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Research Article

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Convertible staircase lift

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ABSTRACT

The present work investigates the design and analysis of a staircase lift, which can be used as a Material Handling System. A staircase lift is a mechanical device for lifting people and wheelchairs up and down the stairs, who may find difficulty in doing so themselves. For sufficiently wide stairs, a rail is mounted to the treads of the stairs. A chair or lifting platform is attached to the rail. A person on the chair or platform is lifted as the chair or platform moves along the rail, old age and goods are to be carried across the staircase. A staircase lift is a type of lift that can be mounted on the staircase without altering civil structure. Not only altering, but the person need not change the seat from the wheelchair to the staircase lift, there is a foldable supporting rod for the staircase lift which directly attaches to the wheelchair. This lift runs on electric power and consists of a motor, reduction gearbox, rope drive, two rails and a sliding chair. In this system, we use a DC motor for changing the polarity of the power supply which will make the motor run in reverse direction. Advantages over the conventional hydraulic lift are no civil structure and alteration is required, low cost, less bulkiness, less power, less maintenance required. Easy design, easy installations can be of industrial use too. Moreover, considering some drawbacks due to weight carrying capacity completely depends upon the capacity of the motor. There is a lot of scope for further modification in the project as using a monorail instead of two, using a belt drive or chain drive instead of a rope drive. Incorporation and automation/timer unit will ease the use of the device. Rack and carrier arrangement for using the device for a curved staircase and use of work & roller reduction gear assembly.

KEYWORDS: Platform, Rails, Wire rope drive, AC motor, Civil structure

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INTRODUCTION

Nowadays, people who are physically handicapped cannot climb stairs. Not only handicapped few of the injured people cannot climb the stairs. Establishing a lift over there is not possible as the civil structure cannot be changed and if any construction of a lift takes place then automatically there will be a alter in the civil structure (PengjiaWanga *et al.*, 2014). Keeping that in mind we've designed a staircase lift which is adaptable for all kinds of buildings (Al-Kodmany, 2015). In general, the staircase lifts in the present market are foreign imported and too expensive (Khidir *et al.*, 2017). But this is affordable. And the main problem is that a person travelling in a wheelchair should be transported to staircase lift which requires another person's help but this convertible staircase lift doesn't need to change from wheelchair to staircase lift, there are two foldable handles and a belt attached to it so that the wheelchair can be directly attached to the staircase lift (Shirafuji *et al.*, 2017). This is the invention made.

GUIDELINE FOR MEASURING STAIR LIFT

Measuring your staircase can be an essential easy-step process to determine which type of stair lift you may require in your home. As a guide, please follow our guide to finding your staircase type to ensure we give you the right stairlift advice.

Step 1: Side of Stairs, Left or Right

Stand at the bottom of the stairs and look up the staircase to determine if it would go on the left side or the right side of the stairs. The most common side for a stair lift to be installed is the wall side. If the staircase is open plan, then determine which side would be most practical for access to the stair lift from the bottom of the stairs.

Step 2: Measure from the Top Step to the Bottom Floor Area

Stand at the top of the stairs and measure from the top stair tread (A) and extend your tape measure down the staircase. The tape measure should lightly touch each edge of every stair tread and the tip of the tape measure should be extended right down to the bottom floor area (B) which is past the very first stair tread.

Step 3: Measure Width of Staircase

Measure the width of the staircase from (C) to (D) making sure you measure from the skirting board and not the wall.

Step 4: Measure the Bottom Clearing Distance

Measure from the end of the bottom step (E) to the nearest obstacle (F). This could be a nearby door, radiator, wall or cupboard for example. By measuring the clearing distance, it will give you an idea of how much room is available at the bottom of the stairs. A minimum space is required of around 18"-20" for the stairlift to be parked for getting on and off safely. If the space is limited, you may require a hinge track system.

MODELLING

The different views are shown in Figures 1, 2 and 3.

COMPONENTS REQUIRED

Track

The dimensions of a track or rail depends on the dimensions of the stair. The width of the track or rail should be such that enough space is available for people to use the stairs. The carriage and seat are mounted over the rail in a way that these can move up and down following the track. The strength of the rail must be good enough to withstand the weight of the carriage and load on the base. Rails are kept fixed upon the stairs. In the case of the rotary tracking system, the rail is fitted on the wall. We have used a mild steel bar to make the rail required. Steel bars have cross- section of L shape which thickness is about 4 mm. The length of the rail is about 7 ft. We made a structure to place the rail inclined like the slope of the stairs. Two parallel steel bars relate to some pieces of the bar (Figure 4).

