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Modification of the Geneva Paper Cutting Tool

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Abstract- This project has been carried out to study and modify the performance of the paper cutting tool. The performance has been enhanced and limitations of the initial design overcome, by combining the Geneva mechanism with a Scotch Yoke mechanism. This was done by substituting the lever mechanism used initially, with a Scotch Yoke mechanism. The replacement brought about the possibilities of executing calibrated punching and stamping operations. A prototype of the proposed combination has been designed and fabricated. The performance of the fabricated tool was studied and a comparison has been drawn between the initial and modified tools.
Keywords – Geneva Mechanism, Scotch- Yoke Mechanism, Cutting tool, Lever Mechanism,

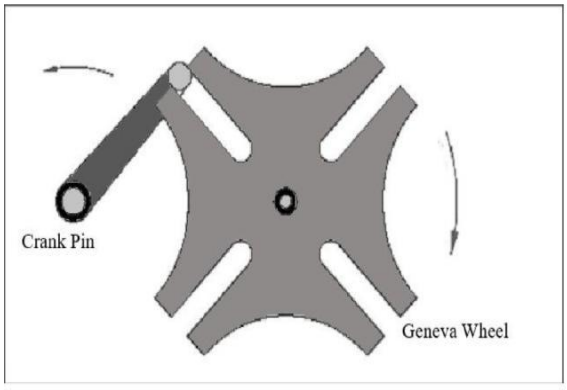
I. INTRODUCTION

With the rise of startups and small businesses, there is a rise in need of these units performing efficiently and with greater productivity. Many businesses fall as they fail to keep up with the changing market demands. Automation of processes plays a vital role in ensuring that the demands of customers are met on time and with greater efficiency. The earlier Geneva cutting tool used a lever mechanism for carrying out the operation and was quite easy to manufacture. But at the same time, the model was incapable of carrying out any other operation and was bulky. Keeping this aspect in mind, the idea of a Geneva- Scotch Yoke cutting tool was developed.

The main concept of this project is to replace the lever mechanism from an earlier model of a Geneva Paper cutting tool with a Scotch- Yoke mechanism. This replacement brought about the addition of a variety of operation that could be carried out like punching and stamping and also eliminated the limitations of the previous model.

The Geneva mechanism (depicted in Fig. 1) used here provides intermittent motion to the workpiece. This mechanism consists of a Geneva Wheel, a crankpin, and a frame. Continuous rotary motion is provided to the crankpin, which in turn rotates the Geneva wheel through engagement and disengagement. The Geneva wheel only rotates when the crankpin is engaged to the Geneva wheel. This provides intermittent rotary motion to the wheel and hence, the workpiece is moved forward by the same amount.

The Scotch- Yoke mechanism (depicted in Fig. 2) used for cutting mechanism converts the rotary motion to reciprocating motion. The parts of this mechanism include a sliding bar, a yoke on the bar with the slot cut out and a base connected to the yoke attached by a pin through the yoke slot to the sliding bar. As the base rotates, the smaller bar is forced to slide back and forth in the yoke slot, creating a linear up and down movement.



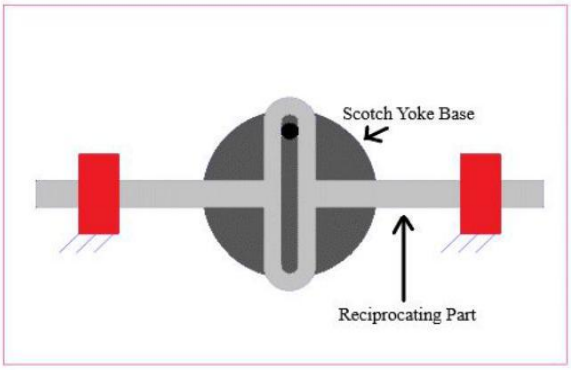


Fig. 1 Geneva Mechanism Fig. 2 Scotch- Yoke Mechanism

The Geneva and scotch yoke mechanisms have thus been combined which resulted in the modification of the initial cutting tool. Here, the intermittent rotary motion of the Geneva wheel acts as the feeding mechanism and the Scotch Yoke mechanism acts as the cutting mechanism.

