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Automatic Paper Cutting Machine Using Geneva Mechanism

Sunil H V[1], Ankit Yadav[2], Shivu L[3], Santosh Choudri[4]
[1234]*(Department of Mechanical Engineering, Bangalore Technological Institute, India)*

Abstract: *The design and fabrication of paper cutting machine using Geneva mechanism is useful to cut papers in equal and accurate dimensions. Geneva drive is an indexing Mechanism that converts continuous motion into intermittent motion, Due to which paper is moved between the equal intervals of cutting period. Then the paper cutting is achieved by crank & lever mechanism. The cutter will be back to its original position by lever crank mechanism. The objective of this concept is to design the Geneva mechanism operated paper cutting machine which eliminates the most time taking process of paper marking and helps in feed equal dimension paper in each rotation. This machine is used to reduce the manual work of paper cutting, and also time saving. This machine is very useful for paper manufacturing industry also we can avoid the human errors and also we can use this equipment also in school, colleges, stationary shop's, paper stores, etc*

Keywords: *Geneva Mechanism, Lever Crank Mechanism, Paper Cutter, Paper Roller, Sprocket.*

1. Introduction

Now a days, there is lot of competition in the market. So there is need of developing a new method or process for effective manufacturing. That process or methods should fulfill the requirement about accuracy Productivity. This paper represents the automatic paper cutting machine by using Geneva mechanism. This equipment is very accurate to cut the papers. This concept will be mainly used in the paper manufacturing industry to cut the papers in huge numbers. The equipment is fabricated in less cost and good efficient.The aim of this concept is to reduce the human fatigue and time savings in industries by eliminating the paper marking time. Here it has analyzed to use Geneva Mechanism. This is the mechanism used to get intermittent motions. This mechanism consists of the following parts like Geneva wheel, rotating disc, bearing, frame and DC motor.In industries the paper cutting machines go through a time taking process of paper marking which is required to cut the paper of required dimensions, so this model is designed by using Geneva mechanism which eliminates the paper marking time and feeds the paper of equal length in each rotation.Geneva mechanism is used as a mechanism for transforming rotary motion into intermittent motion running with acceleration jumps at the beginning and the end of the active phases. The rotating drive wheel has the pin that reaches into a slot of the driven wheel advancing into it by one step. The drive wheel also has a raised circular blocking disc that locks the driven wheel in position between steps.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. In the most common arrangement, 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 wheel rotation of the drive wheel. A four bar mechanism is a basic 1 degree of freedom mechanism. A 4 bar is created by selecting four link lengths and joining the links with revolute joints to form a loop. A wide variety of paths are possible by arbitrarily choosing a point on the coupler curve. These different curves can be obtained by constructing a physical model of the mechanism and viewing the path of various points without detailed mathematical analysis. It is also possible to develop a mathematical model of the mechanism in terms of its four link lengths. The analytical expressions for these paths are algebraic and require many computations to determine the coordinates for points on the path. A procedure to determine the link lengths of a 4-bar mechanism that will guide its coupler curve in a prescribed manner. The mathematical formulation of this procedure for designing a 4-bar mechanism. The use of a computer for the design of 4-bar mechanisms. This activity precipitated much interest in creating additional analytical approaches to specify mechanisms capable of satisfying a desired task. Interestingly, the number of points is usually three, four or five. This methodology of path generation is referred to as an exact method.

2. Literature survey

The design and analysis of paper cutting machine based on Geneva was analyzed by Vijay et al. [1], they presented a comparison of the position, velocity, acceleration, and jerk between the classical Geneva wheel mechanism and the proposed mechanism. This analysis presents a kinematic study of a mechanism incorporating a Geneva wheel and a gear train to achieve intermittent motion and was declared as a designated analysis and succeeded largely due to its positive economic factors. The design and fabrication of paper cutting machine using Geneva mechanism is useful to cut papers in equal and accurate dimension.

The analysis and synthesis of Geneva mechanism with elliptical crank has been studied by Han Jiguang Yu Kang [2],it has been analyzed that for both internal and external Geneva mechanism, the kinematics coefficient of the Geneva mechanism is a constant if the groove number of the Geneva wheel is a constant. The elliptic crank using as the drive crank of the Geneva wheel is equal to the mechanism which has a variable length and a variable speed along the elliptical moving crank. Therefore the kinematics coefficient of the Geneva mechanism can be changed.

