HyperSeal
ME 463 – Spring 2016

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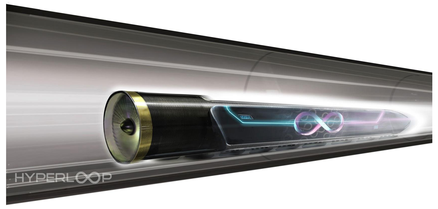
PURDUE MECHANICAL ENGINEERING

Background

Technology called the Hyperloop is being developed to carry people and cargo 200 miles apart at speeds of nearly 700 miles per hour. Pods for transport operate in a near vacuum environment. Currently no prototype exists.

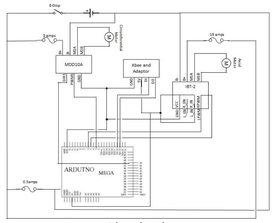


Project Objective

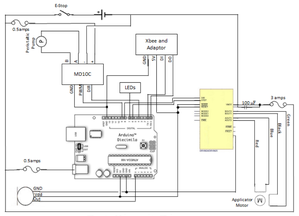
Leaks are expected to develop in Hyperloop tube walls over regular use of the Hyperloop. These will cause loss of vacuum environment, and reductions in efficiency. Use of human maintenance is hazardous and costly.

Electronics

- Controlled by two microprocessors (Arduino Uno and Arduino Mega
- Microprocessors communicate with Xbee radio modules
- Arduino Uno on robot acts as master while Mega on the base is the slave
- Sonic sensor is located on the robot and is monitored to determine when leak has been found
- Base is powered by 12V lead acid battery while robot runs on a 12V NiMH



Base Circuit Diagram



Bot Circuit Diagram

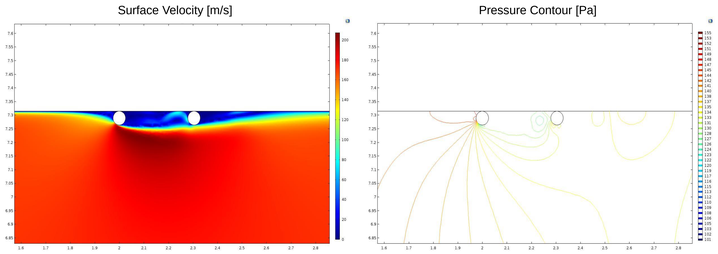
Suggestions for Future Design

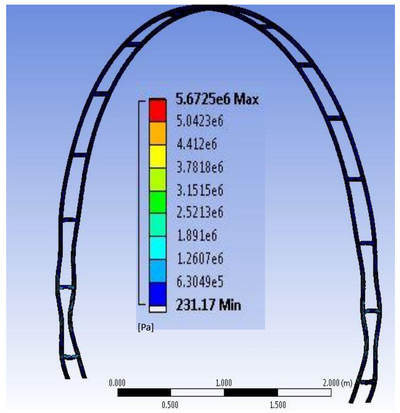
HyperSeal Design
- Wider and higher quality belt for circumferential system
- Higher torque circumferential motor
- Extra set of wheels on robot for stability
- Right angle gearbox for axial drive

Consideration for Hyperloop Development
- Powered center rail at top of tube to reduce need for batteries
- Smart tube communication to narrow down leak locations
- Access ports to replenish sealant

Analysis

- CFD analysis used to obtain pressure distributions
- FEA analysis carried out using forces derived from pressure gradient
- 5052 aluminum yield strength of 190MPa
- Maximum observed stress of 5.6725MPa on rails





Overall System

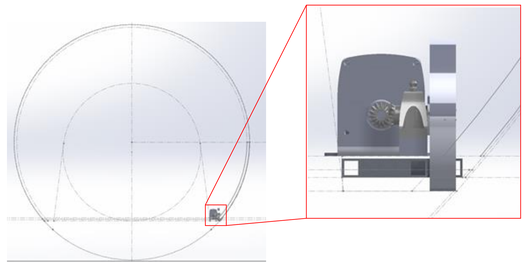
- Design: **$9193.93**
- Prototype: **$336.95**

