Design and Fabrication of Power Generating Manual Treadmill

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Abstract – *In today's world due to ever increasing health consciousness and fitness the idea of building manual treadmill arises with some extra modification in the existing treadmill and with this, effort loss during exercise is also used for purpose of generation of electricity including a controller display circuit for showing parameters like timer, speed, distance, pulse rate and calories. With the provision of AC motor to the manual treadmill by means of gear transmission mechanism, the power is harnessed from the legs of the person performing exercise to the belt which is then transferred to the roller then to the AC motor by means of gear-pinion arrangement and electrical power so obtained is stored in battery by converting the AC current to constant DC by accommodation of bridge rectifier circuit.*

***Key Words*: AC motor, Spring Switch, Treadmill, Bridge Rectifier, Roller, Battery, Bearing.**

1. INTRODUCTION

A Treadmill is a device generally used for walking or running while staying in the same place. The concept of treadmill came into existence from olden days when animals or humans (labours) where used for running the tread-wheel for grinding grains. This concept further developed into reverse mechanism wherein the power now is used to rotate the motor accommodated on the treadmill then to rotate the belt provided, which further provide moving platform for the person who want to exercise his body to maintain in proper shape by the provision of some electrical supply directly from AC mains. But in this paper we will explain about a manual (leg-powered) treadmill which can only rotate when walker push the belt with his feet as while running or walking on treadmill. But the addition is that there is an installation of AC motor to harness electrical power, whose moving parts are mechanically coupled or connected with the moving parts of the machine (rollers) which moves when belt of the treadmill is moving. When the rotor (moving part) of the AC motor starts moving or rotating it will produces emf across its output terminals. This generated emf can be used for charging of Battery or other purposes.

2. LITERATURE REVIEW

2.1 Paper I [A Review Paper on Concept and Utility of Treadmill] (V.R Gandhewar, Priyanka H. Kakde & Himani S. Lonkar)

1) In ancient days concept of treadmill was invented for generating mechanical energy with the help of animals such as horse, dogs etc.

2) First treadmill was introduced by Roman Empire for heavy loading like conveyer belt which we use in industries.

3) We get basic idea after studying literature review of treadmill from all the above inventors we come to know that all the invention are steady while working and work for single purpose but in different forms of design. From this we get a new idea in this field to design a model which will be mobile and provide multiple output that will include human exercise, floor cleaning and electric generation.

2.2 Paper II [Design of Treadmill to Generate Electricity by Using Mechanical Energy] (Mr.Sourabh Borchate, Amit Gaikwad, Ajay Jadhav&Prasad Dhag)

1) Under this literature we get the design procedure flow chart of power generation manual treadmill.

2) Design specification for the treadmill is known, from this specification different formulas are used in order to acquire safe & stress, strain sustainable treadmill.

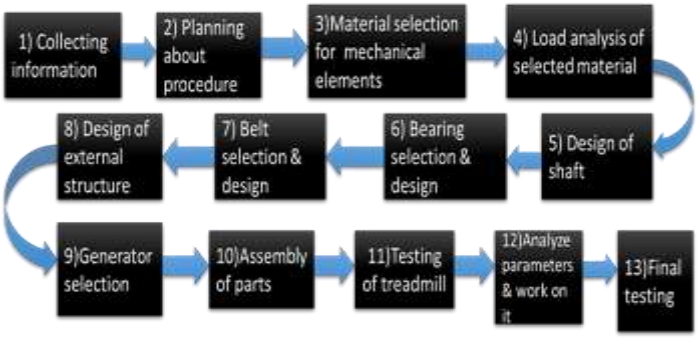

Fig- 2.2 Flow Chart of Power Generation Manual Treadmill.

2.3 Paper III [Design of Manual Treadmill with Electricity Generator for Energy Saving] (Shamshad Ali, Syed Tariq Murtaza & Ashish Kumar Katiyar)

1) "Douglas G. Bayerlein" invented a treadmill in which a generator was coupled with a roller axle through a belt drive system.

2) "Aurel A. Astilean" invented a treadmill having a concave shape of running surface of belt.

3) Objectives of the paper are, to provide a treadmill with Electricity Generator to save electrical energy and also sometimes this can be used to charge batteries for such areas where electricity is not available. With such a simple design, Electricity can be generated at low cost.

2.4 Paper IV [Design And Fabrication of Treadmill Bicycle] (Kirtish Bondre, Sanket Berad Patil & S.J. Thorat)

1) This paper deals with the conversion of conventional bicycle into treadmill bicycle. In this bicycle the frame of the bicycle is completely modified &the treadmill is placed in between two wheels.

2) This paper is somewhat related to the project design for treadmill which actually helpful for designing manual treadmill.

