Wheel Modification of a Wheel Type Stair Climber

Parveen Sharma

Abstract—This article deals with the designing and manufacturing of a Stair Climber, considering the aspect of wheel modification .Stair climber is the vehicle which can climb stair or move along very rough surface. The technical issues in modification of wheels of this vehicle are the stability and speed of the vehicle while climbing stairs. However, the steepness of the stairs is also the important concern of this study. The uses of this special vehicle are in the frequent lift of goods such as books for library, medicines for hospital, regular mails for any institutes, or transportation of any toxic material for industries and give freedom to the retarded person or paralyzed patients to move anywhere over flat surface as well as stairs. Wheel of Stair Climber is modified on the basis of Different criteria like strength, cost, and mobility etc. using complete product design approach. Different types of Stair Climbers are analysed like Legged Stair climber, Wheeled Stair Climber and tracked Stair Climber .On the basis of different criteria it was find out that wheeled Stair climber is better than other Stair climbers. Pugh chart is used for selection of best concept for different wheel climbers. Using of this vehicle, the labour cost can be reduced as well less power is consumed for lifting of heavy loads. Moreover, considering some drawbacks due to lack of implementation of all techniques during manufacturing phase the test and trial run showed considerably significant and encouraging results that might help the future researchers to incorporate a gear box and steering mechanism to make the vehicle more versatile..

Index Terms—Stair climbing vehicle, Tri Lobe Wheel, Pugh Chart.

I. INTRODUCTION

HighlighToday, due to technological advances of robotic applications in human life, it is necessary to overcome natural and virtual obstacles such as stairs which are the most known obstacles to the motion of such robots. Several researches have been conducted toward the design of stair climbing and obstacle traversing robots during the past decade. A number of robots have been built for climbing stairs and traversing obstacles, such as quadruped and hexapod robots. Although these robots can climb stairs and traverse obstacles, they do not have smooth motion on flat surfaces, which is due to the motion of their legs. Buehler* built a hexapod robot that could ascend and descend stairs dynamically.

He has also built a quadruped robot which could climb just one stair. Furthermore, a few wheeled and leg-wheel robots have been proposed that either can climb only one stair or cannot climb stairs individually and need to be supported by a person; Therefore, they are not good enough to be practical. Koyanagi* proposed a six wheeled robot that could climb a stair. Kumar* offered a wheelchair with legs for people with disabilities which could Climb a stair. Halme* offered a robot with movement by simultaneous wheel and leg propulsion. Quinn* built Leg-Wheel (quadruped and hexapod) robots (Mini-Whegs) that could ascend, descend and jump stairs. Kmen *invented a wheelchair withwheels that could climb stairs by human support. Also NASA* designed Urban Robot which was a Tracked robot. It could climb stairs and curbs using a tracked design instead of wheels. The Urban Robot led to the PackBotplatform of iRobot. Besides, Dalvand *designed a wheeled mobile robot that has the capability of climbing stairs, traversing obstacles, and is adaptable to uphill, downhill and slope surfaces. Climbing robots with legs use their legs to hold and move the robot body. The legs mechanisms have a sequential configuration that originates a limitation in the robot movement and great torques in the actuators placed on the legs base. However, as obstacles and stairs exist, crawler-type and leg-type robots become better candidates for application. The robots of the stick type and the biped type are generally designed to carry load up and down stairs. The former uses tires, rubber belts, and the handrail to assist the elders while walking and moving Up-and-down stairs, and the latter uses two legs and the handrail to assist walking and moving up-and-down stairs. This biped locomotors would be applicable as a walking support machine that is able to walk up and down stairs carrying or assisting load. . However, the height of climbing an obstacle generally is the same as the diameter of the robot's wheel.

Lifting recurring loads like books, food grains etc. to store upper level, or even patients to move upper level is not easy job, especially where there is no lifting facilities (elevator). Moreover, in most of the buildings in the world does not elevators or escalators. In this case human labours are considered to be the only solution. Labour is becoming costly in the developed countries, where growth rate is getting negative. This problem can be solved if a vehicle can lift loads while travelling through strains.

In this article the wheel modification of wheel type stair climber has been presented. First various types of stair climbers like wheeled type, Tracked Type and Legged Types are discussed. Then possible types of wheels are designed on the basis of various calculation and analysis. Best concept is selected with help of Pugh chart. Embodiment design is manufactured and tests are performed on the basis of different load.

