Flow of supercritical CO_2 through a converging-diverging nozzle

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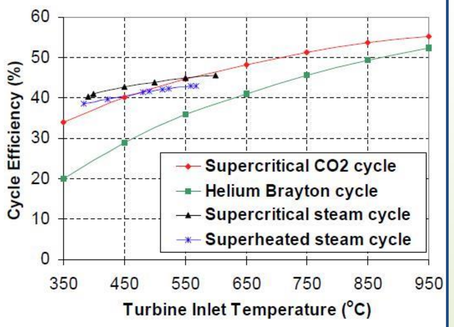
Supercritical CO_2 Power Cycles Symposium

Introduction

Introduction

Advantages of sCO_2 over alternative power cycles

- Smaller turbomachinery due to higher energy density
- High specific heat and density at critical point leads to lower compression power consumption
- Near ambient critical temperature makes dry air cooling feasible



Various Cycle Efficiency Comparison Chart [1]

Issue

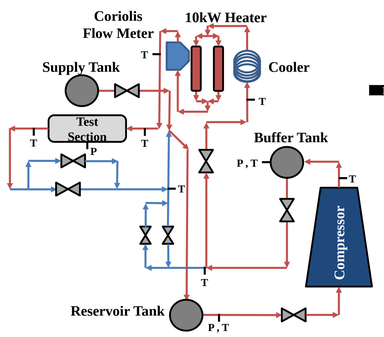
Nucleation in converging-expanding regions of turbomachinery

Objectives

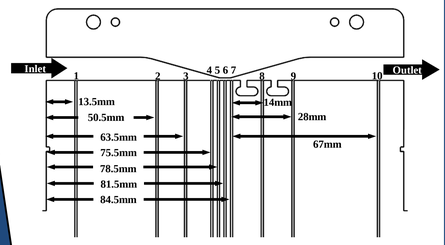
- Numerical calculations of CO_2 flow near-critical point and its condensation point estimation
- Qualitative analysis of condensation behavior at steady state using focused shadowgraph technique

Experimental Facility

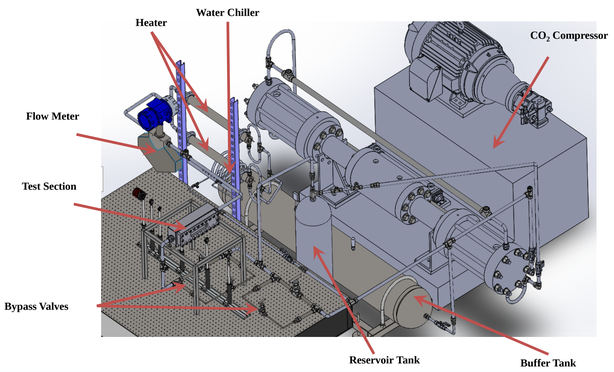
Schematic of Experiment Test Loop



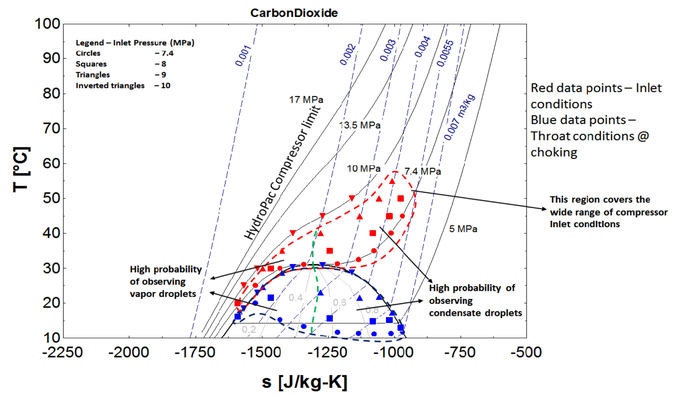
Converging-Diverging Nozzle and Pressure Sensor Locations

