Design of Manually Operated Mosquito Repellent Coil Making Machine

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Abstract - *Paper presents design of mosquito repellent coil making machine. Mosquito repellent coil making machine is used to make coil or stamp the coil shaped mold into sheet of material results into coils of mosquito repellent. Manually operated machine works using human power. This machine works on hand lever principle. Spring is used to regain initial position of lever. Specially designed mold is used to make coils. Size and shape of mold depends on length of coils required. A mold or die is design in spiral shape with die holder to hold it into punch. First stamping force required to stamp is calculated using shear strength of material, then considering best possible lever length for easy operation is selected. According to leverage or maximum load acting at punch rod, further design of spring and punch rod is done using suitable principles. Then design of mold is done*

***Key Words*: Mosquito coil, stamping force, lever, spring, punch rod, punch-die holder, coil mould or die.**

1. INTRODUCTION

Mosquitoes are the very harmful insect presents on earth. Large population of world is affected by mosquito borne diseases. Various methods are used to prevent humans from mosquitos like repellents, insecticides, etc. the most commonly used mosquito repellent in this world is mosquito incense or mosquito coils. Mosquito coil making machine are available in market works on either human power or electrical power, or hydraulic power. Cost of such machines in India is Rs.70000 to 5 lakhs. Such a costly machine is used for high production. In India large population still leaves in villages or rural parts. And income sources in rural India are limited. As mosquitoes are everywhere in tropical region, villagers uses some techniques that are used from long back in their families. These methods are like their traditions. Rural India and Tribal peoples in India uses herbal techniques to repel mosquitoes, like burning cow dung cake, burning Neem leaves, using Citronella leaves oil, etc. as rural India is rich in these sources, and this can be a better source for their income and their development. For this purpose, the only problem is "How to use it?" the solution is use of proper machineries to develop products from the sources available with the required knowledge. But the available machineries are costly, heavy, required skilled operator etc. for this purpose manually operated mosquito coil making machine can play a small role in development of such areas. Their design is given as further.

2. MOSQUITO REPELLENT COIL MAKING MACHINES

Mosquito repellent coil making machine available in India are divided into two types,

1. Powered operated machine.
2. Manual operated machine.

Power operated mosquito repellent coil making machine works on different power sources such as electrical motors, hydraulic systems. These machines are complex in design and bulky in size and shape. These machine are manly used for high production or production in large scale. Manual operated mosquito repellent coil making machines are small in size and shape. They are used for low production or small quantity production. These machines works on human power either hand or pedal power. These machines are available in various designs such as rack-pinion with hand lever operated, or spring with hand lever operated, or crank operated, etc.

3. DESIGN OF MANUAL OPERATED MACHINE

By considering requirements of rural India, a machine is designed to manufacture mosquito repellent coils from mosquito repellent material. For manufacturing of mosquito coils, number of operations are required. These are-

- Dry blending
- Kneading
- Extruding
- Stamping
- Drying and Packaging

Out of all these operations, only stamping operation required special attention, while the other operations can be done manually and separately. So design of stamping machine with mosquito coil mold or die is important. Our machine consist of spring, lever, frame, and mosquito coil mold. Spring is used for both stamping stroke and return stroke. A punch rod is attach with spring at one end and die on the other.

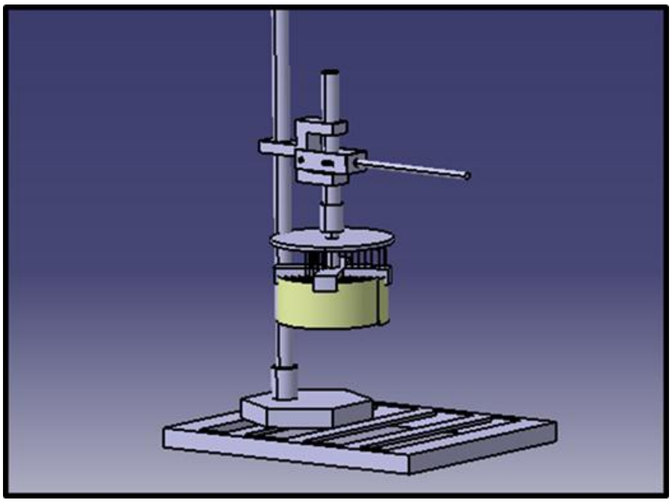

Fig -1: CATIA design of machine

A lever is used to move punch rod to downward position for stamping stroke and when released, energy stored due to stamping stroke used as an energy for return stroke. A stamping die is spiral coil shaped mold for spiral shape mosquito incense. A mosquito coil mold consists of cavities of spiral shape with ejecting coil mechanism for coil ejection. During stamping operation, mosquito incense material is filled in mold cavity, this has to eject in return stroke. Using ejecting plates in mold cavity, coil ejection is done smoothly. Another lever is used for pushing ejecting plate for coil ejection. Before design, we have taken some assumption for design, such as diameter of mosquito coil mold, and punch rod as 145mm and 18 mm. Shunt height is the distance between frame plate and the mold die cutting edge. This height represent stamping stoke length required to stamp mold on material.
Design of such machine is as –

