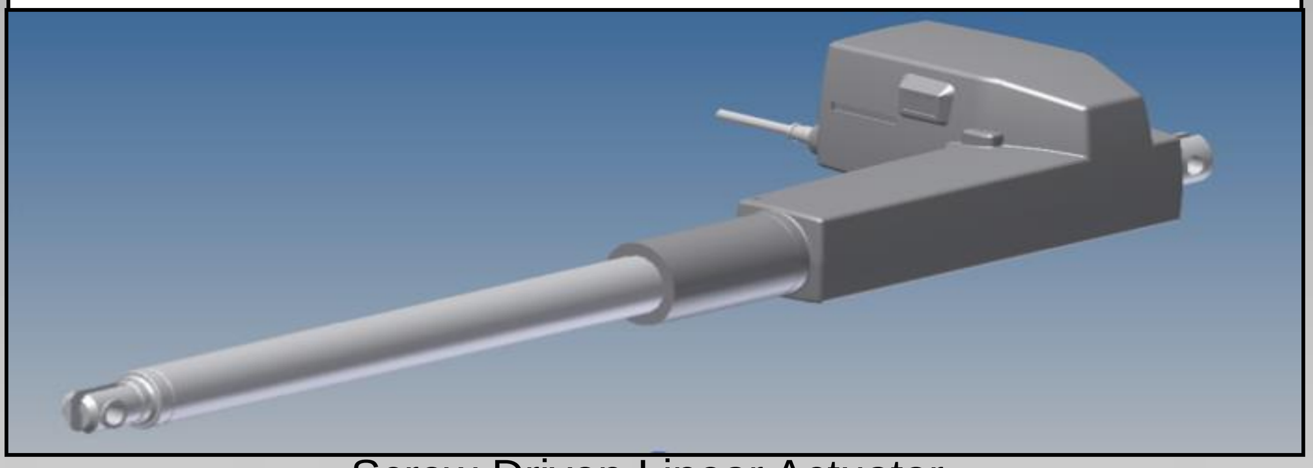
P14006: Assistive Bathtub Chair

SUMMARY

An assistive bathtub chair is a powered device designed to facilitate disabled and/or elderly individuals in taking a bath. Its main purpose is to allow for independence, privacy, and autonomy of the user. MSD Team P14006 was tasked with the responsibility of creating a powered bathtub chair that exceeded the capabilities of the design it was replacing. The end product of this project was a device that is easy to use, requires minimal maintenance, and is operable by a wide user demographic.

OPERATION AND USE

The chair is operated by a two-direction remote to raise and lower the chair by retracting or extending the battery-powered actuator. The actuator assembly is waterproofed to ensure longevity of the system. A locking slide/swivel system grants the user easy access to the tub.



Screw-Driven Linear Actuator

TEAM 14006

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KEY FEATURES

A linear actuator is a screw-driven device that extends or retracts when the screw is rotated by the motor. It is linked to a battery pack that is rated for 40 lift/lower cycles, which is turn operated by a remote control. All electrical components are sealed in waterproof containers that can withstand prolonged submersion. The scissor legs are mounted to the top and bottom plates by clevises; the rear legs are mounted on sliders and are attached to the actuator by a connecting bar. The plastic molded seat accommodates a wide range of users while also providing comfort. Mounted to the bottom of the seat is a locking swivel/slider mechanism for ease of access to the user. Four vacuum cups are attached to the underside of the base to provide a collective suction force of 500 pounds.

