HPC to Enable Next-generation Low-temperature Waste Heat Recovery

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HPC4 MANUFACTURING

Project Objectives

US manufacturing industry fails to recover an estimated 900 trillion BTUs of low-temperature (<230°C) waste heat from its processes each year.

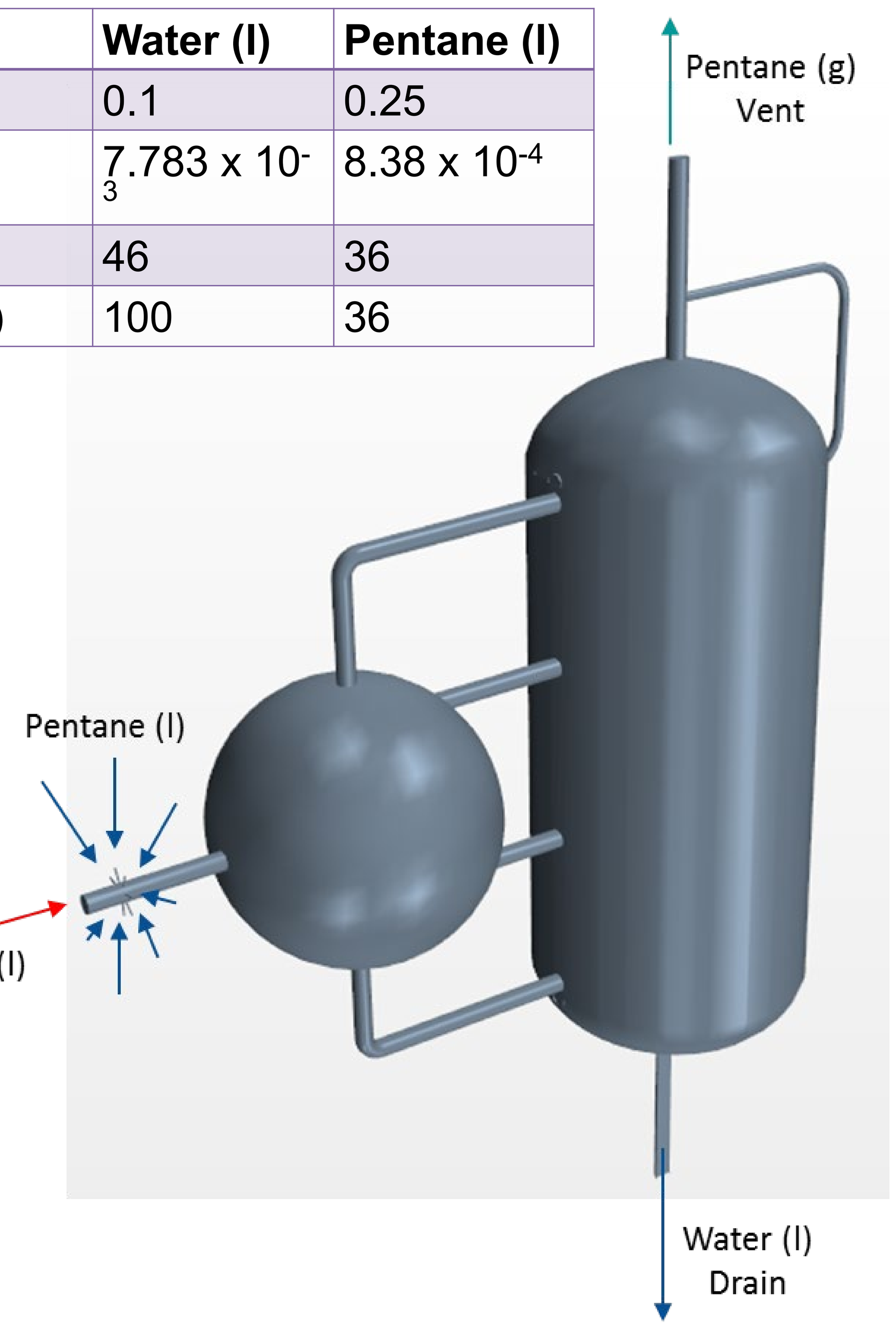
Recovery is challenging with conventional heat exchangers because of their low thermal efficiencies, large footprints, and lack of economics (high setup and operational costs).

- Direct-contact heat exchanger technology can provide
  - Low-cost, compact, longer-lifetime, high efficiency waste heat recovery systems utilizing a low-temperature organic Rankine cycle.

Technical Innovation

Advanced multi-phase computational fluid dynamics (CFD) models are developed to design a direct-contact heat exchanger and separator (DCHXS) system for low-temperature waste heat recovery.

