LIQUID FUELED HIGH VELOCITY OXY-FUEL THERMAL SPRAYING TECHNIQUE FOR DURABLE COATING

AHSAN CHOUDHURI AND C. V. RAMANA
NASA Center For Space Exploration Technology Research
Department of Mechanical Engineering
University of Texas at El Paso

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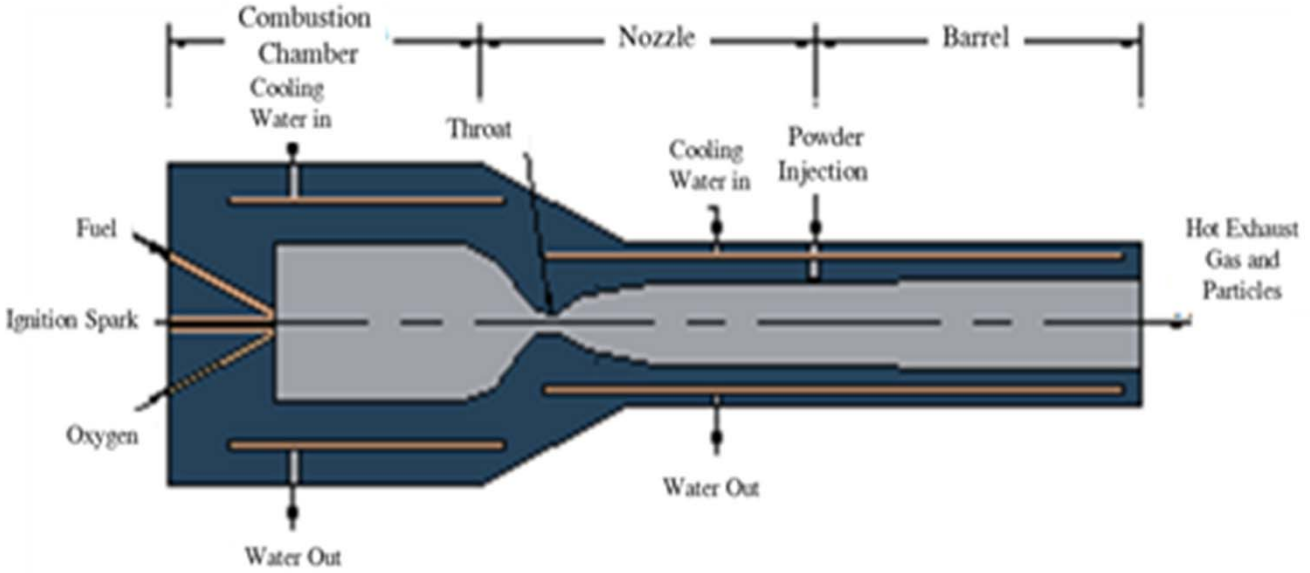
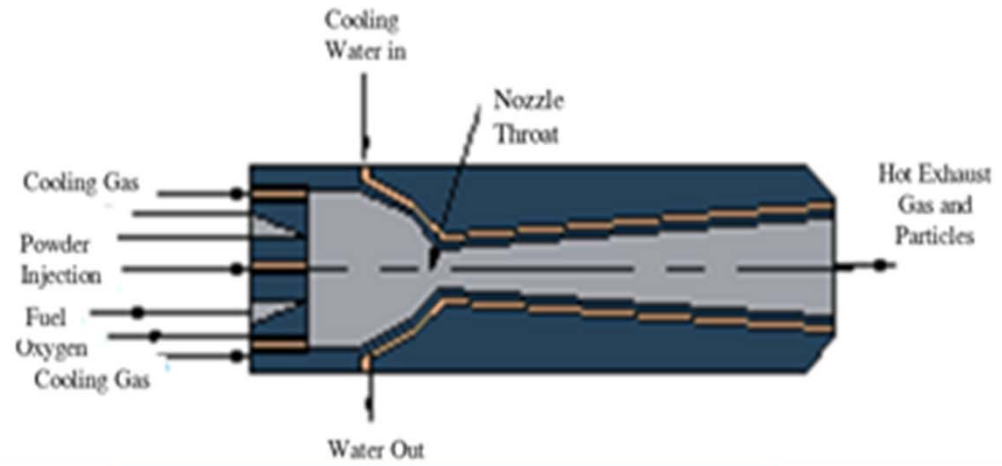
Liquid Fueled High Velocity Oxy-Fuel Thermal Spraying Technique for Durable Coating





Liquid Fueled High Velocity Oxy-Fuel Thermal Spraying Technique for Durable Coating

Introduction

- **Thermal spraying techniques:** are coating processes in which **melted (or heated)** materials are sprayed onto a surface.
- Thermal spraying can provide thick coatings (approx. thickness range is **20 micrometers** to **several mm**, depending on the process and feedstock).
- Coating materials available for thermal spraying include metals, alloys, ceramics, plastics and composites.
- They are fed in powder form, heated to a molten or semi-molten state and accelerated towards substrates in the form of micrometer-size particles.

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Introduction

- The flame and powder are accelerated by a **converging / diverging nozzle** to produce **supersonic** gas and particle velocities, which propel the powder particles toward the substrate to be coated.

- The powder particles flatten plastically upon impact with the substrate; cooling and solidifying to form the coating.

- High particle velocities, uniform heating and low dwell time combine to produce coatings that are very dense and tightly bonded to the substrate.

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Background

- The HVOF thermal spraying technique is widely applicable to high-temperature coating materials including iron, nickel, and cobalt-based alloys.
- High Velocity Oxy Fuel (HVOF) thermal spraying system is a highly promising technique for applying durable coatings on structural materials for corrosive/harsh and high temperature environments in advanced ultra-supercritical coal-fired (AUSC) boilers, steam turbines and gas turbines.

