Analysis of RS-25 Staged-Combustion Turbopump-Driven Propellant Feed System

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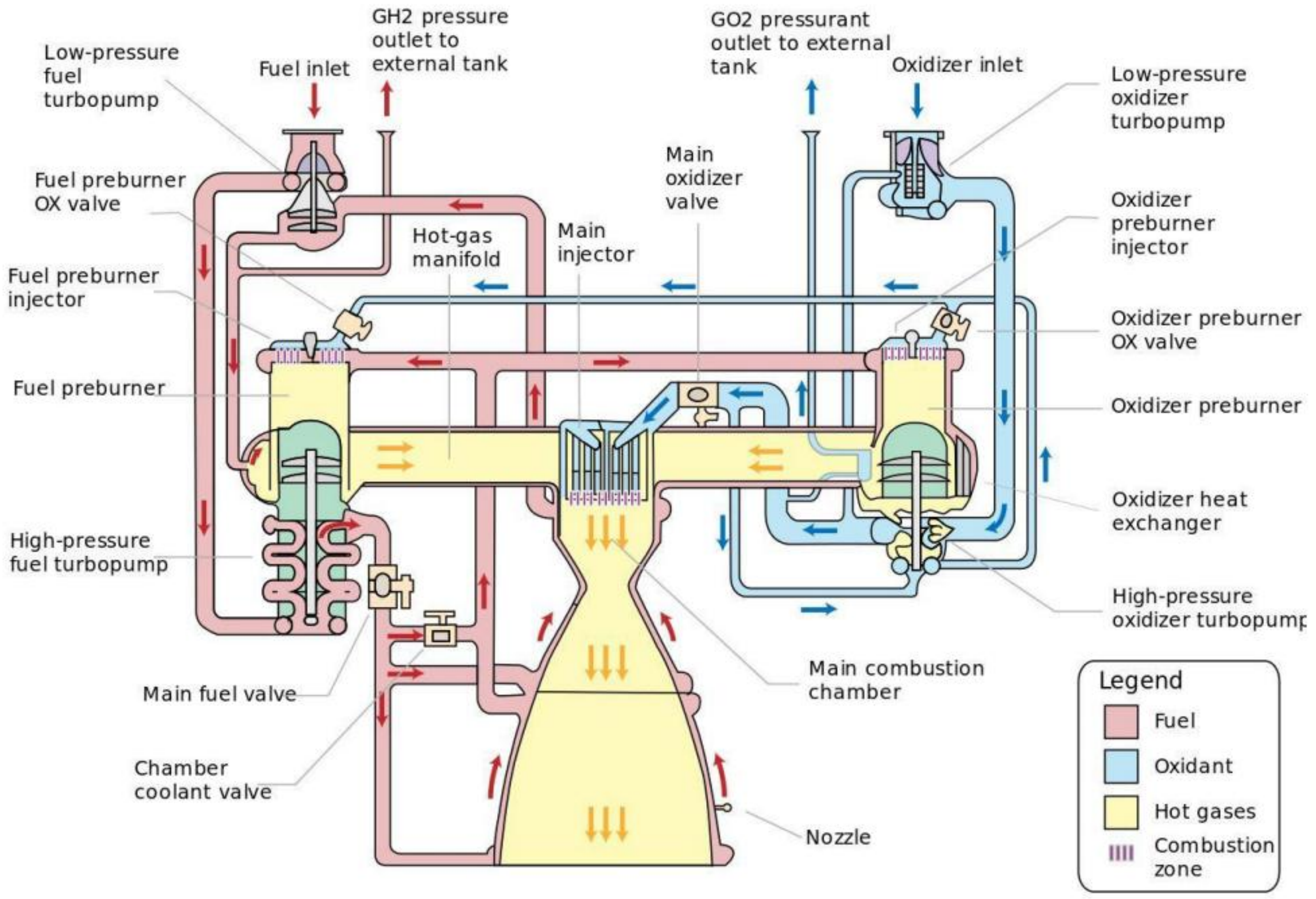
Objective:

Analyze fuel and oxidizer flow paths in turbopump-driven propellant feed system of RS-25 rocket engine

