Journal of Material Science and Mechanical Engineering (JMSME)
p-ISSN: 2393-9095; e-ISSN: 2393-9109; Volume 6, Issue 3; April-June, 2019 pp. 198-201

http://www.krishisanskriti.org/Publication.html

Fabrication Constraints and Material Selection of Track Based Stair Climber

Rishab Kant Dubey[1], Jitendra Bhaskar[2] and S.K. Singhal[3]

[1]M.Tech Scholar, Mechanical Engineering Department
HBTU Kanpur
[2]Associate Professor, Mechanical Engineering Department
HBTU Kanpur
[3]Professor, Mechanical Engineering Department
HBTU Kanpur
E-mail: [1]dubeyrishab12@gmail.com, [2]bhaskar48m@yahoo.com, [3]shalendrasinghal8@gmail.com

Abstract—*A conceptualized model of Stair Climber was designed on a geometrical modelling software. This Stair Climber once fabricated is capable of moving on structured and unstructured environments i.e. on flat, inclined and most importantly on the stairs. This paper discusses the selection of components and their specifications suitable for the designed Stair Climber. The paper focuses on selection of motor based on torque required, power source specifications and also the best suitable diameter of shaft, These components and specifications will help the Stair Climber to provide a smooth and undisturbed motion along the entire stair climbing process.*

1. INTRODUCTION

A Stair Climber may be defined as a piece of equipment that can be used for serving multiple purpose in day to day life. Basic function of Stair Climber is to climb stairs repetitively in a smooth manner with or without any manual assistance.

This Stair Climber can be used at various places and with high accuracy and repetitiveness such as

1. At malls and buildings with no lifts or escalator to carry household items, shopping bags and other important day to day items on the stairs.
2. By installing cameras on the Stair Climber it can be used in offices and places where security is important by site surveillance.
3. By installing cameras it can be used at hazardous places where manpower is under risk.

2. LITERATURE REVIEW

Many Stair Climbing robot or Stair Climbers have been proposed in recent years. Some among them utilizes leg type structure. Some use planetary wheel mechanism with shapes like "Y" or "+".[5]

Some Stair Climber present use tracked mechanism and are widely used due to advantage of continuous motion mode and high transmission efficiency. Hybrid approaches involving more than one mechanism for flat surface and stairs are also available.

Hence, an effort is made for selection of components and its specification for the tracked system based Stair Climber which was designed with the help of geometrical modelling software.

3. DESIGN AND WORKING OF STAIR CLIMBER

Design of Stair Climber

The conceptualized design of Stair Climber was designed on the geometrical modelling software. The dimension obtained with the help of the Static Analysis of the non-variable tracked system. Each part was designed as per After the designing of all parts assembly was performed on geometrical modelling software in order to obtain the proposed model.[1]

Working of Stair Climber

As the Stair Climber detects the stairs it adjusts itself and the tracked mechanism comes to action by touching the nose of the stair with the front part of the tracked system. The angle of attack provided with the use of fixed geometry tracked system helps in counterbalancing the repulsive force thus allowing the Stair Climber to climb the stairs. Grouser attached to the tracked system allows proper gripping while ascending and descending on the stairs. The model of the Stair Climber proposed was designed on geometrical modelling software as shown in Figure 1.[1]

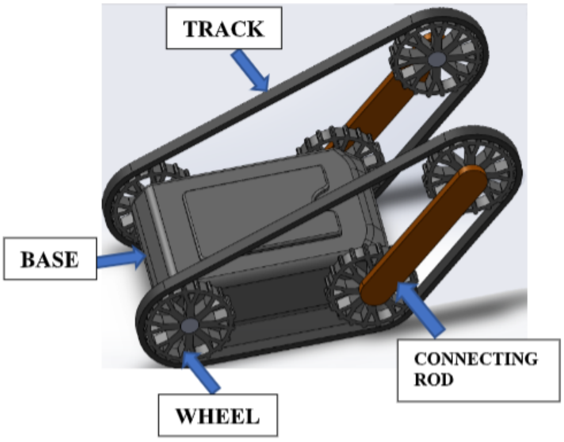

Figure 1: Design of conceptualized Stair Climber on geometrical modelling software

4. SELECTION OF COMPONENTS AND MATERIAL

The main components used in the Stair Climber are listed below-

a) Geared DC motor
b) Battery
c) Gripped Conveyer Belt or Track
d) Wheels
e) Base
f) Controller

