International Journal of Advance Engineering and Research Development
Scientific Journal of Impact Factor (SJIF): 4.72
Special Issue SIEICON-2017,April -2017
e-ISSN : 2348-4470 p-ISSN : 2348-6406

Design and Development of Machine to Perform Stamping and Cutting Operation

Rakesh Prajapati[1], Purvik Patel[2], Saurabh Modi[3]

[1]*Department of Mechanical Engineering, Parul Institute of Technology*
[2]*Department of Mechanical Engineering, Parul Institute of Engineering & Technology*
[3]*Department of Mechanical Engineering, Parul Institute of Technology*

Abstract — *The design and fabrication of paper cutting machine using Geneva mechanism is very useful to cut papers in equal and accurate dimensions. Geneva drive is an indexing mechanism that converts the continuous motion into intermittent motion. By means of this mechanism the continuous rotary motion of the sprocket wheel is converted into intermittent rotary motion of roller. Due to the intermittent motion, the paper is moved between the time intervals of cutting periods. Then the paper cutting is achieved by the crank and lever mechanism. The sprocket will act as a crank, and then the cutter will act as a lever. These two links are connected by a connecting link. The cutter will be back to its original position by the spring effect.*

Keywords- *Crank and Lever Mechanism, Geneva Wheel, Sprockets, Roller chain, Coil Spring, Shaft*

I. INTRODUCTION

The paper cutting machine is designed, in order to reduce the time for marking and cutting the papers. The dimension of the paper to be cut doesn't need marking; instead of it Geneva drive is used. Geneva mechanism is commonly used indexing mechanism where an intermittent motion is required. This intermittent motion is useful in moving the paper between the cutting periods. The fabrication of conventional Geneva mechanism is generally simple and inexpensive. Because there is no special curved profile on any of the components except straight lines and circular arcs. The Geneva wheel as designed with four slots. Hence the intermittent motion can be achieved in 360/4 degree of the wheel. The paper cutting is done by the paper cutter by crank and lever mechanism. The sprocket is considered as a crank. The cutter will act as a lever. This sprocket (crank) is connected to the cutter (lever) by a string (connecting link). The crank has rotary motion which is converted to linear. This linear motion is applied to the paper cutter. Hence, the cutting operation is achieved. After cutting, the spring connected to the cutter will bring the cutter back to its original position.

The main purpose of this machine is to reduce time for marking the papers. Hence, this machine is working fully based on timing.

II. MECHANISM

2.1 Indexing Mechanism

The Geneva mechanism is used here to get the intermittent motion. This Geneva mechanism is also called as indexing mechanism.

In this mechanism, for every turn of the driver wheel A, the driven wheel B makes a quarter turn. The pin, attached to driver wheel a moves in the slots causing the motion of wheel B. The contact between the lower parts of driver A with the corresponding hollow part of wheel B retains it in position when the pin is out of the slot. Wheel A is cut away near the pin as shown, in order to provide clearance for wheel B as it moves. If one of the slots is closed, A can make less than one revolution in either direction before the pin strikes the closed slot and, stopping the motion.

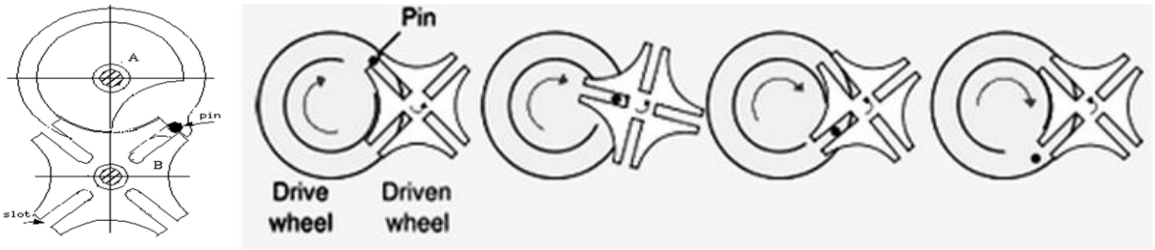


Figure 1. Indexing Mechanism

2.2 External Geneva Mechanism

In this type of mechanism, the Geneva cross is connected with cam drive externally which is the most popular and which is represented by the device below.

