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Smart Treadmill Machine

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Abstract: *This paper deals with the modification of conventional treadmill which is present in the market. Treadmills which are developed in ancient time were large in size and we do not carry with us. So, we design such Smart treadmill which is foldable and portable. We design frame of that treadmill which having three parts, known as base plates of treadmill. In that one base plate is going to fold on other with the help of hinge connection and both folding base plates of frame going to slide over other plate through provided channels by sliding mechanism. The design consists of 2 HP DC motor, two rollers, locking brackets, side brackets, shaft, bearing and treadmill belt. Our main objective is to overcome all disadvantages present in the conventional treadmill with reducing its size, making portable and reducing large space requirement problem of the society. Hence our smart treadmill is perfect for today's smart homes which having requirement of compact equipment.*

Keywords: *Smart Treadmill, Foldable, Portable, Locking Brackets, Side Brackets, Base Plate, DC Motor, Hinge connection, Sliding mechanism.*

I. Introduction

I.1 Introduction about Treadmill

The conventional treadmills consist of running deck on which human is running, who adapts to adjustable speed of belt. The running deck is usually mounted on damping elements, so the running deck has shock absorbing characteristics. By a lifting element, the entire frame including treadmill running deck will be raised and thus simulates a pitch angle for uphill running. Most treadmills for professionals in the fitness area, run for table size of about 150 cm long and 50 cm width, a speed range of about 0 to 20 km/h and slope of 0 to 20%. This is all about conventional treadmills and for athletes, larger and more stable treadmills are necessary. Sprinters reach with some weight relief temporarily speeds up to 45 km/h must therefore run on a large deck of up to 300 cm in length and have up to 100 cm width

As we know that population of India is growing so rapidly with the increasing people health issues are arising in society, according to survey India has over 50 million people suffering from heart-related issues, giving it the number one rank of heart patients in the world. If these rates continue to raise the number will soon reach to 70 million and more. People can afford having training machines at home but due less space they can't. Most of the training machines are so bulky and space consuming that it's not possible to keep them in home as once you done with exercise machine will be still there and consume unwanted space to stop this, we are introducing foldable treadmill machine.

The design of our Smart treadmill consists of Mild steel (M.S) frame which having three parts namely three Base plates. For the folding of one base plate over other base plate is with the help of folding mechanism by using hinge connection, these hinges are also made of mild steel material. We are using mild steel material because of its good properties which are needed to our project such as hardness, high strength, durability, ductility and having less cost as compared to other material. Both the base plates are going to slide on other base plate with help of channels using sliding mechanism. Initially, the size of frame of treadmill is 70 cm width and 130 cm long and after folding it becomes a single rectangle shape structure which is compact in design. On that frame conveyor belt is mounted for running purpose which made of PVC rubber. The material selection for belt is PVC due to its low coefficient of friction which is necessary while running, that the human which run on that treadmill, does not slip over on it. To run the belt 2 HP DC motor is used. In this way, we make such kind of treadmill which is compact in size while close it and gets larger portion for running while open it. Such kind of small and portable treadmill will be perfect for smart homes. Hence this treadmill is known as smart treadmill which having smart features.

I.2 Problem Statement

In India the population is growing so fast because of that availability of space is very low which is demanding to develop small and compact machines. As we know treadmill machines are very bulky and space consuming, people can't utilize it in home because it consumes large amount of space.

- In our day today life, it is necessary to make treadmill machine portable.
- For the above purpose it is must to make that treadmill compact and lighter in weight.
- To reduce the area requirement, this is occupied by the Treadmill.

I.3 Objectives

- To reduce the size and weight of machine.
- To optimise the design of conventional treadmill machine and make it foldable.
- To understand the construction and working Smart Treadmill.
- Modify the design of treadmill with respect to material properties, performance of the treadmill as well as future scope.
- Analyse the modified result with respect to existing result of the treadmill.

