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Design and Analysis of Automatic Stirrup Making Machine

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Abstract: *Now days the world is focusing into automation. Each and every work of human is reduced by a machine, but few areas like construction the usage of machines for bending rods for stirrups which are used to withstand loads in beams and columns are not done by machine because the cost of machine is high and need skilled labor to operate it. So this project is aimed to do bending operation for stirrups using mechanical application and named as automatic stirrup making machine .The main objective of our project is to implement the automatic stirrupmaking machine in the construction sites with less cost compared to the existing bending machines, and increasing the productivity of the stirrups.Automatic stirrup making machine consist of Rectifier, Motor , Ball bearing , Sprocket , Main die, Supporting die, holder. The rod is bent by opposite rotation of two dies with holding the rod in the holder. The main advantage of our project is the square shape of the Stirrups is bent continuously without repositioning the rod in the machine.*

Keywords: *Stirrup, beams, columns, loads, sagging, sprocket*

I. Introduction:

The main objective of this project is to fabricate stirrups using automatic bending machine by reducing the human efforts for the concrete structure like beams and columns.Stirrups bind and hold longitudinal bars of steel in position. The object is to prevent the buckling or spreading out the longitudinal reinforcement and also to prevent concrete from splitting outwards.

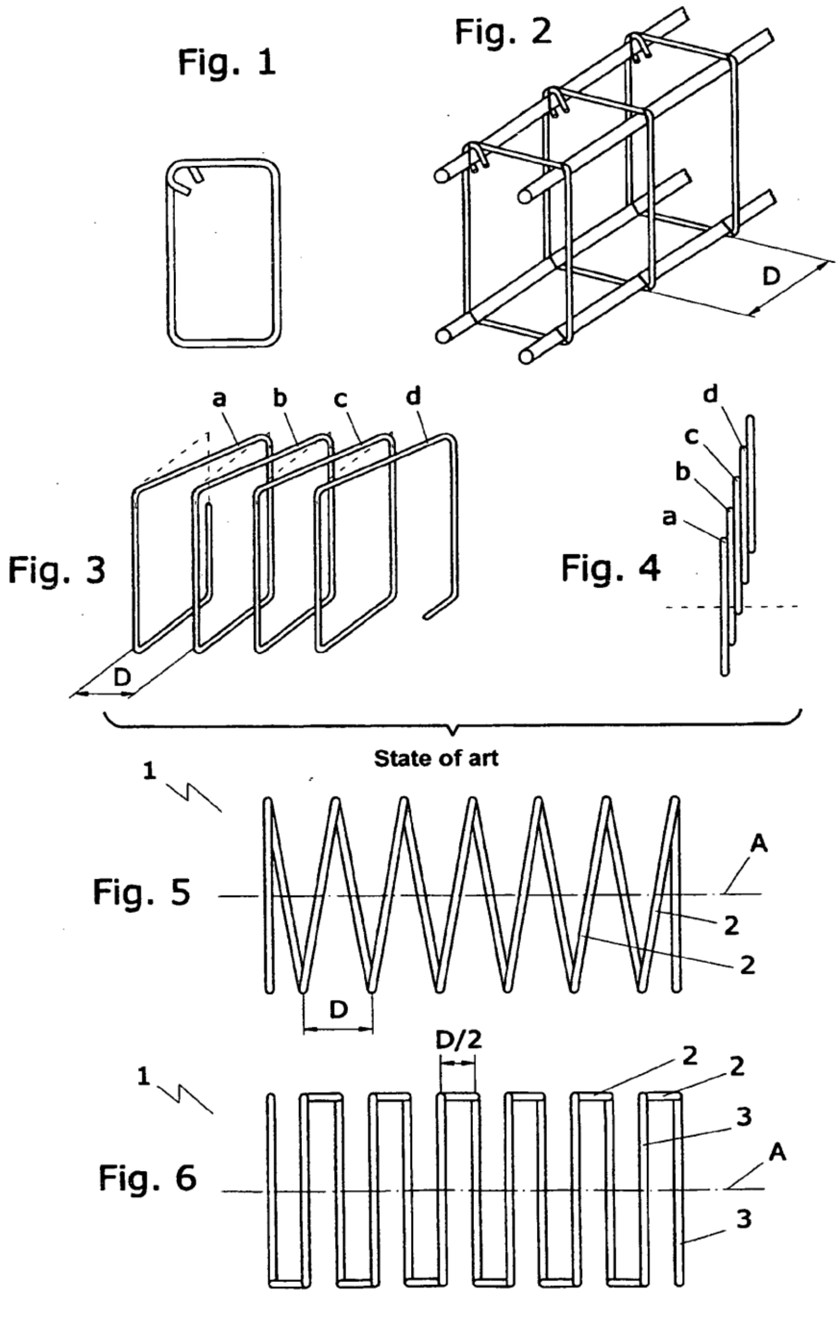
As example column cross section is 80cm x 40cm, and the concrete cover is 4cm, then the stirrup will be = 76 x 2 + 36 x 2 + overlap that depends on stirrup size which is around 10 cm = 152 + 72 + 10 = 234 cm each stirrupGenerally term stirrups are used for lateral tie for beams while term ring is used for columns. Calculation of length for stirrups & ring are same.