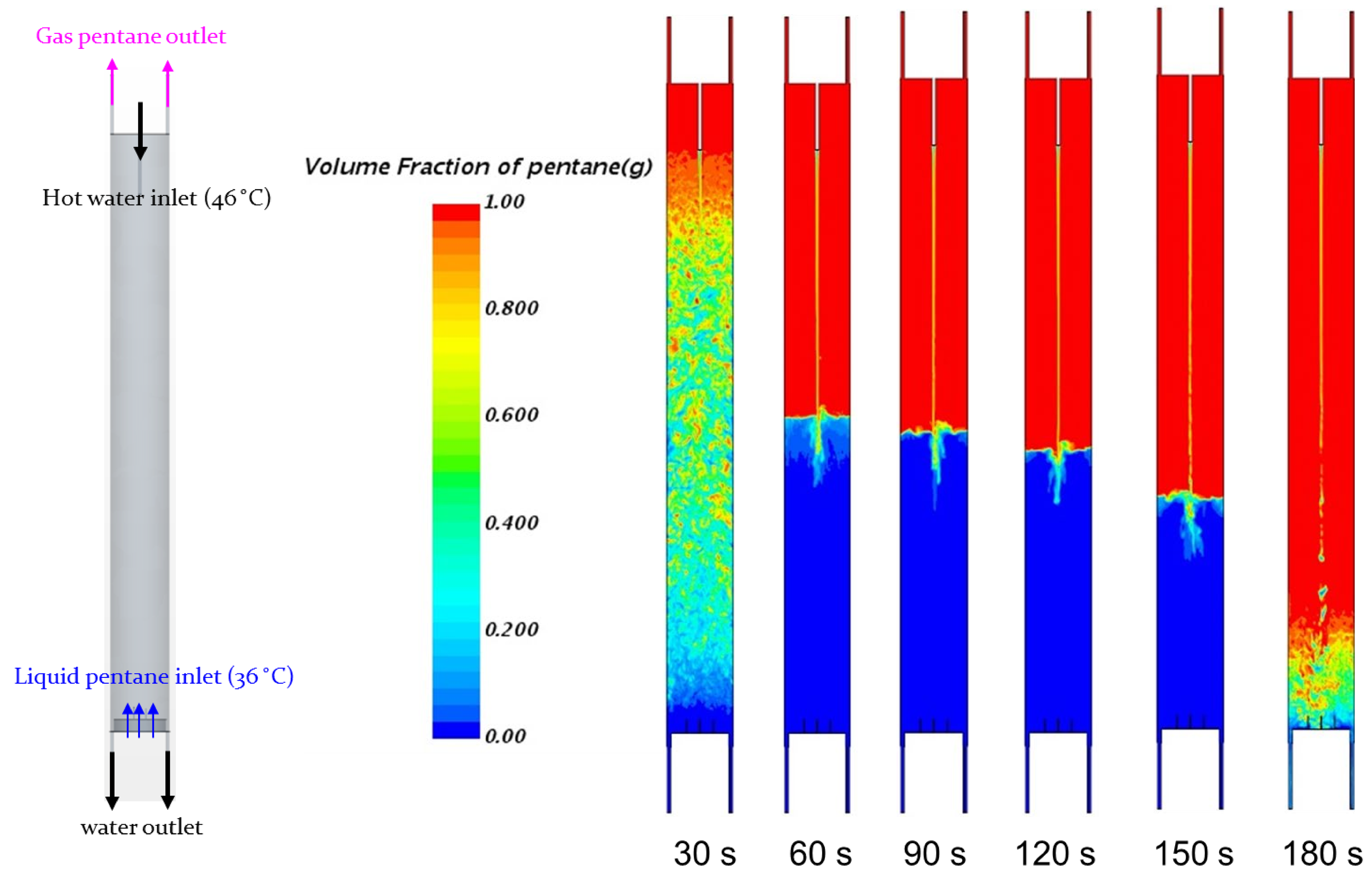
	Water (l)	Pentane (l)
Inlet velocity (m/s)	0.1	0.25
Inlet flow rate (m^3/s)	7.783×10^{-3}	8.38×10^{-4}
Inlet temp (°C)	46	36
Saturation temp (°C)	100	36



