Automatic Stamping Machine using Geneva Mechanism

E. Kavitha[1], Prashanth Vardhan.P[2], S.Vamsi Krishna[3], S.Rahul[4]
1, Assistant Professor, Department of Mechanical Engineering, PVP Siddhartha Institute of Technology, Vijayawada - 520010, India
2,3 , Assistant System Engineer,Tata Consultancy Services,Mumbai
4,Student, PVP Siddhartha Institute of Technology, Vijayawada - 520010, India

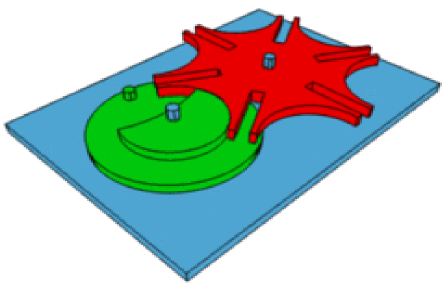
Abstract: On the conventional stamping machine the time for job setting, marking, stamping operation is more. Labor cost is also more. With Geneva based stamping machine the time for job setting, marking, stamping, labor cost and maintenance cost decreases. In this research work, designing and fabricating the prototype of automatic stamping machine using Geneva mechanism is done. This work is specially designed for automatic stamping on papers and metal sheet. It is to introduce automation in industries. The major components involved in this work are dc motor, cam arrangement, chain drive, Geneva mechanism and stamping tool. In this project we are using three rollers for moving the sheet during operation. A dc motor is connected with cam. The cam has a pin which rotates the Geneva wheel. The Geneva wheel is attached to the chain drive. The other end of the chain drive is connected to the rollers which roll the metal sheet or papers and the stamping operation is performed by the stamp tool. It is suitable for making mass production of sheet stamping.

***Keywords:* Conventional stamping machine, Geneva, prototype, automation.**

I. INTRODUCTION-

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 center of watch making. The Geneva drive is also commonly called as 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. 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 rotation of the drive wheel.
The present invention relates to a Geneva Mechanism for intermittently driving a load. The mechanism comprises: a rotating driver having a drive pin; and a star wheel operationally associated with a load which is to be intermittently driven, with the star wheel comprising a plurality of radially extending slots, and each of the radially extending slots being curved along a substantial portion of its length. The drive pin of the rotating driver is engageable with one of the radial extending slots to drive the star wheel in an incremental angular manner, such that a drive pin load on the drive pin and forces applied to the load operationally associated with the star wheel remain in control, and the star wheel reaches a peak acceleration and deceleration in a continuous and controlled manner.

- **Geneva Drive**



The Geneva drive or Maltese cross is a gear mechanism that translates a continuous rotation movement into intermittent rotary motion. The rotating drive wheel is usually equipped with a pin that reaches into a slot-shaped groove located in the other wheel (driven wheel) that advances it by one step at a time.

❖ Design approach

Many factors contribute to a successful Geneva mechanism design, such as materials used, surface finish, tolerances, loads, stress levels, lubricant, etc. Unsuccessful experimental applications of this mechanism usually result in two modes of failure: pin wear and wheel breakage. Of these two modes, wear is the hardest to control.

The present design approach will be to reduce wear by altering the geometry of the Geneva wheel to reduce the contact stress while maintaining acceptable stress levels in other regions of the wheel. R. C. Johnson showed that an optimum wheel diameter exists for minimum wear stress.

In this paper, consideration is given to two additional dimensions (pin diameter and tip thickness) on the wear stress and certain internal beam stresses. This paper will begin by defining the wheel geometry and then developing the relationships between this geometry and the wheel inertia, the maximum pin load, the contact stress, and the internal wheel stresses. These performance parameters will be normalized to the corresponding parameters of a set of predefined “standard” Geneva’s for convenience in interpreting results. For the “standard” set chosen, curves will show the stress and load parameters as a function of inertia and speed.