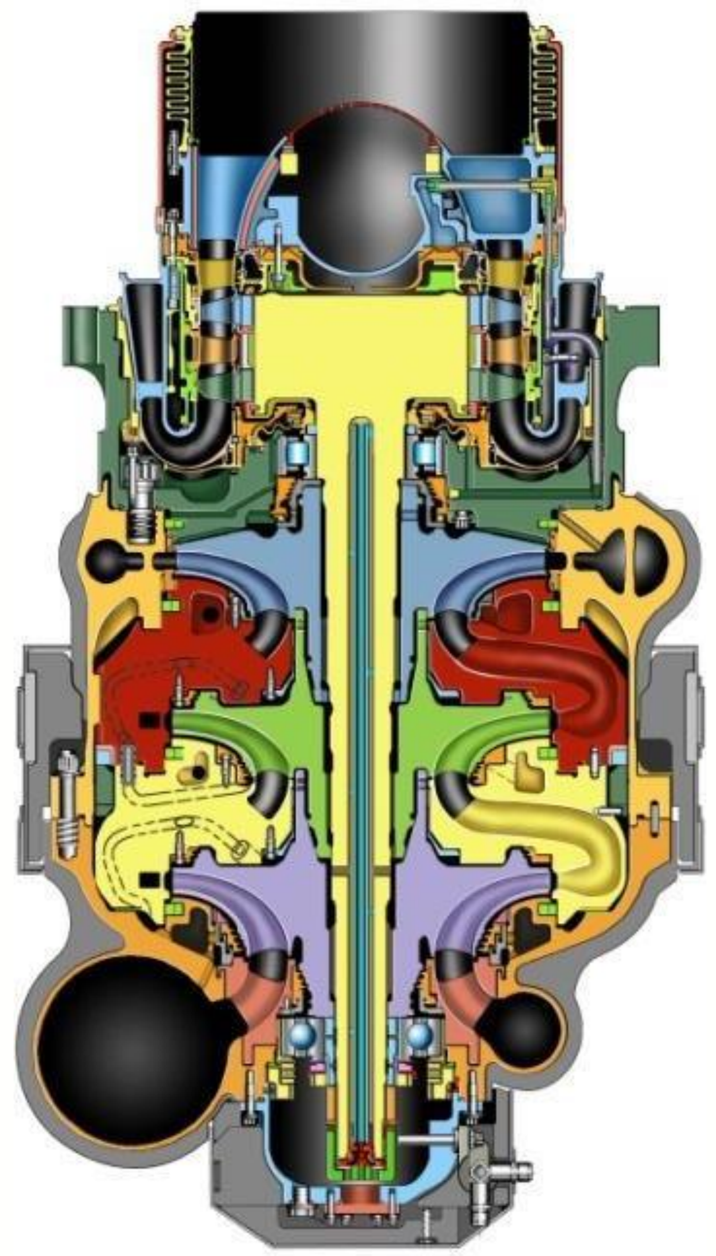


Research Question:

