The numbers don't lie. Choosing the wrong sealing system can be a real drain on an operation's process efficiency, not to mention its reliability, environmental compliance and, ultimately, its overall profitability.

In the world of process equipment economics and reliability, the energy efficiency of sealing systems is frequently regarded as being unimportant and insignificant. A careful look, however, reveals that sealing systems are often key factors in establishing system efficiency, reliability and emission-control improvements. Upgrading these systems can greatly help a process plant in these types of improvement initiatives, as well as in its carbon-footprint and total life-cycle-cost-reduction efforts. Take, for example, mechanical seal and compression packing applications.

Why Consider Sealing Systems In Energy Efficiency?It's simple: they are seldom analyzed or evaluated. The area where a shaft penetrates the casing of a fluid handling device, such as a pump, is a potential leak path. Either a seal chamber or stuffing box with a mechanical seal or compression packing is adjacent to this area. Both are central components in a sealing system that ensures containment of this leak path. The type of system will determine energy consumption, among other things.

Mechanical seals...

Mechanical seals are found in the majority of centrifugal pumps today-—*particularly in those handling volatile, hazardous or valuable fluids.*

Available in a wide variety of types, arrangements and materials, mechanical seals create an extremely restrictive leak path perpendicular to the axis of the shaft between two rubbing seal faces. Leakage is normally not visible and frictional heat is carried away by the pumped fluid surrounding the seal. When conditions around the seal are too severe, support systems are applied to create an artificial environment for the seal. These conditions often include abrasiveness or poor lubricity of the pumped fluid and high temperatures. (Recent design and material technology developments have focused on development of seals that perform in applications without the need for additional support systems to achieve environmental control.)

Seals are energy-efficient devices, but some of the basic, more popular seal support systems in use today can consume large amounts of energy—*in some cases exceeding the power output of the pump driver.*

Sealing system energy losses should, therefore, be carefully considered in any pump system assessment.

Compression packing...

Packing creates an adjustable, close-clearance leak path parallel to the axis of the shaft. Some leakage must be maintained to lubricate and cool the packing material, but frictional heat is always present due to the large surface area in contact with the shaft. When the pumped product is abrasive or the packing needs additional cooling, a clean external flush is typically piped into the stuffing box. This flush is part of the sealing system and can indirectly consume large amounts of energy—*that's why it should be considered in any energy assessment.*

Sealing system efficiency

To take advantage of energy-reduction opportunities, we must first determine the energy consumption of the sealing systems used in process equipment. While the focus is typically on pumps, process equipment that incorporates these systems includes compressors, mixers, dryers and all equipment with a rotating or reciprocating shaft that passes through the wall of a pressurized vessel or housing.

One approach is to analyze the overall sealing system's Life Cycle Costs (LCC) (i.e. all cost contributors, including energy consumption). A useful tool in such an analysis is available on the FSA website (www.fluidsealing.com). This free "Seal Life Cycle Cost Estimator" software enables simplified comparative analysis as to what sealing system is more cost effective. The contribution of energy is an integral component of any analysis.

The "Seal Life Cycle Cost Estimator" tool can be used to analyze sealing systems as simple as a packed pump with no environmental controls, to those that incorporate complex double, tandem and multi-stage mechanical seal arrangements with their own separate lubrication systems, auxiliary pumps, motors and heat exchangers. Users can make total-cost comparisons, as well as comparisons for energy consumption and cost.

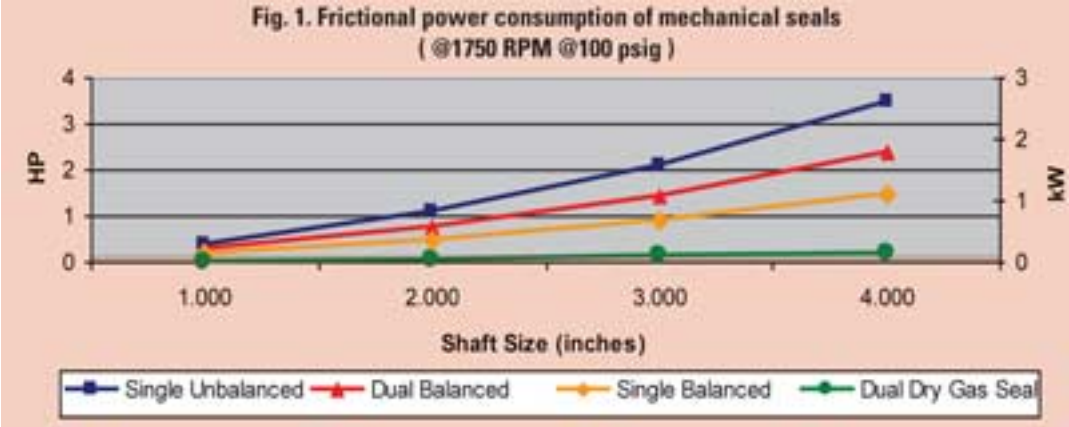
Methodology
To compare sealing system energy consumption and operating costs, three steps should be taken:

1. Identify the points where energy is consumed and label them on a schematic diagram.
2. Prepare a spreadsheet showing the sources, forms and amount of energy consumption.
3. Define current costs for various sources of energy consumed by the sealing systems.

These will be primarily electrical in nature, from prime movers such as motors, and thermal, from a variety of sources. Examples include the cost of cooling water and various forms of energy needed to power the sealing system and replace heat energy consumed in the process system.

Sealing system schematic...
The sealing system schematic helps to determine the source of the energy consumed. The most apparent source is electrical energy from the drive motor, the most common prime mover.

