

Research Article

Design of Stairlift for Curved Path

Ruturaj Kulkarni*, Bhumini Patel, Chinmesh Mulay, Prathamesh Musale and Rohit V. Bhaskar

Department of Mechanical Engineering, K K Wagh Institute of Engineering Education and Research, Faculty of Engineering, Nashik-422003 (Maharashtra) India

Received 14 April 2018, Accepted 15 June 2018, Available online 22 June 2018, Vol.8, No.3 (May/June 2018)

Abstract

In India, a large group of population accounts for old aged groups, physically disabled people & people with damaged limbs due to accidents which faces severe problem in climbing staircases at public buildings, parks, old residential buildings, their private homes. Also the maximum number of buildings is not equipped with elevators or escalators. Most of these buildings have certain limitations of installing elevators or escalators. Hence Stairlift proves to be effective way to tackle such problems faced India & can be game changer for handicapped & old aged population of India. A stairlift is a mechanical device which is used to lift people and goods up and down on the stairs, who may find it difficult in doing so themselves. In this a rail is mounted along the treads of the stairs. A chair or carriage is attached to the rail. A person on the chair or carriage is lifted as the chair or carriage moves along the rail. Our main aim is to design stairlift for Curved Tracks using optimized driving mechanism, also focusing on modular design aspect while designing the system in order to make assembly trouble free and less time consuming during assembly as well as during maintenance and to carry out results for fail safe design. The general considerations of outcomes in design and manufacture of a Curved stairlift which should be useful for lifting people weight up to 120kg

Keywords: Stairlift, Modular Design, Carriage.

Introduction

India still finds difficult to install these systems in most of building structures as large number of these structures are old structures & have their own limitations for in installation of elevators & escalators. This is the project with the vision of countering the social problem faced by the different class of people for mobility on staircases of many indoor & outdoor structures. The new era with developed systems like elevators & escalators. Lifts are invented long back ago. But installation of lift involves ample amount of cost, motor honk, civil structures. If lifts are to be installed in the previously built structure then the alteration cost is too much. To overcome all these factors the concept of stairlift came which reduced extra costing associated with the lift mechanism. A stairlift is a mechanical device which is used to lift people and goods up and down on the stairs, who may find it difficult in doing so themselves. This topic deals with the designing and manufacturing of a stairlift, which can be used as human transportation system. In this a rail is mounted along the treads of the stairs. A chair or carriage is attached to the rail. A person on the chair or carriage is lifted as the chair or carriage moves along the rail. It can also be used to carry goods across the stair case.

Stairlift is a type of lift that can be mounted on the stair case without altering civil structure. This lift runs on electric power and consists of a motor, reduction gear box, rack and pinion drive and a sliding chair. In this system we use DC motor for the forward and reverse motion of stairlift with the help of toggle switches and push buttons. Stairlifts come in various types depending upon position of placement, type of stairs and method alighting. In these, straight stairlift is most popular and it is widely used throughout the world. Curved Stairlifts are used if the staircase inside the house has curves. The chair of the stairlift will be mostly the same as with a straight stairlift, but the track will instead be curved. This allows the user to enjoy a smooth ride that can handle all kinds of turns, including 90° and 180°. The design of Curved Stairlift is challenging part and thus the different mechanisms used like belt drive, chain drive and rack and worm have many limitations for Curved stairlift. The expected outcome of stairlift is that it should be travel 120kg person smooth and safe on curved track.