The analysis and modeling of Geneva mechanism was studied by Georgata and Elena [3], the paper presents some aspects theoretical and practical based on the finite element analysis and modeling of Geneva mechanism with four slots, using the CATIA graphic program. This type of mechanism is an example of intermittent gearing that translates a continuous rotation into an intermittent rotary motion. It consists of alternate periods of motion and rest without reversing direction. Also it gives some design parameters with specify a Geneva mechanism will be defined precisely such as number of driving cranks, number of slots, wheel diameter, pin diameter, etc. Finite element analysis (FEA) can be used for creating a finite element model (preprocessing). The paper focus on the modeling and finite element analysis of Geneva mechanism with four slots. This technique has the ability to change the shape of Geneva mechanism with changing any kinematic properties.

Hrones and Nelson [4], in their paper on Analysis of the Four-Bar Linkage gives review that a 4-bar mechanism is a basic 1-DOF (degree of freedom) mechanism. A 4-bar is created by selecting four link lengths and joining the links with revolute joints to form a loop. A wide variety of paths are possible by arbitrarily choosing a point on the coupler curve. These different curves can be obtained by constructing a physical model of the mechanism and viewing the path of various points without detailed mathematical analysis.

In the Force analysis of the Geneva wheel and face cam in automat, Madhoo et al. [5], driven the automat using single motor for different operations. Here they focus on two main parts they are Geneva wheel and Face cam which are used for their respective operations. Geneva Wheel is used to index the drum which consists of 96 spindles. Due to this Geneva mechanism each of the spindles will hold the ceramic body when the drum is being indexed. Due to which there is a force which is generated in the Geneva wheel is in maximum and minimum position in Cutting mechanism by giving feed through Geneva mechanism.

Kalisindhur et al. [6], designed a mechanism for cutting by giving intermittent feed. This intermittent feed is given by continuous rotation of circular disk in Geneva mechanism. We have designed a belt drive with the help of Geneva mechanism which is used for giving feed and gives smooth operation and smooth movement of the feed at required time interval. The feed from the Geneva drive was cut by using slotted lever mechanism which was designed using slider crank mechanism.

3. Working principle and components used

This model parts are Geneva mechanism, motor, chain sprocket, roller, cutter and spring. Two rollers are mounted according to the required distance the belt is mounted on the rollers on which the paper is placed. The rollers shaft is coupled with the Geneva drive. The Geneva drives shaft is coupled with the motor shaft hence when power is supplied to the motor rollers rotate with a certain time delay according to the Geneva drive and the chain drive moves along the rollers. Motor connecting to the chain sprocket and sprocket connecting to the Geneva mechanism. Motor has been on to rolling the Geneva so that start to the paper roll. One roller has fixed on the try another roller connecting in Geneva wheel. Cutter fixed to the spring connecting to cutter. Motor shaft connect to cutter wire motor has been rotating cutter is upon down motion then cutting to the paper this is the automatic paper cutting machine by using Geneva mechanism. The following steps are followed for conduction.

- When cam pin is in extreme right position i.e. engage position, the crank shaft will be at extreme bottom position. Hence the cutter is in full open position.
- When cam pin is in extreme bottom position i.e. disengage position, the crank shaft will be at extreme left position. Hence the cutter is in partial cutting position.
- When cam pin is in extreme left position i.e. disengage position, the crank shaft will be at extreme top position. Hence the cutter is in full cutting position.
- When cam pin is in extreme top position i.e. disengage position, the crank shaft will be at extreme right position.

Hence the paper cutting is achieved by above four process of Geneva and cutter.

The main components used to fabricate the model are:

- Geneva wheel
- Sprocket
- Roller chain
- Paper cutter or cutting blade
- Paper roller shaft
- Motor
- Power supply

3.1 Geneva wheel

Four Slot driven wheel, we are using thus its advances by one step of 90^0 for each rotation of the drive wheel. Hence the intermittent motion is achieved for ¼ of the 360^0. A mechanism that translates a continuous rotation into an intermittent rotary motion, using an intermittent gear where the drive wheel has a pin that reaches into a slot of the driven wheel and thereby advances it by one step, and having a raised circular blocking disc that locks the driven wheel in position between steps.

3.2 Sprocket

A sprocket is a profiled wheel with teeth, cogs, or even sprockets that mesh with a chain. The sprocket are used for the power transmission between two shafts through the roller chain. A sprocket is a profiled wheel with teeth that meshes with a chain, track or other perforated or indented material. 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. Sprockets are used in bicycles, motorcycles, cars, tracked vehicles, and other machinery either to transmit rotary motion between two shafts where gears are unsuitable or to impart linear motion to a track.

3.3 Roller chain

A roller chain is the type of chain driven most commonly used for transmission of mechanism power between two sprockets. It consist of a series of short cylindrical rollers held together by side links. It is driven by a toothed wheel called a sprocket.