When just this source is examined, large differences in the electrical energy consumption between various mechanical seal types can be seen as shown in Figure 1. Differences in frictional characteristics of the four types of mechanical seals cited produce significant differences in the power consumption of the motor. While these are relatively large differences they do not include the energy consumption of the auxiliary components of the entire sealing system. When all these sources of energy consumption are included a quite different perspective develops.



Sources: Mechanical Seals for Pumps: Application Guidelines, pgs. 154-156, published by Hydraulic Institute, 2006; and FSA "Seal Life Cycle Cost Estimator" tool, www.fluidsealing.com

Example mechanical seal system analysis...

Figure 2 shows one of the more popular, but least efficient, sealing systems for environmental control and protection of mechanical seals. This type of system is used in hot oil pumping service. Typical application specifics include:

- Single stage, end suction centrifugal pump (API 610 Compliant)
- Provides heat to various area of the plant
- Process fluid — *Hydrocarbon @ 315 C (600 F)*
- Specific gravity 0.8
- Specific heat 1.67kj/kg-ºC (0.4BTU/lb-ºF)

- System pressure — *345 kPa (50 psi) in seal chamber*
- Pump shaft — *3600 rpm, 50 mm (2.0") diameter in seal area*
- Pump driver — *50 hp (typical)*
- Sealing devices
- Mechanical seal *or*
- Compression packing

- Heat lost at the pump must be replaced at the system boiler/heat exchanger

Origin of energy consumption...

The initial perception from Fig. 1 may be that most of the sealing-system energy consumed is by the drive motor in overcoming the frictional heat created by rubbing contact between the stationary and rotating faces of the seal. As shown in the schematic, that portion represents less than 1% of the total power consumed by this sealing system, reflecting the relative efficiency of the mechanical seal itself.

It is also notable that the total power consumed by this least-energy-efficient system, 47.4 kW (63.5 hp), exceeds that of the drive motor itself. Virtually all of that is due to the power required to replace heat lost through dilution of the pumped fluid.

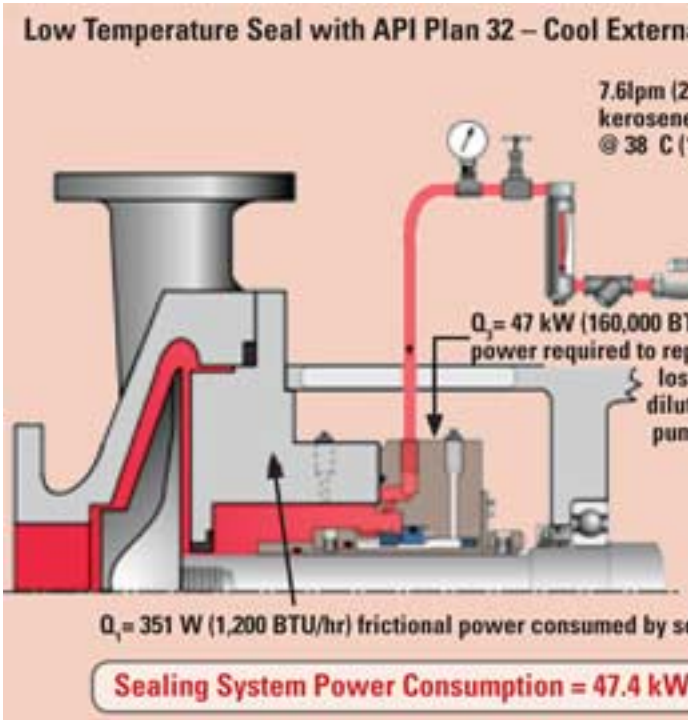


Fig. 2 Least energy-efficient mechanical seal system
Mechanical Seals for Pumps: Application Gu
pgs. 250-251, published by Hydraulic Institute, 2006)

Based on an FSA study of over 28,000 seal applications where pumping temperature exceeds 200 C (400 F) this is a realistic case. Over 20% of the mechanical seal applications surveyed employed this API Piping Plan 32.

To show that sealing systems represent an opportunity for significant improvements in energy efficiency, we can look at more-current types of energy-efficient systems. The power consumption of many of these proven—*but much less frequently applied*—systems is less than 50% of this least efficient example. Dry gas seals, one of the latest technologies and most efficient sealing systems, consume 0.5 kw (0.7 hp)—
about 1% of this least-efficient system
. They also effectively provide a zero emission seal.

Conclusion

Sealing system energy assessments should be an important part of any plant energy assessment. Selection of an energy-optimized sealing system can lead to significant overall plant energy savings that go right to the bottom line. While not covered here, systems with much greater energy-efficiency than the example illustrated are available. Consultation with your mechanical seal or compression packing manufacturer will enable selection of the most energy efficient system for your application. **UM**

About FSA…

The Fluid Sealing Association (FSA) is an international trade association whose membership represents over 85% of the manufacturing capacity for fluid sealing devices in North America. Its Mission Statement notes that the association seeks to promote a safe, clean environment for society and be recognized as the primary source of technical information; influence and support development of related standards; and provide education in the fluid sealing area. The FSA Web site (www.fluidsealing.com) provides an ideal place for seal users to find technical articles, obtain publications and learn out about upcoming seal training opportunities. There, too, is where you can download the "Seal Life Cycle Cost Estimator," discussed in this article. (The FSA will be offering 2 full-day workshops at MARTS 2010, one on mechanical seals, the other on compression packing and gasketing. Please visit ww w.MARTS conference.com for details.)