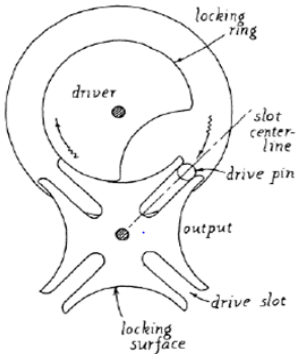


Figure 2. External Geneva Mechanism

2.3 Internal Geneva Mechanism

The Geneva cross and cam drive are connected internally in the closed box, which is also common and is illustrated by below.

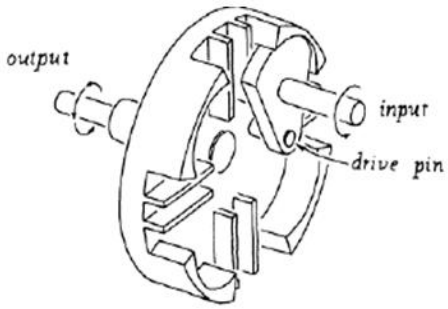


Figure 3. Internal Geneva Mechanism

2.4 Spherical Geneva Mechanism

The Geneva mechanism cross is in spherical shape and cam drive is connected in externally, which is extremely rare and is illustrated in below.

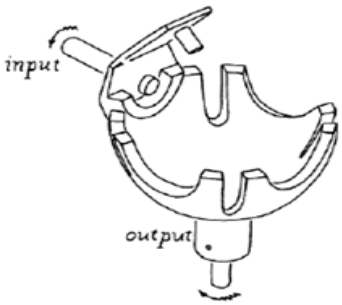


Figure 4. Spherical Geneva Mechanism

III. FOUR BAR CHAIN MECHANISM

The crank and lever mechanism is a four bar mechanism. A four bar mechanism consists of four rigid link which are linked in the form of quadrilateral by four pin joints. A link that makes complete revolution is called crank, the link opposite to the fixed link is the coupler and forth link is a lever or rocker if oscillates or another crank if rotates. This four bar mechanism has three inversions.

Here the crank rocker or crank lever mechanism is used. In a four bar linkage, if the shorter side link revolves and the other rocks (i.e., oscillates), it is called a crank-rocker mechanism.

The crank is a rotating element which is used to transmit the power. The crank and lever mechanism is used to transform rotational motion into translational motion by means of a rotating driving beam, a connection rod and a sliding body. A flexible body is used for the connection rod. The sliding mass is not allowed to rotate.

Figure 5. Four Bar Chain Mechanism

IV. COMPONENTS

4.1 Geneva Wheel

In Geneva wheel, the driven wheel has four slots and thus advances by one step of 90 degrees for each rotation of the drive wheel. If the driven wheel has n slots, it advances by 360°/n per full rotation of the drive wheel.

Figure 6. Geneva Mechanism

The drive wheel is connected to the sprocket which rotates by the roller chain. The Geneva wheel is connected to the shaft which has the paper roller. This paper roller is kept to feed the paper.

The driver sprocket drives the pin to rotate in the sprocket axis. When pin mesh with the Geneva, it rotates the Geneva wheel by sliding in between the slots given. The Geneva is the driven wheel which moves with an intermittent motion. Hence the power is transmitted to the roller with a given interval of time.

4.2 Sprocket

A sprocket or sprocket-wheels a profiled wheel with teeth, cogs, or even sprockets that mesh with a chain, track or other perforated or indented material. The name 'sprocket' applies generally to any wheel upon which radial projections engage a chain passing over it. It is distinguished from a gear in that sprockets are never meshed together directly, and differs from a pulley in that sprockets have teeth and pulleys are smooth.

Figure 7. Sprocket

4.3 Roller Chain

Roller chain is the type of chain drive most commonly used for transmission of mechanical power on many kinds of domestic, industrial and agricultural machinery, including conveyors, wire and tube-drawing machines, printing presses, cars, motorcycles, and bicycles. It consists of a series of short cylindrical rollers held together by side links. It is driven by a toothed wheel called a sprocket. It is a simple, reliable, and efficient means of power transmission.