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Background

- Nevertheless, most commercially available HVOF thermal spraying systems use gas-fuelled spray guns, there is recent interest/trend in using liquid fuel such as kerosene due to its lower operational cost, superior combustion gas acceleration, and higher tendency to promote momentum output of powder particles compared to gas-fuelled systems.

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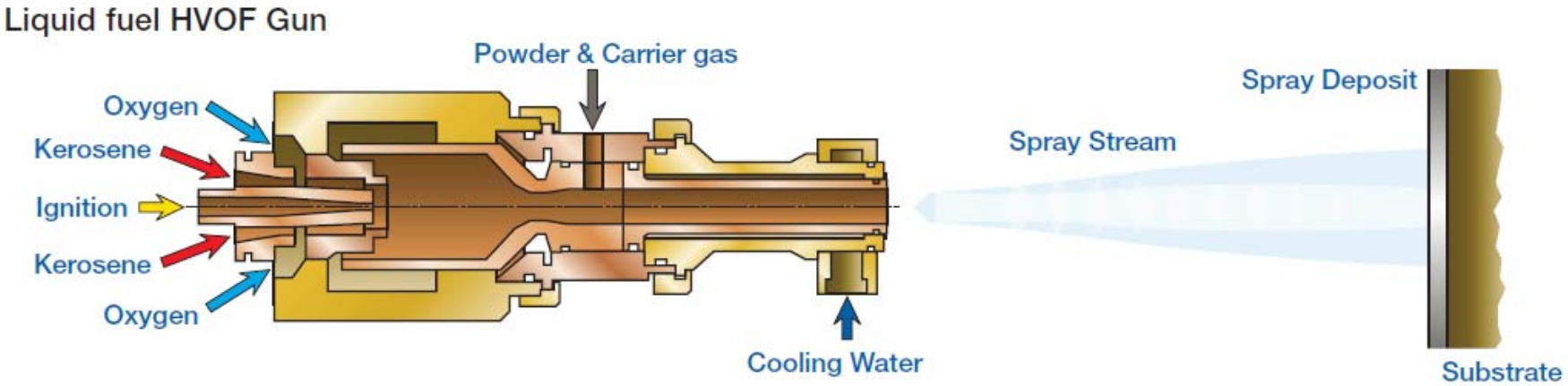

The HVOF (High Velocity Oxy Fuel) Spray process

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Objectives

- The overarching aim of the research team is to develop a comprehensive understanding of the physical and thermo-chemical processes of a LHVOF thermal spraying system and intricate interactions with coating materials.
  - *combustion chamber design*,
  - fuel-oxygen *injector configurations*,
  - *nozzle design*,
  - *oxygen/fuel ratio*,
  - *gas flow rate*,
  - *combustion chamber pressure*,
  - *particle size*, and
  - *position of substrate* .

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Objectives

- Inconel 718, Fe-Al, Fe-Ti-Al and Fe-Zr-Al will be systematically studied.
  - Microstructure analysis and Mechanical Characterization
  - Thermo-mechanical and Thermo-chemical
  - A high-pressure combustor rig will be utilized to determine how thermal stress cycling, oxidation degradation (and their complex interactions) can cause coating failures.

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Objectives

Oxidizer	Fuel	Coating Particles
Gaseous Oxygen	Kerosene / RP-1	Fe-Al
	Jet-A	Inconel 718
		Fe-Ti-Al
		Fe-Zr-Al

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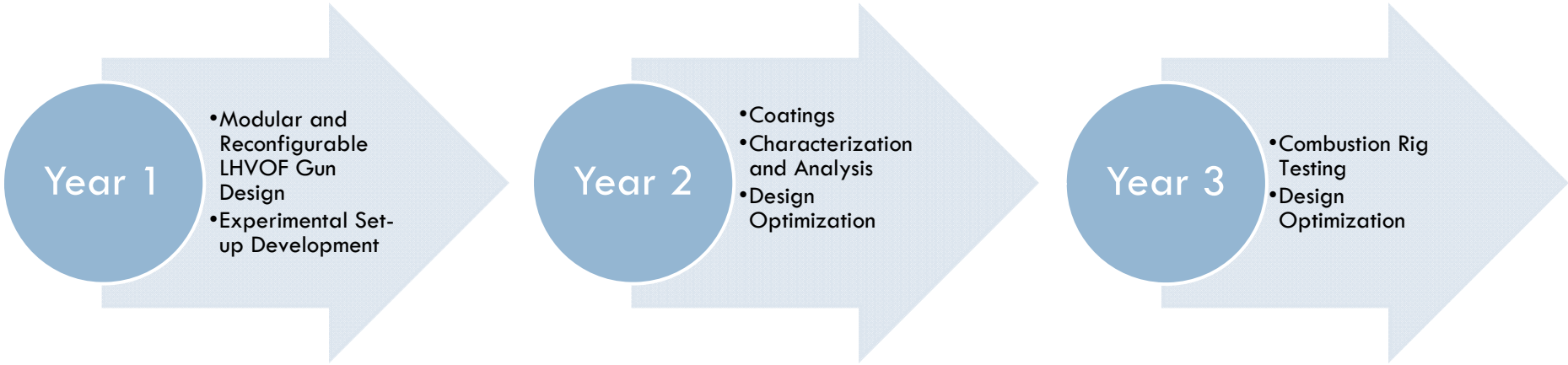
Plan



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Requirement Overview

- Deep Throttle Capability
- Maximum Exit Mach Number: 4
- Maximum Exit Temperature: 3000 K

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Requirement Overview

- **Five Modular** Sections:
  - **Injection system**
  - **Combustion chamber section**
  - **Converging-Diverging Nozzle**
  - **Barrel section**
  - **Cooling jacket**

