

Novel Reciprocating Pump for High Temperature Molten Salts

William Sames, Ph.D., President, Cinco Research Corporation
email: will@cincoresearch.com , cell: 979.595.8818
152 Judge Don Lewis Blvd, Elizabethton, TN 37643

Amos Manneschildt, Project Manager, Cinco Research Corporation

Lane Carasik, Ph.D., Assistant Professor, Virginia Commonwealth University



About Cinco Research

- ▶ Founded in 2021 by Dr. William Sames to develop technical solutions related to manufacturing and engineering of clean energy and defense components.
- ▶ Consolidated ongoing R&D efforts related to DOE, DOD, and private industry to enable reinvestment in mission.
- ▶ Specialty in manufacturing, mechanical engineering, materials science, and additive manufacturing.
- ▶ Acquired General Machine and Tool Company, Inc. in February 2022 to provide manufacturing support to ongoing DOE, DOD projects. General Machine specializes in low-medium volume production of precision components and fabrications with nuclear applications. Machining, welding, and fabrication of Inconel, steel, and stainless steel
- ▶ 15,000 SF machine shop
- ▶ 5,000 SF conditioned R&D/flex space



New Nuclear Development Partner

- ▶ Cinco Research has 3.5+ acres of industrial HUBzone land in Elizabethton, TN (approx. 2 hours from ORNL), pad ready. Will build-to-suit 100,000+ SF in support of production for new nuclear components
- ▶ Next door to 15,000 SF machine shop and 5,000 SF Flex facility that can support production and assembly
- ▶ Contact for details:
 - ▶ William Sames, will@cincoresearch.com
 - ▶ Cell: 979.595.8818



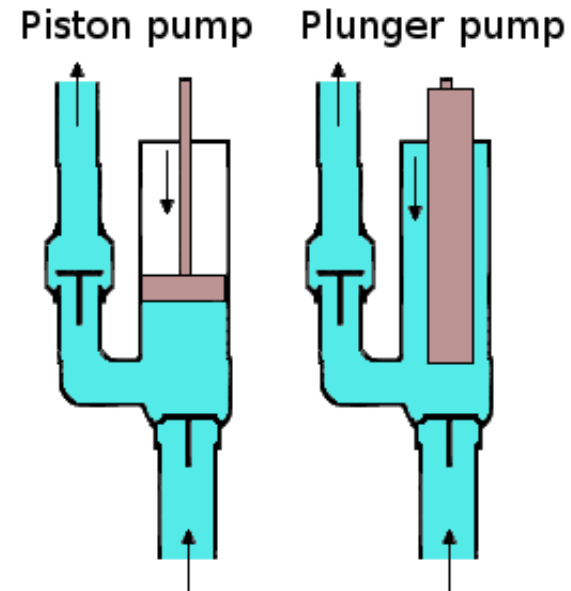
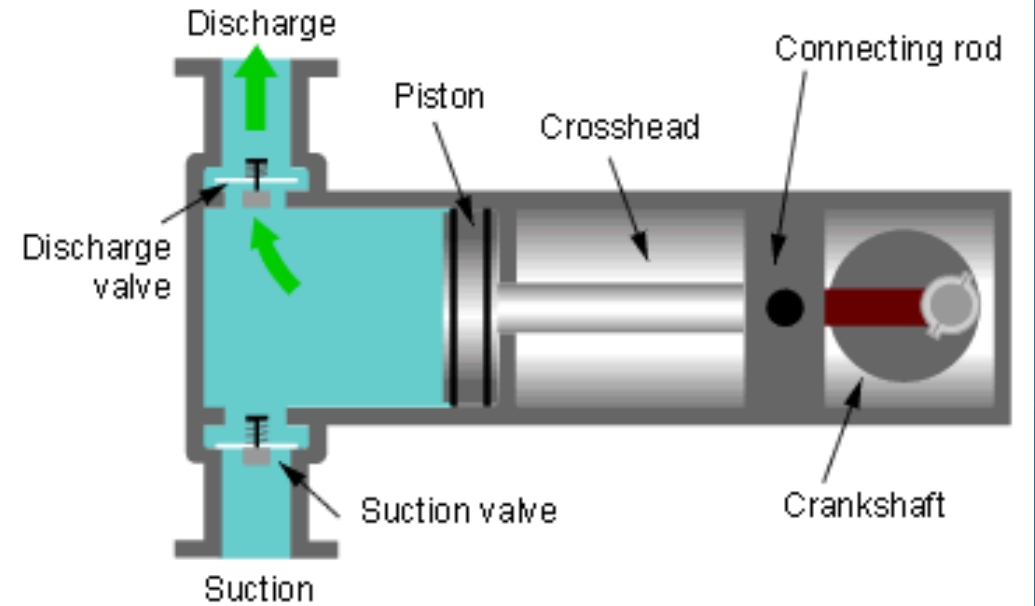
Acknowledgements