REQUIREMENTS

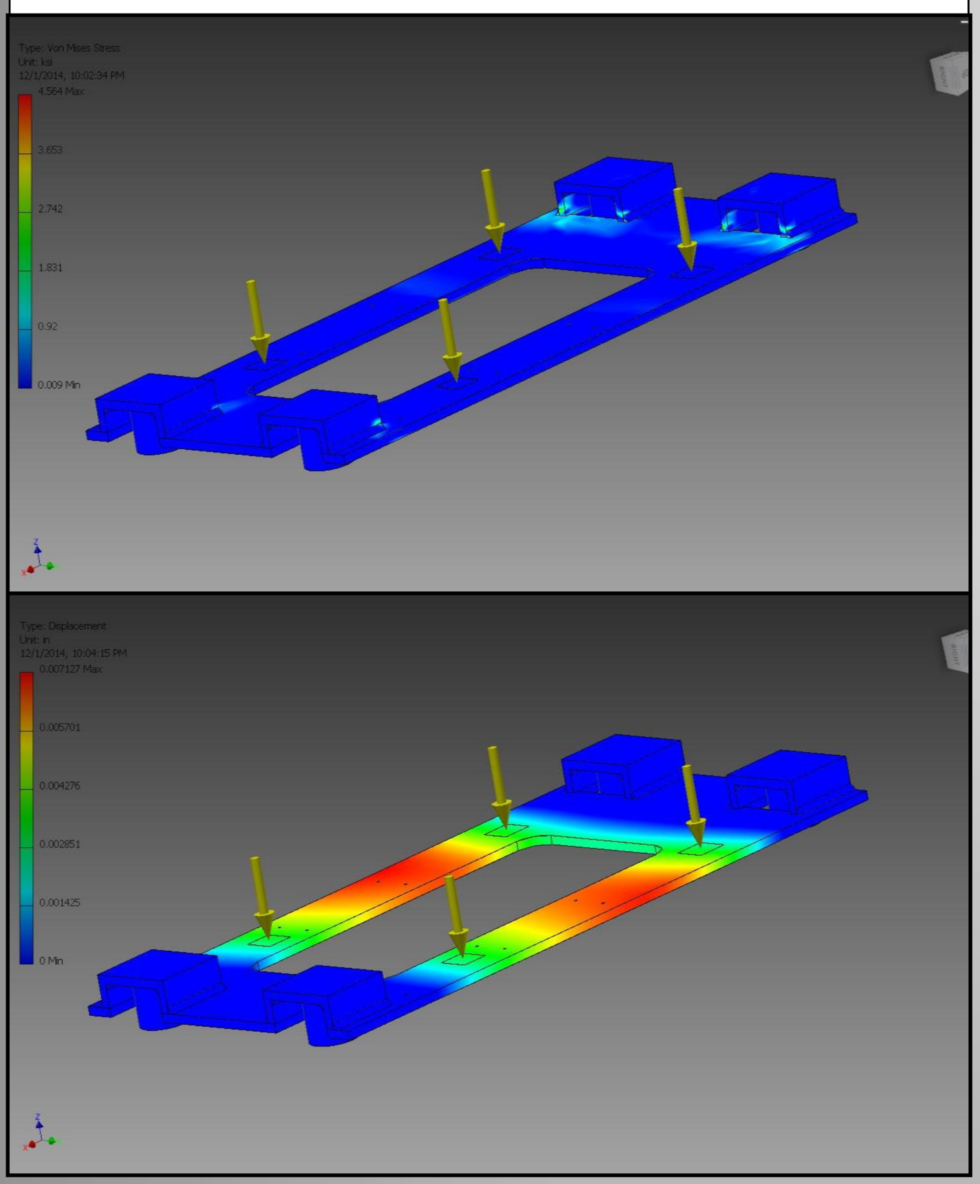
Customer Need	Importance	Description	Status
CN01	1	Chair turns 180-360 degrees	✔
CN02	1	Chair has handles/armrests	✔
CN03	1	Requires minimal setup	✔
CN04	1	Comfortable and safe to use	✔
CN05	1	Operates through a powered system	✔
CN06	1	Sturdy attachment to tub; cannot move	✔
CN07	1	Non-corrosive	✔
CN08	1	Easy to use	✔
CN09	1	Easy to clean	✔
CN10	1	No use of Nickel - allergic	✔
CN11	1	Able to lift at least 150 lbs	✔
CN12	1	Accessible to 10th percentile women (height)	✔
CN13	1	Controls/handles must be easy to use	✔
CN14	1	Compatible with existing tub/system	✔
CN15	1	Takes 0-5 minutes to rise	✔
CN16	2	Easy to maintain/fix	✔
CN17	2	Minimal noise	✔
CN18	2	Flexible temperature control	✔
CN19	2	Can fold down to fit in car	✔
CN20	2	Lightweight	✔
CN21	2	Way to measure temperature	✔

Green section signifies requirements of most importance, Blue section shows options that were met on a basic level