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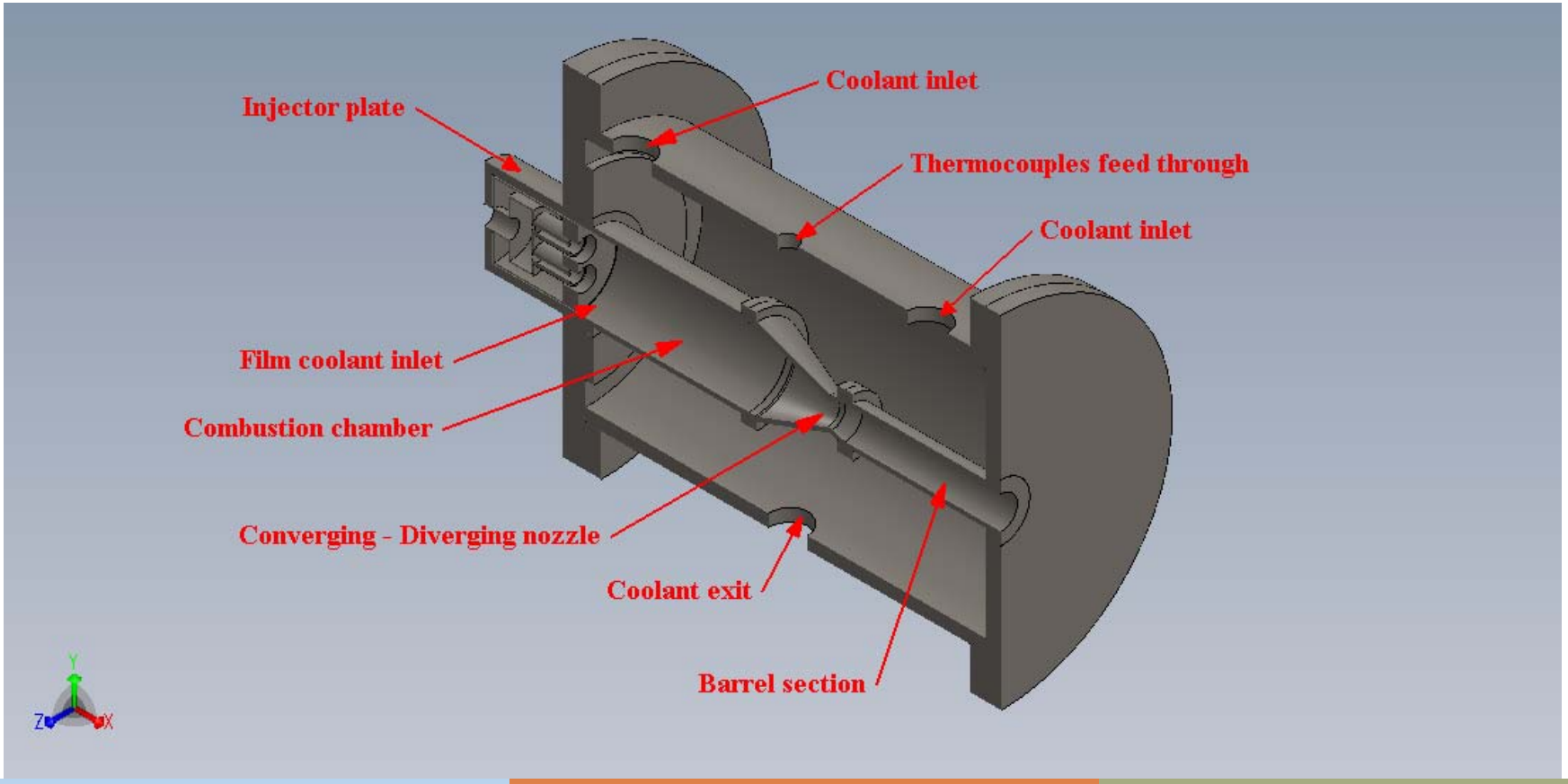
Technical Approach



