

HYDAC Solenoid Linear Actuator

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Team #8



Customer Background

Polytechnic Institute

PURDUE

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

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ıq.	DESIGN REQUIREMENTS	DESIGN TARGETS RATIONALE	VALIDATION	COMMENTS	
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1	Reduce overall response time by 50%	the client, on which the whole project is based on.	edge capture, or a mechanical device.	Obtain state of art response time and colulate	
	The ofient desires ordeced response time of the linear actuators [1]			what a 50% improvement is.	
_	This is the other of vitter of the main				
	Reduce ontent force by 50%	constructed of the client, on which the whole	Record output force by firme		
2		project is based on.	Dealers	Obtain state of set force and calculate what a 509	
	The ofient desires increased output force of the linear nebaters, this may be achieved by reducing the response time [1]			inger-verseut is	
	Internel Pressent > 343 Far	As per the client, the royptrements for the internal success is at least M5 Bar. Our deises	Menuratement via baremeter or		
	TRACTOR CALIFORNIA S 243 Per-	internal pressure is at least 545 Bise. Our delega meant he able to reach and maintain that pressure.	similar instrument.	The internal pressure of the actuator mand be	
		panel by star to reach and mannak the process.		greater than 345 Bar	
	Design, material, and sofiety limitations may require internal p	mootre limit [1]		print the second	
		The client requires the poletube dismeter to be			
	Poletube-diameter (13 mm	no more than 13 mm. The Team will cannot the	Manuracent via precision	The pointshe diameter must not enceed 12 mm	
	Contration distance in 13 man	poletabe is able to withstand the necessary focces	colliner or simpler instrument.		
1		while constinue the size correlevants.			
	The client desires the poletable disaneties to be compatible with current generation devices [1]				
		Due to the internal space limitations of linear			
	Coll Length 6 32 mm		Measurement via precision		
	Concentration a 32 min	The Tunn will work to maximize the coll	colliper or similar instrument.		
5		preferences within the pixes space.		The coil length must not encoded 32 mm	
	Limiting the coil length herves ample internal space for other components [1]				
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٠		Nambar to the above requirement, the coll			
	Col Dispeter 5 20 mm	diameter is limited to 29 mm. The Yeam will	Menorement via precision		
	CONTRACTOR OF THE OWNER.	ottempt to correct the maximum performance	colliper or similar instrument.		
		within the given space.		The coil diameter anatinet exceed 29 mm	
	The client desires the coil diameter to be connertible with car	manufacture during 100			
		The client's cogginements for the linear extentor	Measurement via taking the		
	Armstern shoke 5.0.3 mm	rowpare at least 0.5 mm of armstere whole. The	difference is length from the		
		nears will work to meet and possibly exceed this.	octuated system and unscitnated	The annature stroke must be greater than or equi-	
'		Gapter		10.0.5 000	
	The client requires at least 0.5 mm of semantary stroke to ensure full actuation [1]				
			Test the solution with a summer		
		Actuators perform one action repeatedly, so the	wave, for quick actuation to		
	Durshility a 1,000,000 operations	colisities of the actuator to portions that one	weift datability. Can use		
		inclices is very important.	Andesas or Sentine presentor.	The actuator must be able to withstand 1,000,000 actuations	
				ALTER AND	
	Durable actuators allow for continued use without maintenance or replacement for an extended time period [1]				
-					
		The client has a standard voltage ducy will use for their actuator opplications and that input voltage	Varify via electrical		
	Mast operate on 12 Voc or 24 Voc	their actuator applications and that input voltage should apply to that standard voltage.	increase and a second s		
		should apply to that standard voltage.			
				1	

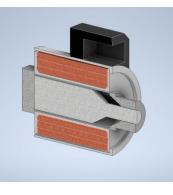
Experimentation and Concepts

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.

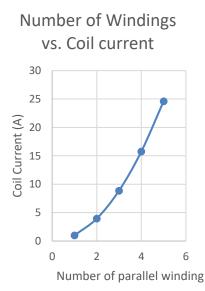


Temporary voltage increase concept

Final Design

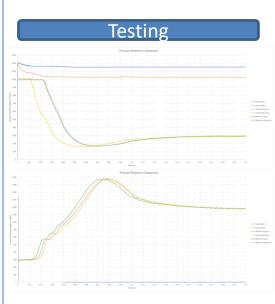


The Team found that winding two parallel coils proved to be the best balance between reaction time and thermal stability. The parallel design reduced the overall resistance to 3.2 Ω from the standard 12.2 Ω . Introducing more than two parallel windings would result in higher than acceptable coil currents.



FMEA





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)