DESIGN AND ANALYSIS OF FLOOR MOPPING MACHINE

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ABSTRACT

With the advancement of technology, manual floor cleaning machines are getting more attention of researchers to make life of mankind comfortable. The concept is developing in economic countries but the reasons for non-popularity is the design complexity, cost of machines, and operational charges in terms of power tariff. In this paper, a floor cleaning machine is proposed. This is capable of performing cleaning of floor and corners effectively, semi-automatic water spray, cleaning of byre, dry as well as wet cleaning tasks. This floor cleaning machine is designed by keeping the basic considerations for machine and operational cost reduction, efforts reduction, environment friendly and easy handling. The machine will work on electricity. This work can be very useful to improve the life style of mankind.

Key words: *Design, Manufacturing, Power efficient.*

1. INTRODUCTION

Manual machines available in the market are of high ranges and high weights. So, keeping the focus on weight as well as cost, they are affordable to all such as organization committee of hotels, hospitals, hostels. Hence, there is need to design and develop a floor cleaning machine which is multi use and cost effective. In some places such as bus stations, temple halls, byres the floors are not regularly cleaned due to non-availability of machines. There is no machine in the markets which can be used on smooth as well as rough surface floors. Considering weight criteria, machine assembly, handling the machine is very flexible. This machine is affordable to all because of its uses and cost. Main mottos of research are: 1. To reduce the human efforts. 2. To increase the effectiveness of cleaning the floors..

2. MATERIALS AND METHODOLOGY

Table -1: Materials

Sr. no.	Part name	Material	Specifications
1	Chassis		
2	Shaft	Mild steel	
3	Pulley	IS:432- 1989	Hardness-130 BHN
4	Tank	Mild steel	
5	Bolts	B.S.10720.1983	
6	Bracket		
7	Bearings	AISI52100 (CROME STEEL)	Hardness-325 to 375 BHN
8	Belt	3 Ply fabric rubber	Operating speed-300m/s Coefficient of friction-0.3 to 0.6

For this machine speed reduction by belt and pulley mechanism is used. Later 3D modelling and simulation was carried out using CATIA software. The CATIA tool is used to determine the basic structure of machine, weight, working visualization of machine. Then to clean the floors, sponge is fixed by nut and bolts into the bracket. In case of cleaning of byres brushes are fixed. The bracket is fixed onto the shaft. 5 kg load is applied onto the bracket so that while revolving it sponge will rub the floor very cleanly. Considering Ergonomics position of handle is fixed. To ease of operation 1 switch is provided on the handle. Almost for the all parts of machine Mild steel is chosen. It is also beneficial in terms of cost and availability.

This machine is simply operated by pushing or pulling the handle with less effort as heavy load wheels are provided. It is mainly designed to clean the Educational institutes, malls, hostels, colleges, byre, hotels so that hectic work of sweepers can be reduced to great extent.

2.1 BODY PARTS

Motor

1 HP, 230 V, 2.5A, 1440 RPM Induction motor is used. It gives sufficient torque at 360 RPM which is required to rotate the bracket loaded by 5 kg. Basically there is torque requirement of 16 N-M to revolve the bracket without getting any load. This motor gives torque of 19 N-M at the speed of 360 RPM.

Speed Reduction Step

In this part a pulley of 2" is fixed to the motor shaft and another pulley of 8" is fixed on the main shaft. Also on this shaft a bracket is fixed.

Main Shaft

The shaft on which bigger pulley is fixed is called main shaft. Also on this shaft bracket is mounted. So as shaft rotates the bracket also rotates with same speed.

Bracket

It is clamping of cleaning material. There are 2 such brackets. On the first bracket sponge is clamped and on the other bracket brushes are clamped with the help of nut and bolts.

Tank

It stores the water in it. While doing wet cleaning it provides water as per the requirement.

Switch Board

It is fixed onto the handle. It is used to start and stop the machine as per operator's wish.

Telescopic Arm

It's a front part of machine on which small DC motor of 350 RPM, 24 v DC, High torque motor is mounted to revolve smaller sponge bracket. This functional arm is specifically used to clean corners and area beneath cupboard, cot, etc.

Wheels

Here 4" fibre wheels are used. Their load carrying capacity is around 100 kg. Rubber is wounded on their periphery for avoiding slippage.

Frame

It is a Main part of machine which holds all other parts on it. It is made up of mild steel because is satisfies all the conditions required. Also it is easily available in the market.

2.2 WORKING

2.2.1 Principle

Speed and torque are inversely proportional to each other. That means if speed gets reduces, then torque gets increased so as to get same power output.