- ▶ The work discussed herein was performed under Dept. of Energy SBIR Phase 1 Award DE-SC0021764
- ▶ The pump technology reported and discussed herein has been filed as a Provisional Patent 63/378,535
- ▶ Dr. Lane Carasik, Virginia Commonwealth University (VCU), and student team is acknowledged for their support and effort on the testing and analysis of the Cinco reciprocating pump



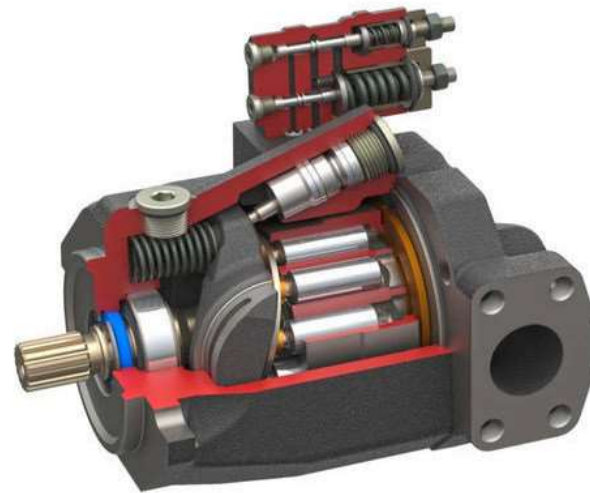
What is a reciprocating / piston displacement pump?

- ▶ Many terms to describe the concept of a piston motion being used to evacuate fluid from a chamber, utilizing some form of valve or gates to control the evacuation and filling of the chamber in coordination with the piston motion to create a pump that moves fluid.
- ▶ In a single piston system, the resulting fluid has a periodic flow rate. Reciprocating pumps often have 3 (a “Triplex” pump) or more pistons moving in coordination via a crankshaft to limit this effect and increase pump capacity.
- ▶ In common use for oil well drilling “mud pumps”, often high pressure ~7,500psi



Typical Commercial Piston Pump Solutions; Typically Low-Temperature Focus, Utilize Seals

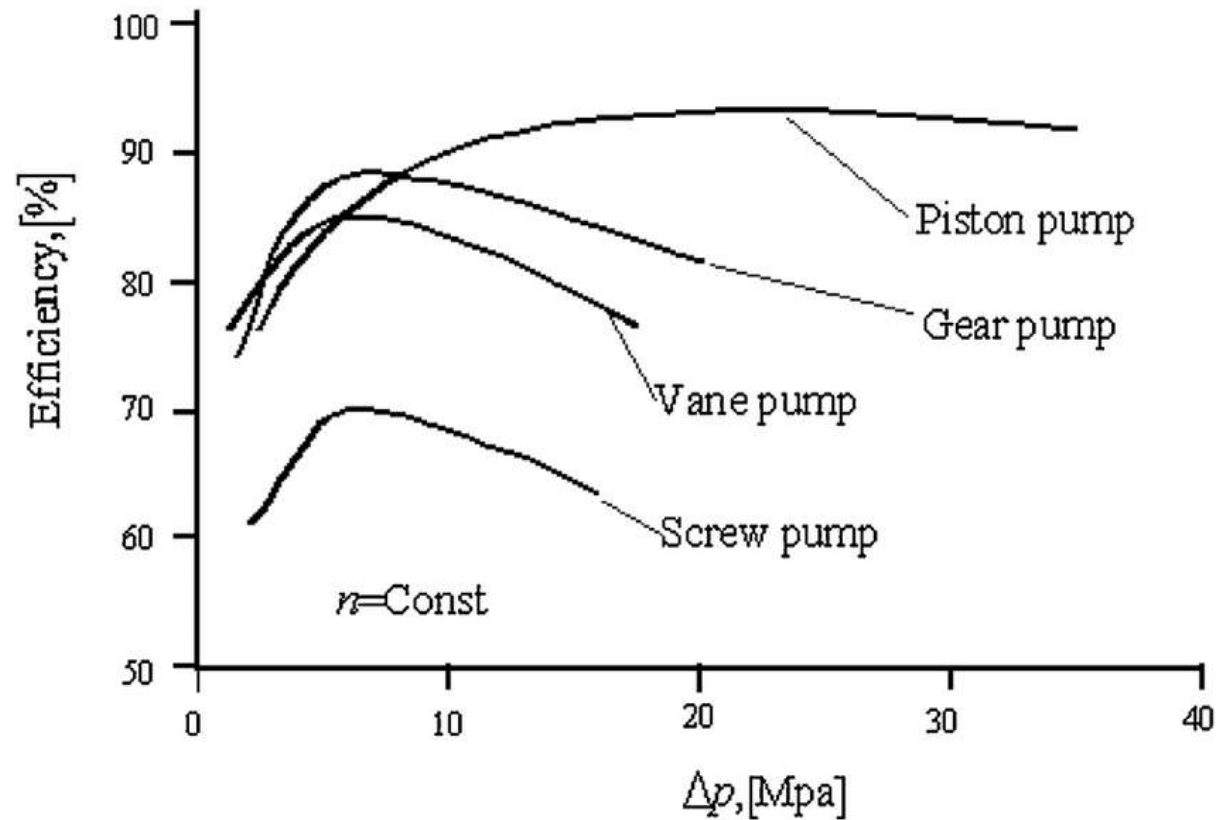
- ▶ Crankshaft Driven, “Triplex”
- ▶ Typical for “mud” pumps in well drilling
- ▶ Swashplate used with rotating shaft to drive piston motion
- ▶ Typical for hydraulic applications