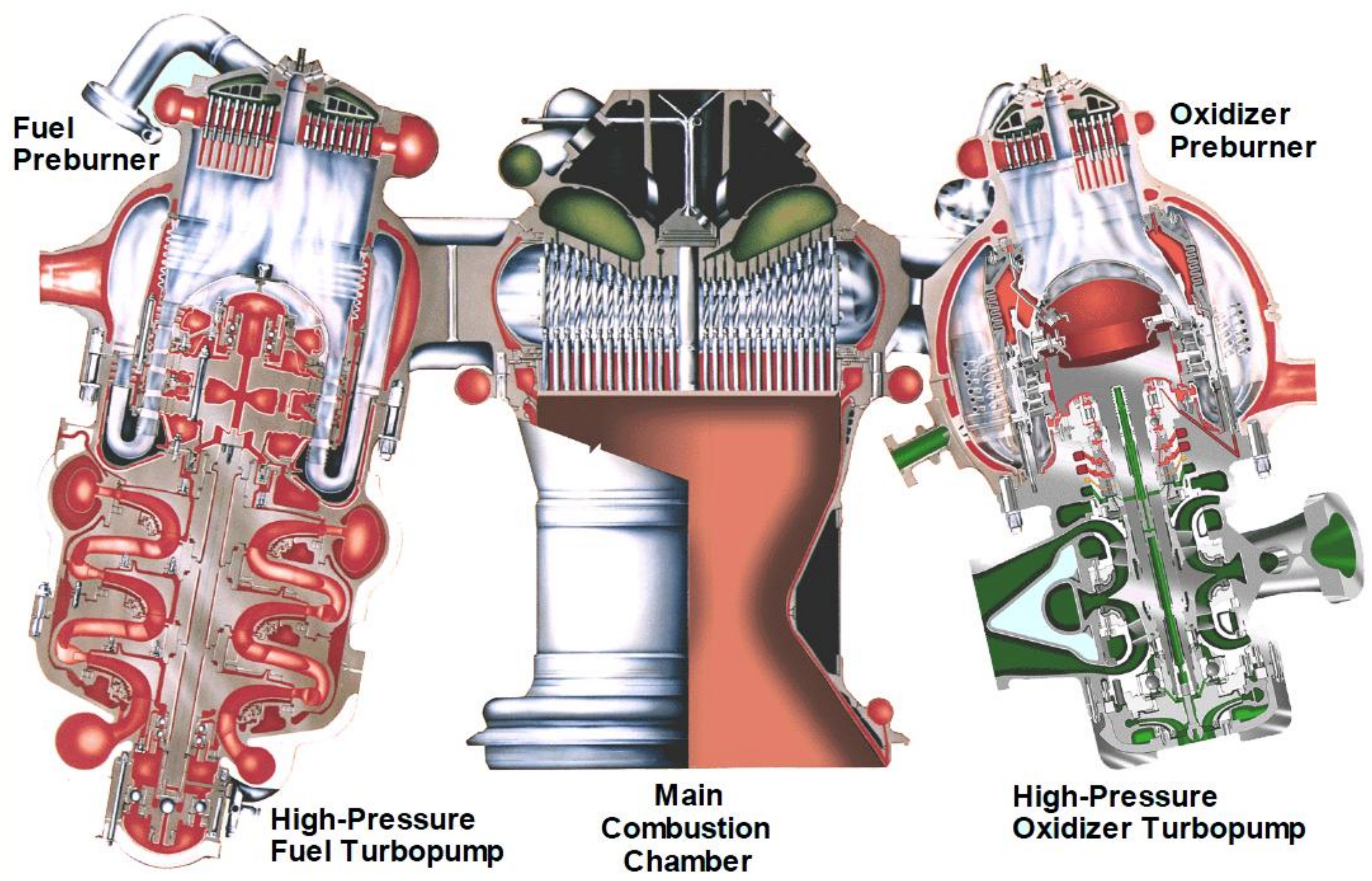
How accurately can foundational theoretical principles and associated equations determine thermochemical states and flow properties throughout this system?

Method:

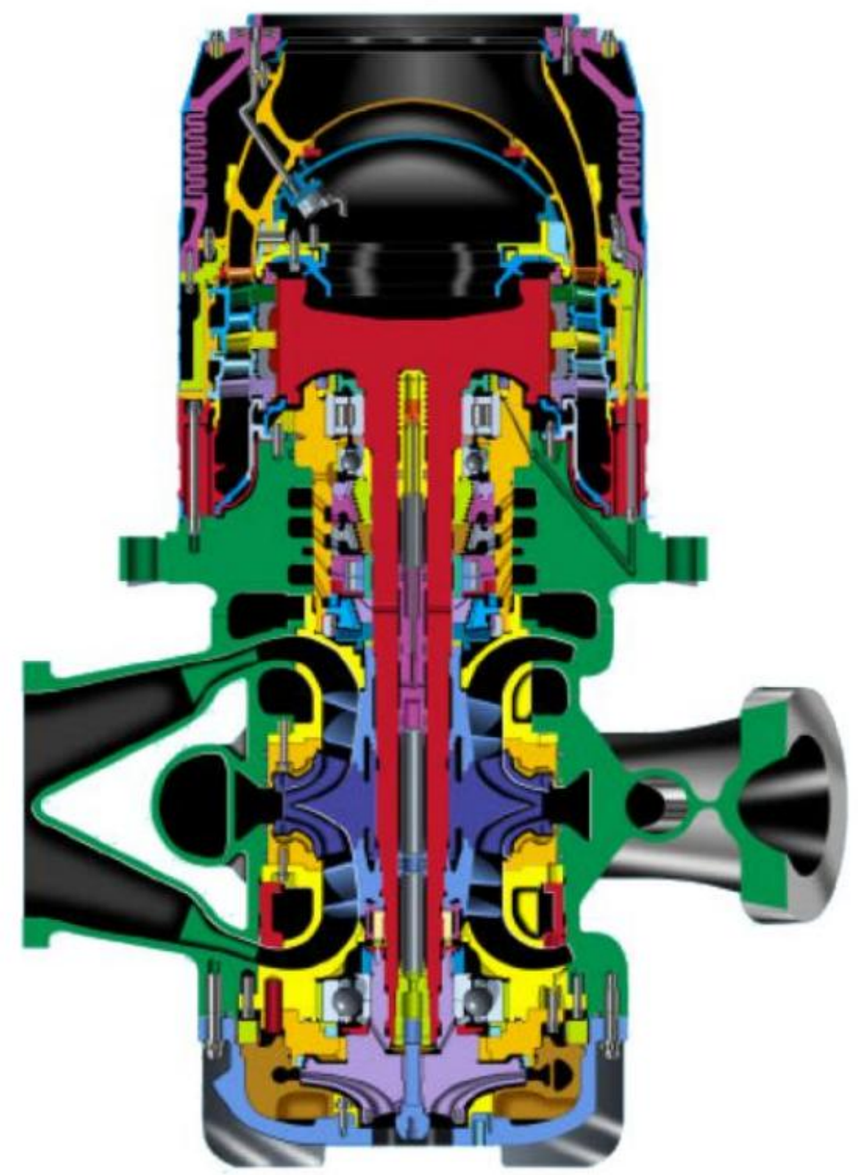
- Identify appropriate thermodynamic/propulsion equations for relevant aspects of each subsystem
- Utilize best available and computed parameters as inputs/outputs between linked subsystems
- Develop Excel spreadsheet to compute resulting thermochemical states and flow properties
- Compare results with NASA reported values



High-Pressure Fuel Turbopump (HPFTP)



RS-25 Powerhead



High-Pressure Oxidizer Turbopump (HPOTP)

Total GH2-rich preburner product mass flow supplied to injectors	100.1 kg/s
Y_{H2} in combined GH2-rich preburner flows supplied to injectors	0.475
Y_{H2O} in combined GH2-rich preburner flows supplied to injectors	0.525
C_p of combined GH2-rich preburner flows to injectors	8368 J/kg-K
Temperature of combined GH2-rich preburner flows to injectors	948 K
Molar flow rate of GH2-rich flow from HPFTP preburner	18045 mol/s
Molar flow rate of GH2-rich flow from HPOTP preburner	8456 mol/s
Mole fraction X_1 of GH2-rich flow from HPFTP preburner	0.681
Mole fraction X_2 of GH2-rich flow from HPOTP preburner	0.319
MW of combined GH2-rich preburner flows to injectors	3.78 g/mol
Pressure of combined GH2-rich preburner flows to injectors	23355 kPa

Computed sea-level (SL) performance

Resulting jet thrust (SL)	2302 kN
Resulting pressure thrust (SL)	-322 kN
Resulting nominal thrust (SL)	1979 kN
Nozzle divergence thrust loss	0.80 %
Resulting divergence-corrected thrust (SL)	1961 kN
Specific Impulse I_{sp} (SL)	441 s

Computed vacuum (vac) performance

Resulting jet thrust (vac)	2302 kN
Resulting pressure thrust (vac)	100 kN
Resulting nominal thrust (vac)	2402 kN
Nozzle divergence thrust loss	0.80 %
Resulting divergence-corrected thrust (vac)	2383 kN
Specific Impulse I_{sp} (vac)	537 s

Conclusions:

- Successfully computed values for thermochemical states and flow properties throughout this system
  - Determined resulting sea-level and vacuum thrust
- Comparatively small differences between computed and NASA-reported values due to parameter uncertainties

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