2.2.2 Working

Torque required to revolve the bracket is about16 N-M. Motor gives 4.94 N-M at 1440 RPM. A smaller pulley is fixed on the motor shaft and bigger pulley is fixed on the main shaft so that speed is reduced to 360 RPM and torque is increased up to 19 N-M. Hence motor will run without getting any load on it.

3. DESIGN CALCULATIONS

Torque requirement and selection of motor

Coefficient of friction in between sponge/ brush and floor = 0.8

Load on the bracket =5 kg and diameter of bracket=40 cm

Torque required= F x R = (0.8 x 5 x 9.81) x 0.4 = 16.87 N –M

Formula P= 2πNT / 60

Where, P= Power N= Speed in RPM

T = Torque 1 hp motor torque = 4.94 N-M at 1440 RPM.

Then at 360 RPM Torque will be19.78 N-M.

Hence, here 1 hp motor at 360 RPM can be used.

Selection of Belt

Smaller pulley =2”

=5.08 cm

Bigger pulley = 8”

= 20.32 cm

Centre distance (C) = 28 cm

Formula for length of belt = 2C + π (D + d)/2 + ((D-d) *(D-d)) / 4C

Where, D= Diameter of bigger pulley, d= Diameter of smaller pulley

Hence, Length of belt is = 97.97 cm

Referring the table no.13.24 from the book ‘Design of Machine Elements’ by V. B. Bhandari, we select belt A-39.

(Width=13 mm, Thickness = 8 mm) 5.3.

Selection of Bearing Radial force (Fr) = 97.33 N

Axial force (Fa) = (weight of shaft and pulley) x 9.81

= 2 x 9.81

= 19.62 N

Effective force (P) = X.Fr + Y. Fa

Let X = 0.56 and Y = 1.5

Hence effective force (P) = 83.93 N

Life in million revolutions (L10) = (60 x N x life in hours) / 1 million

= (60 x 360 x 30000) / 1 million

= 648 Dynamic load carrying capacity(C)

= effective force x $10^{0.333}$=726.28 N.

Referring the table no.15.5 from the book 'Design of Machine Elements' by V. B. Bhandari.

We can select bearing 61802 which is having following,

C =1560 N,

static load carrying capacity (CO) = 815 N

Fa/CO =0.025 and

Fa/ Fr =0.2015 after taking reference from the table 15.5 from B. Bhandari book, Fa/Fr ≤ e. Hence, from same table 15.5 Type equation here.

take X = 1 and Y = 0

Effective load = 97.33 N C

= 97.33 x $640^{0.33}$

= 842.24 < 1560 N

Hence, for 15 mm diameter bearing with designation 61802 can be used.

Selection of Bolts at figure 1,

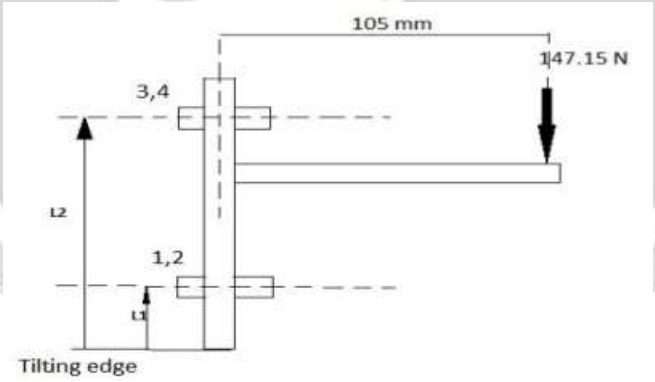

Fig -1: Bolt arrangement

Bolts arrangement Basically the force has two effects at the cross section namely primary and secondary effect.

Primary Effect

Let P1, P2, P3, P4 are the primary forces acting on the bolts.

P1 = P2 = P3 = P4 = P/4 =36.78 N.

Secondary Effect

Ps1 α L1, Ps3 α L2,

Hence, Ps1 = C x L1, Ps2 = C x L2 Similarly for Ps3 and Ps4.

C = (P x L) / ($L1^2 \times L2^2 \times L3^2 \times L4^2$)

= 1.136 N/mm

Hence, Ps1 = C x L1 = 22.72 N and

Ps3 = C x L2 = 90.88 N.

Farthest bolt from tilting edge shall be most stressed.

Design of Main Shaft

Basically the main shaft is vertical. Hence there will not be any bending force.

But because of its weight and torque applied by motor axial forces will be there.

According to maximum shear stress theory,

$(\text{Maximum shear stress})^2 = \{(16M) / (\pi d^3)\}^2 + \{(16T) / (\pi d^3)\}^2$

Since bending moment is zero,

we can get $(Maximum\ shear\ stress)^2 = \{(16T) / (\pi d^3)\}^2$……... (C)

Where, M = Bending moment,

T = Torsion moment = 19.778 N-M

Maximum shear stress = (0.5 x shear yield strength) / Factor of safety (FOS).