II. Component Description

II.1 The main Components of Smart Treadmill

1) Base Plate
2) Base Frame
3) Hinge Connection
4) Channels
5) Side Bracket
6) Locking Bracket
7) Channels

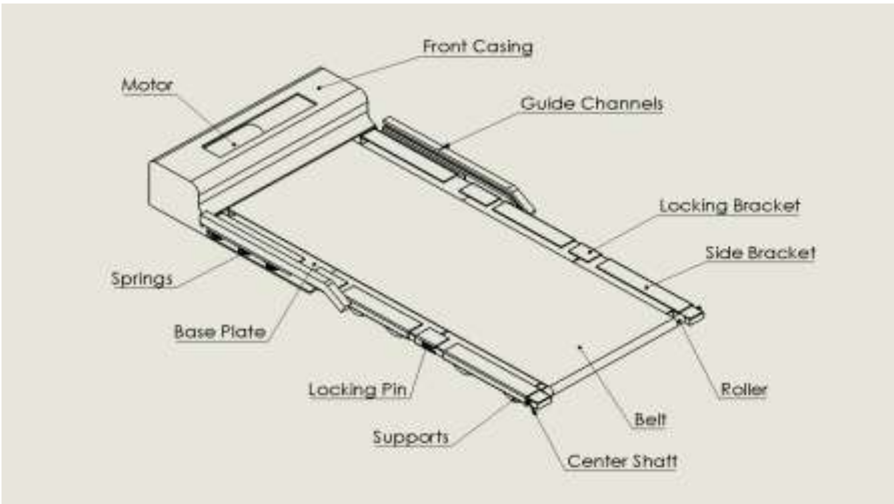

Fig 1: Components of Treadmill

II.2 Working of Treadmill

The design of our Smart Treadmill consists of base frame which having three base plates. The one Base plate is fold over another base plate with the help folding mechanism. This folding mechanism is done with the help of providing hinge connections by hinge pin. Both the base plates are slide over another base plate by using sliding mechanism through channels.

The CAD models of three base plates of frame are shown below:

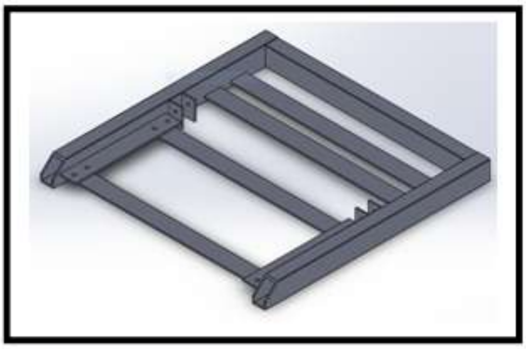

Fig 2: Base Plate No.1

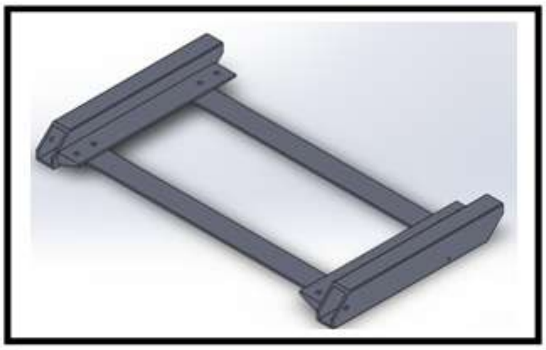

Fig 3: Base Plate No. 2

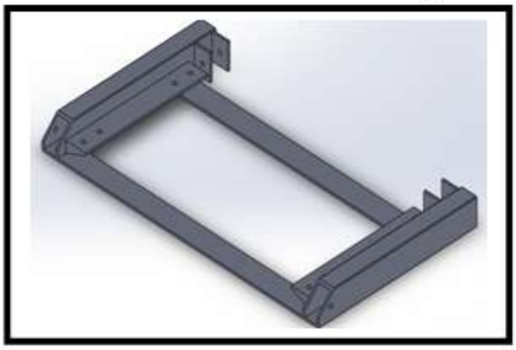

Fig 4: Base Plate No. 3

The front roller and rare roller are mounted at start and end of the assembly of Frame. On that rollers Belt is mounted and that belt rolls over that rollers when power is supplied. Power is supplied through DC motor which is attached to the whole assembly through conveyor. In this way, when power is supplied the rollers gets rotational motion and the rolling action of rollers is takes place. Due to the rolling action, Belt starts running over it with appropriate tension. This is the mechanism of our Smart Treadmill.

