Electric Propellant Feed System (EFS)

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Sponsor: Portland State Aerospace Society

Project Objective Statement

The goal of the EFS project is to design, build, and test an electric propellant feed system for the PSAS LV3 liquid fueled bi-propellant rocket engine prototype by June 6, 2017.

Motivation

Historically, the systems to impel propellants to the combustion chamber of a liquid fueled rocket are based on the employment of turbo-pumps or pressurized gas systems. The complexity and cost of these methods has made building a liquid fuel rocket financially and technically difficult for the amateur rocket community.

The EFS team is investigating the open source development of a low-cost electric powered alternative for providing the pressure and flow requirements of PSAS's LV3 rocket.

Key Customer Requirements

- Design, build and test a technology development platform for the electric propellant feed system.
- Design a pump capable of delivering 350 psi of pressure at ~11 GPM to the LV3 engine.
- Pump performance characterization.
- Scalable design for future pump iterations.
- Open source documentation, design artifacts and build information.

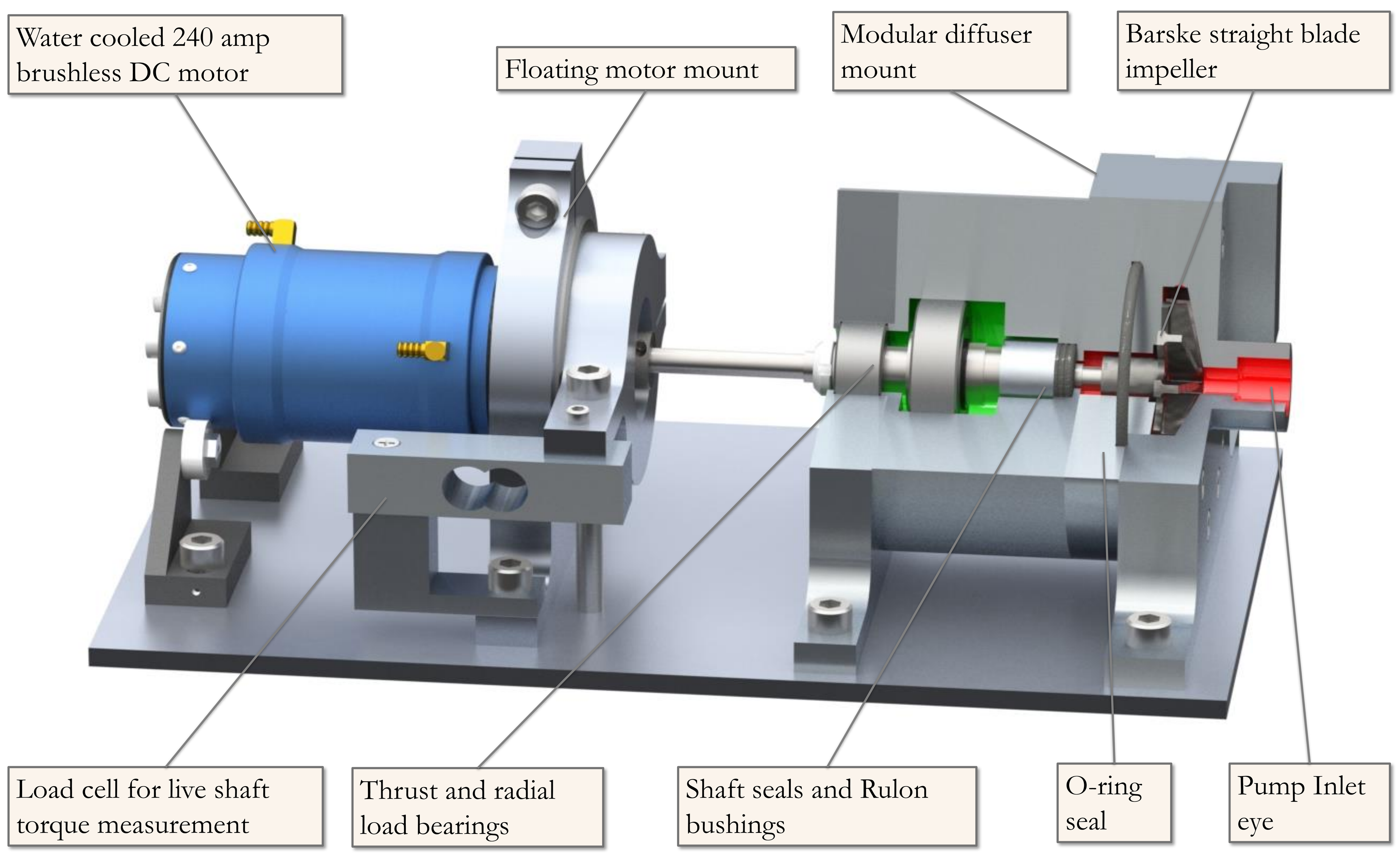
Future Work

- Investigate additional design variations.
- Test pump with pintle injector.
- Adapt system for cryogenic propellant conditions.
- Scale for LV4 and future 8kN engine design.