3.4 Paper cutter or cutting blade

A paper cutting is a tool, designed to cut paper with a straight edge paper cutters vary in size. This paper cutter is used as the oscillator in the four bar crank and lever mechanism.

3.5 Paper roller shaft

It is the element which we are using to feed the paper while the intermittent motion. Paper roller used to feed paper without any damage.

3.6 Motor

In any electric motor, operation is based on simple electromagnetism. A current-carrying conductor generates a magnetic field; when this is then placed in an external magnetic field, it will experience a force proportional to the current in the conductor, and to the strength of the external magnetic field. As you are well aware of from playing with magnets as a kid, opposite (North and South) polarities attract, while like polarities (North and North, South and South) repel. The internal configuration of a DC motor is designed to harness the magnetic interaction between a current-carrying conductor and an external magnetic field to generate rotational motion.The specification of motor used is 12 Volts, 4.5 Amps with 30 rpm.

3.7 Power supply

The ac voltage, typically 220V, is connected to a transformer, which steps that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation.

A regulator circuit removes the ripples and also remains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units. Fig. 1 shows block diagram of power supply.

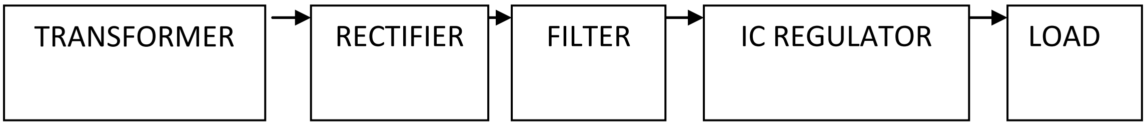

Fig. 1 block diagram of power supply

4. Design calculation

The design calculation of Geneva and motor are shown below:

4.1 Design calculation of geneva wheel

The design calculation of Geneva contains terms as:
R = radius of Geneva Wheel
r_1 = radius of driving crank
r_p = radius of driven pin
e = center distance
α = semi indexing angle (driven)
b = semi indexing angle (driver)
z = number of slots on the driven disk
ω = angular velocity of driving crank
n =speed of rotation of crank (rpm).
□ =angle of locking
Number of slots on Geneva wheel (Z) = 4
N_{motor} = 60 rpm

For Z=4

a) Semi indexing angle:(α) = 45 °

b) Gear ratio (E) i.e. ratio driving crank
Speed of Geneva wheel 1:1

c) Indexing Time ratio: $V = \frac{[Z-2]}{2Z}$ (1)

$= \frac{[4-2]}{2\times4}$

$= 0.25$

d) Semi indexing Angle (driver crank): $\beta = \frac{л\,[Z-2]}{2Z}$ (2)

$= \frac{л\,[4-2]}{2\times4}$

$= л/4$

e) For entry without shock: $(R/e) = \frac{\sin л}{z\,[R/e]}$ (3)

$= \frac{\sin л}{4}$

$= 0.707$

f) Now, on the basic of space available, center distance (e) = 35mm
$\frac{R}{e}$=0.707×35
R=25mm.
Radius of Geneva= 25mm
Hence, Diameter of Geneva wheel = 50mm

g) Angle of locking: $□ = \frac{л}{Z\,[Z+2]}$ (4)

$= \frac{л}{4\,[4+2]}$

= 270°

h) S_{min} = distance between the centre of Geneva wheel radii of curvature of slot on wheel

S_{min} = 0.2929 e
Where,
e = 35mm
S_{min} = 35×0.2929
S_{min} = 10 mm

Length of slot is 18mm and thickness is 10 mm

Selection of motor
M_{td} – net torque on driven shaft
M_{tf} – frictional torque on driven wheel
I – mass moment of inertia of all attached masses reflected to driven
Shaft N – efficiency of Geneva Mechanism = 0.95
When the driven shaft mounted is mounted on antifriction bearings
M_{ti} – inertia torque on driven shaft
Assuming M_{tf} = 0

Net torque on driven shaft: $M_{td} = M_{tf} + M_{ti}$ (5)
$M_{td} = M_{ti}$
Inertia torque on driven shaft: M_{ti} = 1 .α d (6)

Mass moment of inertia of all attached masses reflected to driven: $I = mk^2$ (7)
$= 30 \times 0.05^2$
$= 0.75$ Kg.m^2

Substituting I and αd in eq. (7)
$M_{ti} = 0.075 \times 9.81 \times 1.5625$
$= 1.1496 \times 10^3$ N mm

$M_{ti} = \frac{\text{Mti d}}{w} \text{x} \frac{1}{n}$
$= \frac{1.149 \times 0.314}{1.25} \times \frac{1}{0.95}$
M_{ti} = 0.303 Nm

Instantaneous power required on the driving shaft: $N = \frac{\text{Mti w}}{75}$H.P. (8)
$= \frac{0.303 \times 0.314}{75}$
= 0.00127 H.P.
From this selecting the motor having the large power than that of
N = 0.00127 H.P.
So selecting the synchronous motor having power capacity = 0.002 H.P.