❖ Internal Geneva Wheel

When the dwell period must be less than 180°, other intermittent drive mechanisms must be used. The internal Geneva wheel is one way of obtaining this form of motion. The main advantage of the internal Geneva wheel, other than its smooth operation, is its sharply defined dwell period. The dwell period of all internal Geneva wheels is less than 180°, leaving more time for the star wheel to reach maximum velocity, lowering the acceleration. The highest value of acceleration occurs when the crankpin enters or leaves the slot .The design of the internal Geneva mechanism is very similar to that of the external mechanism. The maximum angular velocity occurs when the crank angle is zero with respect to the centerline c. The maximum angular acceleration occurs when the crank enters the slot. Figure 3 shows a plot of the angular acceleration of the wheel with respect to the crank angle for 3, 4, 5, 6, 8, 10, and 12 slotted Geneva wheels with unit crank link length (r1=1). It can be seen that there exists a non-zero angular acceleration component as the crankpin makes contact with the Geneva slot. In fact this is the maximum angular acceleration of the system during the non-dwell phase.

❖ The Geometry of the Geneva Mechanism

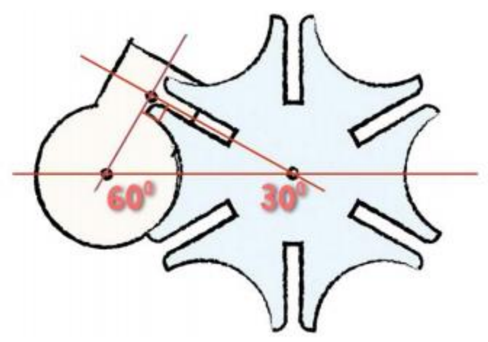


Fig: Geometry of the Geneva

In the four slot Geneva stop, both wheels are the same size. In Geneva drives with different numbers of slots a little geometry soon reveals the relative sizes of the wheel. The Geneva drive is used to provide intermittent motion, the drive wheel turns continuously, the pin on the drive wheel then turns the cross shaped piece quarter of a turn for each revolution of the drive wheel. The crescent shaped cut out in the drive wheel lets the points of the cross pass; the rest of the circle locks the slotted wheel into place while it is stationary. Drive motion can be changed by changing the number of slots in the slotted wheel.

❖ *Wheel Design*

Two types of slot designs for the Geneva wheel were considered. The designs were laid out using the Cadence software for MEMS layouts. Since the technology file available with the software allowed for only three levels of polysilicon, the structural poly0 level was not laid down. For any N slotted wheel, the angle by which the slotted wheel rotates for a given rotation of the constantly rotating wheel is 2p/N. The slots are thus placed at 2p/N radians intervals. An important requirement is that during every rotation, the pin should enter and leave the slots in such a way that the tangent to the constantly rotating wheel at the pin passes through the center of the slotted wheel. This means that if ‘r’ is the radius of the constantly moving disk,then the distance ‘D’ between the centers of the two disks has to be:

$D = r/\sin(p/N)$

And the radius of rotation ‘R’ of the Geneva wheel is given by:

$R = r/\tan(p/N)$

The minimum length of the slot through which the pin on disk W moves should be:
S = D-[(D-R)+(D-r)] = R+r-D
Applying these relations to the wheel
Aa = ab = Ab/ 2

Layout of a four slot Geneva wheel using Cadence. The layout of a four slotted wheel in Cadence with projections on the constantly rotating wheel to so that it can be moved with a probe. The constantly rotating disk can be rotated using a Sandia micro engine driven by comb-drives. The gears of the micro engine can be made to mesh with the gears of the constantly rotating wheel that can be provided on it. To avoid unintentional rotation of the Geneva wheel, a truncated wheel (with a chopped arc angle of 4p/N radians) is placed on the constantly moving disk, which stops any rotation of the Geneva wheel when the pin is moving freely and is not engaged with any of the slots.
The design should therefore, have the truncated disk and the Geneva wheel on the same polysilicon layer and the constantly moving disk in another layer, which would mesh with the micro engine. The Geneva wheel and the chopped disk are made on the Poly2 layer and the constantly moving disk lies below in the Poly1 layer. The engaging pin on this disk is placed on Poly2 layer. The pins holding the Geneva wheel and the other disks are then placed on Poly3 layer, which gets contacted to the Poly0 layer and allows rotation of the disks after release.
A gear can be fabricated on poly1 layer concentric with the Geneva wheel, which can then be meshed with a rack to convert the intermittent rotation of the disk into discrete linear motion. This can then be applied to micro mirrors and other systems requiring such motions.