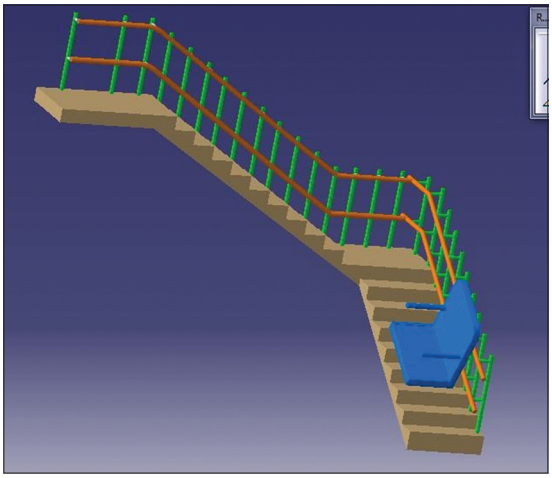

Figure 1: View 1

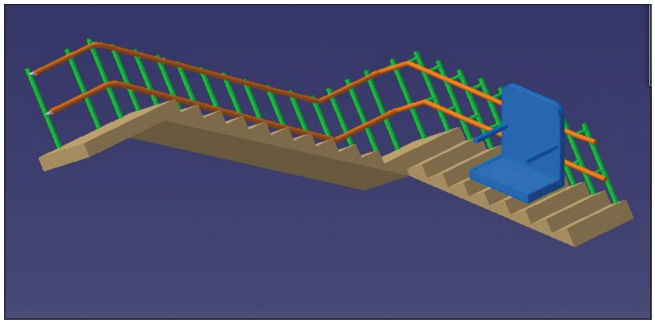

Figure 2: View 2

Carriage

There is a mechanism between the track and the carriage for the movement of the carriage. The movement can be attained by rope drive, belt pulley drive, rack pinion mechanism, guide wheel linear tracking system or chain drive. Sometimes these mechanisms are used at the bottom of the seat and then no carriage is required. We use Mild Steel bars to make the structure of the carriage. Steel bars are welded together at the required dimension. The width of the carriage is larger than that of the track. This is because the extra area is for mounting the motor and transmission system with the carriage (Figure 5). The chair is mounted on the saddle. The chair is easily removable, and the stair lift can be used for material handling.

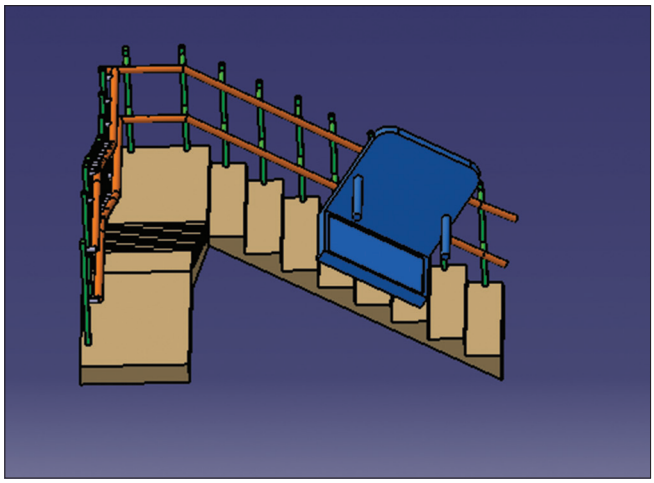

Figure 3: Zoom in view

Figure 4: Track in solid works

Figure 5: Carriage in solid works

Motor

An electric motor is an analectic machine that converts electrical energy into mechanical energy. Motors are mainly of two types: AC motor and DC motor.

DC motor

DC motors are electric motors that are powered by direct current (DC), such as from a battery or DC power supply. Their commute can be brushed or brushless.

AC motor

An AC motor is an electric motor driven by an alternating current (AC). The AC motor commonly consists of two basic parts, an outside stator having coils supplied with alternating current to produce a rotating magnetic field, and an inside rotor attached to the output shaft producing a second rotating magnetic field. This motor is used to provide the necessary speed and torque. We are going to use a brushless DC motor for this stairlift (Figure 6 and Table 1).