II. Stirrup Design:

Stirrups length depend upon size of column/beam, cover, diameter of stirrup's bar. Nominal cover is measured from outer face of stirrups to concrete face. Although this cover at site is measured from outer face of main bar. If cover for beam is 25 mm then, for 90 degree hook for 600x400 mm column & 10 mm diameter bar as per IS Code 2502 length will be

$$2\ [(600-2x25) + (400-2x25)] + 20\ x\ 10mm = 2000...$$

If there are four bar of 20mm diameter on 600 mm face then for central stirrup of this side will be [600-25-25-(20/2)-(20/2)]/3=176.66 between center of two bars of this face, now add (20/2)+(20/2) so that outer face to outer face of 20 diameter bar=196.6say 197mm. same way other side of central stirrups are calculated & then add 20 times bar diameter .Add 24 x diameter of bar for 135 degree hook



Failure In A Beam:
Flexure damage is preferred**.** Longitudinal bars resist the tension forces due to bending whilevertical stirrups resist shear forces.Inclined crack

(a)Flexure Failure
(b)Shear Failure

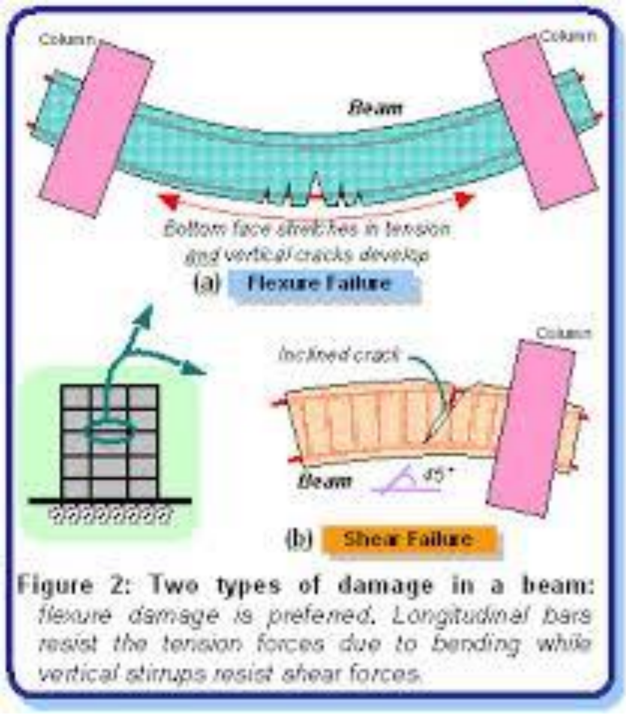


Figure 2: Two types of damage in a beam: flexure damage is preferred. Longitudinal bars resist the tension forces due to bending while vertical stirrups resist shear forces.

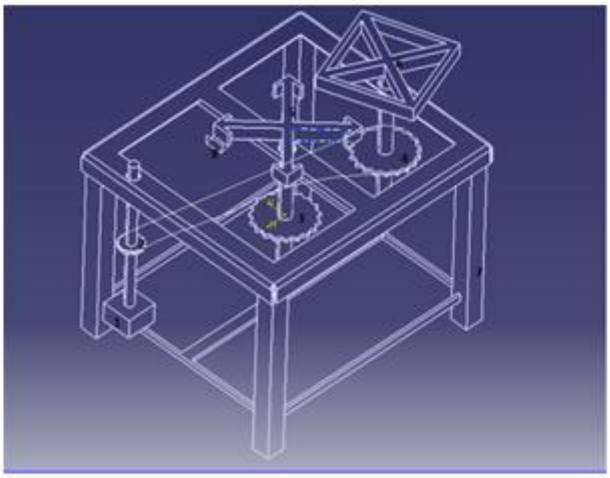
Bottom face stretches in tensionand vertical cracks develop

