A NEWSLETTER FROM CRYOGENIC INDUSTRIES SUMMER 2013

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ACD’s strength in LNG fueling is showing

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LNG refueling, often
used for buses and/or
refuse trucks, is more
simplistic in design
compared to an LCNG
station. To transfer
LNG from the stor7 586.9321 ge
comptankan Lstoron-board

SG S

Du : Medium – Heavy Duty (6 - 24 hours/day)
F R : up to 37 gpm (140 lpm)
D P u : up to 6,000 psi (414 bar)*
D HP R : 15 – 200 hp (11-150 Kw)
D E : Forced-Oil Lubricated
O L u Pu : Lox, Lin, Lar, Hydrogen

*10,000 psi (690 bar) is available with 1.25" (32mm) cold en

In addition to vehicle fueling, ACD's improved sealless AC-32 design is widely used for LNG bulk transfer applications in light end services. ACD currently offers six (6) sizes with ows and pressures up to 700 gpm (2,660 lpm) and 125 psi (9 bar), respectively. The pumps are designed in accordance with the NFPA (National Fire Protection Association) 79 Electrical Standards.

The AC-32 is designed for long life with zero leakage. The need for a conventional shaft seal is eliminated by integrally connecting pump and motor as a single unit design. Reliability of the sealless pump begins with an advanced motor design and system techniques to ensure liquid cooling of the motor is properly transferred throughout the pump to prolong motor life and reduce winding losses.

Other features include:

- state of the art inducers to provide the lowest possible NPSH by employing computer analysis utilizing hydraulic parameters to their highest degree
- lubricated bearings designed and manufactured to exacting speci cations to operate in cryogenic uids

These pumps are used universally in LNG off-loading and loading applications for trailers, rail tank cars, tank-to-tank transfer and recently in bunkering systems for LNG fueled ships. The sealless design, coupled with the motor and bearing con guration allow for reliable operation for an extended period of time (typically years). The bene ts of the sealless pump are enhanced when submerged in a VJ sump (similar to the TC-34 installation) when no icing is visible and the system provides 'instant on' operation.

Driven by economic and environmental factors, LN propulsion is a quickly developing technology for th shipping and rail industries. Starting with medium spee four-stroke engines using natural gas as propulsion fuel number of new technologies have been developed in rec years including those for two-stroke engines. One of th major innovations was the introduction of slow speed, tw stroke diesel engines using dual fuel (natural gas & dies mixture) technology by MAN Diesel & Turbo (MAN) in 20

ACD's reciprocating MSP-SL pumps increase low pressu (minimum 2.5 - 4.0 barg) LNG supplied from boost pumps to h pressure (350 barg) LNG. High pressure LNG is then dischar to a heat exchange system (provided by Cryoquip, Inc) wh vaporizes the liquid to gas. The high pressure natural gas is th fed to the engine's high pressure fuel control valves through

Small Scale LNG

O

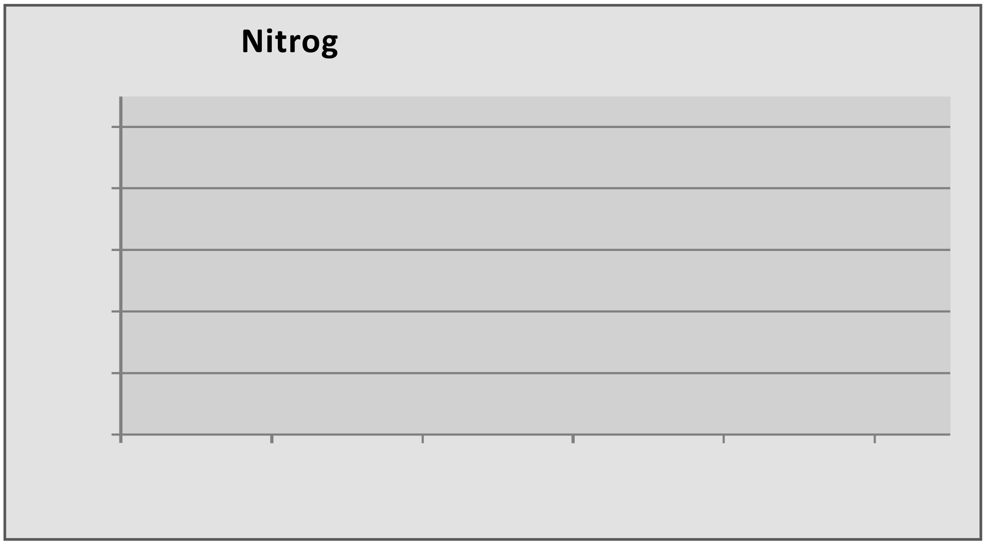

Figure 4 – Typical Cosmodyne Turndown Graph

In light of this market need, Cosmodyne improved the nitrogen expander natural gas lique er to maximize the turndown range. Cosmodyne's nitrogen cycle LNG plant can operate down to approximately 25% of the design capacity with proportional power savings. This wide turndown range is possible since nitrogen refrigeration loop is always in a gaseous phase and can be easily manipulated to operate at reduced ows without recirculating ow through the compressors. (See Figure 3) The plant operator can vary the plant production to match the actual demand to minimize operating costs. Below is a typical turndown range for Cosmodyne's nitrogen expansion natural gas lique er. (See Figure 4)

