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DESIGN OF GENEVA WHEEL BASED AUTO-ROLL PUNCHING MACHINE

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Abstract - *On the conventional punching machine the time for job setting, marking, punching operation is more. Labor cost is also more. With Geneva based punching machine the time for job setting, marking, punching, labor cost decreases and also less maintenance cost. In this project we are designing and fabricating the prototype of Auto roll punching machine using Geneva mechanism. This project is specially designed for automatic punching in metal sheet. This project is to introduce automation in industries. The major components involved in this project are dc motor, cam arrangement, chain drive, Geneva mechanism and punching tool. In this project we are using two 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 and the punching operation is done by the punch tool. It is suitable for making mass production of the sheet metal punching.*

Key Words: **Geneva wheel, Cam drive, Dc motor, Punch tool, Auto-roll punching.**

1. INTRODUCTION [1]

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 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.

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.

1.1 Methodology [2]

This project is designed with using Geneva mechanism moving arrangement and punching mechanism. Punching machine is designed with mechanical arrangement in which movements are controlled by using Geneva mechanism.

Auto roll punching machine consists of two sections. One section is automatic feeding mechanism and the second section is conversion of rotary motion into linear reciprocating motion of punching tool. The first section consists of Geneva wheel disc keyed to shaft at one end and the other end is connected with chain sprocket wheel. This Geneva wheel shaft is supported on nylon bushes. This sprocket wheel transmit the rotary motion from the Geneva wheel to the feeding rollers through a chain drive. Hence when the Geneva wheel is rotated, the paper also moved for punching operation.

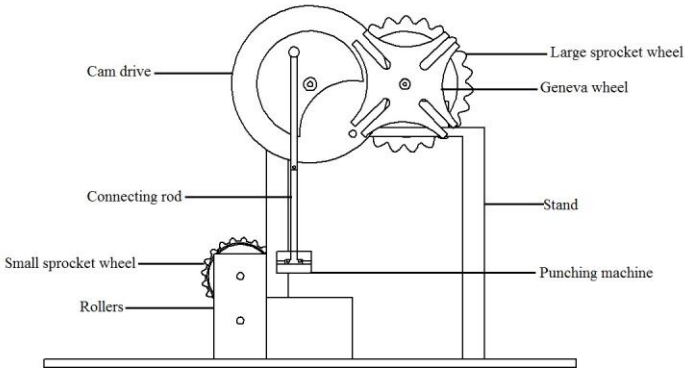

Fig -1: Geneva wheel based auto roll punching machine

The second section consists of electrically operated DC motor, nylon bush, crank wheel with a pin, connecting rod and punching tool. The second section is used to convert the rotary motion of the crank wheel into reciprocating motion of punching tool. The rotating shaft is keyed to the crank wheel at one end and the other end is connected to DC motor. This shaft is supported on nylon bush. The punch tool slide is reciprocated by the connecting the crank wheel through the connecting rod .The paper is fed automatically by the rotation of Geneva wheel.

1.2 Working [2]

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 punching machine. The punching machine consists of a punch head, when the linear rod is moved down it presses the punch head. The punch head consists of punch tools which punches 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 punching operation is done on it.

2. DESIGN

2.1 Design of Geneva mechanism [3]

- 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) = $\frac{b}{\cos(\frac{180}{n})} = \frac{75}{\cos(\frac{180}{4})}$ = 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 (T_c) = 1/N = 1/51 = 0.0196 min
- Available service time per cycle (T_s) = (180 + θ)/360 x N = (180 + 90)/360 x 51
  = 0.014 min
- Dwell time or processing time
  (T_d) = (180 - θ)/360 x N = (180 - 90)/360 x 51
  = 4.901 x 10^{-3} min

