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Design and Development of Coil Winding Machine

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ABSTRACT

The main objective of this project is to develop an automatic coil winding machine which can be used for various winding operations that will greatly reduce an effort behind the manually operated machines and to implement the idea of automation in coil winding machines. This method can also be used to reduce the manufacturing cost and also to increase the rate of productivity. This machine can be used to wind coils of wires pertaining to any limited gauge. Firstly, the manual methods of winding were in practice and this method proved to be very tedious and the time required for winding was more. Hence, it was necessary to make some revolutionary changes in the field of winding. The components produced by this method have good strength to weight ratio and is also cost effective. Manual wire winding had to be a conventional way earlier but it lacked in accuracy as the wire used to be either loose or tight; hence it was need for a machine to be manufactured for greater accuracy at a small scale level. This winding machine is easy to use and it is also portable.

Keywords: Design of Bearing, Design of Belt, Design of Pulley, Design of Shaft, Coil Winding Machine.

I.INTRODUCTION

A manual winding machine usually has a core on a spindle and the user feeds wire, rope, or other material onto the core. The user controls the spindle speed and feeds the material through user hand, guiding it to control the tension and load pattern.

A coil winding machine is a machine for winding coil onto a spool, bobbin and many more. This coil winding machine is one of types of winding machine that available in industries today. The coil winders can be classified according to their speed levels and capacity. From multi speeded machines to medium, large and extra-large machines, these machines come in various types and categories, performing a range function. The common applications for a coil winding machine are to wind coils for transformer, inductors, motor and chokes. Coil winding machine design is dictated by a coil's complexity, material tension limitations, machine versatilities, and automation / operator intervention, production volume and budgetary considerations.

II.PROBLEM DEFINITION

To complete a coil manually will be of great inconvenience and waste of time. Furthermore, to have a good quality of automatic coil winding machine requires expensive tools and it is not so user-friendly. Therefore, fabrication of coil winding machine will be done in this project which is controlled by a simple motor arrangement also adjoining to this we are going to use counter and proximity sensor also guide way's. This machine is inexpensive, easy to operate and build in a small-scale size. This project also can be used for training students in winding of different types of stator.

III OBJECTIVES

- Optimized machine.
- Low maintenance cost.
- The machine should be universally applicable to all gauges of wires.
- Fast cycle time & higher accuracy

IV VARIOUS PARTS OF COIL WINDING MACHINE

The Coil winding machine consists of the following parts,

- Motor

Single - Phase Commutator MotorMake: Samarth230 Volts, 50 Hz,

Power = 0.5hp (0.373 Kw)Speed = 0-1400rpmCurrent = 1.70 Amp.

- Pulleys

The pulley used is a standard FZ section pulley selected as per the belt. The pulley acts as a transmission pulley.

- Main shaft
- Bearing housing
- Ball bearing.
- Body cover
- Die holder
- Stator holder
- Die
- Belt
- Frame
- Teflon paper
- Stator adjustment
- L - type bracket
- Load adjuster
- Brass nozzle
- Motorbase

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V.DESIGN OF VARIOUS COMPONENTS OF THE MACHINE

5.1 INPUT DATA OF THE MOTOR[5]

INPUT POWER = 0.5 hp (373 Watt)

MOTOR SPEED = 0 - 1400 rpm

TORQUE = 2544.205 N-mm

5.2 DESIGN OF PULLEYS

PROPERTIES:

MATERIAL SELECTION: ALUMINIUM / 6061[5]

FOR LARGE PULLEY

Outer diameter of the pulley (D) = 90 mm

Inner diameter of the pulley (D_i) = 17 mm

FOR SMALL PULLEY

Outer diameter of the pulley (d) = 44 mm

Inner diameter of the pulley (d_i) = 13 mm

5.3 DESIGN OF BELT[4][5]

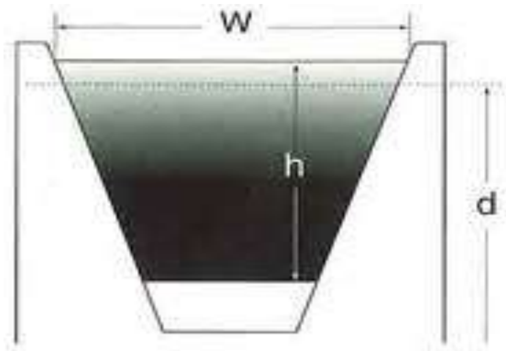

Fig. 5.3.1 V Belt Nomenclature

Considering the **Tensile strength** to be **800N/mm^2** Also the groove angle (2β) = 38°[5]