Literature Review

Pengjia Wang, et al Modular design, or modularity in design, is a design approach that subdivides a system into smaller parts called modules or skids, that can be independently created and then used in different systems. A modular system can be characterized by

*Corresponding author's ORCID ID: 0000-0002-4973-1483
DOI: <https://doi.org/10.14741/ijcet/v.8.3.32>

functional partitioning into discrete scalable, reusable modules; rigorous use of well-defined modular interfaces; and making use of industry standards for interfaces. Besides reduction in cost (due to less customization, and shorter learning time), and flexibility in design, modularity offers other benefits such as augmentation (adding new solution by merely plugging in a new module), and exclusion. The Use of remanufacture engineering related to design concept of stairlift used over here. By implementing the remanufacturing strategy at the end of the product lifecycle, the enterprise can reduce cost and improve competitiveness largely. If the remanufacturing process is not considered when a product is being designed, it will be difficult to remanufacture the product at the end of its lifecycle, as some of the components and parts could have been worn badly, resulting in a product which cannot be remanufactured. Therefore, it is necessary to consider the remanufacturing characteristics during the phase of product design, to facilitate product reuse, upgrade and maintenance, and to make it easier to disassemble and recover.

Shouhei Shirafujia, et al Belt drive, as per in machinery, a pair of pulleys attached to usually parallel shafts and connected by an encircling flexible belt that can transmit and modify rotary motion from one shaft to the other. Most belt drives consist of flat leather, rubber, or fabric belts running on cylindrical pulleys or of belts with a V-shaped cross section running on grooved pulleys. This paper focuses on the flexible belt drives used in engineering applications & systems. Flexible belts, cables and ropes have wide applications in engineering, where they are used as belt drives for power transmission between rotating shafts, band breaks to reduce angular speed of rotating machine parts, hoist devices for lifting or lowering loads in construction or mining industry, devices for fastening marine vessels to the dock, conveyors, and magnetic tape drives, etc.

General Specification for Lift, Escalator and Passenger Conveyor Installation in Government Buildings of The Hong Kong Special Administrative Region 2007 Edition. {Book}[This Book has covered some rules & conditions for better and ethical design and manufacture of stair lift. Platform carriage shall be provided for a stairlift installation to support the platform on the guide rails and direct the platform up and down the guide rail system. The platform carriage shall be provided with handrails to the passenger for easy grabbing. The platform shall be finished with non-slip platform deck and ramp surfaces. The platform shall negotiate vertical and horizontal bends and landing transitions smoothly without transfer of the passenger. A smooth start/stop shall be provided when entering/departing landing zone. The clear height above the platform shall be not less than 2 m long its whole journey. Ramps provided at the platform access edges shall be minimum 150 mm high. Kick plate(s), minimum 150 mm in height, shall be provided at non-

accessed(s). A removable lockout cover shall be provided for the folded platform. 3 numbers of 'Common Key' for the key-operated switch shall be provided. Ramps shall be fitted to the platform access edges, when folded up, to prevent accidental wheelchair roll off. The ramps shall be raised and lowered electrically; operated in sequence only when the platform is unfolded and at rest at a landing. Drive system shall be electrically and mechanically interlocked with the ramps to prevent the stairlift from moving unless the ramps are raised and to prevent the ramps from lowering during the stairlift travelling. Folding and unfolding of the platform shall be electrically operated. Means of folding and unfolding the platform shall be able to be operated manually in case of malfunction or power failure. Key-operated switches at the operation call stations at all landings shall be provided to permit the Stairlifts operations, including calling and sending functions, to become effective only when the respective key-operated switch is in the 'On' position.

Problem Statement

To design a stairlift which is useful for lifting people having weight up to 120kg, up and down the stairs in desired time who may find it difficult in doing so themselves with the help of optimized driving mechanism for curved track, ensuring complete safety of passenger.

Methodology

- a) Selection of optimized transmission mechanism by testing on actual test model.
- b) Integrating design assembly into product design stage.
- c) Design CAD models
- d) Analysis of stairlift models.
- e) To compare analysis and analytical results to ensure safe design model.

