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PEI Technical Note Book

Hydraulic Transfer Efficiency: The True Measure of an Energy Recovery Turbine (ERT)

PEI's Technical Note Book series is aimed at providing the reverse osmosis industry with a more detailed examination of issues affecting pumping and energy recovery equipment in RO service. Issue 1 addressed the effects that feed stream pressure control by valve throttling have on ERT efficiency. This Issue will also be concerned with ERT efficiency, or, more precisely, with what is the real definition of ERT efficiency as most applicable to an actual RO system. As we saw from our last issue, changes in RO system conditions can greatly effect the amount of energy available to the ERT. At the same time, alterations in operating conditions that result in operations removed from design parameters will also cause significant changes in ERT efficiency. However, that subject will be covered in the next issue of the PEI Technical Note Book. In this issue we want to define the combined effect on efficiency and power consumption of all the major equipment components in the high-pressure circuit of the RO system on efficiency and power consumption.

Nearly all flow machines (impulse turbine, reverse running pump turbine and the Hydraulic TurboCharger) employed as energy recovery turbines eventually return the recovered energy to the feed stream. In the case of the Hydraulic TurboCharger, the exchange of brine pressure to feed pressure takes place directly in a single unit, but with all other ERTs the brine energy is converted to mechanical shaft output which is then transmitted through couplings or belt speed reducers to double extended shaft motors or pumps. This sequential flow of energy through each of these components must be combined to define the true ERT efficiency.

Thus, what is ultimately important is the ratio of hydraulic energy returned to the feed stream to the amount of energy available in the brine stream. This ratio is called the **hydraulic transfer efficiency,** or **Nte. Nte** is defined as: **Nte** = H_{out}/H_{in}, where H_{out} is hydraulic energy transferred to the feed stream and H_{in} is the hydraulic energy available in the brine stream.

The hydraulic transfer efficiency provides the most accurate means to evaluate the energy recovery effectiveness of any ERT including impulse turbines, reverse running pump turbines and the Hydraulic TurboCharger.

Examples of Nte calculations for various ERTs

1. **Hydraulic TurboCharger**: Since the TURBO is a self contained pressure exchanger, its efficiency is always stated as Nte. Consequently, when a TURBO is said to be 60% efficient it means that the hydraulic transfer efficiency is 60%. If the TURBO pressure boost, brine pressure and reject ratio are known values, the transfer efficiency can be calculated using this equation: **Nte**= Pbst/(Pb*Rr)

   Pbst = pressure boost developed by the Turbo
   Rr = reject ratio
   Pb = brine pressure

   Example: Pbst=325psi(22.4 bar), Pb=900psi(62bar), and Rr=0.6
   The Hydraulic TurboCharger transfer efficieny equals 60% (**Nte** = 325/(900*0.6) = 0.60)

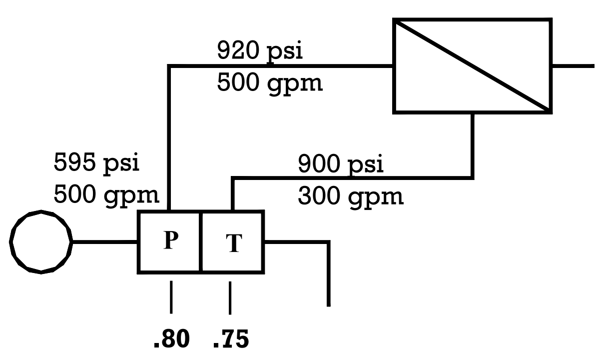


Figure 1. ***Nte*** *= 0.80 * 0.75 = 0.60*

2. **Impulse Turbine with positive displacement pump**: The Pelton Impulse Turbine(PIT) hydraulic transfer efficiency is calculated as follows. Multiply the PIT efficiency * Feed pump efficiency * power transmission efficiency * reduction of motor efficiency (due to part load operation). As an example, (see fig.2) many PIT reciprocating pumps use two sets of V belts and a jack shaft as a speed reducer. The equation (assuming standard component efficiencies) becomes 0.85(PIT) * 0.88(PD pump) * 0.96(1st V belt) * 0.98(two pillow block bearings) * 0.96(2nd V belt) * 0.98(reduction of motor eff due to part load operation) * 0.96 (3rd V belt) = 0.635 This example and the following one assume no brine disposal pump is used with the PIT.