Hence,

F_{t1} = 800N/mm^2(Where, F_{t1}= Tensile strength acting on the belt)

5.3.1 Cross sectional area of the belt is (A) = 0.5 x (a + b) h

= 0.5 x (7 + 4) x 10

= 55 mm^2

5.3.2 Mass per unit length of the belt (m) =(density x A) / 10^6

= (1370 x 55) / 10^6

= 0.7535 kg/m

5.3.3 Centrifugal tension (F_c) = mV^2

= 0.07535 x (6.5973)

= 3.2752 N/m^2

5.3.4Power transmitted per belt(F_1) = F_{t1} - F_c

= 800 – 3.2752

= 796.72 N

5.3.5 $\alpha = \left(\sin^{-1} \frac{(D - d)}{2C2 \times 134} \right) = \quad \sin^{-1} \left(\frac{(90 - 44)}{} \right) = \alpha$ **= 0.1724°**

5.3.6 $\Theta = \pi - 2A = \pi - (2 \times 0.1724) = \mathbf{\Theta = 2.7968^o}$

5.3.7 $\frac{F_1}{F_2} = e^{\mu,\Theta}$

$= e^{\mu'\Theta/\sin\beta}$

$= e^{0.25x2.7968c / \sin 19}$

F_2 = 371.08 N

5.3.8 $P_1 = \frac{(F_1 - F_2) \times V}{1000} = \mathbf{P_1 = 2.808\ Kw}$

5.4 DESIGN OF SHAFT[5]

5.4.1 Material selection of shaft

EN36 (13Ni3Cr80) material (Hardened and tempered steel material) [4] [5]

Tensile Strength (S_{ut}) = 800N/mm^2

Yield Strength (S_{yt}) = 680N/mm^2

Assume length of shaft = 200mm

5.4.2 $\eta_{all} = 0.3\ S_{ut}$

= 204N/mm^2

5.4.3 $\eta_{all} = 0.18\ S_{yt}$

= 144N/mm^2

We will take the minimum of both the values,

Therefore, $\mathbf{\eta_{all} = 144N/mm^2}$

5.4.4 Now,According to ASME code,

This value will get reduced by 25% due to keyway effect,

Hence, $\eta_{all} = 0.75 \times 144$

=108N/mm^2

5.4.5 Now,Power transmitted by the shaft is given by,

$$P = \frac{2 \times \pi \times N \times T}{60 \times 1000}$$

But, P = 373Watt

Therefore, $373 = \frac{2 \times \pi \times 684 \times T}{60 \times 1000}$

T = 5207.438 N/mm^2

5.4.6 Bending moment diagram of shaft [4][5]

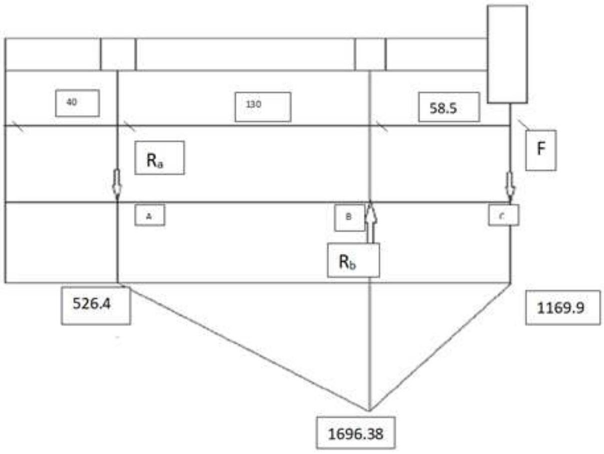

Fig. 5.4.1 Bending moment diagram of shaft

$-R_a \times 130 + F_t \times 58.5 = 0$

$-R_a \times 130 + 1169.92 \times 58.5 = 0$

Therefore , $\mathbf{R_a = 526.46}$ **N**

5.4.7 Now, $\sum F = 0$

Therefore, $-R_a + R_b - 1169.92 = 0$

$-526.464 + R_b - 1169.92 = 0$

Hence, $\mathbf{R_b = 1696.38}$ **N**

5.4.8 Bending moment at point B; $M_b = F_t \times 58.5$

$\mathbf{M_b = 68440.729}$ **N-mm**

Also,Maximum bending moment

$\mathbf{M_b = 68440.729}$ **N-mm**

5.4.9 $T_e = \sqrt{((K_b \times M_b)^2 + (K_t \times T)^2)}$

Where,

K_t = Combined shock and fatigue factor for torsion

K_b = Combined shock and fatigue factor for bending

$= \sqrt{((1.5 \times 68440.729)^2 + (1.0 \times 5207.43)^2)}$

= **102793.087 N-mm**

5.4.10 $\eta_{max} = \dfrac{16 \times T_e}{\Pi \times d^3}$

Therefore, $108 = \dfrac{16 \times 102793.087}{\Pi \times d^3}$

Hence, **d = 16.92 mm~ 17 mm**

5.5 DESIGN OF KEY[5]

5.5.1 The material selected for key is the same as that of shaft.

Hence, Material for key is : EN36 (13Ni3Cr80) material (Hardened and tempered steel material) [5]