https://www.northridgepumps.com/p_219_cat-60-frame-60pfr-piston-pump

<https://www.indiamart.com/proddetail/variable-displacement-axial-piston-pumps-11741518148.html>

For Hydraulic fluid pumping, piston pumps have once of the highest efficiencies compares to other pumps



Reciprocating vs Centrifugal Pumps

- ▶ PD (positive displacement) pump or piston pump; “Minor variations in system resistance do not alter the flow”
- ▶ Piston Pumps should theoretically **provide more consistency in flow rate** compared to an equally sized centrifugal pump
- ▶ **Piston pumps can handle gas content “up to 95 percent gas in some designs...[and] Most PD pumps are capable of handling in excess of 50 percent gas without modification.”** This is a big improvement over *Centrifugal pumps* that “gas fills the impeller eye and can not exit the tip of the impeller against the discharge pressure. The pump *becomes vapor bound and stops pumping.*”
- ▶ “PD pumps operate at high mechanical efficiencies over a **wide range of viscosities.**”
- ▶ PD can be designed with low Net Positive Inlet Pressure Available (NPIPA) more easily than centrifugal pumps. “PD pumps generally **require less absolute pressure than centrifugal pumps**”

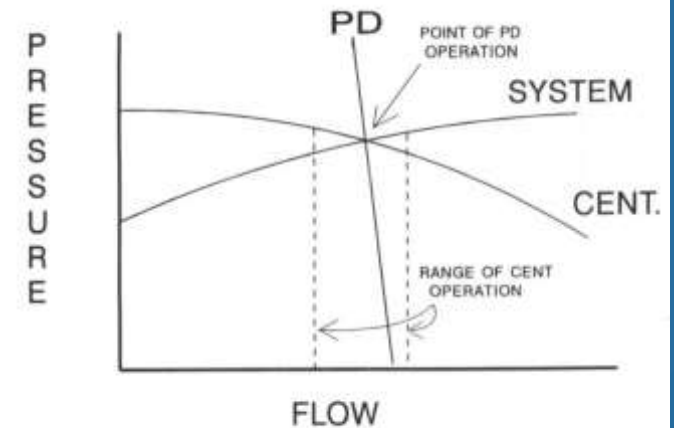


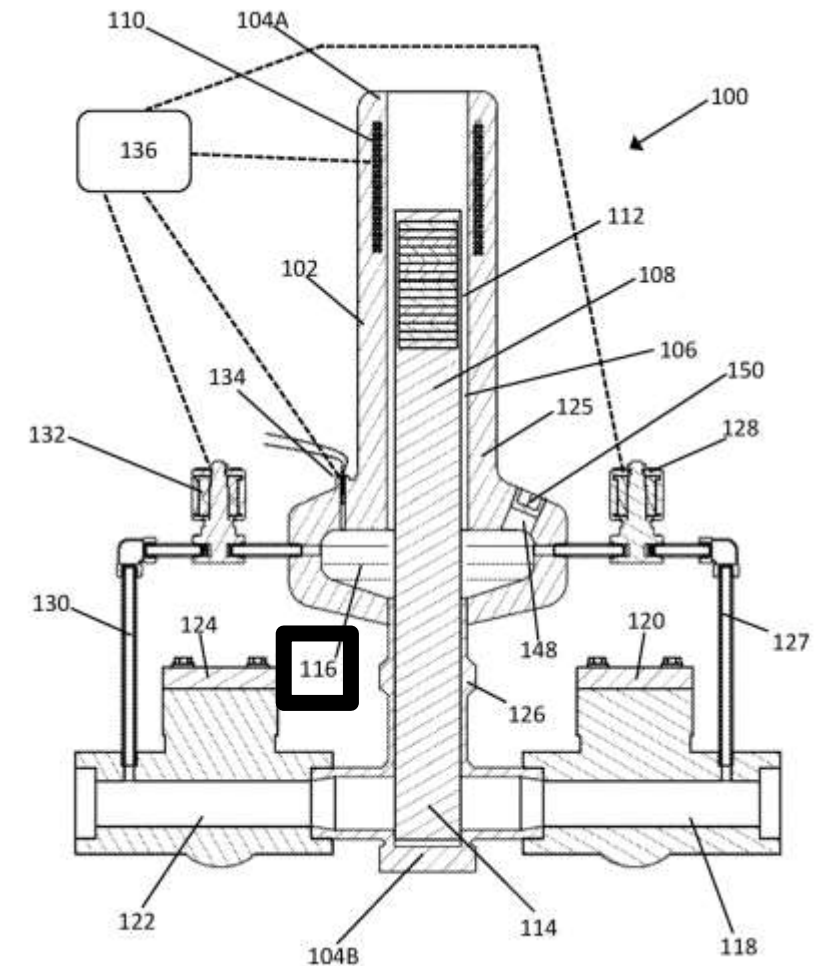
Figure 1. Comparison of System Responses.

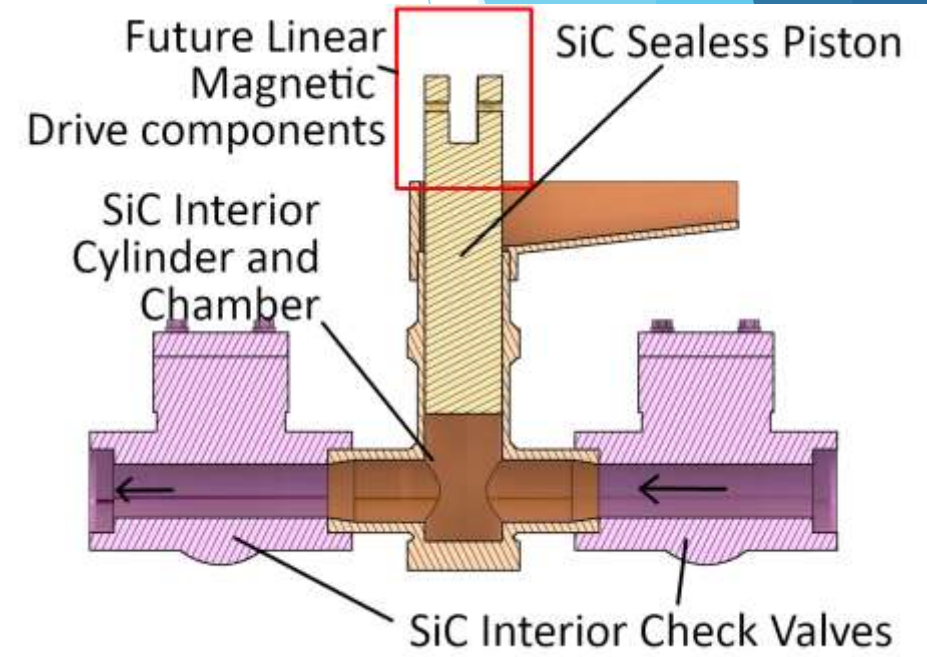
Cinco Research Designed Novel Reciprocating Pump