4.2 Motor calculation

Specification and calculation:

- 30 rpm
- 12 V
- 18 W

Torque of motor: $\zeta = \frac{(\text{P X } 60)}{(2 \text{ X } 3.14 \text{ X N})}$ (9)
$= \frac{(18\text{X } 60)}{(2 \text{ X } 3.14 \text{ X } 30)}$
= 5.72 Nm
= 5.72 x 10^3 Nmm
The shaft is made of MS and its allowable shear stress = 42 MPa

Torque: $\zeta = \frac{3.14 \times fs \times d^3}{16}$ (10)

$5.72 \times 10^3 = \frac{3.14 \times 42 \times d^3}{16}$

D = 8.85 mm

The nearest standard size is d = 9 mm.

5. Fabrication details

The fabrication details with assembled model are shown below:

5.1 3-D model of the proposed machine

The below Fig.2 shows the 3-D CAD geometry of the proposed machine having all required components in it. The 3-D view of the project gives an appropriate idea to fabricate the real model with more idea and less waste material.

This CAD model was designed by using exact dimensions of every components which helped in defining their properties and behavior to the different load conditions while simulation.

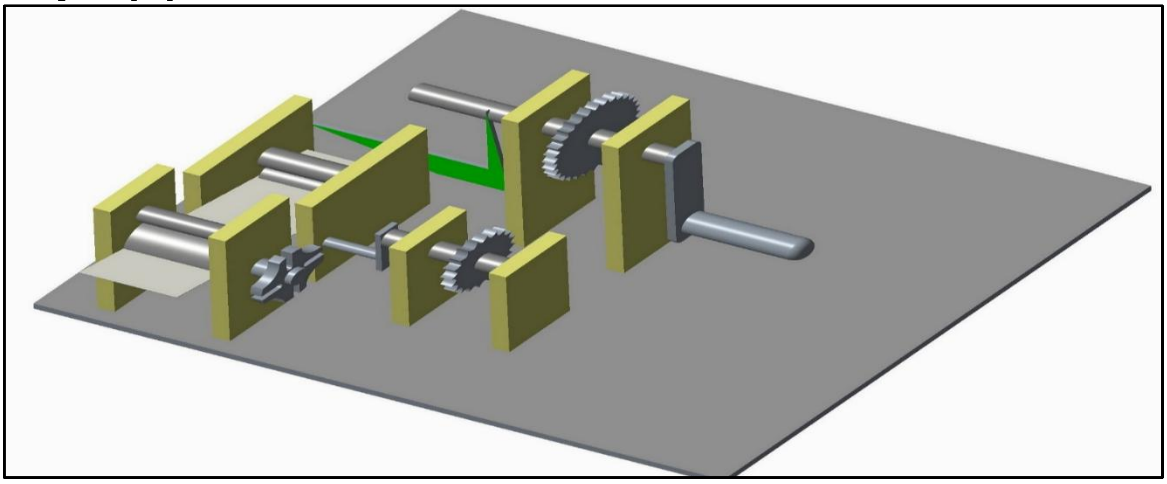

Fig.2 3-D model of automatic paper cutting machine by using geneva mechanism

5.2 Assembled model

The Fig. 3 and Fig. 4 show the assembled model of proposed system.