The wide turndown range has many bene ts compared to plants that operate in "campaign mode." "Campaign mode" operation is when a plant runs at full capacity until the storage tank is lled to a set level and shuts down. The plant restarts when the storage tank runs down to a low level set point.

First, with turndown operation, the plant does not need to be turned off and on. Frequent starting and stopping of a plant can reduce reliability and plant equipment life.

Secondly, in many areas, electric utility companies adjust the electricity rates on the plant's peak load (maximum) electricity draw during a billing cycle. Hence, during the early stages of the LNG plant life where the demand is lower th the full capacity of the plant, "campaign mode" operation w result in higher electricity rates since the rate will be bas on LNG plant's full capacity load. With wide turndown, t LNG plant will operate at much lower production with low power resulting in lower electricity rate.

Lastly, many plant feed gas supply agreements have mandatory minimum take requirement. Plants operatin in "campaign mode" will be penalized since the LNG pla owner must pay the minimum gas costs even when th plant is turned off. Furthermore, even without a minimu take requirement, uncertain demand for LNG can ma scheduling pipeline draws dif cult and can result in unnecessary penalties for under or overestimating th amount of pipeline draw. Operating the plant at a low capacity can make scheduling more predictable.

Cosmodyne's nitrogen cycle natural gas lique er's wid turndown range gives the operating exibility to deal wit the unknown market demands during the early years the LNG plant life. This new feature will allow the LNG pl operators to minimize their operating costs even when t plant is operating at lower than the full plant capacity an deal with the uncertainties of the market.

Droplet CFD

n Energent’s Variable Phase Turbine [1-2] (VPT) the uid at the inlet is liquid, ashes inside the nozzle upstream of the turbine rotor, and is two-phase inside the rotor blade passage. A previous article [3] discussed calculating the trajectories of droplets inside the turbine rotor.

In the converging section of the nozzle, the pressure decreases. When it declines to the saturation pressure, vapor bubbles form. At this pressure, the liquid is the continuous phase, the vapor the dispersed phase. With a continued decrease in pressure, eventually the liquid is the dispersed phase as droplets. The development of the dispersed phase, from the formation of vapor bubbles as the dispersed phase, the transition to liquid droplets being the dispersed phase, and the droplet breakup is not an easy task to model in computational uid dynamics (CFD).

At rst CFD is being used to investigate the ow eld around droplets. An objective is to use the information gained from the calculations to develop a reduced order model that can be incorporated into traditional CFD codes and 1-D nozzle codes. Experimental work has been found for model problems to begin investigating computationally. By nding problems to study that have been investigated experimentally, the methodology used in the CFD simulations can be validated.

A starting point is to examine the ow eld around a single liquid droplet. An objective is to study the breakup of the droplet. In the meantime, the breakup of a 2-D water column subjected to a shock wave is investigated, for which there is experimental data from Tohoku University [4], Japan. By considering rst the breakup of a 2-D liquid column instead of a 3-D spherical droplet, the computational cost is reduced.

Initially the calculations were done by solving the Euler equations. Although the physical viscosity is ignored, numerical viscosity is still present. Figure 1 is a series of snapshots of a liquid column breaking up, displayed as a Schlieren image of the density gradient.

The momentum interaction between the dispersed liquid pha

Figure 7 shows the re ected and transmitted shock waves, a well as the unsteady ow conditions both inside and behind th cylinder cloud.

Figure 7 Flow variables of the 2-D calculation at t=3.5.

A one-dimensional model is derived from the volume-averag Navier-Stokes equations, where the viscous stresses within t continuous phase are assumed to be negligible, but the moment coupling terms are still considered. The 1-D model equations th were solved do not include the unclosed uctuation terms creat during the volume-averaging procedure, such as the Reyno stress. This is a reasonable assumption in dilute multiphase ow However, in dense ows this assumption may not be appropria

The miscellaneous particle forces are assumed to be included in drag coef cient for the quasi-steady drag force on a single partic

$$F_i \qquad 1 \; \rho C_D A_p \quad u_i - v_i \quad u_i - v_i$$

where

CRYOGENIC INDUSTRIES TO RELOCATE HEADQUARTERS

This Fall Cryogenic Industries will relocate its headquarters of ces from Murrieta, CA to Temecula, CA. The new facilities will house administrative, nance, treasury, legal, internal audit,