Solving New Demands in LNG Technology Using Field-Proven LNG Expanders and Pumps

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Abstract

With the increasing utilization of expander and pump technology in all aspects of the LNG industry, new demands in expander and pump technology naturally arise. There is a need for expanders and pumps that are designed for larger flow and head conditions. In response to this demand, several design configurations have been developed using already field-proven machines. These configurations not only solve the requirement of larger flows and heads, they provide numerous additional benefits including greater flexibility, increased efficiency, and compact configurations to minimize the footprint.

Compact Pump – Expander Configuration

Two examples of the compact pump-expander configuration are shown in Fig. 1 and Fig. 2. The design consists of a pump and expander separated by a seal and mounted on a common shaft with a common induction motor/generator. Due to the separation between the expander and pump the machines may operate in different fluids, the pump for the LNG stream and the expander for the MR stream. The motor/generator may be submerged in the pump fluid flow (Fig. 1), or in the expander fluid (not shown), or separated by seals from both the pump and expander fluid (Fig. 2). In the third case the motor/generator may be cooled using another fluid readily available in a liquefaction plant, such as liquid nitrogen or liquid propane. The induction motor/generator operates as a motor if the power generation from the expander is not enough to drive the pump, or it may operate as a generator when the power generated by the expander is larger than the input required to operate the pump. Thrust is balanced using the trademark TEM design, common to all Ebara International Corporation, Cryodynamics Division (EIC) pumps and expanders. Depending upon the process and design, the TEM device may be located in the pump side, the expander side, or within the separated generator cavity and balanced using the liquid nitrogen or liquid propane.