- Refine motor control and motor data acquisition.

Acknowledgments

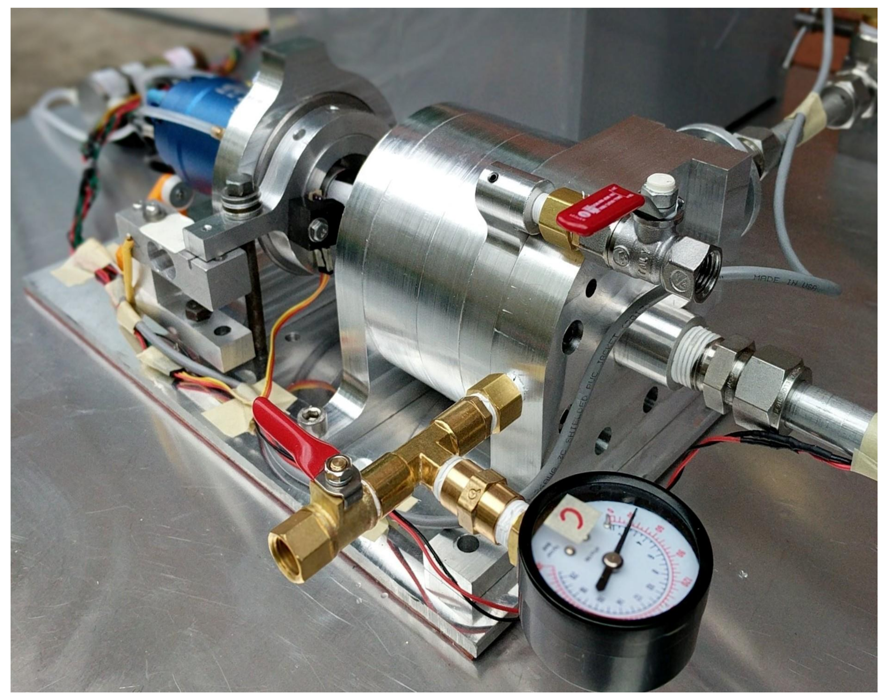
We thank our mentors Erin Schmidt, Andrew Greenberg and Raúl Bayoán Cal for their support, Chris Auclair for sharing a wealth of MasterCam knowledge, Haneef Mubarak for lending a valuable hand, and Mike Chung for allowing us to live in his machine shop. Funding for this project was provided by Portland State Aerospace Society.

Design Features



Impellers

The EFS system uses an unorthodox Barske straight blade impeller to meet the unusually high head, low flow engine requirements. Final designs were 3D Printed in stainless steel.



Experimental Test Platform

- Microcontroller used for motor control and system data acquisition.
- Variables monitored: Suction pressure, discharge pressure, volute and seal cavity pressures, RPM, flow rate, inlet temperature and shaft torque.
- Constant inlet pressure (~45 psi) is provided via a pressurized tank and regulator.
- Flow is controlled during testing using a gate valve on the discharge side.
- Motor and speed controller require water cooling .

Figure 1: PSAS Launch Vehicle-3 (LV3) CAD model.

Measured Performance

The electric feed system is actively being tested over a wide range of operating conditions. Initial feedback at lower rotational speeds has provided promising results. A plot of the system running at 17,500 rpm is shown below.