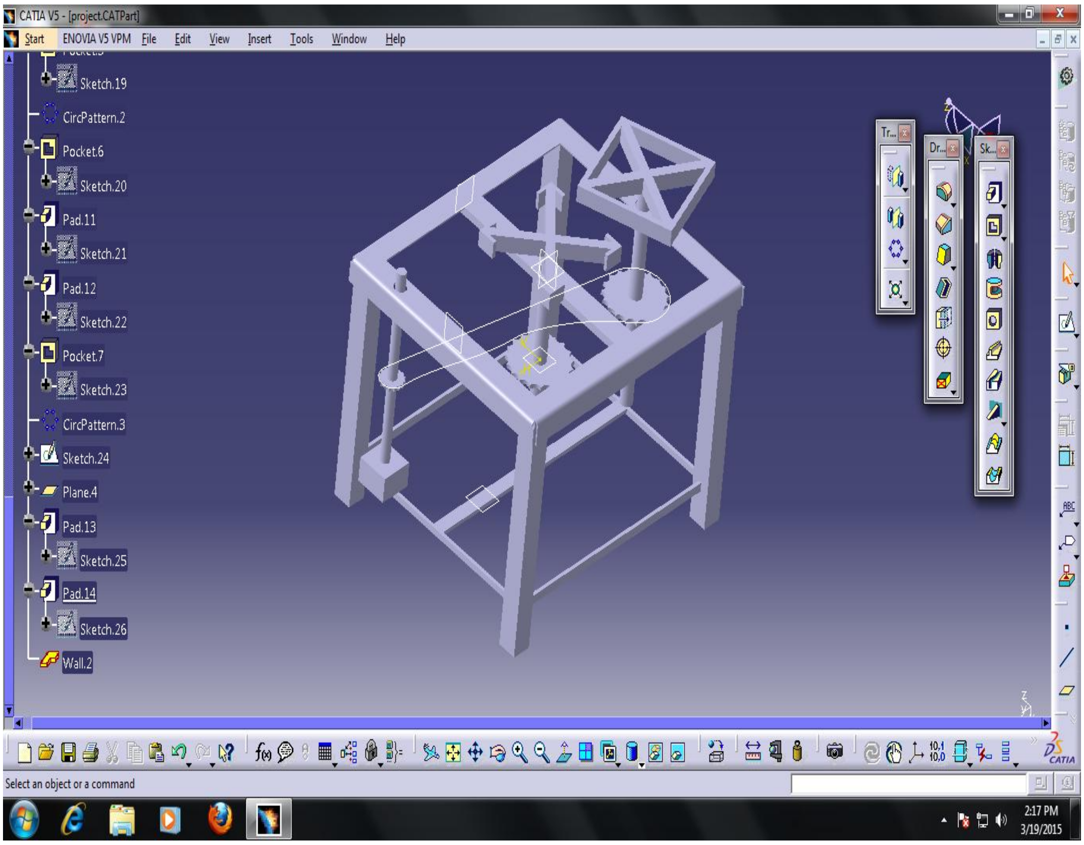
Characteristics Of Machine:
- ➢ Rod size of 6mm, 8mm.
- ➢ Any material based on requirement.
- ➢ Size of the stirrup made by the machine is 200x200 mm.

Application
- ➢ Exclusively used in civil construction field.

List Of Components
- Rectifier
- Motor
- Ball bearing
- Sprocket
- Main die
- Supporting die
- Frame

Diagram:





III. Design Calculation:

Observation:

Speed of the driver sprocket (n$_1$) = 45 rpm
Speed of the driven sprocket (n2) = 14.5 rpm
Power (N) = 50 W

STEP1: (selection of transmission ratio)

$i = n_1 / n_2$
$= 45 / 14.5$
$i = 3.07$……………(pg.no.7.74)

STEP 2: (selection of numberof teeth on driver sprocket)

(When space is a problem)………………………..Pg.no.7.74
$Z_1 = 14$

STEP 3: (number of teeth on driven sprocket)

$Z_2 = i \times Z_1$
= 3.07 x 14
= 42.98
$Z_2 \approx 43$

STEP4: (selection of standard pitch)

P_{max}= a\30
= 600/30
P_{max}= 20
P_{min}= a/50
= 600/50
P_{min}= 12
Selection of pitch lies between P_{max} and P_{min} and it is closer to P_{max}
P_{max}= 15.875 mm

STEP5: (Selection of chain)……………..Pg.no.7.72

Chain no: 10A-1/R50
d_r = 10.16 mm
A = 0.7 cm^2 = 70 mm^2
M = 1.01 Kgf/m
Q = 22200 N

STEP6: (Calculation of total torque acting on the driving side of the chain (P_T))……..pg.no.7.78