   Impulse turbine with centrifugal pump: The Nte for this case involving the PIT and a centrifugal pump would be: 0.85(PIT) * 0.72(feed pump efficiency) * 0.99(coupling efficiency) * 0.98(reduction of motor efficiency due to part load operation) = 0.59

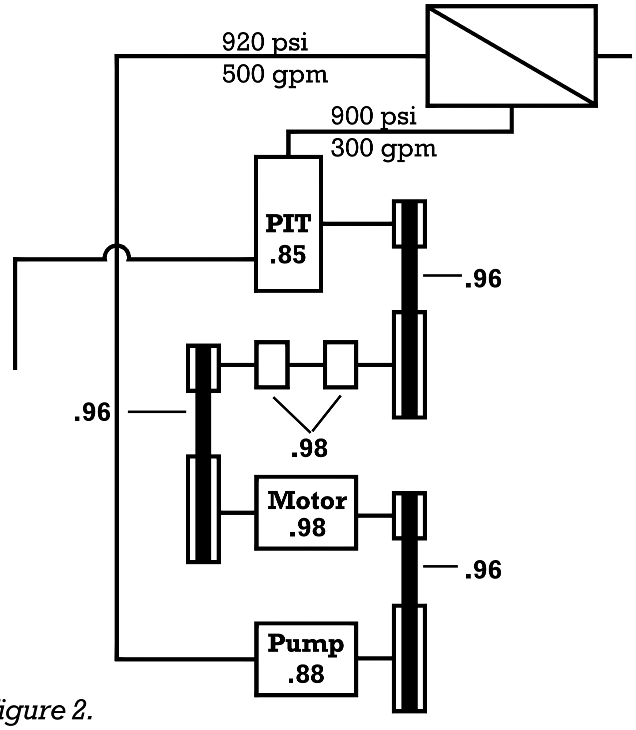


Figure 2.
*With PD: **Nte** = .85*.96*.98*.96*.98*.96*.88 = 0.63*
*With Centrifugal: **Nte** = .85*.99*.98*.72 = 0.59*

3. **Reverse Running Pump Turbine (RRPT).** The RRPT example is similar to the PIT with centrifugal pump except the typical efficiency for an RRPT is 0.7 instead of 0.85 for PIT. Therefore, the hydraulic transfer efficiency of the RRPT is 0.7(RRPT) * 0.72(feed pump efficiency) * 0.99(coupling efficiency) * 0.98(reduction of motor efficiency due to part load operation) = 0.49

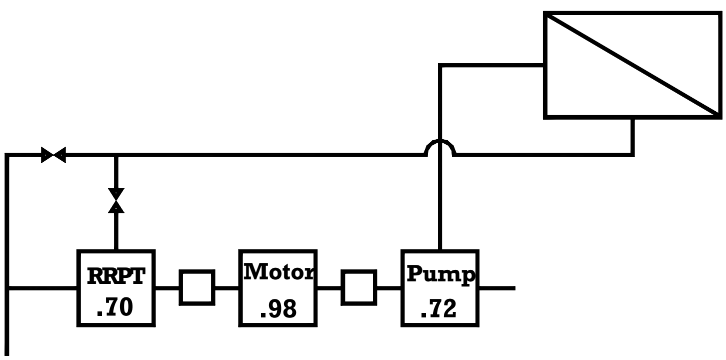
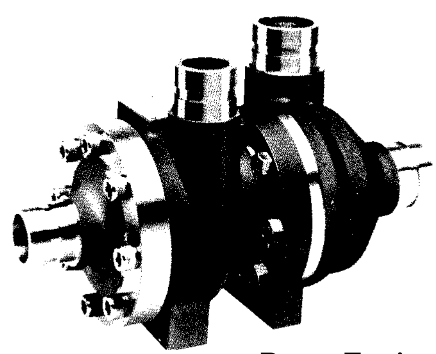


*Figure 3. **Nte** = .70*.98*.72 = 0.49*

These three examples were calculated for typical component efficiencies for 500 gpm (113m3/hr) at BEP (best efficiency point). If either the PIT or the RRPT were operating at conditions other than BEP, there would be additional efficiency reductions. Those cases will be the subject of our next Technical NoteBook, Issue 3.

As you can clearly see, when comparing advertised ERT efficiencies care must be taken to ensure the comparison is accurate. Any comparison lacks validity if the efficiency terms being compared are not the same. The Hydraulic Turbocharger in many cases displays higher true efficiency than the Pelton Impulse Turbine, and in all cases the Turbo efficiency is better than a Reverse Running Pump Turbine. Understanding the minimal difference between the Turbo and PIT true efficiency allows the system designer to evaluate the big picture. The installation and operation advantages and capital cost reduction potential of the Turbo, clearly make the ERT choice for reverse osmosis easy- PEI's Hydraulic TurboCharger .



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