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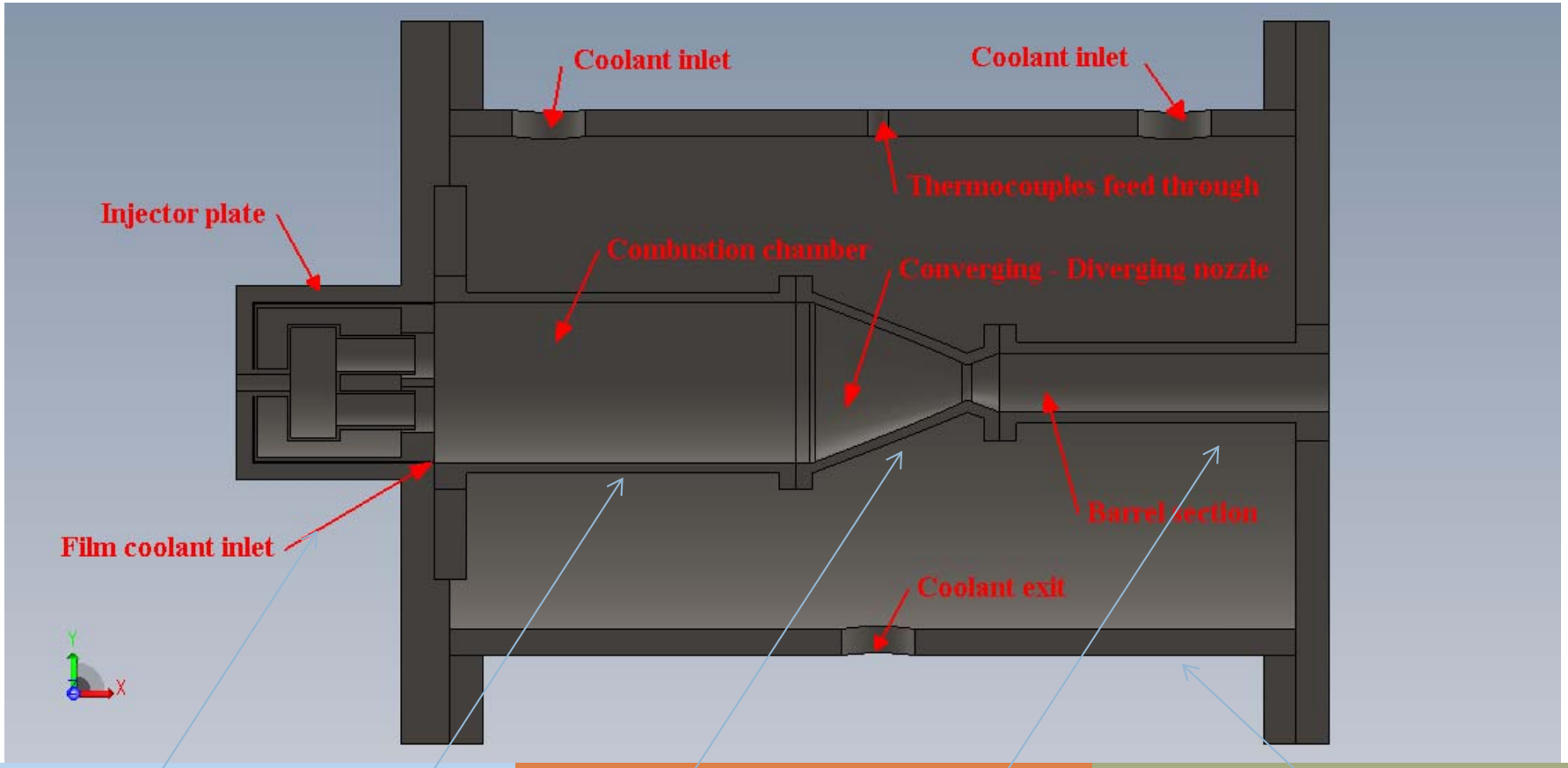

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Technical Approach

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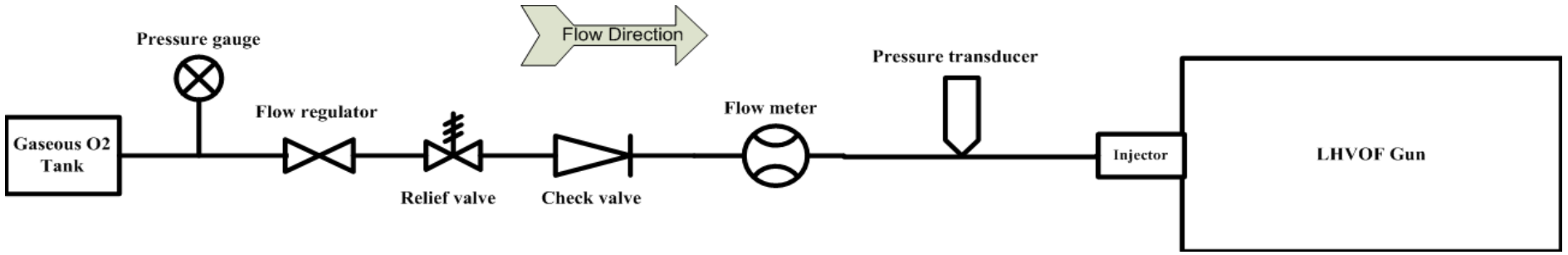
System Layout



Oxidizer line

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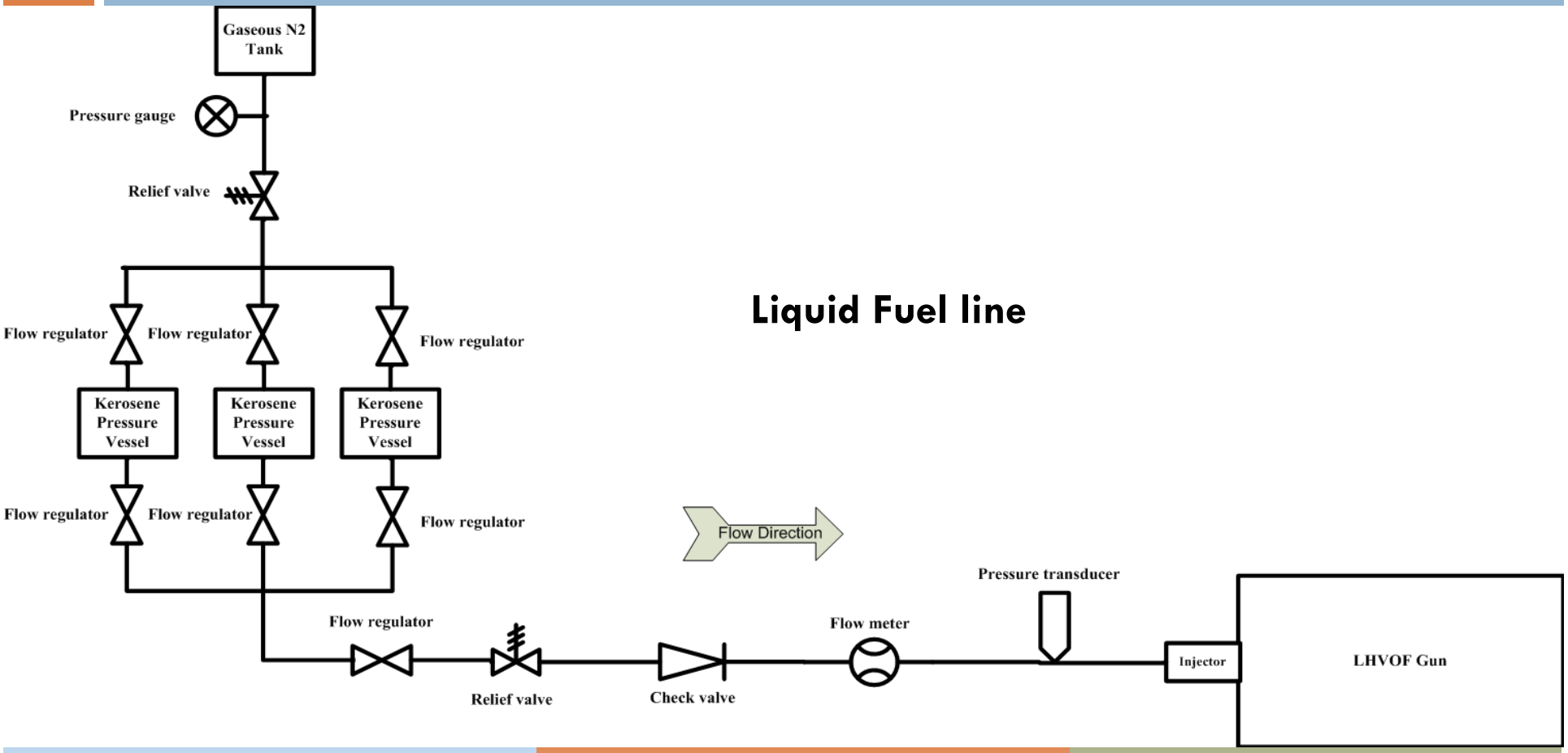