2.2 Design of roller chain drive [4]

- 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

2.3 Motor calculations [5]

- Current (I) = 1.5 Amps
- Voltage (V) = 12 V
- The consumed electric power of the motor (Pin) = I x V = 1.5 x 12 = 18 W
- The output mechanical power of the motor (Pout) = T x ωout Watts
- The speed of the motor (N) = 51 x 20 = 1020 rpm
- The actual Torque of the motor
  (Tin) = Eb x Ia 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 (ω_{in}) = 2 x π x rpm / 60
  = 2 x 3.14 x 51 / 60 = 5.34 rad/sec
- Fundamental equation for Gear pair = Tout / Tin
  = ω_{out} / ω_{in} = Tout / 0.1341 = 106.8 / 5.34
- Tout = 6.282 N-m

2.4 Puncher specifications [6]

- Punching diameter = 5.5 mm
- Punching distance = 80 mm
- Punching Capacity = 22 sheets

2.5 Roller specification

- Diameter of Rollers = 45 mm
- Length of the rollers = 430 mm
- Center distance between two rollers = 45 mm

2.6 Design in solid works

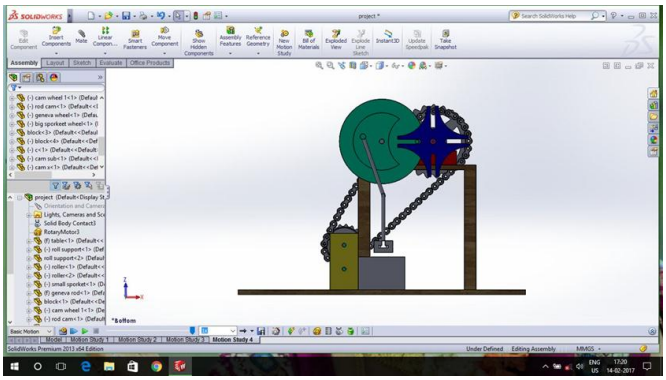

Fig -2: Design in solid works

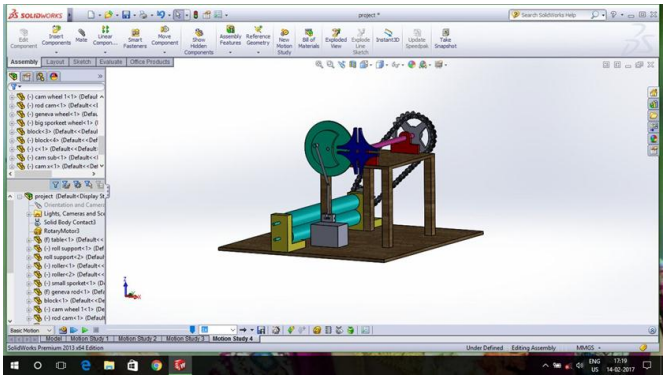

Fig -3: Auto roll punching machine

3. RESULTS

3.1 Power required to punch

- Power required to punch (p) = 2πNT/60 W
- Torque input to the cam drive (Tin) = 6.22 N-m
- The output torque of cam drive (T) = Tin ($\sqrt{2}$ cosθ – 1)= 6.22 ($\sqrt{2}$ cos0 – 1) = 2.57 N-m
  (At maximum acceleration θ = 0)
- Power required to punch = 2 x π x N x T / 60
  = 2 x 3.14 x 51 x 2.57 / 60
  = 13.72 W

3.2 Punching 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 mm2
  = π x 5.5 x 0.5
  = 8.63 mm2
- Force required to punch F = A x τ Newton
  = 8.63 x 0.5
  = 4.315 N

3.3 Punching on G. I. Sheet

- Hole diameter = 5.5 mm
- Thickness of sheet = 0.5 mm
- Ultimate shear strength of galvanized iron sheet (τ) = 800 KPa
- Area under shear stress A = π x d x t mm2
  = π x 5.5 x 0.5
  = 8.63 mm2
- Force required to punch F = A x τ N
  = 8.63 x 0.8
  = 6.904 N

4. CONCLUSION

The project carried out by us is used to make punching on paper and G. I. Sheet with more prescribed than a conventional punching machine. As conventional punching machine takes more time for Job setting, Marking, Punching operation. Labor cost is also more. With this Geneva wheel based auto roll punching machine the time taken for all this process can be reduced and production time also reduced and production rate 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 punching application.

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