Initially, the size of frame of treadmill is 130cm long and 70 cm width but after folding and sliding mechanism it becomes rectangle shape having dimension 67cm long and 70cm wide. This structure is looking like rectangular box which acquires less space when gets close after the use of treadmill. When it will open came in previous size and due to this user gets usable area for running. So, this is our compact, foldable and becomes portable Smart treadmill after getting close it. Which overcomes all the disadvantages of conventional treadmills.

Fig 5: Assembly of Base Frame

III. Calculations

III.1 Design of Shaft

Material: Medium carbon steel
Designation: C45
Condition: Tubes, Cold drawn and Tempered
Properties:
i) Yield Tensile Strength (Syt) = 600 N/mm^2
ii) Ultimate Tensile Strength (Sut) = 700 N/mm^2
Maximum allowable load = 150Kg = 1471.5N
Length of Shaft = 610mm

Uniformly Distributed Load, UDL = 1471.5/0.610 = 2.412KN/m
Consider Simply supported load,

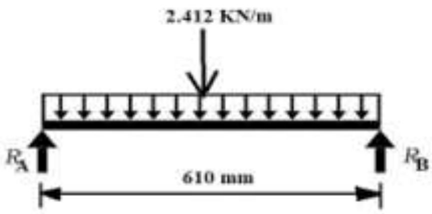

Fig 6: Load on Shaft

Tp = 0.3 Syt

where Tp = permissible shear stress

Hence, Tp = 0.3*600 = 180 N/mm^2

and Tp = 0.18 Sut = 0.18*700

Tp = 126 N/mm^2

Taking smaller value from both,

i.e Tp = 126 N/mm

Assume Kb = 1 and Kt = 1

Hence, $P = \frac{2\pi NT}{60\times10^6}$

$1.5 = 2\pi*1500*T/ 60*10^6$

T = 9549.29 N-mm

Now,

Mmax = UDL*Total length*Length/2

Mmax = (2.412*610) *305

Mmax = 448752 N-mm

As Per ASME Code:

$Tp = \frac{16}{\pi d^3}\sqrt{(Kb * M)^2 + (Kt * T)^2}$

$d^3 = \frac{16}{\pi * Tp}\sqrt{(Kb * M)^2 + (kT * T)^2}$

$d^3 = \frac{16}{\pi * 126}\sqrt{(448752 * 1)^2 + (9549.29 *)^2}$

d^3 = 18142.79

d = 24.27, approximately d = 25mm

Hence, diameter of shaft = 25mm

III.2 Design and Selection of Bearing

Equivalent Dynamic load is given by,

P = X*Fr + Y*Fa

where, P = Equivalent dynamic load factor

Fr = Radial Load

Fa = Axial Load

X = Radial Load Factor

Y = Axial Load Factor

Fr = 150*9.81/4 = 735.75

The bearing is subjected to pure bearing load,

Hence, P = 1.2*Fr = 1.2*735.75

P = 882.9 N

Bearing Life (L_{10}):

L_{10h} =16000

$L_{10} = 60*n*L_{10h} /10^6$

where, n = Speed of Rotation

L_{10h} = Rated Bearing Life

L_{10} = Bearing life

Hence, $L_{10} = 60*1500*16000 /10^6$

L_{10} = 1440 milli. Revolution

Dynamic Load Capacity (C):

$C = P* (L_{10h})^{(1/3)}$

$C = P* (1440)^{(1/3)}$

$C = 882.9* (1440)^{(1/3)}$

C = 9970 N

From V. B Bhandari table, no 15.5,

Bearing 6005 is selected with D_i = 25mm, D_o = 47mm and B = 12mm

III.3 Design of Roller

The outer diameter of bearing is equal to inner diameter of roller as the roller mounted on bearing.