II. LITERATURE REVIEW

From the article titled, Automatic Paper Cutting Machine Using Geneva Mechanism [1] (Sunil H V, Ankit Yadav, Shivu L, Santosh Choudri) the design process involved was considered. In this project, a lever mechanism in combination with the geneva mechanism was used. This resulted in a reduction in mark up time and human fatigue. But the use of lever mechanism limited the operations that could be carried out. The fabrication of this tool was done using Mild Steel which contributed to its bulkiness.

A machine that could carry out multiple operations, at different positions of the base frame has been described in the paper, Multi-Function Operating Machine [2] (Mr. Pradip R. Bodade, Mr. Rangnath B. Tarmale, Mr. Aniket G. Nathe, Mr. Rajat R. Manalwar). This model involved the use of a Scotch Yoke mechanism, for carrying out the cutting operation through a hacksaw.

Review on Geneva Mechanism and its Applications (Ankur Prajapati, Chinmay Patel, Dhwanit Pankhania, Brijen Kanjia, Aakash Dubey) was also studied. In this article different journals have been reviewed with reference to the authors' project work. The project work carried out was the "Semi-Automatic bar Cutting Machine". By using Modification of the Geneva Paper Cutting Tool the Geneva Mechanism, the intermittent motion of the Geneva wheel was used as a feed mechanism for their machine. [3]

The study of various applications of Scotch Yoke mechanism such as in a syringe pump [4], a hacksaw machine [5], a dual shaper [6] and a multi-purpose Scotch Yoke mechanism [7] provided deeper insights into the application of the mechanism and guided for the use of the same. The lever mechanism was thus replaced with the Scotch Yoke mechanism as the cutting mechanism.

III. METHODOLOGY

The study of various research papers containing applications of the Geneva and Scotch Yoke mechanisms. Their analysis has been done in order to make a cutting tool combining both the mechanisms. Design and fabrication of the tool have been done with the help of CATIA and 3D printing technology, respectively. The steps (depicted in Fig.3) have been briefly described in the following sections:

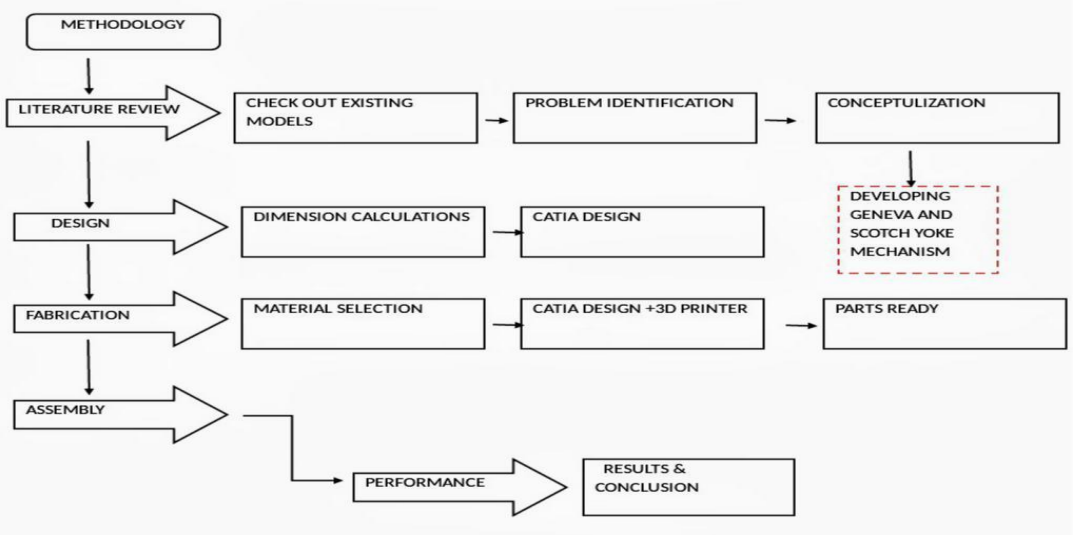


Fig. 3. Proposed Methodology

3.1. Design

The 3D models of Geneva Mechanism and Scotch Yoke mechanism have been designed in CATIA. The images of different parts modeled in CATIA have been depicted in the figures 4(i) and 4(ii).