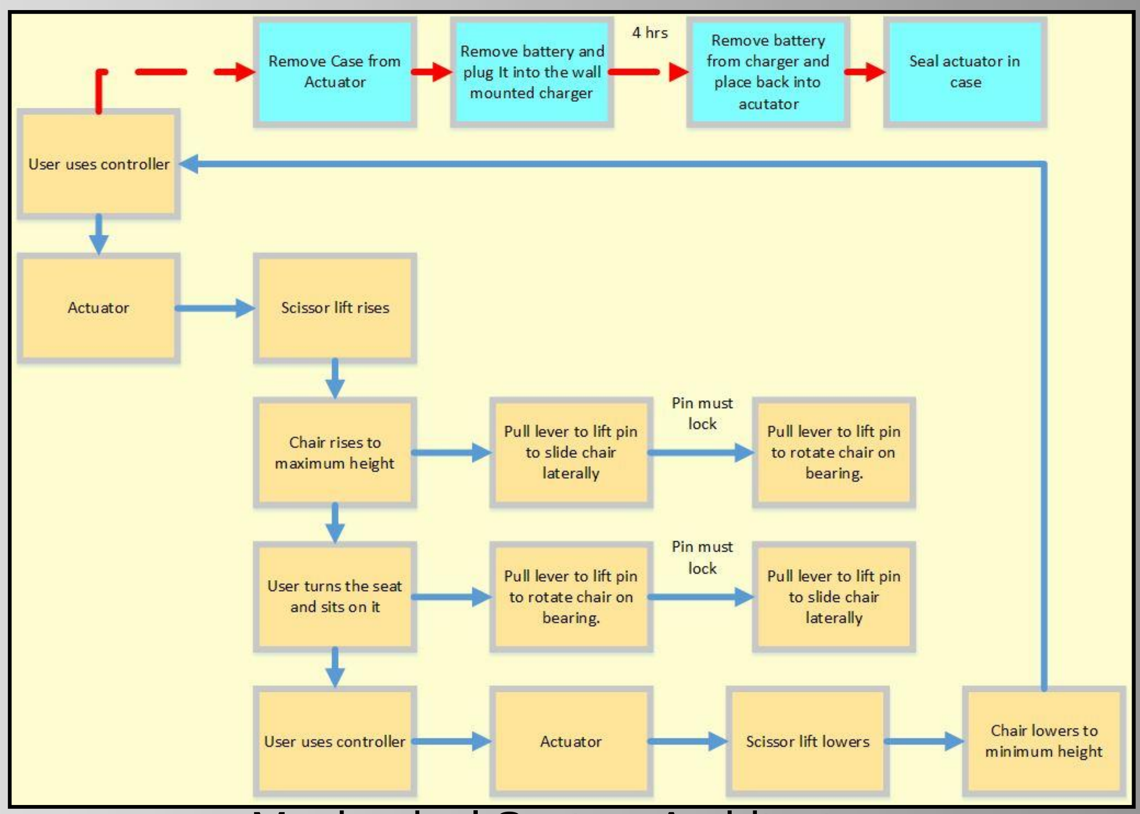
DESIGN PROCESS

The first design concern was how the device would be powered. Out of the initial concept selection, two main designs were considered: a water-powered lift, and a battery-actuator system. The battery option was chosen on the basis of simplicity, functionality, and mobility. The linear actuator and battery system was capable of bearing extreme loads, allowing for a high maximum user weight. A scissor lift with a rail and carriage system was chosen over a single-pillar design for both increased strength and stability. Vacuum cups were most effective at securing the device to the tub.

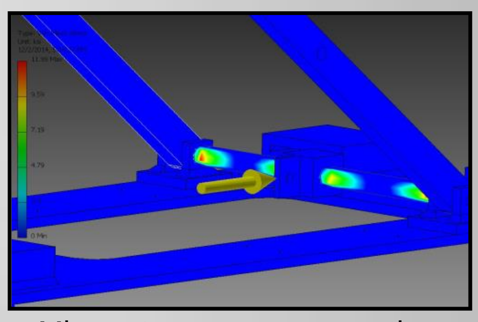
P14006 Full Project Assembly



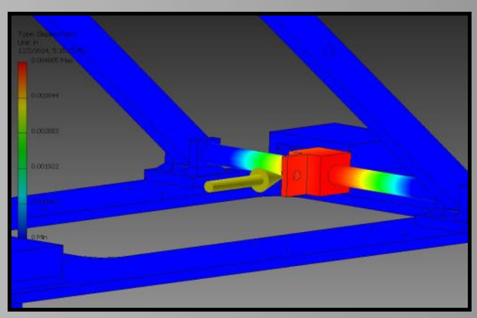
Von Mises stress analysis and displacement
(max allowable disp. : 0.035in ; actual disp. : 0.007 in)



Mechanical System Architecture



Von Mises stresses on connecting rod



Deflection of adapter and rod
(allowable disp. : 0.035in ; actual disp. : 0.005in)

CALCULATIONS & TESTING

The main points of analysis focused on the stresses and moments on the legs, pins and clevises, sliding mechanisms, and rod connecting the actuator to the rear legs. It was found through ANSYS that buckling was the most likely mode of failure in the legs. As a countermeasure, 304 stainless steel and a slightly wider leg thickness was appropriated. Due to the high amounts of concentrated stress on the connecting rod, the shaft was made thicker, consisted of a material of proper strength and ductility, and a stress-distributing adapter was added between the actuator and the rod. Multiple waterproofing tests were conducted to determine which method proved to be most effective. Electrical components were placed in rubber-sealed containers, while a bellow was placed of the extending segment of the actuator to accommodate movement without allowing ingress of fluids.

PROJECT OUTCOME

The final version of the prototype remained faithful to the initial concept decided on at the end of the MSD I course. Slight modifications were made to accommodate cost and time constraints, in addition to supplier availability of certain parts. The device became focused on meeting the needs of a specific client, but the device was still designed with mass-market use in mind. The system is easily able to support loads of over 350 pounds, the seat can accommodate any males or females from the 10th to 90th percentile, and the battery lasts for approximately a month of use before requiring a recharge. The iterative process and emphasis on informed decision-making ensured that the project exceeded its initial requirements and was delivered to the client in a timely manner.

Special Thanks :