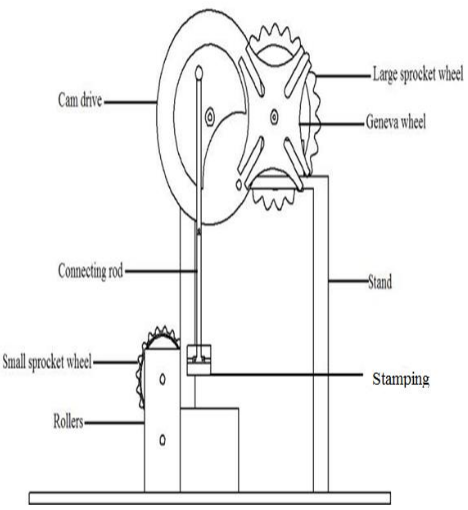
II. METHODOLOGY:

Now a days, in small as well as at large scale industries, for various operations like stamping, cold automatic pressing, embossing, coining, blanking, drawing take maximum jobs, handling time, more man power requirement, more cost of attachment, high maintenance. To reduce the effort of man power, our design is used, so that one person can operate or handle all operations at a time.

PROBLEM SOLUTION

For this problem our design work is used which is known as automatic stamping machine. In this we used the attachment for the stamping. In this, we implement Geneva mechanism which gives higher accuracy. Using this attachment, it will stamp one by one simultaneously with certain time delay in between the stamping and rolling operation. “This is specially the need of manufacturing firms for mass production”. The basic principle that has taken into account for the attachment on stamping and stamping machine is “the conversion of rotary motion into intermittent motion”. The indexing of the Geneva wheel is important as it depends on the number of slots.

BLOCK DIAGRAM AND COMPONENTS DESCRIPTION



COMPONENTS	QUANTITY
Nylon	As per required
MS rod	As per required
Motor	1
Rollers	3
Chain drive	1
Sprockets	3
Geneva drive	1
Driving disc	1
Bearing	As per required

Fig Block Diagram

Auto roll stamping machine consists of Motor, gear box (to reduce speed), Geneva mechanism (rotary disc and Geneva wheel with the correct dimensions), Stamping ram(universal joint, flat metal and stripper to guide the ram), Belts and pulleys, chain and sprockets and rollers(to pass sheet metal. The rotary disc faces have a pin which touches the slot in the Geneva wheel and also rotates the Geneva wheel. Due to the rotation of rotary disc the stamp will slides up and down. Due to the rotation of a Geneva wheel, the metal sheet feeding rollers are rotated by the chain drive mechanism and hence the metal sheet is fed automatically.

❖ *Implementation*

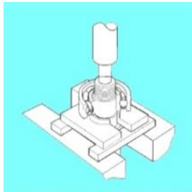
Basic components of Auto roll stamping machine is as follow

Motor

Chain Drive

Geneva Wheel

Rollers



Stamping Ram

❖ ***Working Principle***

When the motor is powered the cam drive disc is rotated. The linear rod which is attached to the cam drive disc with eccentricity from the center is reciprocated on the stamping machine. The stamping machine consists of a stamp head, when the linear rod is moved down it presses the stamp head. The stamp head consists of stamp tools which stamps the paper in required manner. The cam drive disc has a pin attached to it, which enters into the slot of the Geneva wheel and turns the Geneva wheel. For every one rotation of cam drive disc, the Geneva wheel rotates 1/4th of the rotation.
The shaft of the Geneva wheel is attached to the sprocket wheel. When the Geneva wheel rotates, the sprocket wheel also rotates which in turn rotates the rollers attached to the other sprocket wheel. The two sprocket wheels are connected by a roller chain. With the help of rollers, the paper moves forward and the stamping operation is done on it. When the switch is ON, the motor rotates the gear box. The gear box is connected to the rotary disc with the help of belt. Hence, the stamping slide with stamping tool moved up and down and makes a stamp on the metal sheet.

❖ *Geneva 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 which results in the end of the motion.

