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Integration of advanced high-pressure pumps and energy recovery equipment yields reduced capital and operating costs of seawater RO systems

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Abstract

High-pressure pumping and brine energy recovery equipment account for as much as 40% of the capital costs in seawater reverse osmosis (SWRO) desalination systems. Energy consumption by the high-pressure feed pump accounts for at least 35% of the operating costs. Recently developed equipment integrates into one package the function of high-pressure pumping, energy recovery and control of feed and brine flows resulting in a substantial reduction in capital and operating costs of SWRO systems. The integrated equipment package is based on proven technology blended with state-of-the-art fluid machine design and clever integration of numerous components heretofore installed individually in SWRO systems. This package will make a substantial contribution toward the reduction of capital and operating costs for SWRO systems with capacities between 50 and 500 m³/d permeate production per train.

Keywords: Desalination; Reverse osmosis; Energy recovery; Pumps; Turbines; Tonkaflo; Hydraulic pressure booster

1. Introduction

Most SWRO pumping and energy recovery equipment has been borrowed from other industries and, in particular, high-pressure feed

pumps and energy recovery turbines such as the Pelton wheel and reverse running pumps. Notable exceptions are the TONKAFLO[®] feed pump and the hydraulic pressure booster (HPB[™]) energy recovery turbine, both developed specifically for RO service.

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The TONKAFLO® pump manufactured by Osmonics, Inc, was designed for brackish water RO service and has been in widespread use since 1978 with over 10,000 installations. The pump is noted for reliability, smooth and quiet operation, low maintenance cost and competitive pricing in higher pressure applications.

FEDCO's brine energy recovery turbine, the HPB™, was designed for seawater RO service. The unit combines simplicity and ease of installation of turbo-charger devices with greatly improved performance through superior hydraulic design and manufacturing. The HPB™ is believed to be the lowest priced energy recovery unit offered for SWRO service and has the highest efficiency of its type.

RO systems require other expensive equipment including means to regulate feed and brine flows. Typically, valves in a high-grade SS alloy are used for flow control through a throttling process. However, a variable frequency drive (VFD) provides the most efficient means to regulate flow and pressure (when used with centrifugal feed pumps).

Often a pump is needed periodically to circulate a cleaning solution through the membrane to reduce fouling and to restore membrane performance. In some cases, another pump is needed to recirculate a portion of the brine through the membrane to obtain higher flow velocities in the membrane feed channels.

The SWRO original equipment manufacturer (OEM) needs to obtain and install several pumps, an energy recovery turbine and flow control components described above, all of which must be in materials that are expensive and often with long delivery times. The negative potentials of this critical task are threefold: the commercial success of the OEM is jeopardized due to high cost of manufacture, system reliability and performance can be compromised and general acceptance of SWRO may be impeded.

For small-scale SWRO to advance as a mainstream industry, integrated packages must be

introduced that include all pumping function (high-pressure feed, cleaning and brine recirculation where needed), brine energy recovery and means to control feed and brine flows. The consistency of performance and quality possible with pre-engineered packages will allow SWRO to achieve its fullest commercial potential.

2. Objectives for an integrated equipment package

The objective is to integrate the following components into a single package:

- high-pressure feed pump
- energy recovery turbine
- membrane pressure and flow control
- membrane cleaning pump
- brine recirculation pump (where needed).

The heart of the integrated RO package (IROP) is the feed pump and the energy recovery turbine. For IROP to gain acceptance, these components must be reliable, efficient, easy to maintain and have a low cost. Some of the considerations in component selection are discussed below.

2.1. Feed pump

The TONKAFLO® pump manufactured by Osmonics, Inc., has reliability, smooth operation and compact size, which are essential for the IROP. Osmonics asked FEDCO (an Osmonics partnership company) to develop modifications to the TONKALFO® pump that would allow SWRO applications yet not sacrifice the simplicity and reliability of the existing design. The ensuing development program yielded the following enhancements:

- A water-lubricated thrust bearing (Water Bearing™) was developed able to handle higher thrust loads from high-pressure SWRO pumping. The Water Bearing™, integrated with the pump housing, is maintenance free

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