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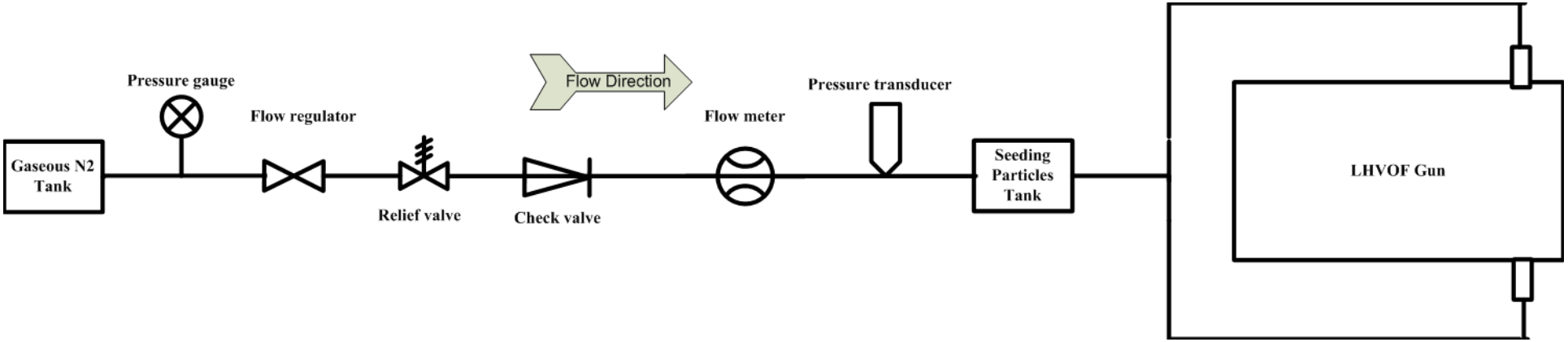

Seeding particles/coatings powder line

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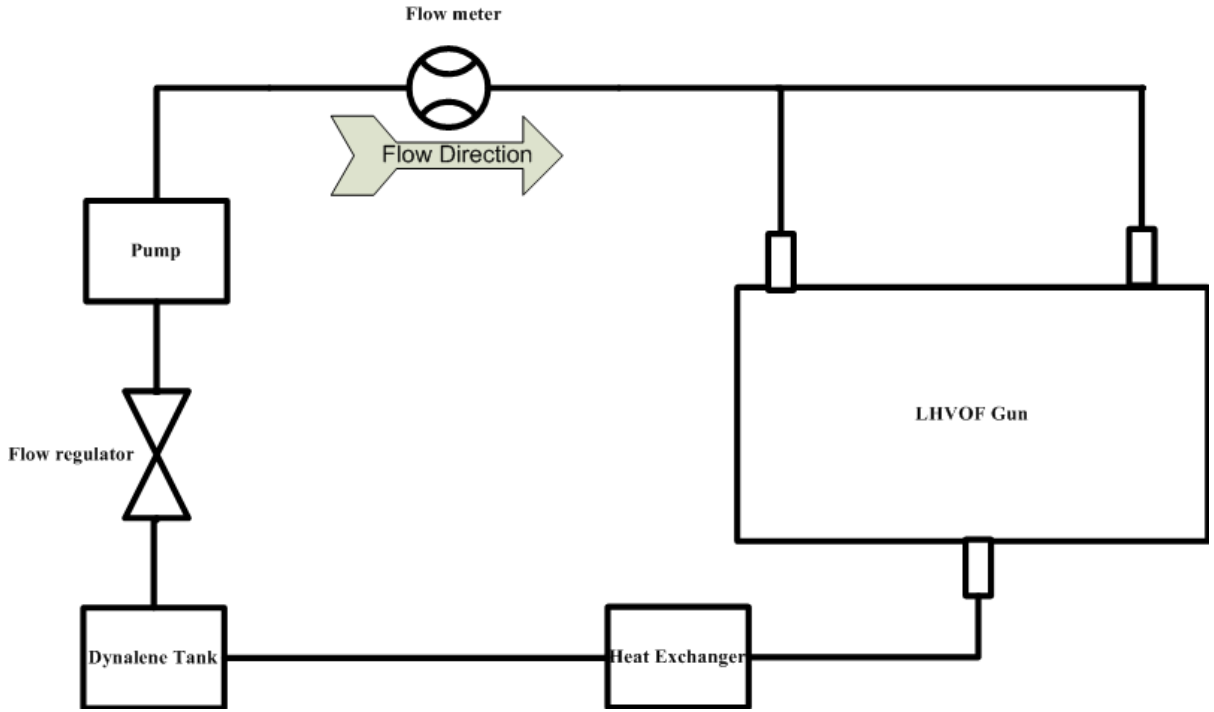