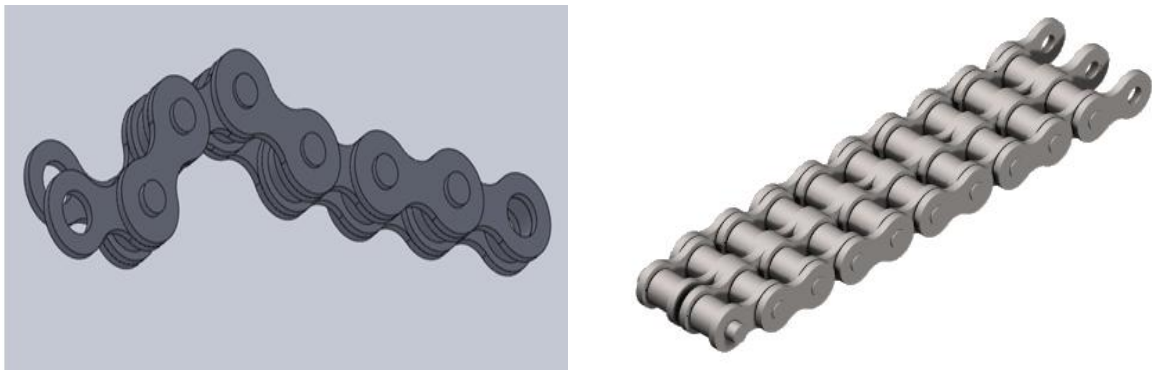
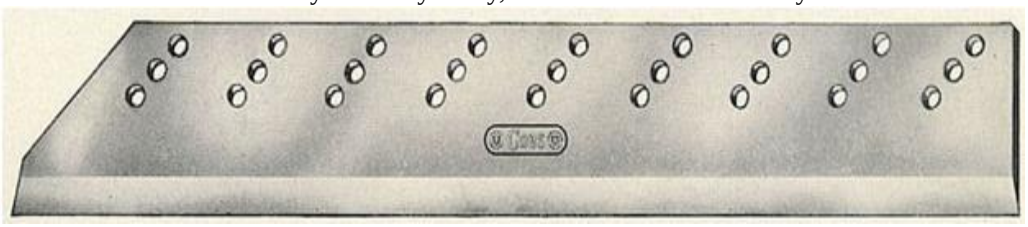


Figure 8. Roller Chain

The roller chain design reduces friction compared to simpler designs, resulting in higher efficiency and less wear. The original power transmission chain varieties lacked rollers and bushings, with both the inner and outer plates held by pins which directly contacted the sprocket teeth; however this configuration exhibited extremely rapid wear of both the sprocket teeth, and the plates where they pivoted on the pins. This problem was partially solved by the development of bushed chains, with the pins holding the outer plates passing through bushings or sleeves connecting the inner plates.

4.4 Paper Cutter

A paper cutter is a tool, designed to cut a large set of paper at once with a straight edge. Paper cutters vary in size. The surface will usually have a grid either painted or inscribed on it, often in half-inch increments, and may have a ruler across the top. At the very least, it must have a flat edge against which the user may line up the paper at right-angles before passing it under the blade. It is usually relatively heavy, so that it will remain steady while in use.



On the right-hand edge is a long, curved steel blade, often referred to as a knife, attached to the base at one corner. Larger versions have a strong compression coil spring as part of the attachment mechanism that pulls the knife against the stationary edge as the knife is drawn down to cut the paper. The other end of the knife unit is a handle.

