The Ladder Climber

Design Team
Younes Albahrani, Saad Farhad
Andres Janna, Jhony Quintal, Shahan Sarkissian

Design Advisor
Prof. Hamid Hashemi

Abstract
The goal of this project was to create a low cost and portable device that would help users carry heavy loads up ladders. The device should be no more than 100 pounds and should be able to fit on the majority of ladders available in the market with minimal installation time. The device will be able of carrying a maximum load of 100 pounds. The Ladder Climber will be equipped with necessary features to prevent harm to both the user and the loads being carried. The safety features will include: an automatic shut-off once the device encounters an obstacle (e.g. user’s hand) and a safety brake system in the event of power loss. The device will be powered by a battery and controlled by a tethered remote control, granting control to the user whether on or off the ladder. Design work remains to improve the method of physically carrying the load so as to provide maximum ease of use for the user. Due to the time limit, the safety brake and automatic shutoff were not completed.
The Need for Project

Currently, there is no device that is portable and allows the users to carry loads up and down ladders. The ladder climber is a device that will help users safely lift a weight of 100 lbs of material such as shingles, paint, or tools up and down a ladder while avoiding any injuries or death. According to a source, around 200,000 people are treated yearly for ladder-related injuries with an average of 300 deaths. The Ladder Climber will reduce the risk of these injuries and deaths related to carrying loads up and down the ladder. The device will offer portability to be easily moved from a job site to another, and it will be easily installed on any conventional ladder because of its 3 piece design, and light weight.

The Design Project Objectives and Requirements

The product will be a low cost and portable addition to conventional ladders that help users in carrying loads of around 100 lbs up and down ladders.

**Design Objectives**

The objective of the design is to create a low cost and portable Ladder Climber that would help users carry a load of around 100 lbs up and down ladders. The device should fit on the majority of conventional ladders available in the market with minimal installation.

**Design Requirements**

The design is an addition to conventional ladders that can be attached to aid users in carrying objects up and down the ladder. This device will be light to ensure ease of portability by the user. It will also be able to remain stationary in elevated positions without requiring the user to manually apply brakes. The device will have an expandable width, which will allow the device to be fitted on ladders ranging from 16” to 22” wide. The design has to follow OSHA regulations, including having a factor of safety of 4.

Design Concepts considered

This section discusses the alternative designs for the individual parts and identifies their merits and drawbacks.

**Side Wheel:**

The 5th wheel was designed to prevent the device from derailing off the ladder. The side wheel is designed to be attached on the sides of the device and meant to roll on the sides of the ladder known which as the stringers. The side wheel was designed to fit near the halfway point between the two carts.

The Ladder Climber is designed to fit on a variety of different ladders and it became apparent that a large number of ladders would not allow for a side wheel to roll over the sides. These ladders had obstructions along the length of the ladder, in the middle of the side of the stringers.
and would cause the side wheels to not function as intended.

**Guide**

The guide is meant to fulfill the obligations of the 5th wheel design; however it does not fall in the path of obstacles usually present on the sides of ladders. The guide consists of a structure with a smooth material attached to the end. When installed, the smooth material props up against the side of the ladder providing alignment and preventing the device from derailing.

**Braking system:**

*Emergency brake operated with solenoid*

The emergency brake was designed to prevent the device from losing elevation in the event of power loss. The emergency brake system would consist of an arm fixed at an angle and retracted with the help of a solenoid; this system would allow the Ladder Climber to move upwards but prevent movement downwards by latching itself onto a rung. During descent, the arm would be retracted and allow the free movement.

**ESC**

ESC-Electronic speed controller is essentially an electrical current modulator and also functions as a dynamic brake by converting the motor into a generator and therefore producing a counter torque.

**Anti-Back Drive Pin Transmission**

This is a mechanism that is fitted onto transmission systems. This mechanism operates by preventing the movement of the shaft when the torque originates from anywhere but the motor. This is a simply mechanism that is fitted onto the variety of transmission that were considered. This mechanism would replace the emergency brake system and the dynamic brake system.

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**Recommended Design Concept**

The Ladder Climber will be constructed of lightweight aluminum 6061-T6. The clamps must provide force between the ladder and the wheels.

**Design Description**

The design must be able to climb up and down a ladder without slipping while carrying the required load. This requires the climber to have enough friction between the ladders and the wheels. The friction will be provided by the clamping force.

**Analytical Investigations**

The most important concept for the design to work is the clamping
force that will allow the system to climb without slip. After calculations, a necessary force of 240lbs on each wheel is necessary. The system must also be rigid enough to sustain the load and the forces that are applied to it. In addition to the clamping force, FEA was done to all the parts to ensure that there would only be minor deformation. Buckling and bending were also investigated in the necessary parts. All of the parts had a deformation of less than 0.01 inch. This means that the system will not derail once the load is applied including the necessary safety factor of 4.

FEA analysis demonstrates that the device will be able to withstand all the forces that will be applied to it, which reduces the risk of injury to the user.

**Experimental Investigations**

An experiment was conducted to ensure that the wheels would not slip. They were put on an aluminum surface, and with the help of weights attached, the necessary torque was applied to the wheel. The experiment showed that the wheel had no slip. This means that once the motor powers the device with the required torque, the wheels will be able to carry the system up and down without problems. This was a very vital part of the design since it is the most important aspect of the Ladder Climber. If there is slip between the wheel and the aluminum of the ladder, the system would simply rotate in place and not go up or down the ladder.

**Key Advantages of Recommended Concept**

The final design has increased the safety, reduced weight, and improved portability of the device. To start, a second center beam was added to prevent the derailing of the system. The center beam was also modified to have an adjustable width of 16” to 22”. This would allow the climber to be adjusted to different ladder widths without having to modify the device. A guide was also added to the design to help guide the system up. The design was also made as small and light as possible. The lighter and more compact the design, the easier it would become to attach and store.

**Financial Issues**

The estimated cost for the “Ladder Climber” is estimated at $914. The aluminum raw material costs an approximate of $110,
which includes the aluminum sheets, guiders and hollow bars. High quality clamps were selected since they play one of the most critical points in the design; they totaled $320. The derlin layer that goes on the guiders (2 on each side) came to be $23. The power supply and power train, including motor and gearbox are $400. The design will have one motor gearbox and power supply on each side of the device. The wheels, four in total, have a total cost of $40, and finally the electronics for the device will sum up to a total of $200.

All of the prices above were quoted at the retail value. If ordering all of these items for mass production and getting respective discounts, it is estimated that the cost of the device after manufacturing will be 650 dollars. An estimated 8 hours are necessary in the tool shop (including welding) to assemble a complete unit. The biggest issue is the cost of the power supply and power train, which needs to match the device specific power, torque, and dimensions.

Recommended Improvements

A lighter device with a better power train will greatly improve the device. The biggest improvements that may be done to the design have to do with weight reduction and safety issues. The lighter the device, the more practical it will be for the users, and the easier it will be to store. A better power supply that has a longer lifetime is also of great importance for the design. The current battery charges in 60 minutes and under average loads it is estimated to last from 2 to 4 hours. If we make the device more practical, it will allow for a bigger market in the future.