3. DESIGN

3.1 Calculation for Bearing Design

Radial load ($F_{r)}$ = 200 kg = 200 * 9.81 =1962 N

Axial load (F_a) ≈ 600 N (loading condition)

Speed,

V=π*D*N assuming (velocity 7.5km/hr)

$\frac{7.5*1000}{60}$ =π*0.03*N

Speed(N) = 1326 rpm (as velocity varies speed also varies)

Dynamic load (C)

Average life = 10000 hours

Equivalent load (From Design data book)

$F_e = (xF_r + yF_a)\, k_o k_s k_p k_r$

x & y = constant

k_o= oscillation constant

k_s = service factor

k_p= preloading factor

k_r= rotational factor

$e = \frac{Fa}{Fr} = \frac{600}{1962} = 0.34$

e > 0.25 (For deep groove ball bearing)

x = 0.56, y = 1.6

Assuming,

k_o= constant rotational speed of races = 1

k_s = light shock load = 1.5

k_p= for no preloading bearing = 1

k_r= outer races fixed & inner race is rotating = 1

Equivalent load

$F_e = (xF_r + yF_a)\, k_o k_s k_p k_r$

= (0.56 * 1962 +1.6 *600)*1.5

F_e = 3088.08 N

 Dynamic load, C

$L = (\frac{C}{Fe})^n * K_{ref}$

Reliability is 50% as assumed life is 10000 hrs

K_{ref} = Reliability Factor

= 5.0

L = 60 millions revolution

n = index of ball bearing

$60 = (\frac{C}{3088.08})^3 * 5.0$

C = 7071.58 N

From design data book dynamic load above 7071.58 is 8800 i.e.

From design data book considerable bearing (deep groove) is **0302 (**as per standard diameter of shaft is 15 mm)

Light shock load (For SKF bearing it is **6302**)

3.2 Calculation for Roller Design

Load analysis of the selected material: -

Maximum applied load = 150kg = 1471.5 N

Design of roller: - Maximum allowable load = 150 kg = 1471.5 N

Length of roller = 600 mm.

Uniform distributed load= 2.45 N/mm (Consider simply supported load.)

Material: -

Designation - C45

Condition - Tubes, cold drawn and tempered.

Yield strength (syt) - 600 N/mm^2

Ultimate tensile strength (Sut) - 700 N/mm^2

Tp = 0.3*Syt = 0.3*600 = 180 N/mm^2

Where,

Tp = Permissible shear stress,

Syt = Yield tensile strength.

Tp = 0.18*Sut = 0.18*700 = 126 N/mm^2

Where,

Tp = Permissible shear stress,

Sut = Ultimate tensile strength.

Selecting whichever is smaller value – Tp = 126 N/mm^2

Assuming,

K_b =1.5 and K_t =1

Where,

K_b = bending stress factor

K_t = life load factor

$$P(KW) = \frac{2\pi NT}{60*10^6}$$

$$1.5*1 = \frac{2\pi*1326*T}{60*10^6} \qquad (P = K_b*K_t)$$

T = 10802.37 N-mm.

M_{max} = (2.45*600) *300 = 441450 N-mm.

As per ASME code,

$$\frac{\pi d^3 T_p}{16} = \sqrt{(K_b * M)^2 + (K_t * T)^2}$$

$$\frac{\pi d^3 * 126}{16} = \sqrt{(1.5 * 441450)^2 + (1 * 10802.37)^2}$$

d^3 = 26768.097

d = 29.91

d ≈ **30 mm.**

3.3 BELT SELECTION:

Normally standard belt sizes are available in market of sizes ranging from

Ranges:

Length:- 40inch to 60inch

Width:- 13inch to 22inch

In our project we have used a belt of

Length:- 46inch

Width:- 16inch

4. DESCRIPTION OF TREADMILL COMPONENTS

4.1 Roller

Roller is used to rotate the belt and used to reduce friction while walking or running and reduce the effort of a person and to produce maximum power.

4.2 Bearing

Bearings are used to freely rotate rollers and to support the rollers to neglect friction. The bearings are pressed in rollers by means of punching press machine.

4.3 Belt

Belt is used in an assembly to build tension along the rollers to build friction among the extreme rollers and to provide moving mechanism for the treadmill and to actuate motion in the assembly for the rotation of the roller to transmit power to the AC motor to acquire desired current.

4.4 Gear

A Gear-Pinion arrangement is used wherein the pinion is coupled to the motor by means of adapter bush with variable nut-bolt size adjuster and gear is welded on the front roller. The power from gear is then transmitted from roller to pinion and from pinion to motor shaft.

4.5 AC Motor

An AC motor is a device which is used as dynamo in the circuit arrangement for conversion of mechanical energy into electrical energy it is in direct couple with pinion by means of adapter bush to the AC motor.

4.6 Bridge Rectifier

The simple working of the complete electrical circuit is when we run or walk on the treadmill the AC generator converts mechanical energy into electrical energy that generated AC current is transferred to the Bridge rectifier where AC is converted to the Constant DC.

4.7 Battery

The provision of battery is made to store the current during the rotation of the motor which can then be used for further domestic purposes like illumination, rotating small motors, etc.