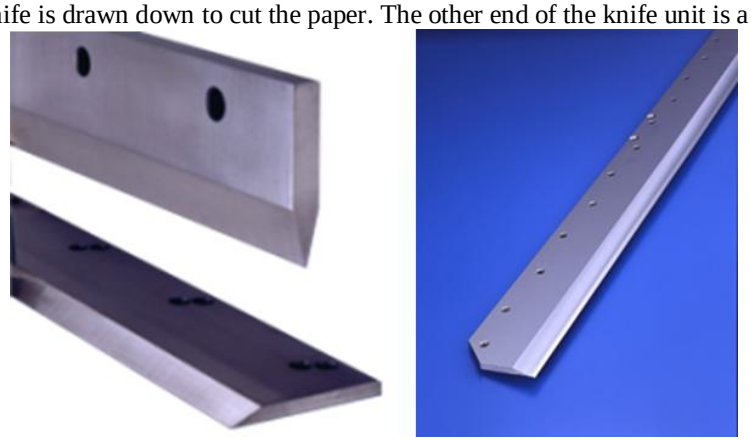


Figure 9. Cutter Blade

The blade on a paper cutter is made of steel which makes it almost impossible to break. A variant design uses a wheel-shaped blade mounted on a sliding shuttle attached to a rail. This type of paper cutter is known as a rotary paper cutter.

4.5 Paper Roll

Paper roller is an element which is used to roll the paper while the intermittent motion. The paper roller used here is a shaft. A shaft is used to roll the paper. A shaft is a rotating machine element which is used to transmit power from one place to another. There are two types of shaft which are transmission shaft and machine shaft.

Figure 9. Paper Roller

The power is delivered to the shaft by some tangential force and the resultant torque (or twisting moment) set up within the shaft permits the power to be transferred to various machines linked up to the shaft. In order to transfer the power from one shaft to another, the various members such as pulleys gears etc., are mounted on it. These members along with the forces exerted upon them causes the shaft to bending. In other words, we may say that a shaft is used for the transmission of torque and bending moment.

4.6 Coil Spring

A coil spring, also known as a helical spring, is a mechanical device, which is typically used to store energy due to resilience and subsequently release it, to absorb shock, or to maintain a force between contacting surfaces. They are made of an elastic material formed into the shape of a helix which returns to its natural length when unloaded.

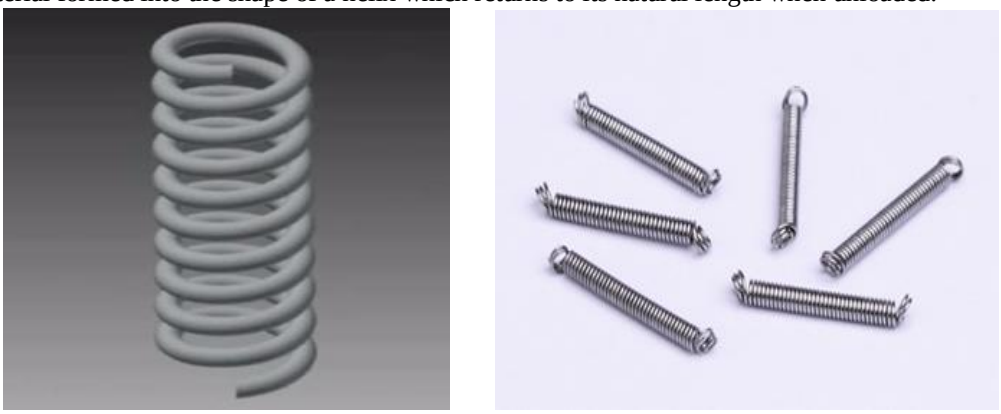


Figure 10. Coil Spring

One type of coil spring is a torsion spring: the material of the spring acts in torsion when the spring is compressed or extended. The quality of spring is judged from the energy it can absorb. The spring which is capable of absorbing the greatest amount of energy for the given stress is the best one. Metal coil springs are made by winding a wire around a shaped former - a cylinder is used to form cylindrical coil springs.

4.7 Shaft

A shaft is a rotating machine element which is used to transmit power from one place to another. The power is delivered to the shaft by some tangential force and the resultant torque (or twisting moment) set up within the shaft permits the power to be transferred to various machines linked up to the shaft.

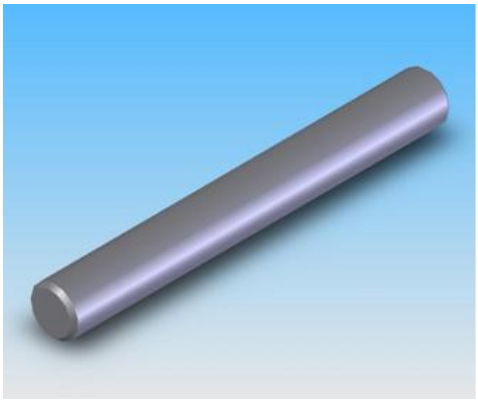


Figure 11. Shaft

In order to transfer the power from one shaft to another, the various members such as pulleys gears etc., are mounted on it. These members along with the forces exerted upon them causes the shaft to bending.

