIntegration

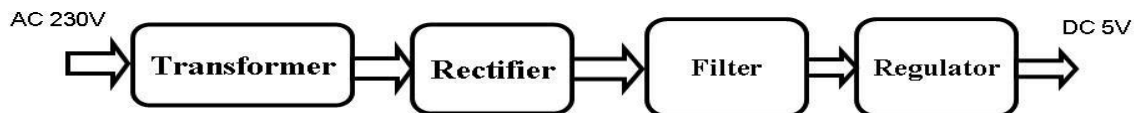


Fig.6.7RegulatedPowerSupplyLineDiagram



Fig. 6.12 Fixing of I.R Sensor

I.R sensor Module Programming

```
void setup() { //putyoursetupcodehere,torunonce: pinMode(2, INPUT); pinMode(3, OUTPUT); } void loop() {
if(digitalRead(2)==1) { digitalWrite(3, LOW); } else { digitalWrite(3, HIGH); } delay(800); }
```

Code Analysis

- pinMode(2, INPUT); sets pin 2 (connected to IR sensor) as input.
- pinMode(3, OUTPUT); sets pin 3 (likely connected to an alert like an LED or buzzer) as output.
- In loop(), if the IR sensor detects an obstacle (digitalRead(2) == 1), it turns OFF the output (digitalWrite(3, LOW)), otherwise it turns it ON (digitalWrite(3, HIGH)).
- delay(800); pauses the loop for 800ms between readings.

Overall calculations:

Given Data:

- Driving wheel speed $N_d = 13 \text{ RPM}$
- No. of slots in Geneva $= 4$
- Hole diameter $d = 5 \text{ mm}$
- Sheet thickness $t = 0.15 \text{ mm}$
- Punches per minute $= 13$ (matches the Geneva rotation)
- Shear strength of paper $= 100 \text{ kPa} = 0.1 \text{ N/mm}^2$ (Assume)

Punching Force Calculation

Punching Force formula: $F = \pi \times d \times t \times \text{Shear Strength}$ Substituting: $F = 3.14 \times 5 \times 0.15 \times 0.1 = 0.2355 \text{ N}$

Thus, required punching force is approximately: $F \approx 0.47 \text{ N}$

Torque Required

crank radius $(r) = 120 \text{ mm} = 0.12 \text{ m}$ Torque (T): $T = F \times r = 0.0564 \text{ N-m}$

Power Requirement

Power (P) $= 2\pi N_d T / 60$

$P = 2 \times 3.14 \times 13 \times 0.0564 / 60 \approx 0.38 \text{ W}$

1. GENEVA WHEEL OUTPUT $N_g = N_d / 4 = 13 / 4 = 3.25 \text{ RPM}$

SHEET FEED PER PUNCH: 15 cm

Parameter	Value
Punch Hole Diameter	5 mm
Sheet Thickness	0.15 mm
Shear Strength of Paper	200 kPa (0.2 N/mm ²)
Punching Force	0.47 N
Torque Required	0.0564 N-m
Driving Wheel Speed	13 RPM
Geneva Wheel Speed	3.25 RPM
Punches per Minute	13
Feed per Punch	150 mm
Power Required	0.032 W

IV. Conclusion

The project titled "**Fabrication of Auto Roll Punching Machine Using Geneva**

Mechanism with IR Sensing" has been successfully designed, fabricated, and tested. The machine combines the precise intermittent motion of the Geneva mechanism with automated material sensing through an infrared (IR) sensor system. The Geneva mechanism ensures accurate and stepwise rotation of the punching roller, leading to consistent and repeatable punching at a controlled speed.

Importantly, the integration of the **IR sensor** plays a crucial role in **preventing dry runs**—meaning the punching action only occurs when the material (sheet or paper) is present.

This feature not only avoids unnecessary wear and tear of the punching tool but also improves operational efficiency and extends the machine's service life.

The project demonstrates:

- **Reliable punching operation** with precise feed control.
- **Automation** without the need for constant human supervision.
- **Prevention of tool damage and energy savings** by avoiding dry punching cycles.
- **Low power consumption**, making the machine suitable for small- and medium-scale production units.
- The project proves that integrating simple mechanical systems with basic automation can create a **reliable, cost-effective, and efficient production** solution for lightweight materials like **paper** and **thin sheets**.

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