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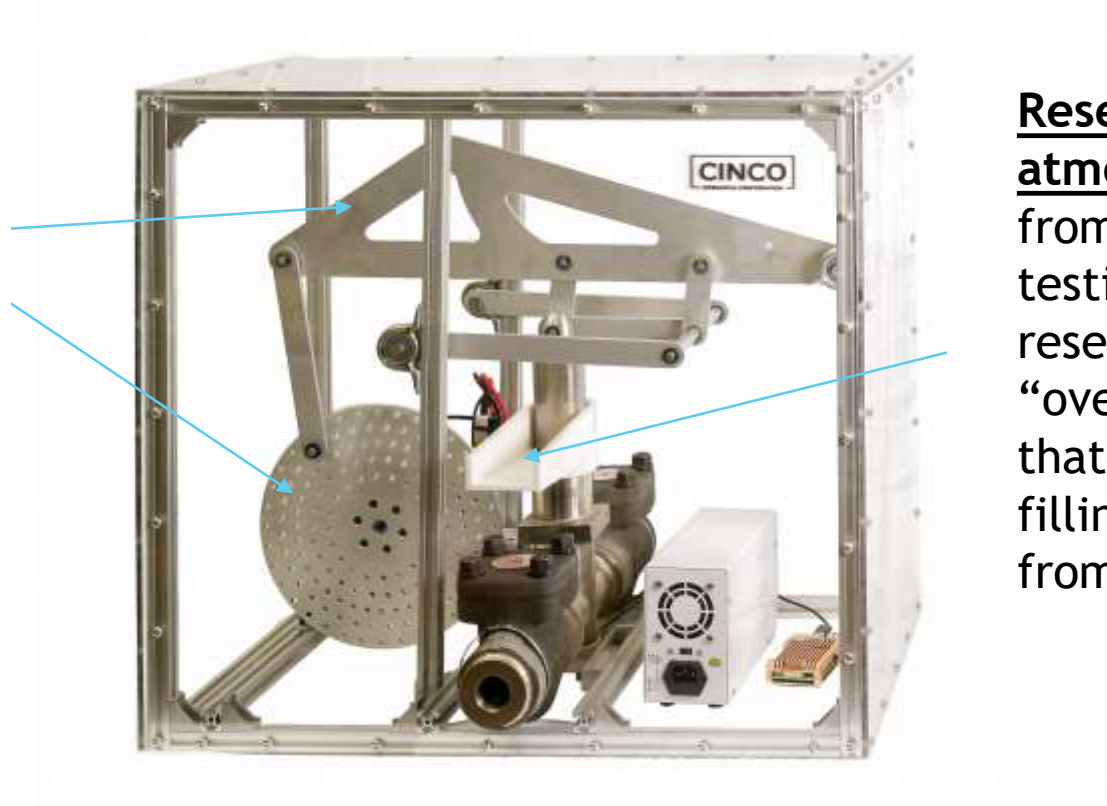
- ▶ The key innovation is a reservoir placed at the top of the pumping chamber that allows for eliminating seals
 - ▶ Eliminates seals from working fluid region
 - ▶ Enables self priming and system control
- ▶ Prototyped in Stainless Steel, but designed with intention to move to a ceramic piston or all ceramic pump
 - ▶ An all-ceramic pump with no bearings or seals in contact with working fluid is the developmental goal to provide molten salt pumping capabilities at the highest temperature range, in theory up to the operating range of the selected ceramics, which would provide a large improvement in operating range compared to all metallic systems that have bearings and seals in contact with working fluid
 - ▶ Phase 1 stainless prototype was successful and allowed for IP development to engage customers and partners openly for next steps
- ▶ Eliminating seals in the working fluid region enables both high temperature and hygienic use cases