V. DESIGN CALCULATION & EXPERMENTAL SET-UP

5.1 Design calculation for Geneva wheel and cam

Number of Slots, Z= 4

Radius of Geneva wheel, R = 40 mm

Distance between centers of Geneva Wheel &driven wheel, a= 56.5 mm

Radius of driving Wheel, rd= 60 mm

Radius of cam, r = 40mm

Radius of pin, rp=2.5mm

5.2 Design for calculation Geneva wheel and cam

Angle of locking section, $\gamma = \pi/2\ (Z+2) = 270$

Semi-indexing angle (driven) $\alpha = \pi/Z = 45^{\circ}$

Semi-indexing angle (driver) $\beta = \pi\ (Z-2) / (2Z) = 45^{\circ}$

Gear ratio $\epsilon = 1$ for $Z=4$

Radius ratio, $\mu = R/r = 1.000$

Indexing time ratio, $\nu = \beta/\pi = 0.2500$

5.3 Design calculation for Geneva cross

Slot width, t = 5 mm

Length of Slot, l= 25 mm

Shaft diameter, ds= 15 mm

Thickness, b = 5m

5.4 Design calculation for paper cutting feed

Length of the paper to be feed can be adjusted by changing the diameter of the roller.

The paper feed length = (circumference of the roller)/no. of slots in Geneva wheel

$L = (2 * \pi * R) / n$

$L = (2 * \pi * 30) / 4$

L = 47.1 mm

Where n is the number of slots in the Geneva wheel.

R is the radius of the roller,

L is the length of the paper to be feed.

Frames are rigid structures. They maintain their shapes with or without external loads. Frame and base are called as structures. But frame and base are main elements, because they are the main support for the machine elements.


Figure 12. Experimental set-up

In our paper, the base is taken 70 cm in length, 35 cm in width and 2 cm in thickness. The base is made up of mild steel. Hence it is rigid and bears more load on it. It can able to withstand the load produce during the working period.

5.5 Material Selection

Table 1. Part Material

Sr.No.	Part Name	Material	No. of Material
1	Geneva wheel	Mild steel	1
2	Sprockets	Cast iron	2
3	Roller chain	Stainless steel	1
4	Paper cutter	Steel	1
5	Paper roller	Mild steel	1
6	Coil spring	Steel alloy	2
7	Shaft	Mild steel	3
8	Frame and base	Mild steel	1

5.6 Cost Estimation

Table 2. Material Cost

Sr.No.	Part Name	Cost
1	Geneva wheel	1200
2	Sprockets	1400
3	Roller chain	360
4	Paper cutter	150
5	Paper roller	250
6	Coil spring	350
7	Shaft	1800
8	Frame, base and other materials	2500
9	Service charge	3000
TOTAL		**11010**

VI. CONCLUSION

The design and fabrication of paper cutting machine using the Geneva mechanism is will be very useful in small scale industries. There are many machines based on paper cutting but it has some demerits like large in size, costly, need skilled people to operate and it needs electrical input. But our machine will overcome these demerits by compact in size,

less cost, no need for skilled people and there is no need for electrical input. The only need is slight manual input to rotate the handle. The design procedure is done for fabricating the Geneva wheel and other elements of this machine. The paper feed is adjusted by changing the circumference of the roller. Thus the paper cutting in accurate dimensions without marking the paper is achieved by getting the intermittent motion by Geneva mechanism. This intermittent motion is used to feed the paper between the cutting periods of the crank and lever mechanism. The crank and lever mechanism helps in cutting the paper. This mechanism actuates the cutter when the Geneva is in disengaged position. Thus the required intermittent motion is achieved. Hence the paper is feed and cut by crank and lever mechanism. The main aim for the mechanism is to reduce timing for paper cutting and neglect the time for marking the paper, this aim is achieved in our paper cutting machine using Geneva mechanism.

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