5. Control Panel Circuit & Spring Switch

Treadmill controller is designed for a wide variety of user preference, custom workouts with energy calculations based on individual weight, age, gender and target heart rate goal.

The treadmill monitor display has the large bright display which shows Speed, Elapsed Time, Distance, Calories, Heart Rate and Target Heart Rate (user defined).

5.1 Working of Spring Switch

A Spring switch is same as that of reed switch but instead of ferrous strip enclosed in a glass casing, there is spring and small metal plate enclosed in a small plastic box casing, associating the wire to be taken out as output from both of these elements by soldering this wire on spring and metal plate and is used as an electromagnetic switch which helps control the flow of electricity in a circuit through panel. Whenever the permanent magnet fastened on pulley come close to the spring switch while rotating, the magnetic field due to the magnet causes spring to come towards the plate and complete the circuit and vice-versa i.e. switch

causes ON(1) and OFF(0) effect giving rise to some commands embedded on circuit and showing the output on panel.

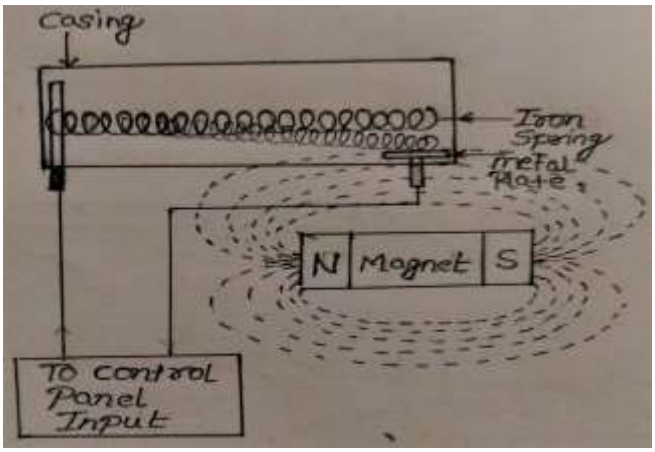

Fig-5.1: Diagrammatical representation of Spring Switch

Fig-5.2: Actual Spring Switch

6. Required components and their quantities

Table 6.1 Required components and their quantities

Sr. no.	Elements	Quantity	Specification
1.	Mid rollers	9	Length = 500mm Diameter =30mm Material= Stainless steel
2.	Extreme rollers	2	Length = 500mm Diameter of Front Roller = 40mm Diameter of Back Roller = 50mm Material of Front Roller = Wrought Iron Material of Back Roller = Rubber Coated C.I.
3.	Gears	2	Teeth on Gear = 127 Teeth on Pinion = 25 Material = Cast iron
4.	Mid bearings	18	Bearing Number = 6302
5.	Extreme bearings	4	Bearing Number = 6202
6.	Shafts	2	High Carbon Stainless Steel
7.	Bolts	18	High Carbon Steel
8.	Motor	1	Speed = 2200rpm Power Output = 18W Current = 0.65A
9.	Belt	1	Belt Length = 56 inch Belt width = 16 inch Belt Material = Fabric

7. WORKING

The manual treadmill works on the basis of energy conversion. When a man is exercising on a treadmill his efforts get wasted. But in this treadmill, the human effort is converted as useful work. Power generating and exercising can be done at a time. The conveyor is driven manually. The main roller is fixed on the front side and a spur gear (driver gear) is fitted to the roller. When the conveyor is moved by leg power it rotates the roller and the spur gear attached to the roller also rotates. Motor shaft is directly coupled with small gear which is in meshing with big gear and hence

power from treadmill to motor is obtained, which in turns converts mechanical energy into electrical energy.

7.1 Working Principle

The same concept which is used in bicycle generator is used in treadmill generator for power generation in the form of electricity. In treadmill generator the AC motor is used for conversion of mechanical energy into electrical energy. When the person operates the treadmill the power transmitted due to the effort so obtained is directly transferred to the rotor of AC motor which the actuates the emf due to which reverse current flows from motor to its output in form of electrical energy which is in the form of ac to make use of the energy so obtained is rectified to constant dc by means of bridge rectifier circuit to charge batteries and for lighting the led bulb or for other requirements.

Motor Rating and Some Specification

In our project we have used a AC motor of rating:

Speed: 2200 rpm

Power Output: 18 watts

Current Output: 0.65 amps

Output from AC Motor when measured:

Current output: 0.3-0.6 amps

Voltage output: 17.5-26.67 volts

Power output: 7-16 watts

Carrying out different test and observation we specifically recommend a AC motor of rating

Speed: 1237-1500 rpm

Power output: 104-108 watts

Current output: 1 amps

As AC motor is used current output is in ac form therefore an bridge rectifier is used for conversion of AC to DC for charging the batteries directly

For further better results dynamo or DC motor can also be used for output.

8. CONCLUSION

During the test run of the project it was observed that the current was obtained at some specific speed and the current output is taken out from the motor to battery and the assembly of treadmill so obtained is free from any failure and deformation.

Fig-8.1 Final assembly of the manual treadmill

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