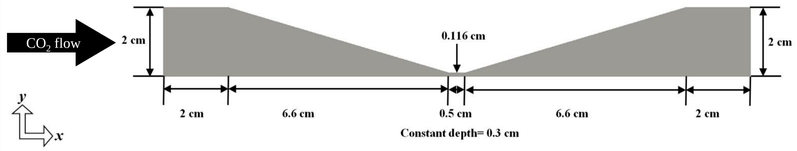


CAD model of the experimental test facility

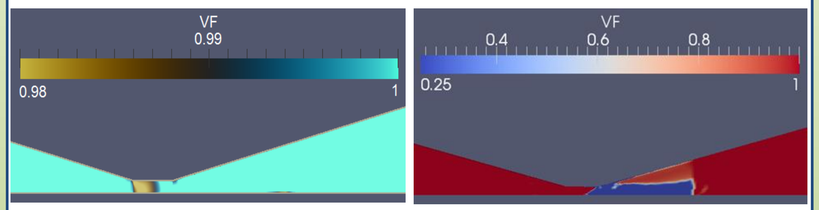


Numerical Investigation

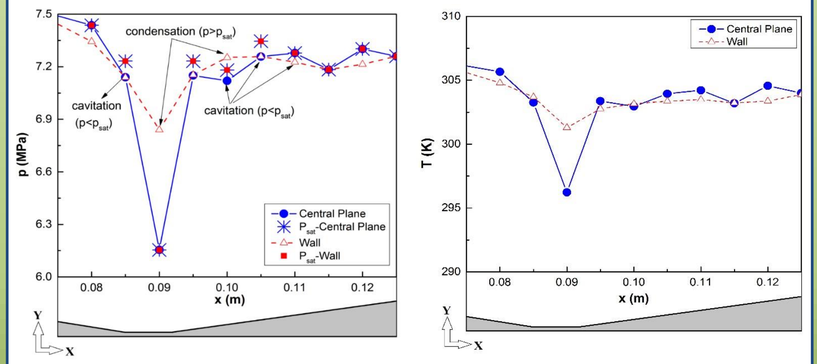




1-D Venturi Nozzle Flow Profile

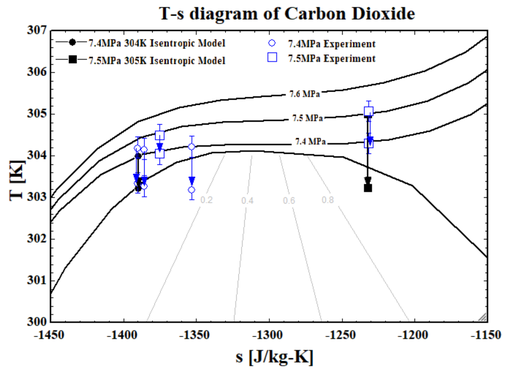


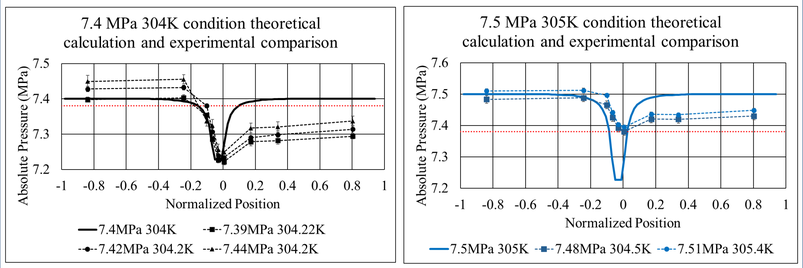
Simulation of Condensation Behavior at t=2ms for central plane (left) and wall (right) Flow being left to right [2]



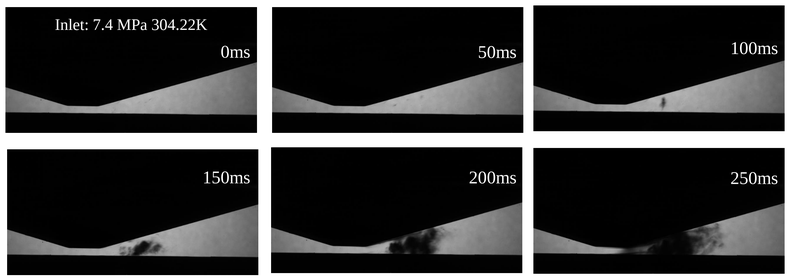
Average pressure and temperature along the nozzle from condensation behavior simulation at t=2ms [2]

Experimental Results





Comparison between isentropic model and experimental cases in different conditions



Condensation captured near the throat in 50ms intervals

Conclusions and Future work

- Nucleation behavior of supercritical CO_2 flow through converging-diverging nozzle was investigated using high speed shadowgraphy.
- Nucleation behavior is very sensitive to the inlet conditions near the critical point.
- Quantitative analysis of condensation behavior of supercritical CO_2 flow through converging-diverging nozzle using other optical diagnostics like schlieren, interferometry etc.
- Numerical and experimental investigation of nucleation behavior for flow through nozzles with different expansion rates.

[1] V. Dostal, "A supercrical carbon dioxide for next generation nuclear reactors" Massachusetts Institute of Technology, Department of Nuclear Engineering, January 2004, page304
[2] D. Jarrahbashi, S.R. Pidaparti, D. Ranjan, Nucleation of super-critical carbon dioxide in a venturi nozzle, Nuclear Engineering and Design Volume 310, 2016, Pages 69-82