II. DESIGN AND MODIFICATION OF WHEEL OF WHEEL TYPE STAIR CLIMBER

A. Types of Stair Climber

- legged type
- tracked (belt & chain)type
- wheeled type

Manuscript received December, 2013

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Fig.1 Legged type

Fig.2 Tracked (belt & chain) type

Fig. 3 Wheeled type

B. Difference b/w legged type and Wheel Type Stair Climber

Sr. no.	TOPIC	WHEEL TYPE	LEG TYPE
1.	Design	The design of wheel stair climber is simple than legs.	The design is not easy as wheel
2.	Steering	Steering the wheel is simple.	It is very difficult to steer the legs.
3.	Motion	Wheels have smooth motion.	As there are legs so motion is not smooth as wheels.
4.	Working speed	Wheels move faster as there is only one rolling motion.	Legs don't move faster than wheel and there are more than one motion.
5.	Stability	Wheels are more stable than legs (four wheel drive) on stairs.	Legs are less stable on stairs.
6.	Safety	As wheels are more stable they are safe vehicle on stairs.	Legs are less safe vehicle on stairs.
7.	Construction	The construction is simple because wheels required less no. of links (shaft or spindle) to walking mechanism.	Legs required more no. of links .

C. Types of wheel stair climber

- ❖ Tri-lobe wheel stair climber
- ❖ The octopus type stair climber (combination of leg and wheel),
- ❖ Tri-star wheel stair climber.

Fig.4 Tri-lobe wheel stair climber

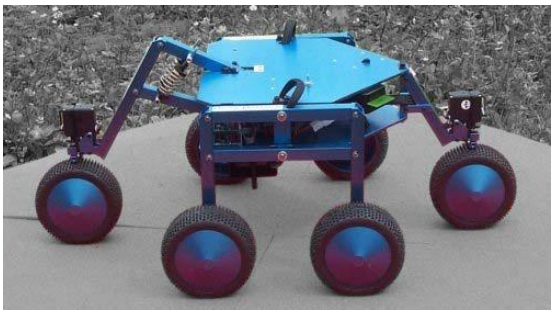

Fig.5 The octopus type stair climber (Combination of leg and wheel)

Fig.6 Tri-star wheel stair climber

D. Modification in Tri Lobe wheel

On the basis of following points:-

- Strength
- Light in weight
- Simple in design
- Easy to manufacture
- Low in cost
- Reliable

Various concepts are generated on the basis of above points:-

Concept 1 (fan type tri-lobe wheel):-

The wheels are so designed that less material is used and have less no. of stresses on them. The wheel should so strong to lift the load through stairs, should have smooth motion, more balance and consume less power. The study of strength is done with the help of designing software in terms of bending stress.

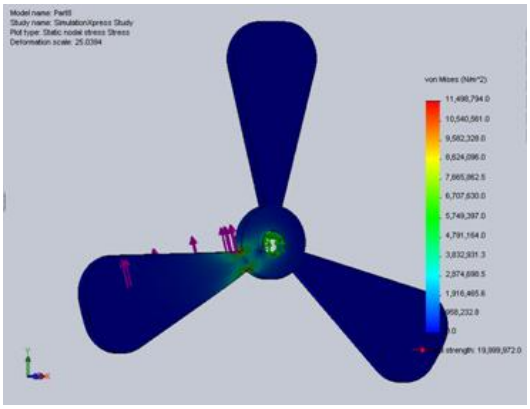

Fig.7 Bending stress 12MPa

Concept 2 (Rectangular type tri-lobe wheel):-

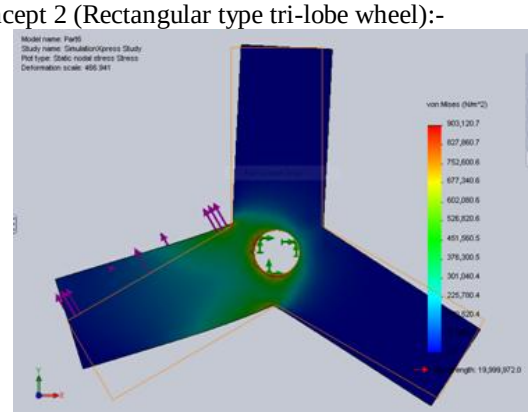

Fig.8 Bending stress- 9MPa

Concept 3 (New type tri-lobe wheel):-

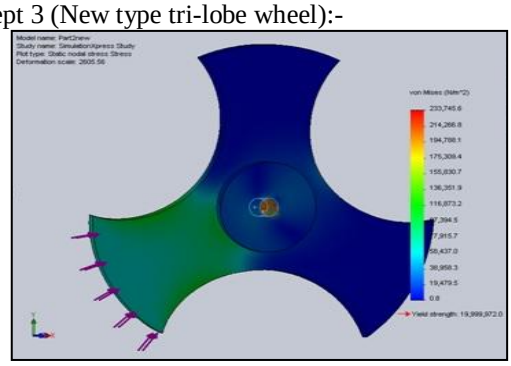

Fig.9 Bending stress 0.2MPa

SELECTION OF BEST CONCEPT (PUGH CHART)

SR.NO.	TOPIC	CONCEPT 1	CONCEPT 2	CONCEPT 3
1.	Strength	1	3	5
2.	wear	5	4	1
3.	Cost	3	2	4
4.	Life	1	3	5

