Quick-Connect Windowed Non-Stick Penetrator Tips for Rapid Sampling

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Standard penetrator sampling systems were designed in order to allow for sampling via penetrators to produce a full set of sample acquisitions including volatile liquids, fine powders, and solid fragments. A gravity harpoon sampler has been designed with a removable tip and a quick coupling. The separation allows for sample handling and eliminates sample cross-contamination. Also, this design allows for multiple use of the penetrator body, which is the largest and heaviest part of the penetrator, while allowing for multiple changes of the light-mass, penetrator tip to avoid sample cross-contamination.

The penetrator tip design has been improved by adding a spring trap to retain the sample, as well as a means for connecting to a quick coupling. Quick connect tips have been demonstrated in a sample handling carousel. The penetrator was released and rewound and the tips were released into a circular platter for rotation into instrument stations. The pyro-harpoon sampler was fabricated and tested with a NASA Standard Initiator (NSI) pyrotechnic charge. Initial tests collected cryogenic ice, but removal of the small pyro-harpoon from the ice was

difficult. A brass metal sheath was then fitted over the harpoon tip, and removal from the ice was greatly alleviated by leaving the sheath in the ice. Quartz windows in the tips allow direct optical and spectral imaging and gas chromatography-mass spectrometer (GCMS) pyrolysis, and were found to survive impact. All systems were successfully tested by dropping into sand and into cryogenic ice.

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Modeling Unsteady Cavitation and Dynamic Loads in Turbopumps

Magnitudes and frequencies of cavitation-instability-induced loads can be estimated.

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A computational fluid dynamics (CFD) model that includes representations of effects of unsteady cavitation and associated dynamic loads has been developed to increase the accuracy of simulations of the performances of turbopumps. Although the model was originally intended to serve as a means of analyzing preliminary designs of turbopumps that supply cryogenic propellant liquids to rocket engines, the model could also be applied to turbopumping of other liquids: this can be considered to have been already demonstrated, in that the validation of the model was performed by comparing results of simulations performed by use of the model with results of sub-scale experiments in water.

The need for this or a similar model arises as follows: Cavitation instabilities in a turbopump are generated as inlet pressure drops and vapor cavities grow on inducer blades, eventually becoming unsteady. The unsteady vapor cavities lead to rotation cavitation, in which the cavities detach from the blades and become part of a fluid mass

that rotates relative to the inducer, thereby generating a fluctuating load. Other instabilities (e.g., surge instabilities) can couple with cavitation instabilities, thereby compounding the deleterious effects of unsteadiness on other components of the fluid-handling system of which the turbopump is a part and thereby, further, adversely affecting the mechanical integrity and safety of the system.

Therefore, an ability to predict cavitation-instability-induced dynamic pressure loads on the blades, the shaft, and other pump parts would be valuable in helping to quantify safe margins of inducer operation and in contributing to understanding of design compromises. Prior CFD models do not afford this ability. Heretofore, the primary parameter used in quantifying cavitation performance of a turbopump inducer has been the critical suction specific speed at which head breakdown occurs. This parameter is a mean quantity calculated on the basis of assumed steady-state operation of the inducer; it does not account for dynamic

pressure loads associated with unsteady flow caused by instabilities. Because cavitation instabilities occur well before mean breakdown in inducers, engineers have, until now, found it necessary to use conservative factors of safety when analyzing the results of numerical simulations of flows in turbopumps.

The model has been implemented within CRUNCH CFD, which is a proprietary CFD computer program that has been extensively tested and validated for predicting mean pump performances. The provision of the capability to simulate cavitation instabilities involved two major enhancements of CRUNCH CFD: (1) incorporation of a capability to model the varying properties of real cryogenic fluids in the presence of cavitation and (2) development of more-sophisticated physical submodels that, in comparison with corresponding prior models, represent more accurately the rates at which vapors are created or condensed back to liquids.

The model has been demonstrated to provide accurate estimates of the magni-