Selection of Optimized Mechanism

For efficient, optimum and safe performance of Stairlift, choosing the correct driving mechanism is the key. Stairlift manufacturers throughout the world use different types of driving mechanisms depending upon the nature of stairs, load carrying capacity and comfort of user

- a) Belt Drive

After Calculations

For travelling distance 6m and load of 200 kg following result obtained

- Diameter of driving pulley-250mm
- Diameter of Driven pulley-2500mm

Conclusion

- As the diameter of driven pulley (D) = 2500 mm which is too large.
- Short service life.
- Slipping of may be Concern for users safety
- Hence due to restricted space considerations & above conclusions belt drive will not be the appropriate drive for stairlift.

b) Chain Drive

This is another method of driving the stairlift. A chain is defined as a series of links connected by pin joints. It is quite similar to belt drive. The only difference is that belt is replaced by chain and driving and driven pulleys are replaced by sprockets. The chain drive is an intermediate between belt and gear drives.



Fig.1 Actual testing Model of Chain drive Stairlift

Outcomes of Chain Drive Mechanism

- Lubrication needed.
- Noise.
- Speed upto 1.5m/s.
- Load carrying 100kg.
- Requires external housing.
- Frequent adjustment requirement for slack.

Also not suitable for curved track, So the option of chain drive eliminated.

c) Rack and Pinion –The design of stairlift using rack and pinion drive was done, including the PMDC motor with worm gear box. The CAD parts are shown below. Fig.2 shows 'T' section of guide rail, Fig.3 Driving Module and Fig.4 is view of complete assembly.

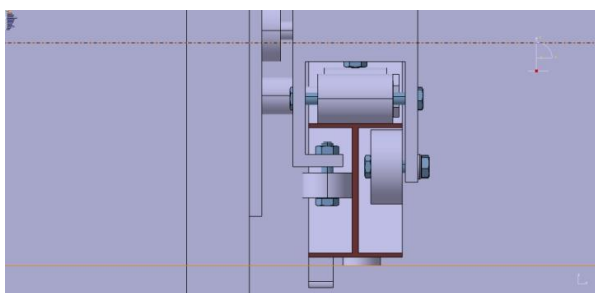


Fig. 2 'T' Section

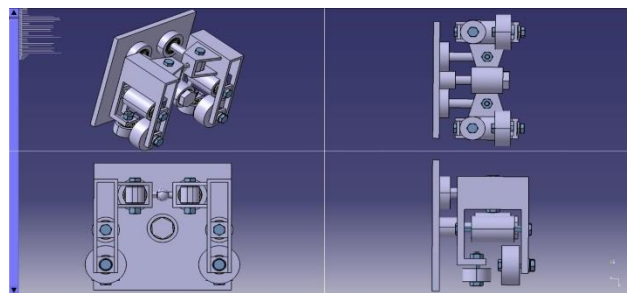


Fig. 3 Driving Module

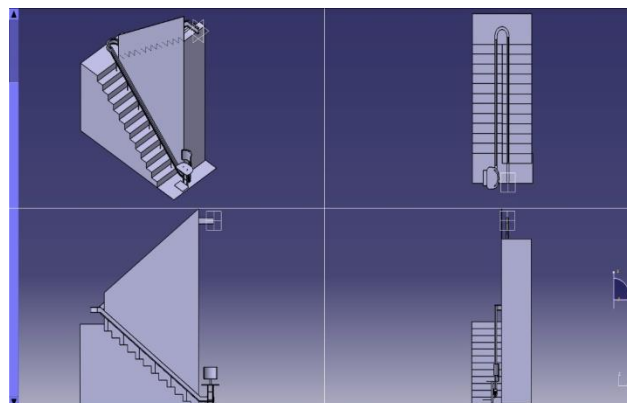


Fig.4 Assembly

Structural Analysis

The structural analysis carried out using ANSYS software by applying forces of certain portion and fixing at some point for rollers, shafts & rib. The Fig.5 shows equivalent stresses on rib, Fig.6 shows equivalent stresses on shaft and Fig.7 shows equivalent stresses on roller.