❖ *Geneva Wheel Design*

The basic design criterion of a Geneva wheel is that the centerlines of the slot and crank are mutually perpendicular at engagement and at Disengagement. The crank, which usually rotates at a uniform angular velocity, carries a roller to engage with the slots. During one revolution of the crank the Geneva wheel rotates a fractional part of the revolution, the amount of which is dependent upon the number of slots. The Circular segment attached to the crank effectively locks the wheel against rotation when the roller is not in engagement and also positions the wheel for correct engagement of the roller with the next slot. The design of the Geneva mechanism is initiated by specifying the Crank radius, the roller diameter and the number of slots. At least 3 slots are necessary but most problems can be solved with wheels having from4 to 12 slots.

The angle (β) is half the angle subtended by adjacent slots i.e., where n is the number of slots in the wheel. Then, defining r2 as the crank radius we have, where c is the center distance. Note that the actual Geneva wheel radius is more than that which would be obtained by a zero-diameter roller. This is due to the difference between the sin and the tangent of the angle subtended by the roller, measured from the wheel center. The final step in the design process is to choose a convenient radius for the circular pert of the Geneva wheel, which meshes with the input wheel locking the Geneva wheel. A ball bearing is used to fix the shaft on base stand. The bearing is selected according to the diameter of the shaft. The driver gear and cam are inserted to the shaft on threaded end. The Maltese cross is also fitted with sprockets on its end. Sprockets are designed according to the film frame width.

❖ ***Fabricating process***

The Geneva Wheel Mechanism, which was manufactured, had 9 parts. They are two Geneva wheel pieces, two circular locking slots, a crank pin, a spacer plate, two shaft pins to carry the Geneva wheel and the input shaft and a base plate. The Geneva wheel was manufactured with nylon material. Then the profile was stamp marked on the material. The plate was put in an indexing milling machine and the profile was milled to the required dimensions including the cutting of slots. The locking wheel was also stamp marked and milled to the required dimensions. The crank pin was made by gas cutting the required shape and length and the roller pin was fitted at the required distance of50 mm from the crank center. All the other components were tuned to the required dimensions. The holes for carrying the shafts were then drilled by using a 16mm drill taking care of the distance between the centers.

❖ ***Geneva wheel analysis***

The analysis of Geneva wheel is done by drawing the position of the pin and the Geneva wheel at the required position. The position of the Geneva wheel is given by, double differentiating with respect to time we get the equations that are valid only in the region – (90-b) to (90-b) of the input crank angle. At all other angles the Geneva wheel is stationary and hence both angular velocity and acceleration are zero.

III. Design Calculations

❖ ***Design of Geneva mechanism***

Geneva wheel radius (b) = 75 mm
No. of slots in Geneva wheel (n) = 4
Drive pin diameter (p) = 8 mm
Allowed clearance (t) = 2 mm
Centre distance (c) = $\frac{b}{\cos(\frac{180}{n})} = \frac{75b}{\cos(\frac{180}{4})}$= 106 mm
Drive crank radius (a) = $\sqrt{c^2 - b^2} = \sqrt{106^2 - 75^2}$ = 75 mm
Slot center length (s) = (a + b) - c = (75 + 75) – 106 = 44 mm
Width of slot (w) = p + t = 8 + 2 = 10 mm
Angle between two slots (θ) = 2 x 180/n = 2 x 180/4 = 90º
Angle at the entrance of the pin into the slot (Ø) = 45º
Stop arc radius (y) = a – (p x 1.5) = 75 – (8 x 1.5) = 63 mm
Thickness of Geneva wheel (h) = 6 mm
Stop disc radius (z) = y – t = 63 – 2 = 61 mm
Thickness of crank drive (i) = 9mm
Height of pin = h + t = 6 + 2 = 8mm
Distance of drive pin from the center of the disc (a) = 75 mm
Number of revolutions per minute (N) = 51 rpm
Total cycle time (Tc) = 1/N = 1/51 = 0.0196 min
Available service time per cycle
(Ts) = (180 + θ)/360 x N
= (180 + 90)/360 x 51 = 0.014 min
Dwell time or processing time
(Td) = (180 - θ)/360 x N
= (180 - 90)/360 x 51 = 4.901 x 10-3 min