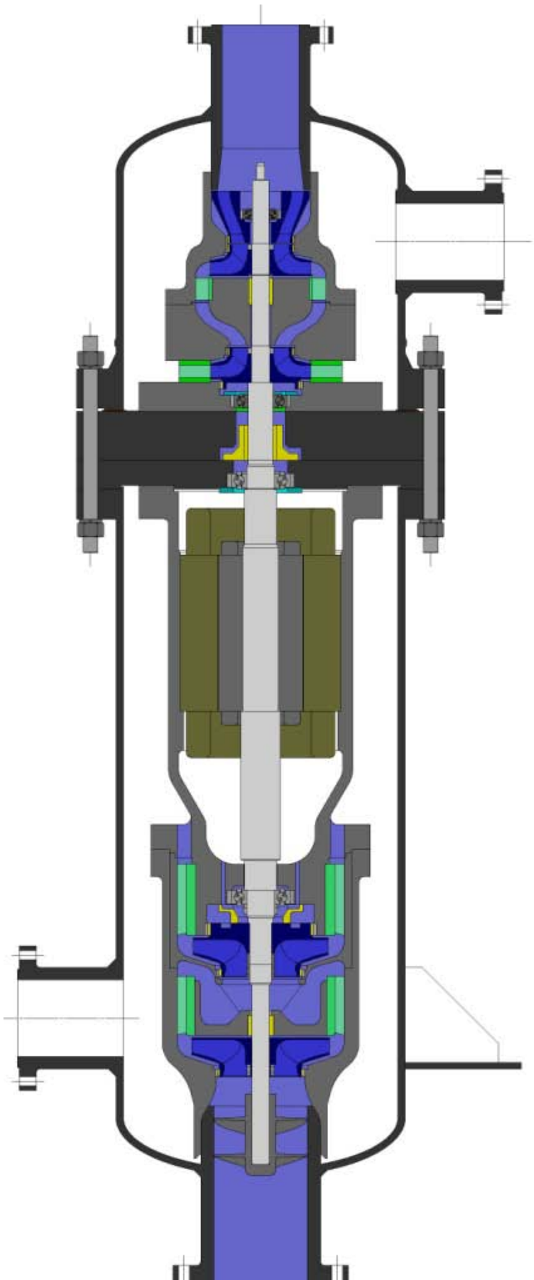

Fig. 1: Compact Pump-Expander Configuration with Submerged Motor/Generator

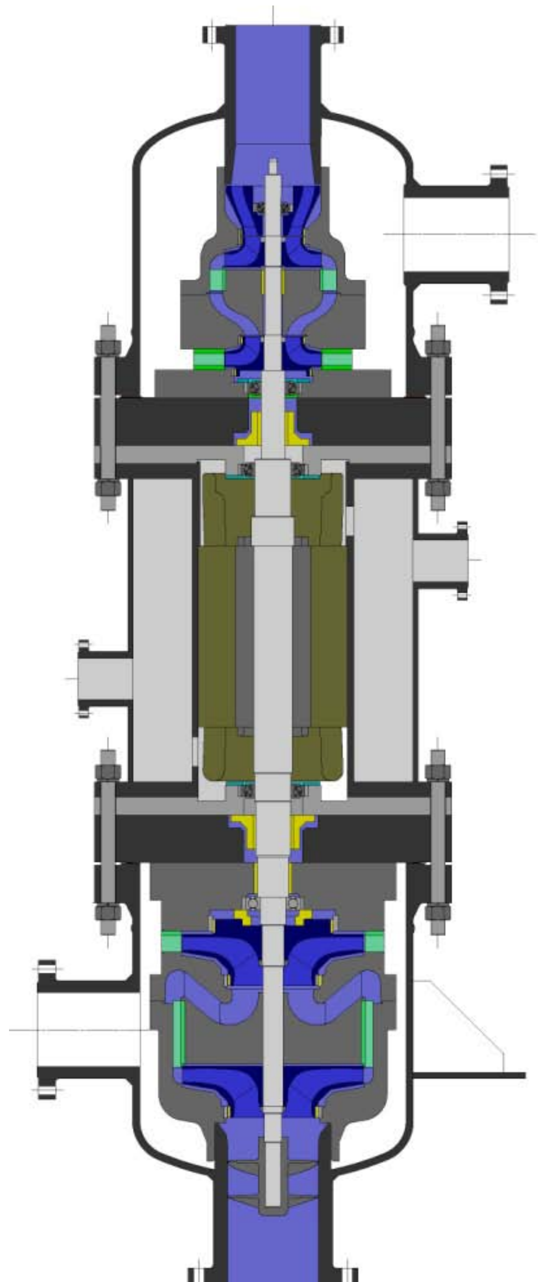

Fig. 2: Compact Pump-Expander Configuration with Separated Motor/Generator

Compact Expander-Expander Configuration

The compact expander-expander design incorporates two expanders mounted on a common shaft with a common generator and separated by a seal (Fig. 3). One expander operates in the LNG stream and the other in the MR stream. The generator may be submerged in the MR fluid (Fig. 3), or in the LNG fluid (not shown), or be separated and cooled in another fluid similar to the pump-expander design (Fig. 2). Also, like the pump-expander design the expanders in the expander-expander configuration are balanced with the TEM. The TEM may be located in the MR, LNG, or liquid nitrogen or liquid propane fluid. The expanders may be multiple stage, single phase, or two-phase depending upon the process requirements.

