Team #8

HYDAC Solenoid Linear Actuator

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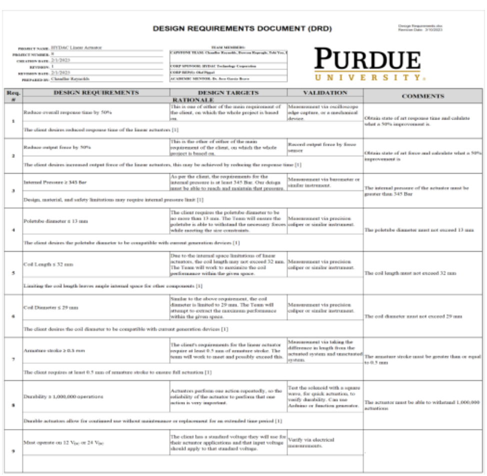
Customer Background

HYDAC produces solenoid linear actuators, which are small devices that the magnetic field produced by a coil (solenoid) to move a small armature a short distance. These solenoids are used to operate hydraulic valves reliably even in extreme conditions.

Problem Statement / Scope of Work

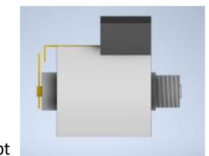
The project aims to enhance a solenoid linear actuator for HYDAC, focusing on increased output force and reduced response time within specified dimensions. Emphasizing reliability, robustness, and efficiency, the team will explore electromagnetism principles, evaluate existing solenoid designs, and adhere to ANSI standards. Theoretical optimizations will lead to prototype development, with comparative testing against the original design. Experiments will be conducted using university and HYDAC facilities to refine the final product.

Requirements



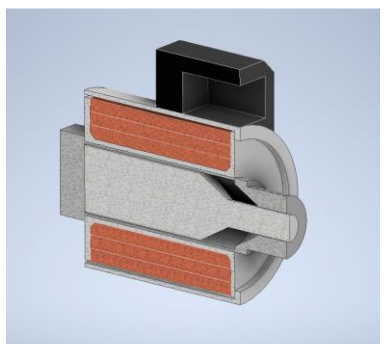
Experimentation and Concepts

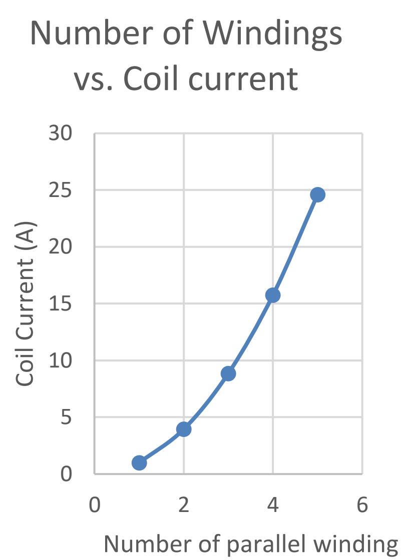
In order to meet the client's requirements of increased response time for the solenoid, while maintaining dimensional constraints. Our teams sought ways to increase the magnetic power of the solenoid and to more efficiently use the magnetic power. We were not able to find success in designing a pole tube or a solenoid housing that would more efficiently use the magnetic power. Although we found the magnetic coil could be improved. With the conventional coil, if the current remains the same, the more turns in the coil the more magnetic power. However having more turns is only possible with thinner wire, which has higher resistance, which means less current and decreased performance. Increasing the voltage would cause overheating. We explored ways to temporarily increase the voltage until the actuation was complete. With the short time of increased voltage lowering the chances of overheating. This would require substantial circuitry redesign and was not practical. We found parallel coils, where two wires were winded at once, allowed greater current at equivalent turns to a conventional one. As each wire is half the length, with half the total resistance. We experimented using three wires led to too high of a current, which will overheat.



Temporary voltage increase concept

Final Design





The Team found that winding two parallel coils proved to be the best balance between reaction time and thermal stability. The parallel design reduced the overall resistance to 3.2 Ω from the standard 12.2 Ω. Introducing more than two parallel windings would result in higher than acceptable coil currents.

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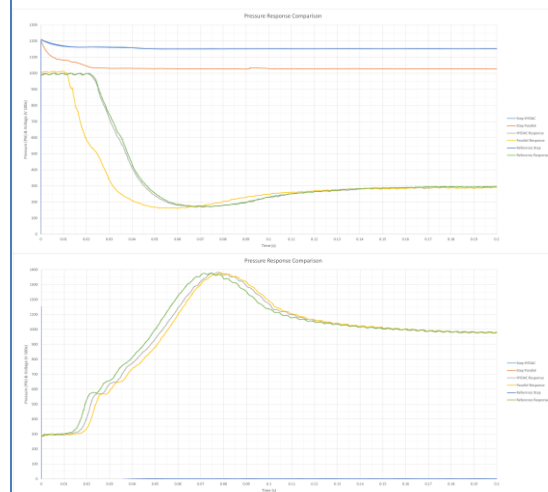
Testing



Response Times from Hydraulic Testing:

HYDAC Coil (off the shelf):

34.9 ms (Falling Edge) 43.6 ms (Rising Edge)

Reference Coil Prototype:

35.5 ms (Falling Edge) 41.3 ms (Rising Edge)

Parallel Coil Prototype:

20.0 ms (Falling Edge) 46.1 ms (Rising Edge)