Coolant line

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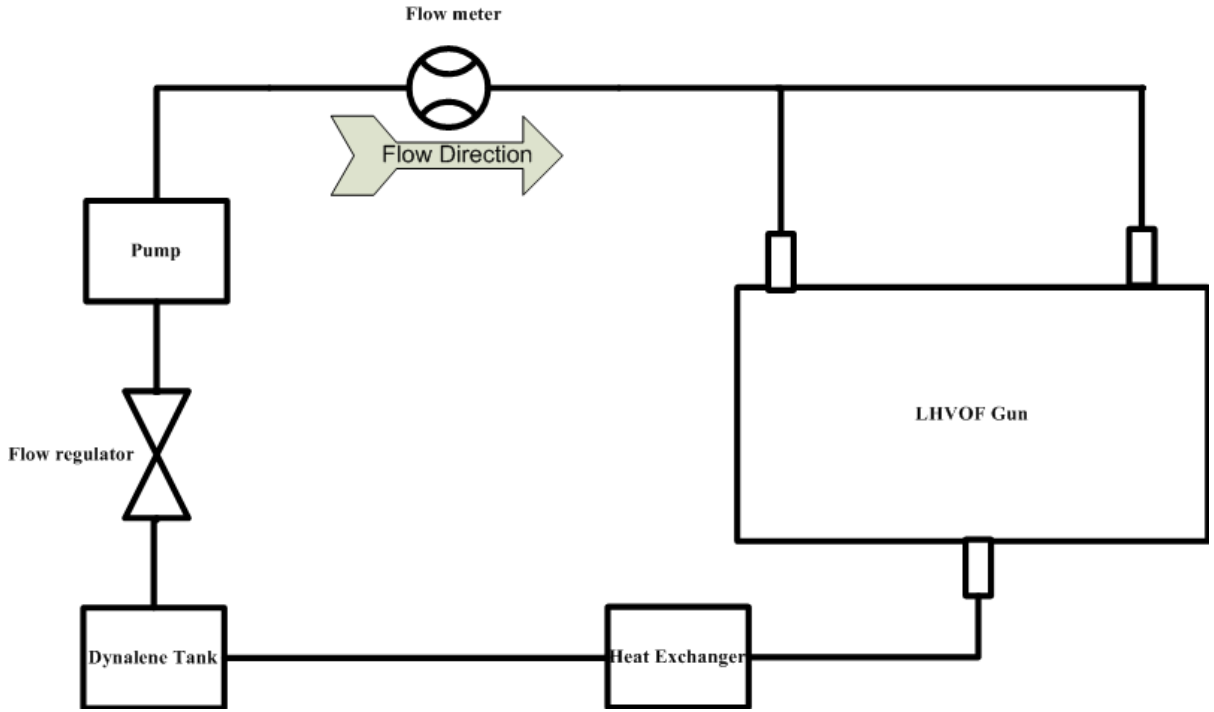
System Layout



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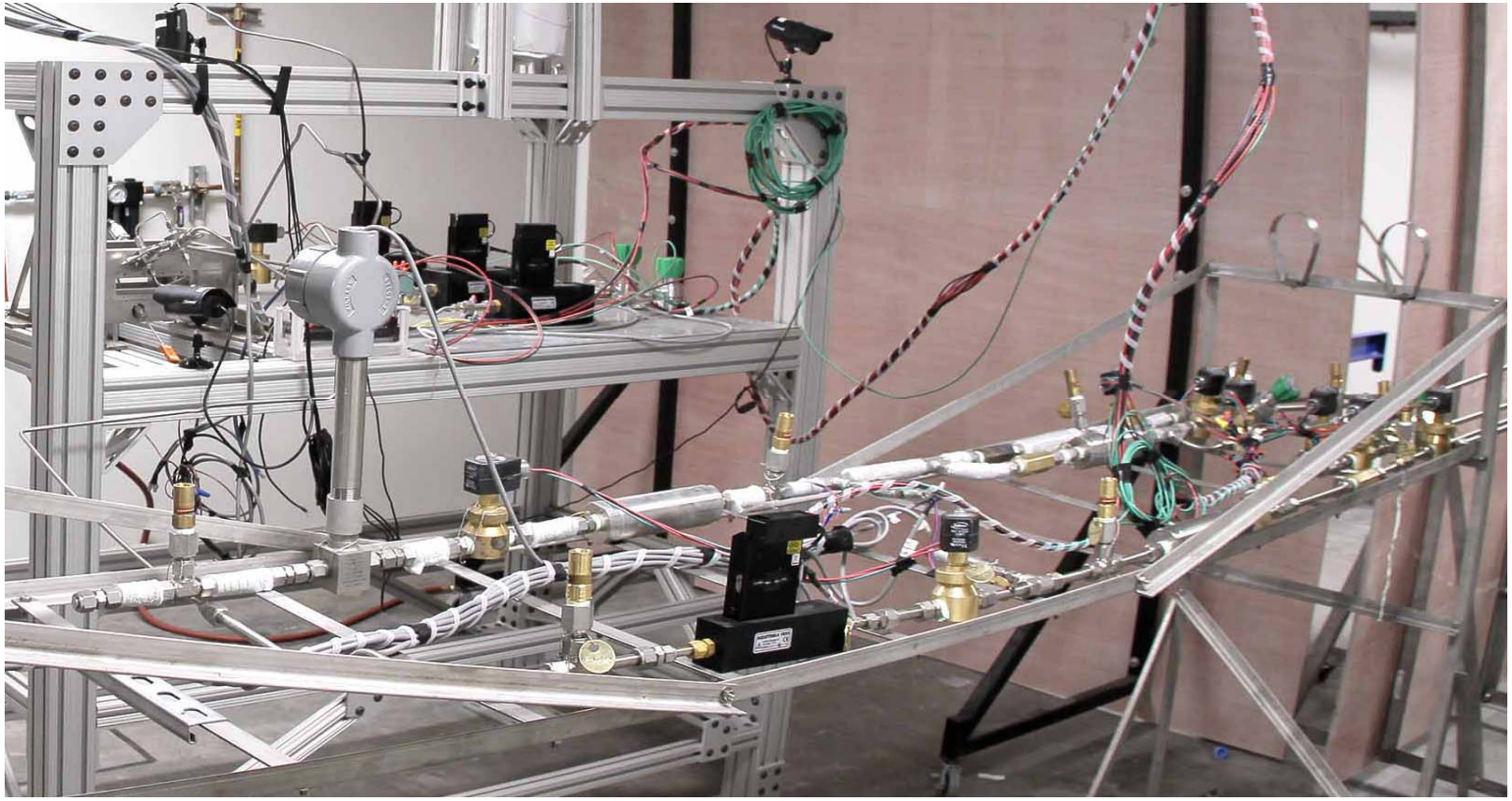