❖ ***Design of roller chain drive***

- Pitch of chain (p) = 3.17 mm
- No. of teeth on smaller sprocket Z1 = 18 teeth
- No. of teeth on larger sprocket Z2 = 28 teeth

- Diameter of smaller sprocket d1 = 70 mm
- Diameter of larger sprocket d2 = 130 mm
- No. of links in roller chains = 49 links
- Center distance between two sprocket wheels = 410 mm

❖ ***Motor calculations***

- Current (I) = 1.5 Amps
- Voltage (V) = 12 V
- The consumed electric power of the motor (P_{in}) = I x V = 1.5 x 12 = 18 W
- The output mechanical power of the motor (P_{out}) = T x ω_{out} Watts
- The speed of the motor (N) = 51 x 20 = 1020 rpm
- The actual Torque of the motor

  (T_{in}) = E_b x I_a x 60 / 2 x π x N
  = 9.55 x 1.5 x 60 / 2 x 3.14 x 1020
  = 0.1341 N-m
- Angular speed (ω_{out}) = 2 x π x rpm / 60 = 2 x 3.14 x 1020 / 60 = 106.8 rad/sec
- Pout = 0.3141 x 106.8 = 14.3 W
- Efficiency of motor = Pout / Pin = 14.3 / 18
- = 0.794 x 100 = 79.4%
- Input angular speed (ωin) = 2 x π x rpm / 60
- = 2 x 3.14 x 51 / 60 = 5.34 rad/sec
- Fundamental equation for Gear pair = Tout / Tin
- = ωout / ωin = Tout / 0.1341 = 106.8 / 5.34
- Tout = 6.282 N-m

Stamp specifications

- Stamp length = 55 mm
- Stamp width = 25 mm

Roller specification

- Diameter of Roller 1 = 35 mm
- Diameter of Roller 2 = 90 mm
- Length of the rollers = 230 mm
- Center distance between two rollers = 160 mm

IV.EVALUATION OF RESULTS

❖ **Power required to stamp**

- Power required to stamp (p) = 2πNT/60 W
- Torque input to the cam drive (Tin) = 6.22 N-m
- The output torque of cam drive

  (T) = Tin (√2 cosθ –1)
  = 6.22 (√2 cos0 – 1)
  = 2.57 N-m
  (At maximum acceleration θ = 0)
- Power required to stamp = 2 x π x N x T / 60
  = 2 x 3.14 x 51 x 2.57 / 60
  = 13.72 W

❖ ***Stamping done on papers***

- Hole diameter (d) = 5.5 mm
- Thickness of the paper (t) = 0.5 mm
- Ultimate shear stress of a carbonless paper (τ)= 500 KPa
- Area under shear stress

  A= π x d x t mm^2
  π x 5.5 x 0.5 = 8.63 mm^2
- Force required to stamp

  F = A x τ Newton
  = 8.63 x 0.5 = 4.315 N

The project carried out by us can be used to make stamping on paper and G. I. Sheet with more prescribed than a conventional stamping machine. As conventional stamping machine takes more time for Job setting, Marking, Stamping operation this can be used to reduce the work. With this Geneva wheel based auto roll stamping machine, the time taken for all this process can be reduced and production time is also low. The rate of production will be high. No extra skill is required for operating this system. Operation is very smooth and in this system we can get more output by applying less effort. It is very much useful for making series of holes of same diameter and constant pitch. Thus it can be useful for stamping application.

The project carried out by us is very much useful in the field of small scale industries. It is also useful for the workers to carry out a number of operations on a single machine. Our project is to ultimately reduce the power consumption and manufacturing cost and also to reduce the floor space.

V.CONCLUSIONS

Geneva drive indexing mechanism converts the continuous motion of the driver wheel into intermittent rotary motion of the sprocket. Cam with pin arrangement is integrated with Geneva drive. Input shaft having driver wheel is at one end and cam drive is at the other end. Geneva drive and sprocket are mounted on the output shaft. By cam with Geneva drive arrangement the continuous motion of the driver wheel converts into intermittent motion of sprocket. Due to sprocket rotation the paper advances. Thus the stamping process occurs.

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