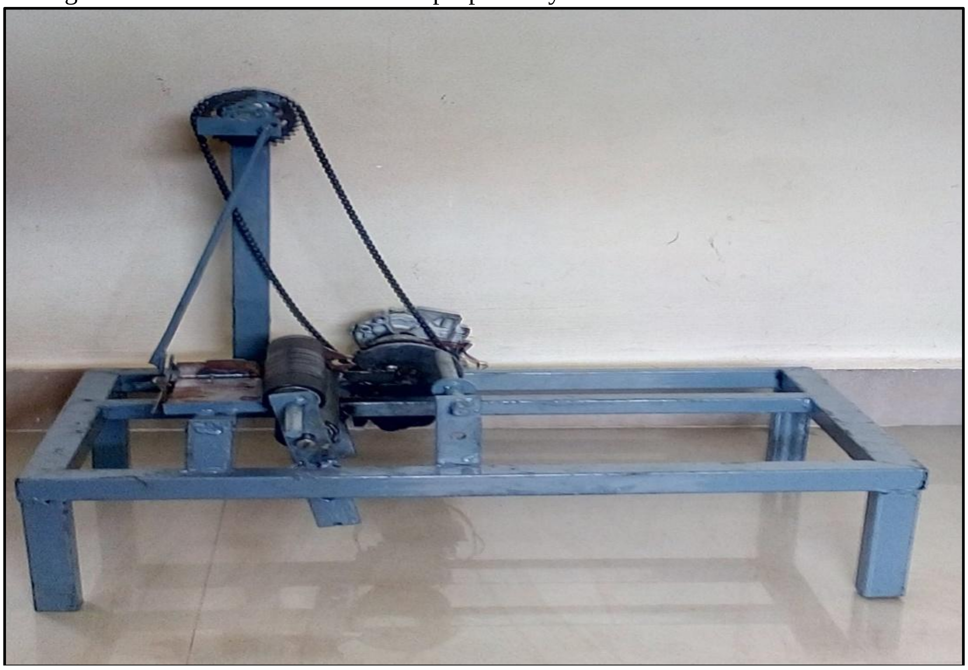

Fig. 3 the side view of assembled model

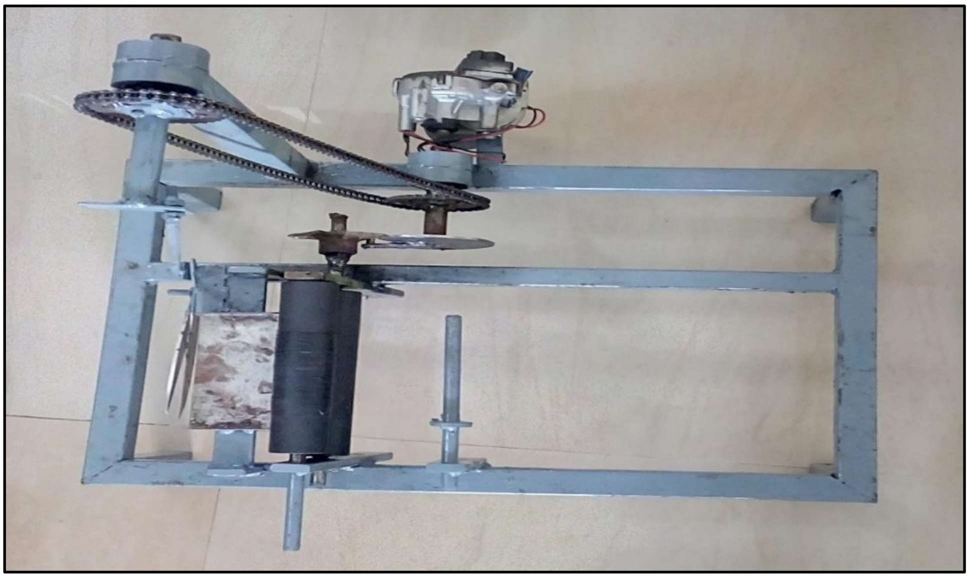

Fig.4 the top view of assembled model

5.3 Results and analysis

The obtain shape and size of the paper is dependent upon feed of the paper through roller which is driven by the Geneva mechanism so indirectly the no. of slot of Geneva are playing role in feeding the amount of paper. Thus to get the A-4 size cut of paper, intermittent motion need to change accordingly and compared with the standard size with most efficient outcome by consuming less power and energy given to system.

6. Advantage disadvantage and future scope of the proposed machine

The advantages, disadvantages, applications and future scope of this proposed machine are:

6.1 Advantages

The advantages are as follows:
- It will reduce the time for marking the paper.
- The dimension of the paper will be accurate.
- Manufacturing cost is less.
- No noise pollution.
- Can be used for small scale industries.

6.2 Disadvantages

The disadvantages are as follows:
- Not able to cut the papers above 15 cm width.
- Not able to cut bunch of papers i.e. more than 5 papers.
- Not be used for large scale industries.

6.3 Future scope

- Implementation for large industries is possible.
- By changing cutter shape we can cut paper with different designs.
- By modifying Geneva slots we can cut different standard size paper.
- Machine can be modified to cut lather and other thick sheets.

7. Conclusion

The design and analysis of paper cutting machine using Geneva mechanism will be very useful for small scale industry. There are machine based on paper cutting but it has demerits like large in size, costly, need skilled labours to operate and it need electrical input. But we have our machine which will overcome this demerit by compact size, less cost no need for skilled people and there is no need of electrical input. The main aim of this machine is to reduce timing for paper cutting and neglect the time for marking the paper. This aim can be achieved by our machine.

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