I. Stamping force required to stamp coils in one operation is

Stamping force = shear strength of material× perimeter of area to be stamped

$$F = \%penetration \times \tau_s \times t \times L$$

Where L=arc length of spiral

Arc length of spiral is given by-
Outer diameter of spiral is 145mm, i.e. coil outer diameter will be 145mm.

$$l = \int_0^n \sqrt{r^2 + (\frac{dr}{d\theta})^2} d\theta$$

$$r = \alpha + \beta\theta$$

r = distance from the origin,
α= start point of the spiral,
β=affects distance between each arms.
The distance between each arm is

$$\frac{145 - 0}{4.25} = 34.12$$

$$\beta = \frac{34.12}{2\pi} = 5.43$$

n = end angle after 4.25 turns
$= 4.25 \times 2\pi = 8.5\pi$

Now,

$$r = 0 + 5.43\theta$$

Therefore,

$$l = 1948.16\ mm$$

Our mosquito coil mold consists of two spirals,

$$l_{total} = 3896mm$$

As our stock material is in dough state, considering shear strength of stock is 0.01MPa, and 98% penetration, with thickness of stock material is 3.5mm

$$F_{stamping} = 134N$$

II. Lever design

Considering human ergonomics to use hand lever machine both on standing position and on sitting position, best possible lever length is selected by taking number of trials on different machines and by inspection on existing manual machine operators. Using Class II lever, where load is in between fulcrum and effort. To get maximum Mechanical Advantage, and for safety factor, we design lever and machine for force greater than stamping force, assuming 200N. According to human ergonomics, maximum force applied or effort applied by average human by hand is 45N. Using this data-

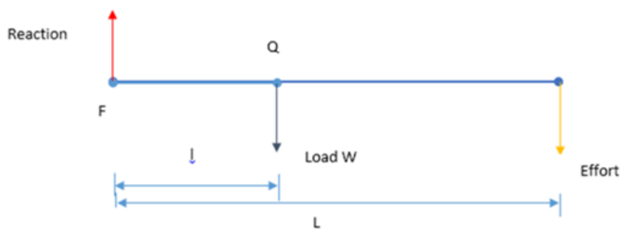

Fig -2: FBD of Lever

By principle of Moment at fulcrum,

$$\sum M_F = 0$$

$$W \times l + effort \times L = 0$$

$$leverage = \frac{L}{l} = -4.44$$

Here negative sign shows that direction of load is opposite in nature. So to take leverage of 4.44, length of lever selected is 240mm and load arm length is 55mm.
At point 'Q', load is acting on punch rod attached at Q, having diameter of 18 mm. so the compressive stress generated at point Q should be less than allowable compressive stress.

$$\sigma_c = \frac{force\ acting\ at\ Q}{cross\ sectional\ area} = \frac{200}{\pi/_4\ d^2} = 0.7859MPa$$

Material of punch rod attached at Q is C-10 hot rolled having Allowable compressive stress of 218MPa.

Therefore, $\sigma_c \lll \sigma_{c-allowable}$
Hence design is safe in compression.
Now, shear stress in pins at Q and F, taking pins of diameter 8mm of material SAE1035 having allowable shear stress is 367MPa
Pins at Q and F are in double shear,

$$\tau_Q = \frac{F_Q}{2A_Q} = 1.989MPa$$

And,

$$\tau_F = \frac{R_F}{2A_F} = 2.43MPa$$

As shear stress induced in pins are less than allowable shear strength, design of pins are safe in shear.

III. Design of spring

A helical spring is used for our design. For spring design, following data is important.
Minimum load acting on spring due to mold weight is 40N
Maximum load acting on spring due to leverage is 200N
Wahl's stress factor=1.15(assume)
Spring material is carbon steel
Design factor of safety is 1.25
Allowable yield stress in shear = 840MPa
Endurance stress in shear = 323MPa
With reference of Design Data book for Machine element by B.D.Shivalkar and Machine Design by R.S. Khurmi,

Spring Index C from Wal's stress factor,

$$K = \frac{4C-1}{4C-4} + \frac{0.615}{C} = 9.76$$

a. Spring Wire diameter,

d=D/C

Shear stress factor,

$$K_s = 1 + \frac{1}{2C} = 1.05$$

Mean load,

$$W_m = \frac{W_{max} + W_{min}}{2} = \frac{200+40}{2} = 120N$$

Variable load,

$$W_v = \frac{W_{max} - W_{min}}{2} = \frac{200-40}{2} = 80N$$

Mean shear stress,

$$\tau_m = K_s \times \frac{8W_m \times D}{\pi \times d^3} = \frac{3131.558}{d^2}$$