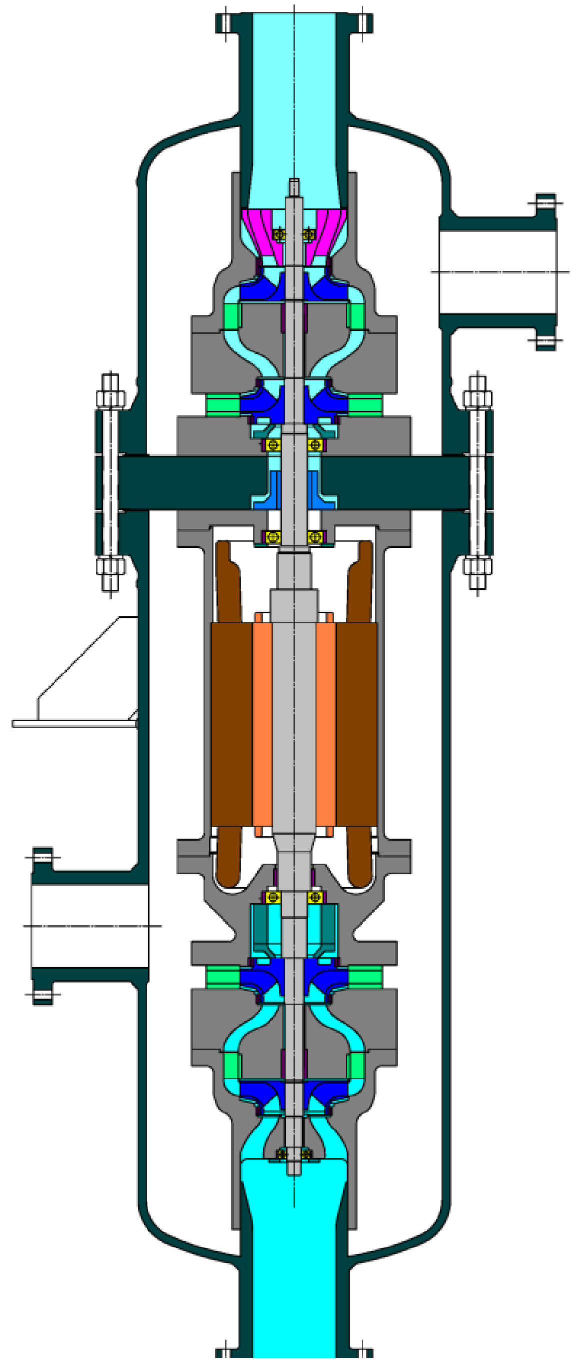

Fig. 3: Compact Expander-Expander Configuration

Advantages of Compact Configurations

The compact pump-expander and compact expander-expander designs have a multitude of advantages. Due to mounting the machines on a common shaft, but with thrust in opposite directions, overall thrust is minimized; therefore, less fluid is required to balance which increases hydraulic efficiency. By separating the motor/generator from the process fluids, no heat is transferred to the process fluids, thus increasing the process efficiency. If the motor/generator is submerged in a process fluid, it is more desirable to put it in the MR stream, rather than the LNG. When separating the motor/generator from both fluid streams, it is possible to also balance the thrust using the third cooling fluid, which maximizes the hydraulic efficiency. The compact design allows for a smaller footprint that is more readily integrated into an existing plant.

Specifically, the compact pump-expander design increases electrical efficiency and reduces, or eliminates the electrical power required for the pump because of the power generation of the expander. It is also possible for a positive power output, if the expander generates more electrical power than is required for the pump, which will increase plant efficiency even more.

In both the pump-expander and the expander-expander configurations, the compact nature of the design reduces cost and the increased process efficiency reduces the payback period and increases production. These designs also serve two needed plant functions in one small and compact design that minimizes the overall footprint required, and the piping required, while increasing process efficiencies and the overall plant efficiency.

Tandem Expander

The tandem expander design consists of two expanders located within one vessel and operating in series. Each expander is equipped with a submerged generator and a variable speed drive. Figure 4 is a simplified view of a possible configuration. The first expander in the fluid flow (A) is a single phase expander, which may be multi-stage. Expander A expands approximately half of the overall desired head. The second expander in the fluid flow (B) is a two-phase expander and may also be multi-stage. Due to mass conservation, each machine sees the same flow rate. Expander B may also be a single phase machine, depending upon the process conditions and requirements.