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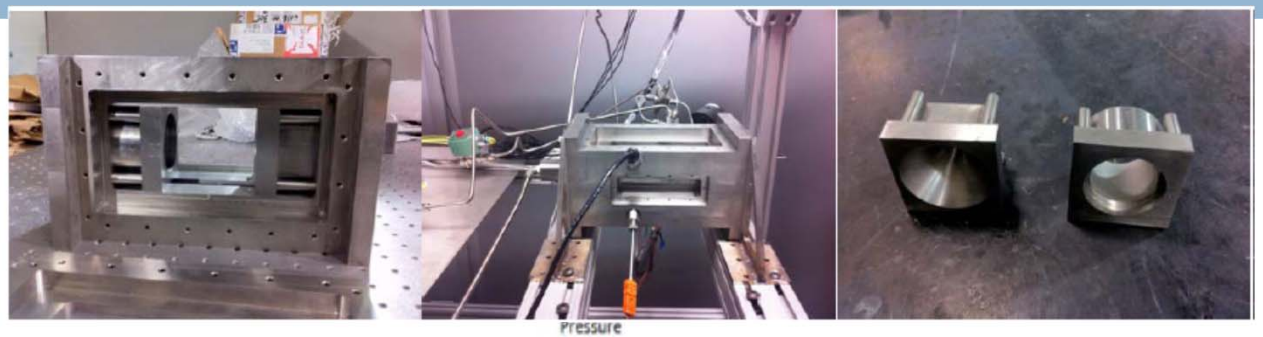