Variable shear stress,

$$\tau_v = K \times \frac{8W_v \times D}{\pi \times d^3} = \frac{228.65}{d^2}$$

$$\frac{1}{F.S.} = \frac{\tau_m - \tau_v}{\tau_y} + \frac{2\tau_v}{\tau_e}$$

$$d = 3.226mm$$

For better long life, spring selected is SWG10having standard wire diameter 3.251mm
$D = 3.251 \times 9.76 = 31.72mm = 32mm$

b. Maximum deflection needed to design spring is the stamping stroke length in our machine.

Taking 50mm,

$$\delta_{max} = \frac{8WD^3n}{Gd^4}$$

$$n = 8.5 \approx 8$$

Total number of turns for ground end spring is

$$n' = 8 + 2 = 10$$

c. Free length of spring

$$L_f = n'd + \delta_{max} + 0.15\delta_{max} = 90.01mm$$

d. Pitch of spring,

$$pitch = \frac{free\ length}{n'-1} = 10mm$$

e. Spring rate

$$k = \frac{Gd}{8C^3n} = 2.731\ {}^{N}/_{mm}$$

IV. Design of punch or stamping rod

f. Compressive stress in punch due to stamping material

$$\sigma_c = \frac{k \times L \times t \times \sigma_s}{A} = 0.525MPa \lll \sigma_{c-allowable}$$

Hence design is safe in compression and diameter of rod selected is safe.

g. Length of punch rod

Critical load on punch is

$$P_r = \frac{\pi^2 EI}{4L^2}$$

Where, E = Elastic limit =206GPa

$$I = \frac{\pi}{64}d^4 = \frac{\pi}{64} \times 18^4 = 5152.99mm^4$$

L=length of punch rod

$$L_{max} = 3269.64mm$$

L_{max} is the length of rod at which 200 N force is sufficient to start buckling, so length less than L_{max} should be safe in buckling. Considering ergonomics of human with machine, length of punch rod decided for better operation is

$$L_{punch\ rod} = 300mm$$

V. Design of Mosquito Coil Mold Die

Mosquito coil mold die consists of sheet metal bend into special shape having cavities for stamping coils. Mosquito coil mold is actually a type of steel rule die. Steel rule die is used for cutting material into shapes as desired. The main basic application of steel rule die is in bakeries for biscuits manufacturing.

Height of die block

$$H = 10 + 5T + 0.7\sqrt{d}$$

Where, T = material thickness,

d = total diameter of die =145mm

$$H = 10 + 5 \times 3.5 + 0.7\sqrt{145}$$

$$H = 35.9mm \approx 36mm$$

According to "Machineries Handbook" by Eric Oberg on steel-Rule die design, the rule material width is taken as height of rule. Standard height of rule is taken as 0.95", 1", 1.25", and 1.5" i.e. in metric form, 24.13mm, 25.4mm, 31.75mm, and 38.1mm.

Therefor height of die block taken as H=38.1mm

This die is fitted in die punch holder and ejecting plates are also fitted in cavities of mold die, so extra height is given for fitting purpose. Taking allowance of 22mm, total die block height is

$$H_{total} = H + 24 = 38.1 + 22 = 60.1mm$$

Steel rule die is made of sheet of steel or other material such as, in our condition, brass sheet, and standard thickness of rule taken maximum of 1mm as per "Machineries Handbook" by Eric Oberg on steel-Rule die design.

h. Bending stress in die block

$$\sigma_b = \frac{1.5 \times total\ load\ act}{H^2} \times \left(1 - \frac{2d}{3d_0}\right) \leq \sigma_{permissible}$$

$$\sigma_b = 0.2769MPa$$

As material of die block is brass, so from design data book, $\sigma_{permissible} = 47MPa$

Therefore, $\sigma_b \lll \sigma_{permissible}$

Therefore bending stress generated due to total load is smaller than permissible, so design is safe.

Fig -3: Coil Mold Cavity

Fig -4: Coil Ejecting Plate

4. RESULT AND DISCUSSION

Design of manual operated mosquito repellent coil manufacturing machine is done with simple and basic mechanism of spring and lever. Comparing with existing machines used for manufacturing of mosquito coils, we found that, machine is less in weight around 10kg while the existing manually operated machines weight is near about 50 to 60 kg, This machine is easy to operate. This machine is less costly than existing machines, manufacturing cost is Rs10000 only, while the cost of existing machine is near about Rs70000 Because of simple mechanism used, it requires very less maintenance. As easy to operate, unskilled operator or a simple person can use it easily.

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