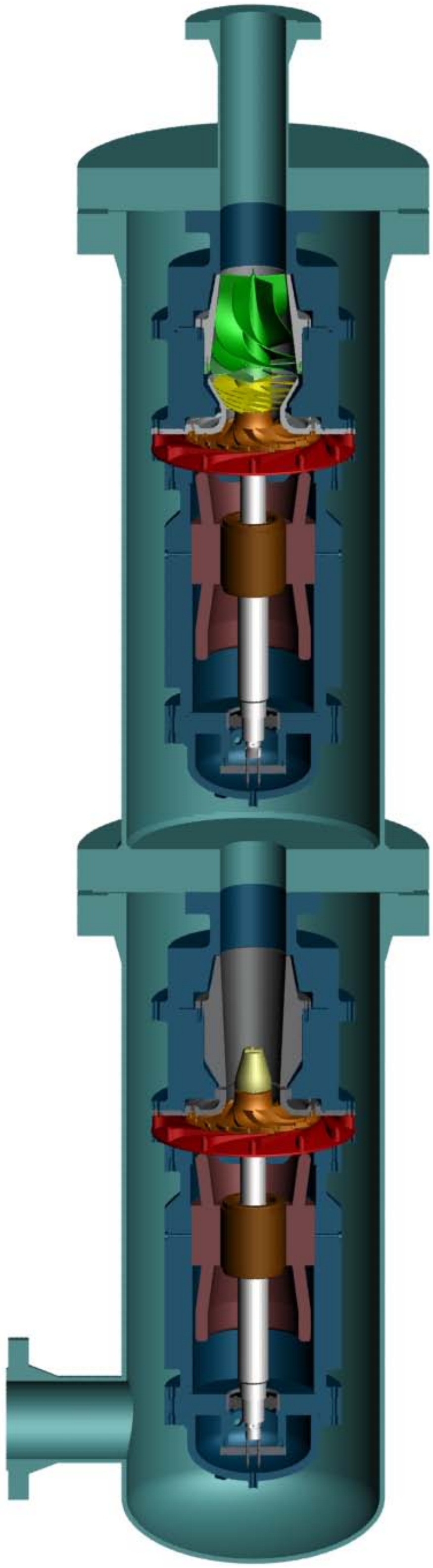

Fig. 4: Tandem Expander

Tandem Expander Advantages

The Tandem Expander design can accommodate higher head without increasing the size of the generators or the diameter of the vessel. The design also allows for multi-phase capacity and replaces both liquid and two-phase expansion by

Joule-Thomson (JT) valves. The design also improves efficiency by virtue of grater flexibility; each expander operates at a speed that maximizes efficiency. The variable speed for each expander allows for constant adjustment to match process changes without diverging from the best efficiency point (BEP). The design maintains typical vessel diameter; therefore, maintains a small footprint. Cost is saved in the machine design as well by maintaining a reasonable hydraulic diameter, saving material cost, and by maintaining generator diameter. To build an expander to achieve the same results as the Tandem Expander requires increasing the generator size which increases diameter, increasing cost.

Conclusions

The presented designs incorporate field proven machinery, but offer new, cost effective solutions to increased demands for larger flow , larger head, higher efficiency, more flexibility, compact size, cost effective solutions, and retro-fitting for older plants to maintain competiveness.

Biography of Speaker

Joel attended University at the United States Air Force Academy, University of Nevada and Pennsylvania State University, earning a Bachelor of Science Degree in Mechanical Engineering and a Master of Science Degree in Aerospace Engineering. Prior to joining Ebara, Joel worked for ten years as a research engineer for the Advanced Programs Department of the Rocketdyne Division of Rockwell International. During this time he was involved in analysis, development and testing of prototype hypersonic scramjet engines in support of NASA and U.S. Air Force Programs. Since joining Ebara International in 1995 he has worked as a Project Engineer, Project Manager, Chief Engineer, Chief Operating Office of the Cryodynamics Division and eventually Chief Executive Officer of the Corporation. Additional activities during this time have included new product development, hydraulic modeling and design, rotordynamic analysis, field service troubleshooting support, system design, sales support and customer coordination. jmadison@ebaraintl.com