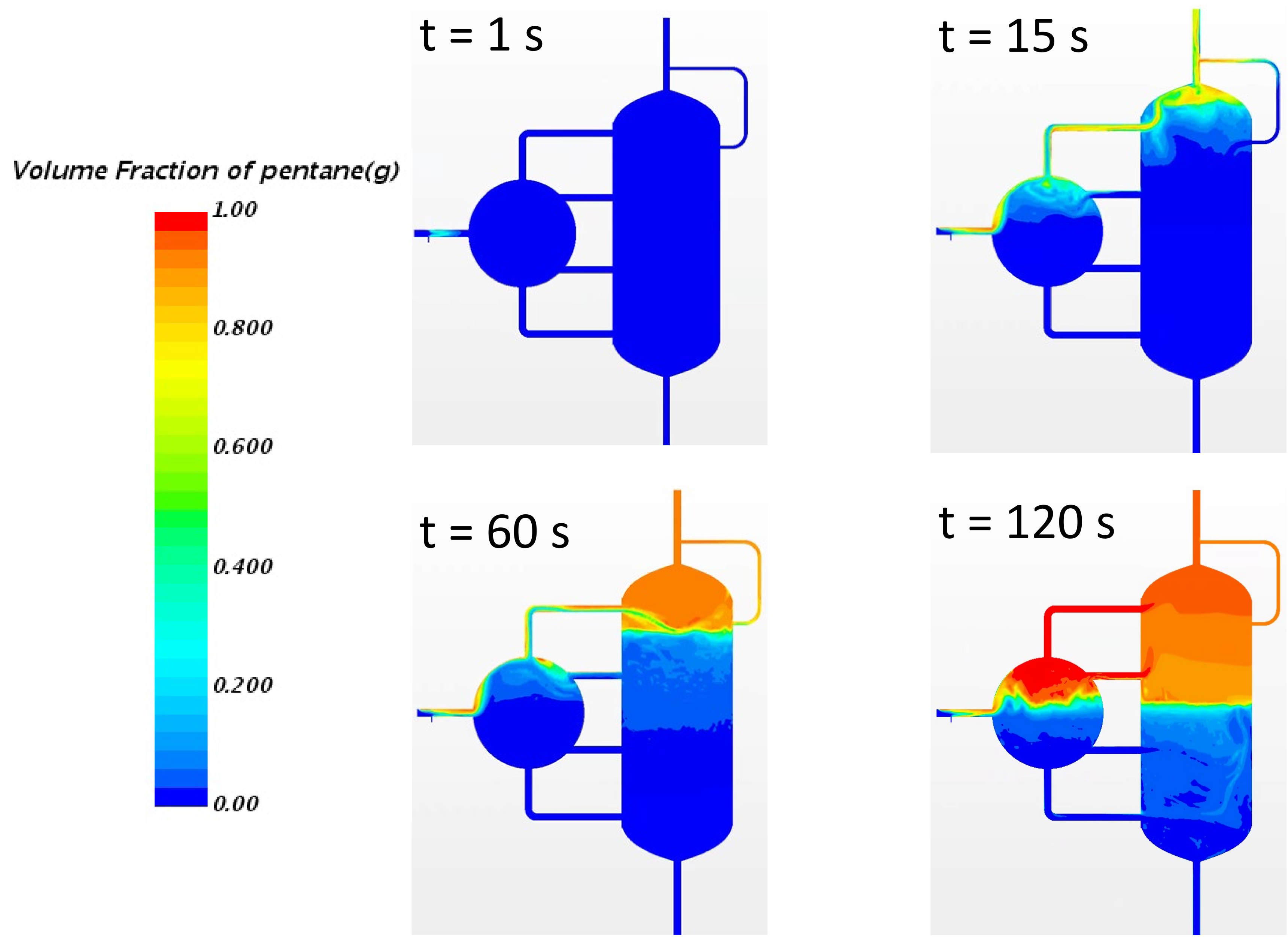
Baseline DCHXS design for performance improvement

Technical Approach

3D transient 3-phase CFD models were developed for water (liquid) and n-pentane (both liquid and vapor) in STAR-CCM+ using a multi-Eulerian framework with Volume of fluid (VOF) approach using Rohsenow boiling and Schiller-Naumann drag models.



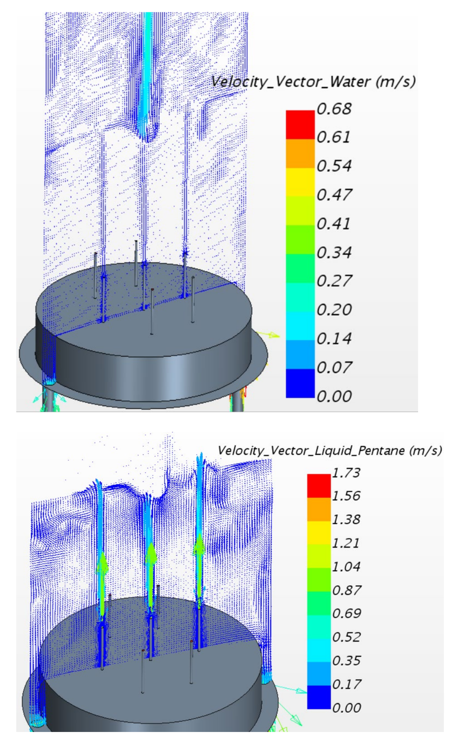
Benchmarking of a 3D CFD model against the experimentally observed active height



Transient evolution of n-Pentane vapor in the baseline DCHXS system

Results and Accomplishments

HPC-scalable transient CFD model was developed for a highly complex multiphysics flow, heat transfer and phase change problem.



Velocity vectors near the sparger nozzles

The baseline DCHXS design will be optimized for increasing the volumetric heat transfer coefficient.

HPC Metrics	CFD Model
Physical time	240 s
Solver time step	1 ms
# CPU cores	1,024
Wall time per second of physical time	25 min

Transition

The ORNL CFD models for the optimized baseline DCHXS design will be evaluated for more realistic waste heat parameters and system conditions, provided by the Eaton team.

Budget/Timeline

Timeline:
Project Start Date: 06/11/2018
Budget Period End Date: 12/31/2019
Project End Date: 12/31/2019

Budget	DOE Share	Cost Share	Total	Cost Share %
Overall Budget	$322,000	$75,000	$397,000	23.3%
Approved Budget (BP-1&2)	$322,000	$75,000	$397,000	23.3%
Costs as of 05/13/2019	$159,000	$45,000*	$204,000	28.3%

*estimated

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