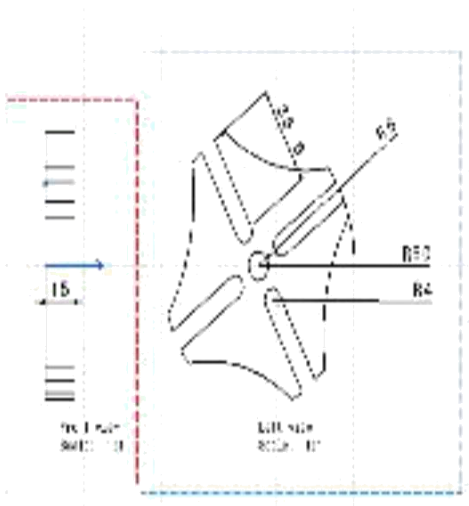


Fig. 4(i) Geneva Wheel

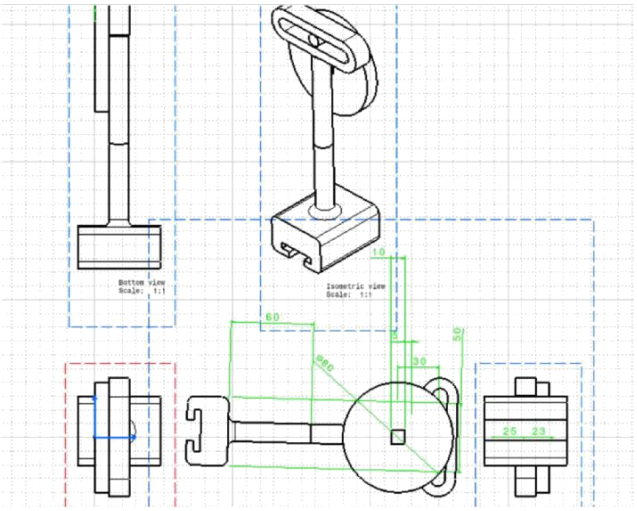


Fig. 4(ii) Scotch- Yoke Mechanism

3.2 Design Calculations

The calculations involved in the design of the various parts have been given below:

Geneva Wheel

The design of the Geneva Wheel was carried out by assuming the geneva wheel radius to be 5 cm. The slots were numbered as 4. Further calculations are given below: b= Geneva Wheel Radius = 5 cm

n= driven slot quantity = 4

p= drive pin diameter = 0.5 cm

t= allowed clearance = 0.4 cm

c= center distance

a= drive crank radius

s= slot center length

w= slot width

$$c = b/\cos(180/n) = 9.51 \text{ cm} \quad (1.1)$$

$$a = \sqrt{c^2 - b^2} = 8.09 \text{ cm} \quad (1.2)$$

$$s = (a + b) - c = 3.58 \text{ cm} \quad (1.3)$$

Modification of the Geneva Paper Cutting Tool

$$w = p + t = 0.9 \text{ cm} \quad (1.4)$$

3.3 Scotch Yoke Mechanism

Design of the Scotch Yoke mechanism was based on the stroke length required for the cutting to be performed. The variation in the stroke length would also be an asset for cutting an increased number of papers. The following dimensions were taken up:

Base: Diameter of the base = 80 mm

iameter of the pin = 10 mm

Reciprocating part:

Total Length = 200 mm

Slot length = 71 mm

Stroke Length:

Stroke Length = Slot Length = 71 mm

3.4. Fabrication and Assembly

The fabrication of parts has been carried out by 3D printing, which is a process of making three dimensional solid objects from a digital file. 3D printed object is manufactured by a layered deposition of material until the whole object is created. The raw material is present in the form of a filament which makes the material handling part easier. The filament is inserted inside a tube where the material melts out through a nozzle. The extrusion temperature ranges from 220 to 230°C.