E. Theoretical Calculation of New Tri-lobe

Assume wheel leg as a cantilever beam
Where,
W= Force acting on the wheel leg during climbing
l= length of the wheel leg.
x= section distance from fixed end.
Here, we know that the bending equation

$$\frac{M}{I} = \frac{\sigma}{Y} = \frac{E}{R}$$

Where, M= bending moment (Nm).
I= moment of inertia (m□ 4).
σ = stress develop on the beam (N/m□ 2).
y= distance between neutral axis and extreme fiber of the beam (m).
E= Young modulus of elasticity (N/m□ 2).
r= radius of curvature of neutral axis (m).
The term I/Y is called section modulus and is denoted by Z.
So we use equation1 as

$$M = \sigma * I$$

And $M = \sigma * Z$
And the Quantity

$$\frac{M}{Z} = 6 * w * \frac{x}{b} * d^2$$

So from above equations
Now, we have to find the value of force W by putting the other values as
σ = 11.4776MPa (bending stress value of wood).
x= 18cm (here x=l).
b= 8cm (width of beam).
d= 1cm (depth of beam).
So, by putting all values we get:-

$$W = 85.019N$$

F. Results

By putting the value of force in the design software we get the value of bending stress **0.2MPa** .And from the properties of wood bending stress value is **11.4776MPa**. so the result shows that Our wheel is safe for that purpose.

G. Detail Design of New Tri Lobe Wheel

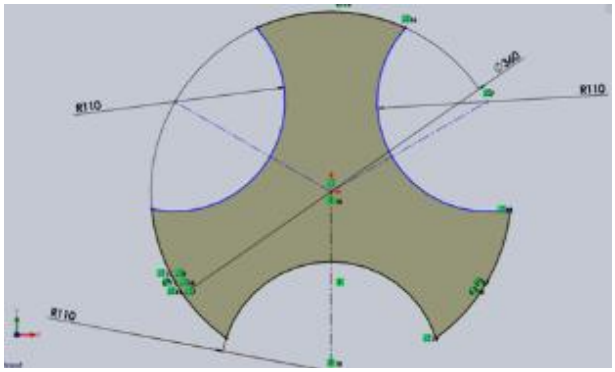

Fig.10 2D Sketch

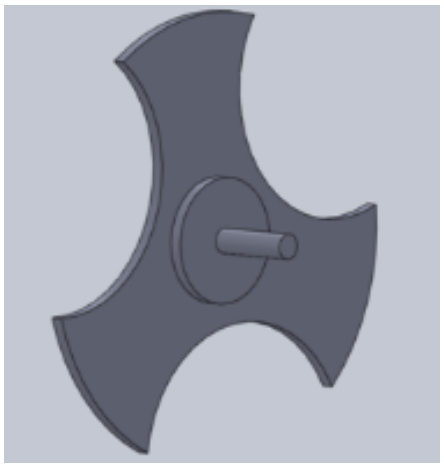

Fig.11 3D Model

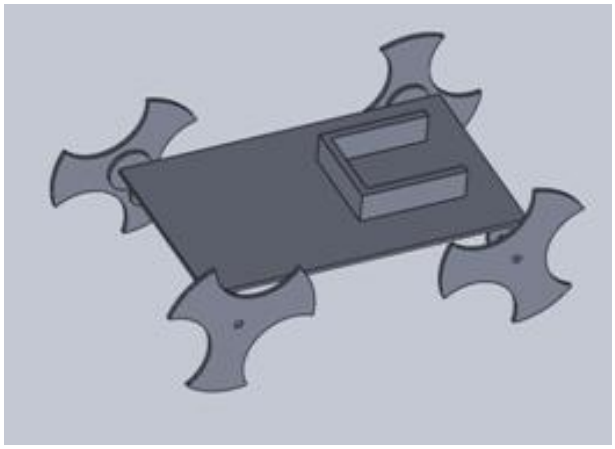

Fig.12 Final Assembly

H. Bill of Material

Sr no.	Materials	Quantity	Cost/piece	Total cost
1.	DC electric gear motor	4	600	2400
2.	Wood	1(standard size 4x6)	850	850
3.	Electric wire	3m	50	150
4.	Battery	2	750	1500
5.	Miscellaneous			1000
	Total			5900

III. MANUFACTURING

The base and wheels of stair climber are made of wood and is manufactured on carpentry shop.

Fig.13

IV. FUTURE ASPECTS

1) The purpose of the stair climber is to carry load through stairs, it has a limit of carrying load that is up to 8kg, so further modification can be of increase the load carrying capacity of the stair climber.
2) It has another area of modification that is steering of the stair climber vehicle.
3) It was observed that the vehicle was disturbed when it faced the stair of different step sizes. This was because of the shape and size of the wheel frame. Therefore for a range of stairs size can be considered for this vehicle. Although, different sizes step are not usually available in building design. It showed good performance when the step size was uniform.

V. CONCLUSION

A lot of designs are available for wheel of stair climber but three designs are selected on the basis of strength, cost, easy to manufacture. Optimum design is selected by comparing the all three concepts .Stair climber is manufactured using wooden material with respect to optimum concept. Steering can be provided in future.

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