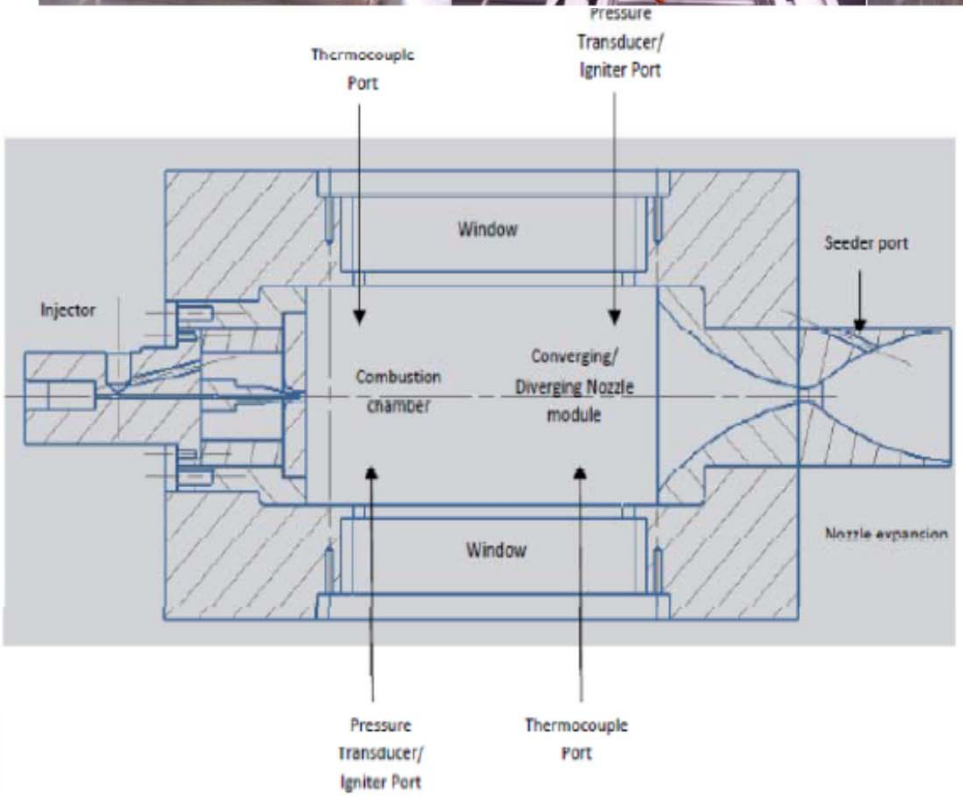

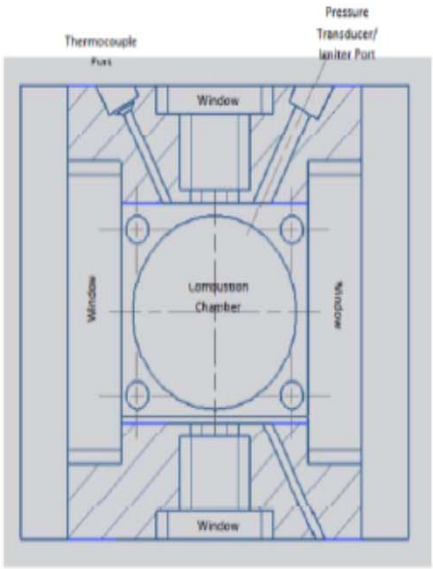

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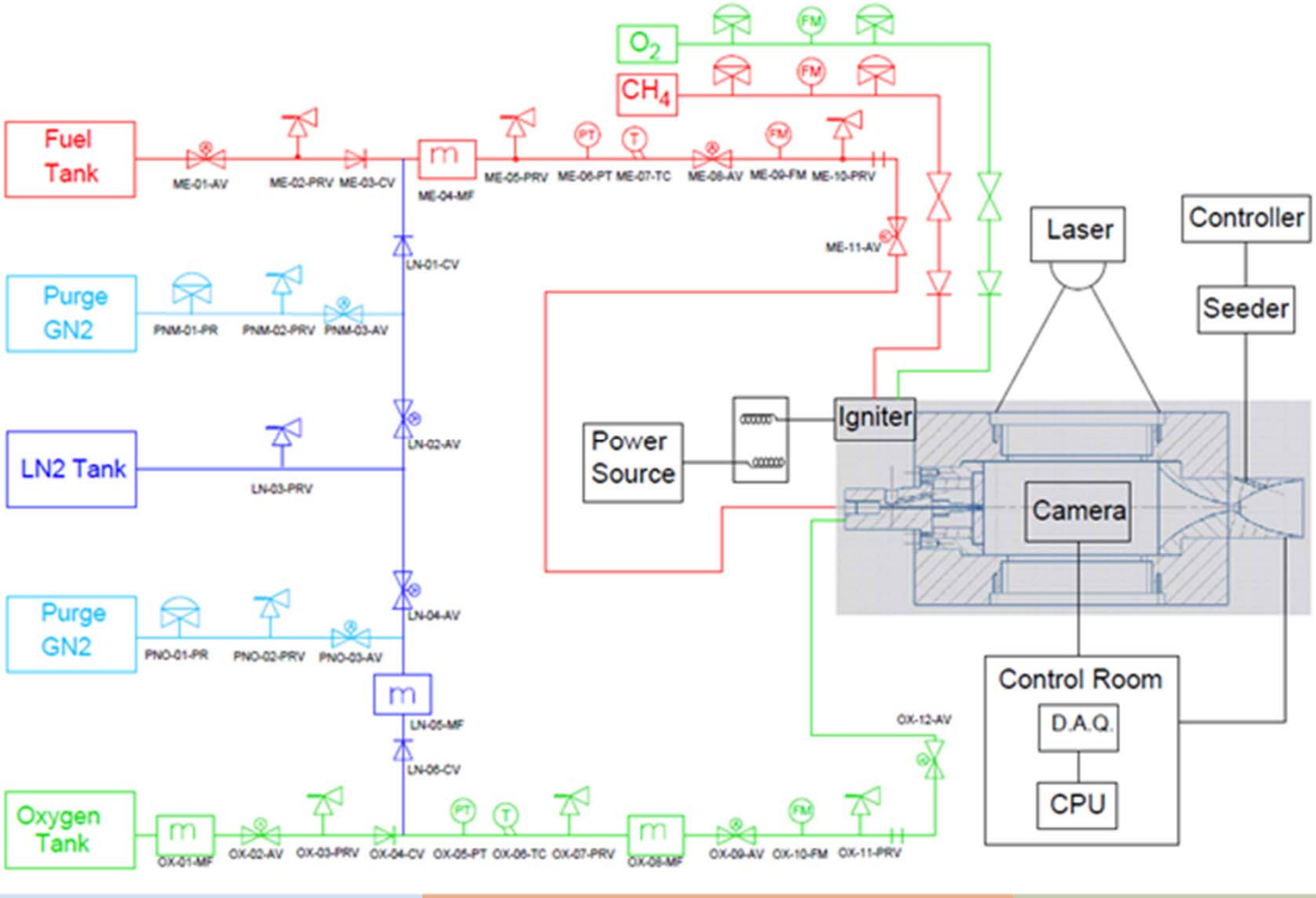

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Year 2 Plan

- Hot Firing : July 1
- Coatings and Characterization: August 1

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Hazards overview

HA #	System	Hazard	Severity	Likehood	HA Index	Mitigation
1	HVOF	Fire	3-Significant	2-Infrequent	2	Separation of propellants
2	HVOF	Asphyxiation	3-Significant	2-Infrequent	2	Proper ventilation system
3	HVOF	Over Pressure	2-Moderate	1-Unlikely	1	Installing pressure relief valves
4	HVOF	Kerosene spill	2-Moderate	1-Unlikely	1	Proper ventilation and diking system

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Students

- Luisa Cabrera (MS Student)
- Diaaeldin M (PhD Student)

Publications

- Luisa A. Cabrera, Diaaeldin M, Norman Love and Ahsan Choudhuri, " High Velocity Oxy-Fuel Thermal Spraying Techniques: A review," 3rd Southwest Energy Science and Engineering Symposium, April 27, 2013, El Paso, Texas, USA
- Diaaeldin M, Luisa A. Cabrera, Norman Love and Ahsan Choudhuri, " Liquid Fueled High Velocity Oxy-Fuel Thermal Spraying Techniques," AIAA SciTech 2014, Jan 13--17, 2013, Maryland, USA

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Thank you