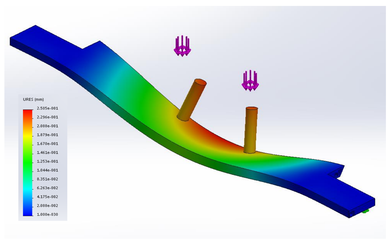
Engineering Targets

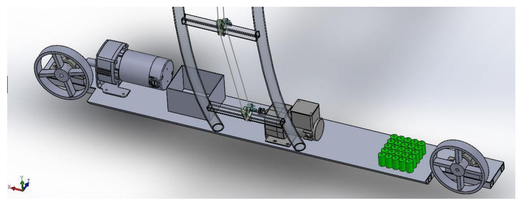
- Withstands pressure differences of **100kPa**
- Lasts for **1 yr.** with maintenance every **6 mo**.
- Continuous run time of **10 hrs.**
- Recharge, refill of sealant, and part replacement occurs within the tube interior **(Y/N)**
- Autonomous operation **(Y/N)**
- Finds leaks of **0.1 mbar-L/s or greater**
- Overshoot in scanning motion **less than 6 in**
- Maximum radial thickness of **6 in** at base

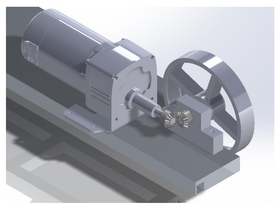
Axial Movement

- Single-wheel drive by a DC motor on each side of base
- Right angle bevel gear connection from gear shaft to wheel
- Battery storage for non-robot electronic components
- FEA showed worst-case deflection of ~2.5mm
- Base component: aluminum plate
- Additional support: aluminum tubing
- Sized to ensure minimal radial extension



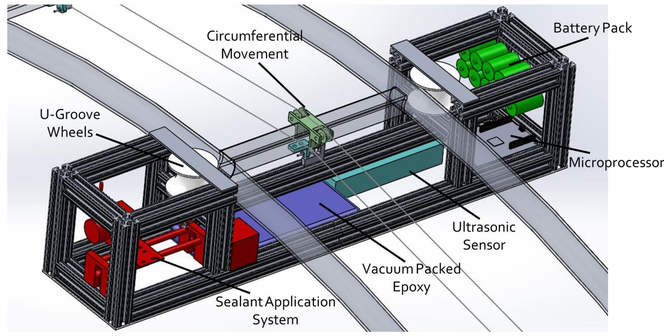






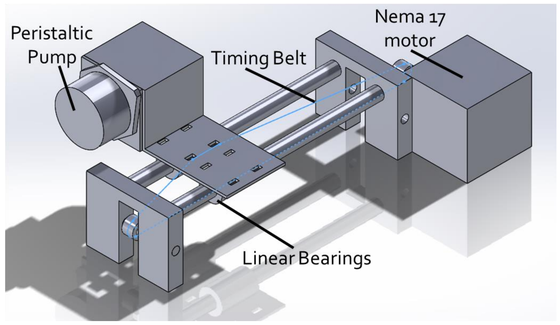
The Robot

- Open frame design allows for easy access to replace parts
- Batteries and electronics are all on-board
- Includes sealant and extruder, microprocessors, batteries, and sensors
- Designed to be 20lbs; prototype is 23lbs



Sealant System

- Applies UV-curing epoxy to leak area
- Stepper motor allows epoxy to be spread across large area without movement of entire device
- LEDs cure epoxy in less than 30 seconds
- Epoxy adheres to steel and concrete



Circumferential Movement

- Based on a ski-lift design
- DC motor powers belt drive and moves robot along rails
- Enables scanning and sealing over 95% of the tube interior
- Designed for easy robot removal and mounting