The Advantages of using a Brushless DC Motor is

- It is much easier to change the polarity in a DC motor.
- DC motors with control box kits are available in the market. It is very simple to set the controller with the motor.
- Brushless motor has a high power to weight ratio.

Motor Speed Control

Because the motor rotates at too high a speed to safely propel the stair lift up the track a type of transmission is employed to reduce the speed while increasing the power available. A worm gearbox is used to reduce the speed found in the motor. A sprocket is attached to the shaft of the motor which transmits power to the input of the gearbox by a chain. The output speed of the gearbox is low and power is transmitted to the final chain drive which is mounted with the length of the rail (Figure 7).

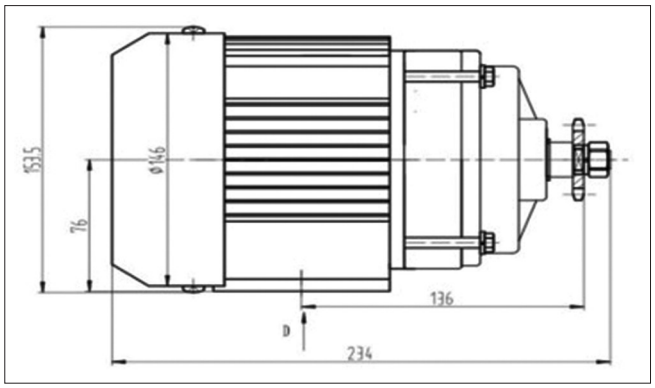

Figure 6: Dimension of the BLDC motor

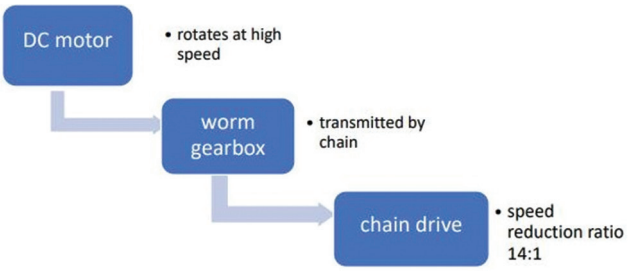

Figure 7: Motor speed control

Table 1: Specifications of the motor

Specification	BLDC motor
Rated output power	750 W
Rated voltage	48V
Rated speed	2800 RPM
No load speeds	3100 RPM
No load currents	<5.0/4.5A
Efficiency	>80%
Reduction ratio	6:1
Actual speed	450 rpm
Load	about 450-500 kg
Applicable Chain	420 Chain

Worm Gearbox

A worm drive is a gear arrangement in which a worm meshes with a worm gear. Worm gears are usually used when large speed reductions are needed (Özgüven & Houser, 1988). The reduction ratio is determined by the number of starts of the worm and the number of teeth on the worm gear (Figure 8).

We are going to use a worm drive with a reduction ratio of 14:1. The rpm of the motor is very high and driving the carriage at a high speed is unsafe and will cause an accident. So, reduction of speed is very important. The worm gear is made of steel and the worm wheel is made of bronze.

Battery

We need to use four 12V batteries for the power supply (Figure 9). These batteries can be recharged.

Figure 8: Worm Gear-Set

Figure 9: Battery

CONCLUSION

The proposed work is determined for modeling of the staircase slider for persons with physical difficulties to climb the stairs on their own. A staircase slider will be a mechanism for a home lifting aid that will allow an individual to slide over the staircase as well as can utilize the same staircase for pedestrian purposes also. The slider mechanism will carry an individual up the stairs, attaching directly above the staircase railing. In this case, an individual must remain standing as they use this slider. This design will not require an overhead control room and it will not be necessary to have structural alteration to the building. The only basic requirement will be that staircase width should be at least 75 cm (about 2.46 ft) - 100 cm (about 3.28 ft) in width. Though making a cost-friendly Stairlift had some limitations, it was a good and challenging project for us. Making a stairlift with roller bearing is not a complicated process and all the components are widely available in the market. DC motors with control boxes are now being manufactured for auto rickshaws and this can be directly used in the stairlift. During the Modeling of this project, it was realized that it would be capable of carrying heavy loads without suffering any deformation or local fractures if it would go into real-world production at an ideal scale. Though the initial cost of the project seemed to be a little bit higher but more accurate manufacturing would shorten this.

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