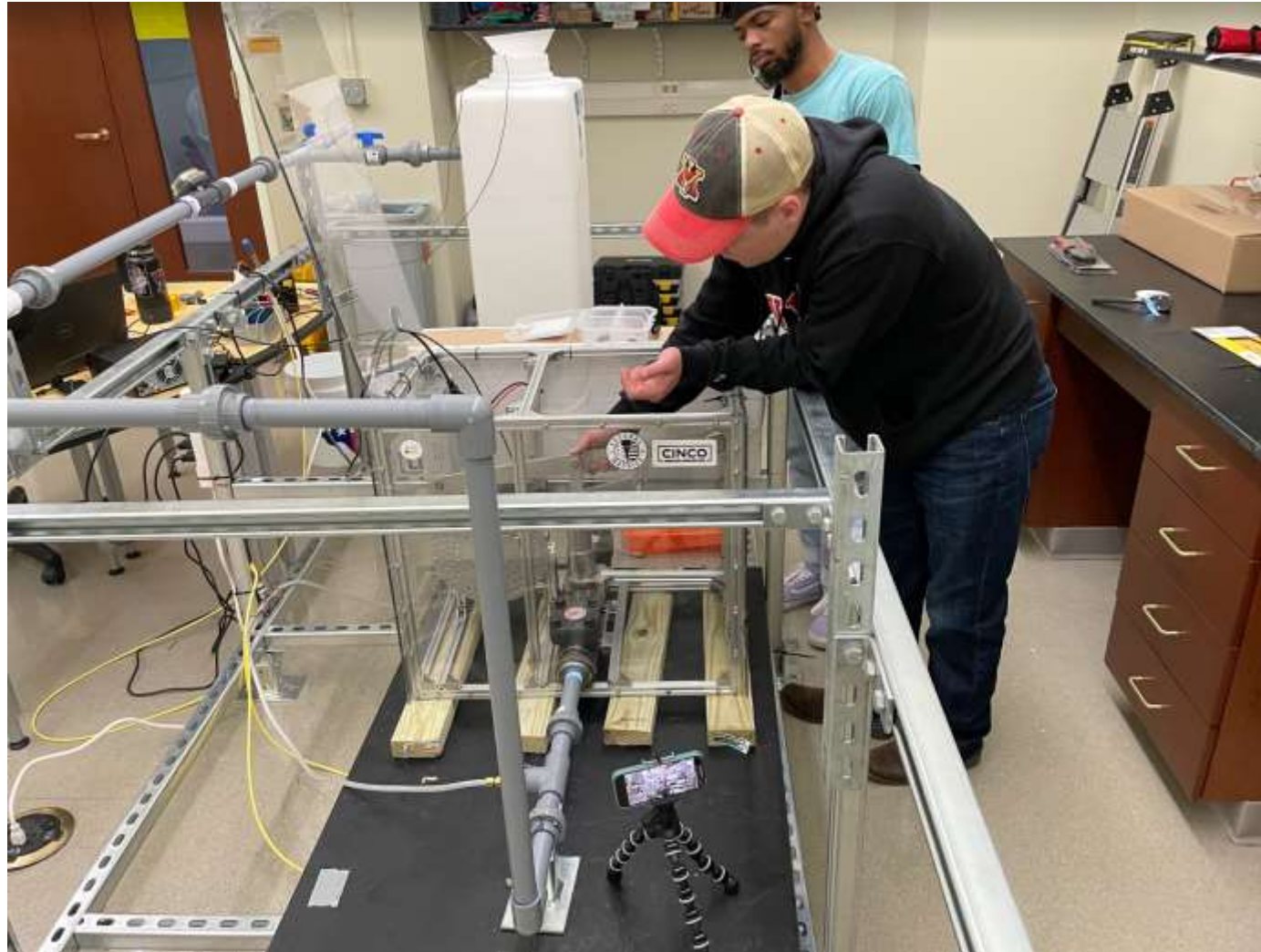
Photobooth Image of Prototype System with 3D printed plastic, open-atmosphere reservoir

Rotary drive / pump jack was utilized as simple mechanical drive, in prototype system. Some side-wall forces remained in prototype, which will be resolved with alternate drive mechanism such as a linear magnetic drive in the next prototype.



Reservoir is open atmosphere, prototyped from plastic for rapid testing. This design of reservoir come with an “overflow” / “feed” ramp that can be connected for filling and dispensing fluid from reservoir.

Testing at VCU



Testing at VCU



Next Steps

- ▶ Further refinement to Beta prototype
 - ▶ Testing of ceramic pistons in metallic chambers
 - ▶ Introduction of linear magnetic drive to replace pump jack
 - ▶ Testing of ceramic pistons in ceramic chambers
 - ▶ High temperature testing (molten salt furnace location access has been secured, see image)
- ▶ Seeking commercial partners
- ▶ Seeking research collaborators
- ▶ Commercialization Plan:
 - ▶ We are seeking to support next generation nuclear companies through development and licensing of technology, contract engineering, and/or contract production of components.



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