$\sum P = P_T = P_t + P_c + P_s$
Tangential force, P_t = 102 N / V
V = (Z_1 x P x n_1) / (60 x 1000)
= (14 x 15.875 x 45) / (60 x 1000)
V = 0.52 m/s
P_t = 102 x 0.005 / 0.52
= 9.74 Kgf
P_t = 97.4 N
Centrifugal tension, $P_c = mv^2$
= 1.01 x $(0.52)^2$
P_c = 0.27 N
Tension due to sagging
P_s= k x w x a……………(k=4 for less than 40°)
= 4 x 1.01 x 9.81 x 0.6
P_s= 23.77 N
P_T= 97.4 + 0.27 + 23.77
P_T = 121.45 N

STEP 7: (Service factor K_s)……………(pg.no.7.76 to7.79)

$K_s = K_1 + K_2 + K_3 + K_4 + K_5 + K_6$
K_1= 1 (for constant load)
K_2= 1.25 (fixed center distance)
K_3= 1 (a_p= 30 + 50p)
K_4= 1.25 (horizontal inclination more than 60^0)
K_5= 1.5 (periodic lubrication)
K_6= 1 (work for 8 hrs per day)
K_s= 1 x 1.25 x 1 x 1.25 x 1.5 x 1
K_s= 2.34

STEP8: (Calculation of design load)

Design load = P_T x k_S
= 121.45x2.34
= 284.2 N

STEP 9: (Check for bearing stress in the roller)

$\sigma = (P_t \times k_S) / A$

$= (97.4 \times 2.34) / 70$

$= 3.2\ N/mm^2$

$[\sigma] = 3.5\ kgf/cm^2$

$= 35\ N/mm^2$

$[\sigma] > \sigma$

The design is safe.

STEP 10: (Calculation of actual length)

$L_P = 2a_P + (Z_1 + Z_2) / 2 + ((Z_2 - Z_1) / 2\pi)^2 / a_P$............................(Pg no 7.75)

$a_p = a / P$

$= 600 / 15.875$

$= 37.875$

$L_P = 2\,(37.8) + (14 + 43) / 2 + ((43 - 14) / 2\pi)^2 / 37.8$

$L_P = 104.66$

$L_P \approx 105$

$L = L_p \times P$

$= 105 \times 15.875$

$= 1666.875$ mm

STEP 11: (Calculation of exact centre distance)

$a = (e + \sqrt{(e^2 - 8m)} / 4) \times P$……………………….(pg no 7.75)

$e = L_p - (Z_1 + Z_2) / 2$

$= 105 - (14 + 43) / 2$

$= 76.5$

$m = ((Z_2 - Z_1) / 2\pi)^2$

$= ((43 - 14) / 2\pi)^2$

$= 21.3$

$a = (76.5 + \sqrt{(76.5^2 - (8 \times 21.3))} / 4) \times 15.875$

$a = 602.77$ mm

$a_e = 0.99 \times a$

$= 0.99 \times 602.77$

$= 596.74$ mm

STEP 12: (Calculation of pitch circle diameter of sprocket)………………………. (pg no 7.78)

For Small sprocket

$d_1 = P / \sin (180 / Z_1)$

$= 15.875 / \sin (180 / 14)$

$= 71.34$ mm

For larger sprocket

$d_2 = P / \sin (180 / Z_2)$

$= 15.875 / \sin (180 / 43)$

$= 217.48$ mm

Outer diameter of small sprocket

$d_{01} = d_1 + 0.8d_r$

$= 71.34 + 0.8(10.16)$

$= 79.47$ mm

Outer diameter of larger sprocket

$d_{02} = d_2 + 0.8d_r$

$= 217.48 + 0.8(10.16)$

$= 225.61$ mm

Working Principle

- Place the bar at work holding part in attachment with Main die in stirrup making m/c
- On energizing the drive motor, the power will be transmitted from the motor to stirrup die axle shaft through chain drive.
- It means that power will be transmitted from driving sprocket to the driven sprocket with calculated speed ratio as to get high torque to drive the bar loaded die.T α (1/N)
- Main die and forming die rotates in opposite direction with the help of idler sprocket.

- The bar placed at main die rotates along with the forming die, but the rotation of bar throughout its length will subject to bending load by forming die.
- The constrained travel of bar along with main die will form the stirrup shape as desired.
- After completing the procedure, the motor will be turned off and the stirrup will be removed from the work holding part.
- Size of the stirrup made by this machine is 200x200 mm as per the shape of Main die

Advantages:

- Compact size
- Low cost
- Portable
- Low power consumption
- Time saving
- Light weight

Disadvantages:

- This machine is suitable only for particular size

IV. Conclusion:

- In latest attempt a successful solution for the manual stirrup making is obtained.
- By changing the fixture in the table we can obtain various sizes of the stirrups.
- Instead of complicated designs the simple kinematic system is used.
- The system can be handled by any operator very easily.
- Due to low cost and simple design this can be marketed to any of the nation.

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