(D) Shear yield strength for mild steel = 380 N/mm^2.

Also we take FOS =2 here. ..(E)

Put all the values from equations D and E into C,

We get, diameter of the shaft = 11.7558 mm.

Hence we used 15 mm standard bar.

Hence, length of this bar is taken as 230 mm so that all assembly can be done.

Design of Frame

In figure, RA and RB are the reactions given by frame. The motor weight is 15 kg.

So, 15 * 9.81 = 147.15 N

force will act on beam whose diameter is to be found.

RA + RB =147.15 N

Taking moment at RA,

we get (147.15 * .220) + 15.45

= (RB * 0.480) RA

= 66.42 N,

RB = 31.679 N ……. …. (G)

After taking the bending moments at various points we can recognize that point at which load is acting has maximum bending moment = 31.88 N-m. … (H)

By formula, (Bending moment)/ (MI) = (bending strength of mild steel/Y) …… (J)

Where, Y = distance between neutral axis to the outermost fibre

= diameter/2

MI= (π *$diameter^2$) / 64,

bending strength = 480 n/mm^2

Put all the values in the equation (J)

we get, Diameter = 10.49 mm.

Hence, here we can take 16 mm standard rod which is easily available in the market.

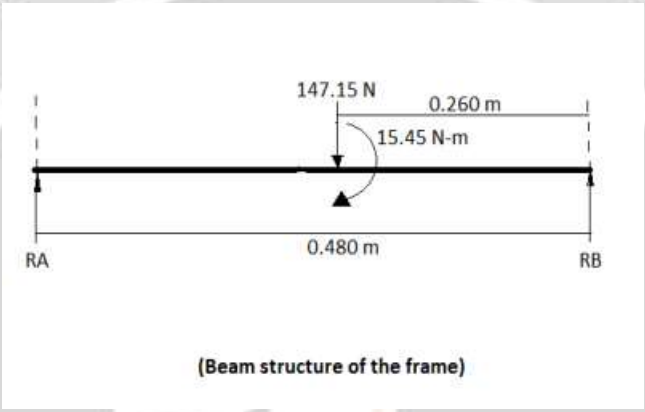

Fig -2: Beam structure of the frame

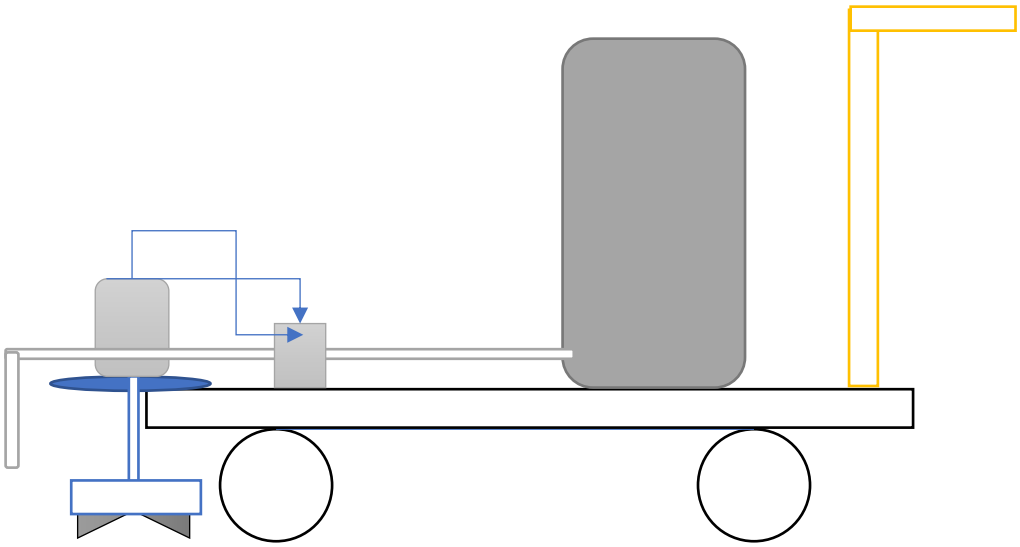

Fig -3: model

4. ADVANTAGES

- Number of cleaning tasks can be done with less cost.
- User friendly, requires less human efforts.
- Less maintenance.
- Every part is bolted, hence it has more flexibility.
- One machine can do dry cleaning, wet cleaning, byre cleaning or any rough surface cleaning.

5. CONCLUSION

Multi -use floor cleaning machine is designed and manufactured using A.C. induction Motor and speed reduction mechanism. Manufactured machine is flexible and effortlessly operated. Effective power given to the bracket does number of cleaning tasks. The need of this project is satisfied and with the help of machine, cleaning of the floor can be done easily.

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