The model has been designed using 3D printing in which PLA (Polylactic acid) is used as the fabricating material. It is a thermoplastic that becomes malleable when superheated, thus allowing us to add layers of it and sculpt them into different shapes.

The fabrication of parts was carried out using the Flashforge 3D printer, which uses PLA as the material. The final fabricated parts have been depicted in Fig. 5. The final assembly of the parts was carried out on wooden supports. It has been depicted in Fig. 6.

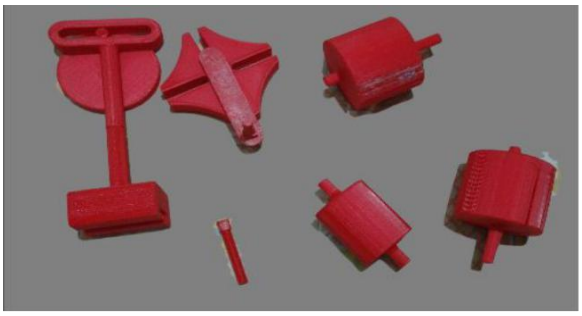


Fig. 5. Fabricated Parts

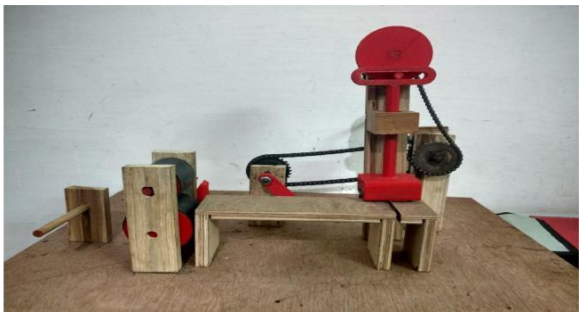


Fig. 6. Final Assembly

The handle (not visible in the figure) made of mild steel has been welded to a mild steel shaft, on which, two sprockets have been attached. The attached sprockets power the crankpin of the Geneva Wheel and shaft of the base of the Scotch Yoke mechanism simultaneously. A cutter has been attached to the reciprocating part at the bottom. This cutter can be replaced by other tools for carrying out operations like stamping, punching, etc.

IV. RESULTS & DISCUSSION

The current tool is a modified form of an earlier model which used lever mechanism (scissors) for cutting paper by the use of Scotch Yoke mechanism. A comparison has been drawn in Table- I given below:

Table I: Comparison between Initial and Final tool designs

Properties	Geneva + Lever Mechanism	Geneva + Scotch Yoke Mechanism
Automation	Possible	Possible
Stamping	Not Possible	Possible
Punching	Not Possible	Possible
Cutting	Possible	Possible
Weight of the apparatus	High	Lower due to plastic parts
Manufacturing cost	High	Low
Maintenance	High	Low
Mobility	Difficult due to a larger size	Easier
Size of Machine	Large	Can be Compact according to

Modification of the Geneva Paper Cutting Tool

Assembling	Easy	Difficult

As listed in the above table both the models could be automated, while the lever mechanism is only capable of cutting operation whereas geneva scotch yoke tool can perform various above listed operations. The weight of the

model has also been reduced in the second model due to the replacement of MS with PLA. This further resulted in the reduction in manufacturing cost as PLA is available at INR 500 per km. And the parts of our model required 350 meters at max, which is an affordable price. Handling properties like maintenance, mobility, and size of the machine were also enhanced which improved the practicality of the modified cutting tool.

V. CONCLUSION & SCOPE OF FURTHER WORK

In this project, an effort has been carried out to replace lever mechanism with a Scotch Yoke mechanism. The components of the mechanism were modeled using CATIA and fabricated by using a 3D printer. The parts were assembled on a wooden base, with the supports made up of wood too. This mechanism can be further modified for carrying out operations like:

Various shapes can be obtained from the workpiece by changing the cutting tool.

Replacement of the table with a rubber belt, which would increase the adhesion between the workpiece and the belt, resulting in increased efficiency.

Can be further modified to operate in a line balancing plant with applications such as a bottle cap press, etc.

VI. REFERENCES

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