Selection of motor

Geared DC motor is used for providing the motion to the Stair Climber. DC motor's speed is calculated by rotation of shaft per minute and the gear assembly helps in increasing the torque and reduce speed which is very essential while climbing the stair.[3]

Stair Dimensions

Stair tread, B= 30 cm

Stair rise, H = 17 cm

Distance between two step noses,

$$A_{H,B} = \sqrt{H^2 + B^2} = 34.48\ cm$$

Slope of the stair (θ) = $\tan^{-1}(17/30) = 29.54^0$

Total mass acting (including Stair Climber) = 60 Kg = 60×9.81 N

Normal force acting (F_n) = mgcosθ

= 60×9.81×cos(29.54^0)

= 512.089 N

Frictional force (F_f)= μF_n

= 0.2×512.089

= 102.42 N

Opposing force (F_o) = mgsinθ

= 60×9.81×sin(29.54^0)

= 290.20 N

Torque required = (F_f + F_o)×r_w

= (102.42 + 290.20) × 0.20

= 78.524 Nm

Shaft

Torque Calculation

Power of motor (P) = 1000 watt

Power transmitted by shaft,

$P = \frac{2\pi NT}{60}$

Where

T = Torque transmitted

N = Rpm of motor shaft (2000-6000 rpm)

$$1000 = \frac{2\pi \times 4000 \times T \times 10^3}{60}$$

T = 2.38×$\mathbf{10^3}$ N-mm

Torque transmitted by sprocket

No. of teeth (Gear), N_1 = 18

No. of teeth (sprocket), N_2 = 18

Ratio,(R) = 1:1

Torque on sprocket = 1×T

= 2.38×10^3 N-mm

Diameter of Sprocket

Periphery = π× diameter of sprocket

2×π×20 = π× D

D = 35.52 mm

Diameter of Shaft

Torque transmitted,

T = Force×radius

2.38×10^3 = F×20

F =119 N

F= 119/9.81 =**12.13 Kg**

Torque transmitted by shaft,

$$T = \frac{\pi}{16} \times \tau \times d^3$$

$$\tau = 70\ N/mm^2$$

where, permissible shear stress (τ) was calculated from design data book

$$2.38 \times 10^3 = \frac{\pi}{16} \times 70 \times d^3$$

d = 5.574 mm

Taking factor of safety = 1.6×5.574

= 9 mm

Thus, we select diameter of shaft = 15mm for safety factor.

Power source

DC rechargeable battery was employed to supply required current to drive high torque motor and related components.

Specification:

- 4 batteries of 12volts each
- Cycle use :14.4V - 15V
- Standby use: 13.5V – 13.8V
- Charging time: 6 – 8 hours with standard charger.

Belt or Track

Belt or Track designed as shown in figure 2 [1] was used for continuous motion along the stairs. Rubber track was adapted as a material for Stair Climber.

Figure 2: Design of Track

Wheels as shown in figure3[1]were used for the motion in the tracked system each track employed three wheels, so a total of six wheels were present in fixed geometry tracked system. Aluminium was used as it is lightweight and has considerable strength.

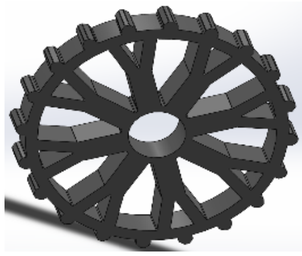

Figure 4: Design of the Wheel

Platform or Base

Platform or Base for carrying load and also for supporting tracked system is shown in figure 4[1]. Stainless steel was uses as a base material.

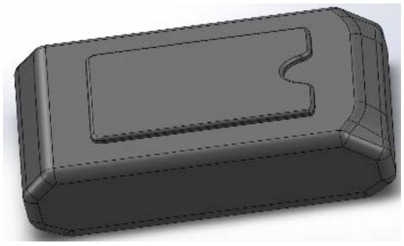

Figure 4: Design of Base

5. CONCLUSION

The conceptual design of the Stair Climber can be fabricated as per the dimensions of the components and selection of best material and specification for component. The fabricated Stair Climber thus can be adopted in day to day life for multifunctional repetitive work on the stairs. This Stair Climber can prove its usefulness at offices, buildings, site surveillance, hazardous places and for older people to carry load along the stairs.

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