Tensile Strength (S_{ut}) = 800N/mm^2

Yield Strength (S_{yt}) = 680N/mm^2

5.5.2 **CALCULATIONS**[5]

5.5.3Allowable shear stress **(τ_{all})** = 144 N/mm^2

Therefore,Crushing stress (σ_c) = 2 x τ_{all}

= 2 x 144

σ_c = 288 N/mm^2

Square key is selected as per the conditions available,

5.5.4 Hence, b = h = d/4

b = h = d/4

= 17/4

b = h = 4.25 mm

Considering crushing of the key,

5.5.5Therefore, $\sigma_c = \dfrac{4 \text{ x } T}{d \text{ x } h \text{ x } l}$

$288 = \dfrac{4 \text{ x } 5207.43}{17 \text{ x } 4 \text{ x } l}$

l = 1.06 mm

5.5.6Considering shear of key,

$\tau_d = \dfrac{4 \text{ x } T}{d \text{ x } b \text{ x } l}$

$144 = \dfrac{4 \text{ x } 5207.43}{17 \text{ x } 4 \text{ x } l}$

l = 2.1272 mm

5.5.7 Also,l = 1.5 x d

l = 1.5 x 17

l = 25.5 mm

5.5.8 Selecting larger value of length from the above three dimensions,

Therefore ,l **= 25.5 mm**

Key dimensions are as follows:

b = 4.25 mm, h = 4.25 mm, l = 25.5 mm.

5.6 DESIGN OF BEARING

5.6.1 The machine which we are going to use is approximately used for 8hrs / day and it is fully utilized.

Hence, rating life for the bearing is chosen as 25000hrs.[5]

Load factor (K_a) = 1.25

Equivalent dynamic load at bearing (F_{rb}) = 1696.384 N

5.6.2 Assuming, outer race is constant and inner race is rotating, [5]

i.e. V=1

5.6.3 Assuming,X = 1 ; Y = 0

$P_{eA} = X \times V \times F_{rB} \times K_a$

$= 1 \times 1 \times 1696.384 \times 1.25$

P_{eA} = 2120.48 N

5.6.4 Now, $C_A = (L_{10})^{1/a} \times P_{eA}$[5]

We are using ball bearing,Therefore,a = 3

$$L_{10} = \frac{L_{h10} \times 60 \times N}{10^6}$$

$$L_{10} = \frac{25000 \times 60 \times 684}{10^6}$$

L_{10} = 1026 million revolutions

5.5.5 $C_A = (L_{10})^{1/a} \times P_{eA}$

$= (1026)^{1/3} \times 2120.48$

C_A = 725204.16 N

Therefore, Accordingly Bearing selected for shaft is “6403” at point B [5]

Hence,d = 17 mm

D = 62 mm

B = 17 mm

C = 22900 N

C_0 = 11800 N

VI.ADVANTAGES

- Same die can be used for different sizes of stator
- Assembling &disassembling is easy
- Space required is less
- Skill worker not required
- Portable
- Cost is less
- Production is easy
- More production in less time

VII.APPLICATION

- Stator winding of different types of ceiling fans
- Winding coils of table fans
- Winding coils of pumps

VIII.CONCLUSION

From the above study related to the designing of the components of the coil widening machine we have studied that the machine we are going to manufacture will fulfill the requirements like reduced cost of production of the coils, increase in efficiency and the accuracy of the coil windings also reduce the human labour.

We have learnt the various parameters required for the designing of a machine and its components. We have also studied about the various properties of materials that are used in the project uptill now. We have also learnt about the drafting of the design required on CATIA software. The various parts to be used in the manufacturing of the machine are considered.

We have also studied much about the industry and how all the working processes are carried out in any of the industry. Various problems occurred during the design were rectified by the guide at the industry.

The machine will save a lot of time required for winding the coils manually. It may also increase the productivity and also improve the quality of the coils to be wound. Hence we studied that the machine which we are going to design is of grrat use in industrial and household applications.

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