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C3Po1F-06 [36]: Recent Progress on Cryogenic Fluid Systems

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Main technical limitations associated with the traditional industrial fluid systems are the following:

- Slow cooling of equipment in order to reach steady-state operation conditions, and associated with it significant loss of the fluids;
- Insufficient thermal and hydraulic stability, due to harmful physical effects (pressure spikes and surge, overpressure, cavitation, reduced density and unstable subcooling);
- Heating and evaporation of cryogens, reduction of accumulated low-temperature thermal energy,
- Limitations of accurate real-time engineering measurement methods of key cryogenic parameters (values of subcooling and density).

The paper discusses improvements in the cryogenic fluid systems using as examples high pressure cryogenic pump and system for loading of cryogenic fuels.

In the paper, functionality and interactions of components within Zero Boil-Off cryogenic system will be evaluated, for example:
- Storage tanks and liquid pipelines,
- Equipment associated with heat transfer processes (heat exchangers, heat insulation), and
- Novel sensors as well as subsystem for monitoring and control.

A novel technology proposed by the authors leads to suppression or substantial reduction of the harmful processes:
- Cavitation in all types cryogenic systems (liquid pumps, cryogenic piping);
- Other thermo-hydraulic abnormalities (for example, fluid-hammer effect); and
- Novel approach to prevent boiling in pipelines.

The analytical and experimental research show that the cryogenic liquid-loading system supports non-interruptive supply of near-isothermal fluid flow with the historically highest density.

The unique cryogenic instrumentation (proposed by authors) for direct measurement of subcooling, density, and other process parameters creates metrological basis for stability and efficiency of novel technical solutions.

Thermodynamic analysis and experimental testing confirm achievement of minimum temperature and maximum density as well as reduction of the service operations, including initial chill-down and snap-start of the system.

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