HEC 15: yakLIFT

Electrical & Mechanical Engineering

Automated Roof Rack System

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Sponsor: Austin Canoe and Kayak
Advisor: Dr. Andres Garcia

Background

Of the U.S population 7.6% or approximately 22.9 million people in 2018 participated in at least one paddling activity. Of the paddling participants in 2018, 72% of the paddlers owned at least one type of paddle craft.

Abstract

YakLift proposed concept has addressed the initial requirements from Austin Canoe and Kayak delivering and innovative product. Initially, we were given the task of designing a Roof Rack capable of loading/loading watercrafts. The team went two steps further and delivered an automated and Modular Rack capable of adjusting to any vehicle.

Objectives

- Design, build and test an automatic modular roof rack that easily facilitates the lifting, placing and securing of paddle crafts on the roof of automobiles.
- To provide customers an automatic alternative to manually lifting a paddle craft onto the roof of a vehicle.

Design Specifications

Column1	*DEPENDENCY*	*MIN*	*MAX*
Avg Car Height [in]	Car Category	56.3	66.8
Avg Car Width [in]	Car Category	38.5	64.1
Minimun FOS	N/A	1.5	-
System Operation Angle [°]	Car Height	45	65
System reach range [in]	Car Height	76	86
Max Load of Roof Rails [lb]	Depending on bar shape	110	165
System max Load [lb]	Weight	80	160
Max Torque [N-m]	ngle of incline & Spool di	23.5	40
Modular	Bicycles - Cargo - Travel Gear		

Main Components

- Tarp Motor
- Linear Bearings
- Spools
- Linear Actuator
- Arduino Uno Micro-controller
- Rope

Design Features / System Highlights

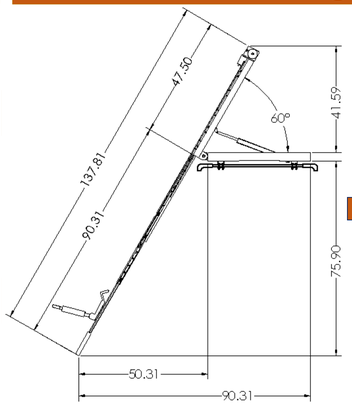

Figure 1: Assembly Side View Drawing

Figure 2: Assembly Isometric View

Figure 3: Assembly Features

Testing / Trials Gallery

System Stages

Figure 4: Assembly at Rest

Figure 5: Angle of Incline Reached

Figure 6: Telescoping Rails

Drawings and Components

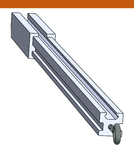

Figure 7: Solid Square Beam drawing

Figure 8: Solid Square Beam Machined Part

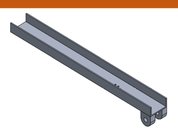

Figure 9: Subframe Drawing

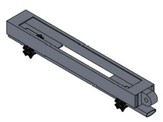

Figure 10: Base Frame

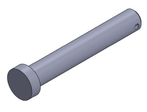

Figure 11: Frame Pin

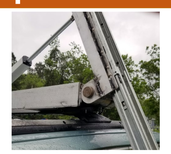

Figure 12: Hinge welded into subframe

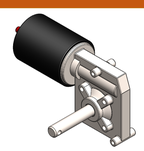

Figure 13: Tarp Motor

Figure 14: Spool

Figure 15: Linear Bearings

Figure 16: Linear Actuator

Building Process

Figure 17: Assembly Material

Figure 18: Visualizing the Assembly Components

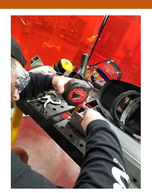

Figure 19: Measuring and the Alignment of Components

Figure 20: Welding Components to Sub Frame

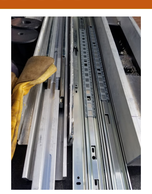

Figure 21: Disassemble of Linear Bearings

Figure 22: Marking the location of Linear Bearings

Figure 23: Welding of the Manufactured Hinges

Figure 24: Complete Assembly

Finite Element Analysis

Structural Design Assumptions

- No Aerodynamic effect except on stage 1 when vehicle is in motion
- FEA model does NOT touch the ground, no ground reaction force.
- Assumed as pin/roller structure
- Assume as a Bonded Contact for an exception in linear bearings and square beams
- Full Load applied once, NOT gradually
- Assumed load locations at Stage 1 – 5
- Assuming the centroid of the kayak for testing
- Static Loading (Vehicle stationary)
- Finite Element Analysis approximates the real thing

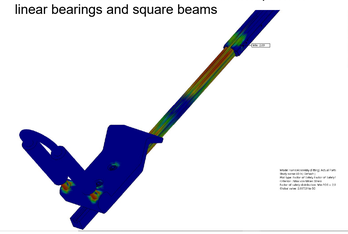

Figure 25: System Minimum FOS of 2.89 at extreme condition with a load of 60lb.

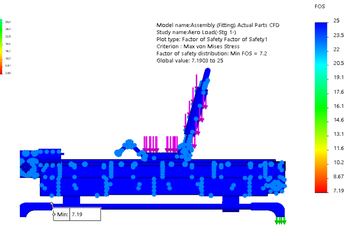

Figure 26: System Minimum FOS of 7.2 under normal driving conditions with load of 60lb and 30lb of air resistance.

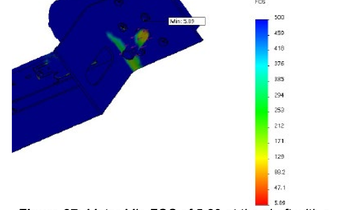

Figure 27: Motor Min FOS of 5.89 at the shaft with a force of 40N-m.

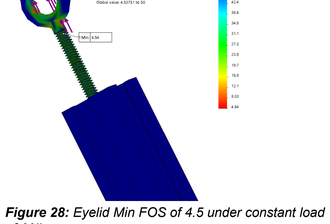

Figure 28: Eyelid Min FOS of 4.5 under constant load of 60lb.

Computational Fluid Dynamics

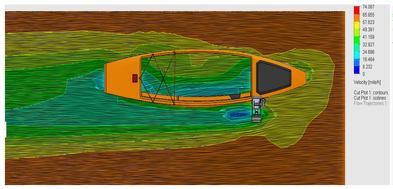

Figure 29: Roof Rack Velocity Contour Cut Plot at 60 mph

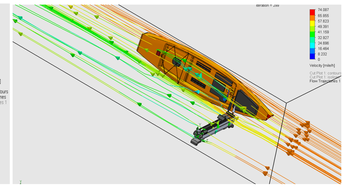

Figure 30: Roof Rack Velocity Vector Field at 60 mph

Future Work

Some future steps for the project is to complete the second half of the project , due to coronavirus the team was not able to gather or machine the parts needed to complete the second unit. The single unit functions and performance as it was design to.

Conclusions

HEC 15 designed an automatic roof rack that requires minimum user interaction, having the loading and unloading process at the user's fingertip. There is not a system with such features available on the market. This system creates almost no work for the consumer, encouraging users to be outdoors enjoying more of nature.

Acknowledgements

Team HEC 15 wants to thank:

- Sponsor: **Austin Canoe & Kayak**
- Project Advisor: **Dr. Garcia**
- Faculty and Chair: **Dr. Barakat**
- Faculty: **Dr. Rashed**