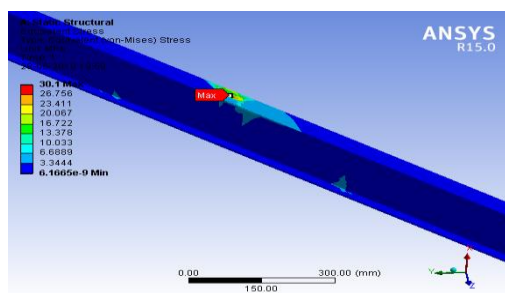


Fig.5 Rib

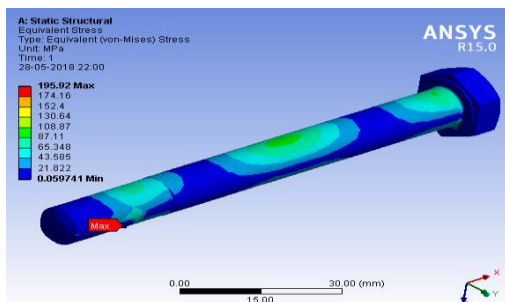


Fig.6 Shaft

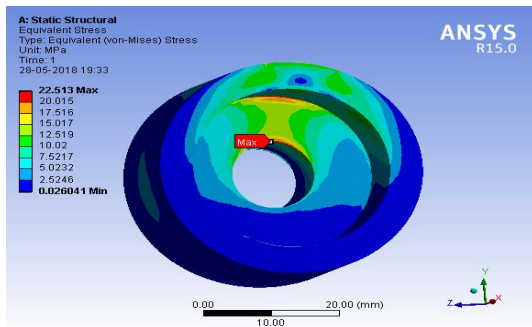


Fig.7 Roller

This assembly of various components in the cad part will be the guiding mechanism for our stairlift. It consist of two arms having 3 rollers each which is to be supported by I section beam. The two arcs are free to move in vertical & horizontal direction with respect to each other & connected by a ball joint .These two arms are connected to the chair with two different shafts.

Result and Discussion

Table.1 Comparison of Analytical & Software Results

Sr No	Sections	Force applied (newton)(n)	Equivalent stresses(von mises stresses)(mpa)
1	Plate	1962	138.26
2	Rack	1962	72.223
3	Rib	1962	30.1
4	Roller a	654	4.7092
5	Roller b	980	8.4197
6	Roller c	881	22.513
7	Shaft a	981	195.92
8	Shaft b	981	157.38
9	Shaft c	885.5	140.75

Following conclusion can be drawn from the comparative study of various results:

- There is 5% to 15.10 % variation in the values of equivalent stresses on Shafts in the analytical & ANSYS calculations.
- There is 19 % variation in the values of equivalent stresses on Rib in the analytical & ANSYS calculations.
- The analytical calculation of results are found to be in safe range & verified by ANSYS

Conclusions

After the extensive study of various aspects of stairlift, following conclusions can be drawn about the product:

- Use of PMDC motor makes system compact. It is lighter in weight and gives high torque at lower velocity.
- For driving mechanism rack and pinion would be appropriate mechanism because of its smooth operation & it can take smooth turns around curves.
- The analytical calculation of results are found to be in safe range & verified by ANSYS
- Focus was on modular design aspect while designing the system in order to make assembly trouble free and less time consuming during assembly as well as during maintenance.

References

PengjiaWanga,(2014) Modular Design of Machine Tool to Facilitate Design for Disassembly and Remanufacturing, 21st CIRP Conference on Life Cycle Engineering, CIRP 15.

Shouhei Shirafuji, Naotska Mastsui,(2017)Novel frictional-locking mechanism for a flat belt: Theory, mechanism and validation, Mechanism and Machine Theory 116

General Specification for Lift, Escalator and Passenger Conveyor Installation in Government Buildings of The Hong Kong Special Administrative Region 2007 Edition

V.B. Bhandari,(2017) Design of Machine Elements, 4th Edition.