Hence, D_i = Inner diameter of Roller = 47mm

To Find Outer diameter of Roller:

Bending Stress, $\sigma_B = 32*Mb/ \pi*(D_o^3 – D_i^3)$

$(D_o^3 – D_i^3) = 32*448752/ (300* \pi)$

$(D_o^3 – D_i^3) = 15236.50$

$(D_o – 47) = \sqrt[3]{15236.50}$

D_o = 72mm

III.4 Design and Selection of Belt

P = 1.5KW

Load Correction Factor = 1.2

Maximum Power = 1.2* 1.5 = 1.8KW

$\alpha_s = 180- Sin^{-1} (D-d) / 2*C$

$\alpha_s = 180^0$

Arc of Contact factor (Fd) =1

Power Corrected = (P_{max})* Fd

= 1.8*1

Power Corrected = 1.8KW

Assume n = 120rpm not 1500rpm as human being run on the belt, to measure velocity;

Belt Velocity is given by,

$v = \pi*d*n/ (60*10^3)$

$v = \pi*72*120 / (60*10^3)$

v = 0.4523 m/sec

Corrected KW Rating = (0.0118*0.4523) / 5.08

Corrected KW Rating = $1.0508*10^{-3}$

Width* Plies = Corrected Power / Corrected Belt Rating

Width* Plies = 1.8 / $1.0508*10^{-3}$

Width* Plies = 1712.93mm

Width = 1712.93/ 4

Width = 428.23mm

Width (W) = 42.82cm, approximately = 43cm

Length of Belt is given by,

$L = 2c + (\pi* (D + d))/2 + (D – d)^2/4*c$

$L = 2*1200 + (\pi*(72+47))/2 + (72 – 47)^2/4*1200$

L = 2587.05mm = 258.705cm

L = 2.5805m

Tension in Belt:

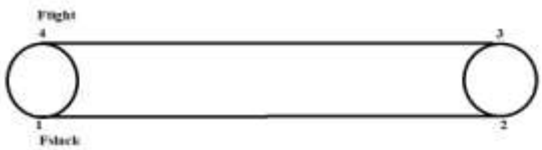

Fig 7: Tension on Belt

At point 1,

F_{Slack} = F1

At point 2,

F_{slack} = F1= F2

At point 3,

F_{slack} = F1 = F2 = F3

At point 4,

$F_{tight} = F_{slack}$ + (Weight of Belt + Weight of human) * λ* g

$F_{tight} = F_{slack} + (W_B + W_H) * \lambda * g$

$F_{tight} = F_{slack}$ + (3 + 150) *2.580*9.81

$F_{tight} = (F_{slack}$ +3872.399) N……………(1)

Now,

$F_{tight} / F_{slack} = e^{\mu * \theta}$

μ=0.085…….For PVC Rubber Belt

$\theta = 180^0$

Hence, $F_{tight} / F_{slack} = e^{0.085*\pi}$

$F_{tight} = F_{slack} * e^{0.085*\pi}$………(2)

Put the equation (2) in equation (1) then we get,

$F_{slack} * e^{0.085*\pi} = F_{slack}$ +3872.399

F_{slack} *6.840 = F_{slack} + 3872.399

F_{slack} = 663.08

F_{tight} = 4535.47

IV. Result

Sr. No.	Components	Dimensions	Material
1	Shaft	d= 25mm	C45
2	Bearing	Bearing 6005 selected (Deep groove Ball bearing) Di= 25mm, Do= 47mm	Chrome Steel
3	Roller	Di=47mm Do= 72mm	Chrome Steel
4	Belt	L= 2587.05mm W= 430mm	PVC Rubber

V. Future Scope

Future homes are going to be smart and small so conventional bulky machines will not fit into them so we need to switch to smart machines with time. This Treadmill machine will be perfect fit for the future homes. In future treadmill can be smart also by connecting it with smart phones. Smart phone will be the controller and it can control speed and time to stop machine etc. features.

VI. Conclusion

As we know that traditional machines consume more space than new smart machines, due to less space we need to switch to smart machines. If we want to keep the work going in same availability of space so our group designed such treadmill machine which is compact, foldable and lighter in weight so it will be easy to move, use and store. Our main focused on making it foldable so it will be suitable for small houses and we have achieved our main objective of our project. Using alternate material reduced a cost a bit. Hence, we are calling it as Smart Treadmill due to its advance features.

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