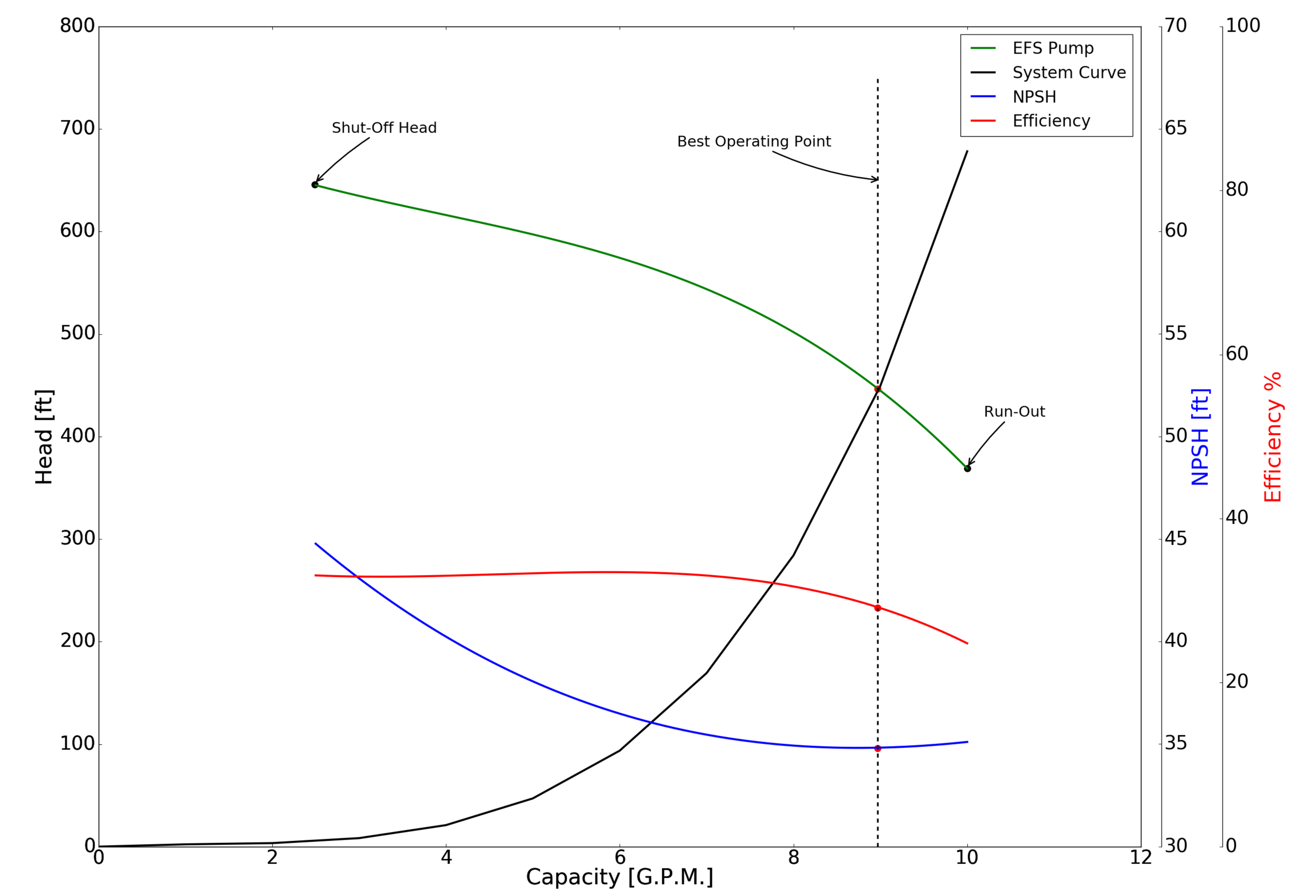


Figure 2: EFS performance characteristics at 17,500 rpm using 11 blade impeller and 8° diffuser.

- The **system curve** is a function of the static head and the major and minor losses in the system. This curve gives the amount of energy the pump has to create in order to operate at a specified flowrate, Q.
- The pump **performance curve** describes the relationship between the flowrate and head produced by the actual pump.
- The **best operating point** is defined as the flow at which the EFS system operates at the highest or optimum efficiency for a given impeller diameter.
- The **shut-off (SO)** is the head a pump will develop when operating against a closed discharge valve (no flow). SO kept at 4 GPM to extend life of pump during testing.
- The **run-out (RO)** is the maximum flow the pump can produce before experiencing severe performance drops.
- The **NPSH curve** shows the minimum amount of suction pressure to overcome pump entrance losses and cavitation.

Project Website

https://github.com/psas/electric-feed-system

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