Life Cycle Optimization of Pump Systems, Supporting Infrastructure and Related Rotating Equipment: *An Often Overlooked Opportunity for Significant Cost Savings in The Plant Environment*

By: Darren Moscato
ITT Plant Performance Services

For many years, manufacturing organizations looking to meet cost-cutting demands have focused their attention strongly on labor costs. Many looked to low cost country sourcing, but, as a result of such factors and realities as plant automation, geopolitical issues and increased logistics and shipping costs, low cost country sourcing no longer holds the attraction that it once did. Many more focused upon "leaning" initiatives, and in many locations, workforces have been reduced to precariously low levels, both in terms of head count and in terms of relative skills, experience and institutional knowledge.

Where does this leave the plant manager who is once again charged with executing a mandate from headquarters such as "reduce the cost per unit of output by x% within y months" when it seems that much of the more obvious fat—and, unfortunately for many, a good deal of the muscle as well—has long since been hacked away?

Fortunately, there is a fruitful area that, for most, has heretofore gone in large measure overlooked or, at best, only superficially investigated, not only by plant personnel but also by the big management consulting companies—life cycle optimization of pump systems, including supporting infrastructure and related rotating equipment.

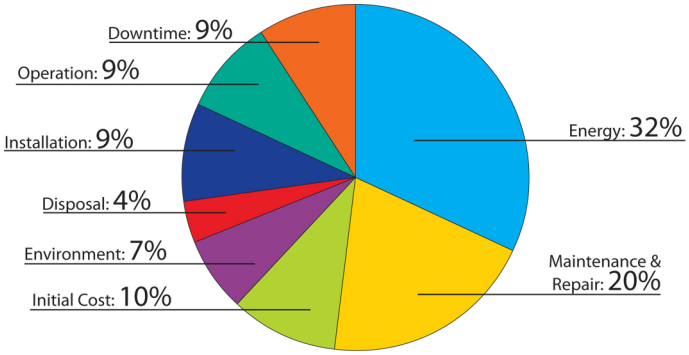
Pumps and related systems—substantial savings opportunities in plain sight

According to the U.S. Department of Energy (DOE), pump systems, in aggregate, consume more energy than any other type of industrial equipment. In addition, according to the FiveTwelve Group, the average annual maintenance and operations spend on pumps is half again greater than for any other type of rotating machinery.

Given the large numbers of pumps in operation in industry and their vital importance to such a wide variety of manufacturing operations, many may accept this as a reasonable state and not be driven to investigate further, but studies show the real story: much of these costs are significantly higher than they need to be. In a European evaluation of nearly 1700 pumps at 20 process plants, for example, average pumping efficiency was discovered to be only 40%, with, even more disturbing, 1 in 10 pumps running below 10% efficiency. In fact, based on a recent DOE study augmented by our own internal research, inefficient pumping systems operating in plants today **cost industry more than $2 billion each year in energy and reliability-related losses**—more than turbines, air compressors, fans or any other type of related rotating equipment.

Lifecycle costs—a full 90% of ownership costs

In large part, what makes the life cycle optimization opportunity so fruitful is the observation that the initial upfront cost of a pump represents a mere 10% of the overall lifecycle costs, with the remaining 90% being spent over time in such areas as energy consumption (32%), maintenance and repair (20%) and wasted downtime (9%), with the latter figure likely even higher in operations without significant system redundancy.



This resulting 90% of life cycle cost is not easy to isolate or to measure, so it is largely overlooked and therefore not only goes unoptimized, but can lead to detrimental decision making as long term costs and impacts are not always taken into account. It is important to realize that decisions made at the planning stage—such as relative pump size, piping infrastructure and control schemes—have impact far beyond the initial equipment cost, and will determine the vast majority of the lifecycle cost as well as the productivity of the equipment throughout the years or decades of its useful life. Further, unchecked operating inefficiencies—which, as suggested by the studies quoted above, are more the rule than the exception and are often significant—can add up to *major* losses. Consider that a *single* 200 horsepower pump consumes $50,000 in electricity every year. If all a plant's pumps are running at an average 40% efficiency, as studies suggest, then the magnitude of the savings that can be generated by raising that average to 60, 70, 80% or more begins to come into focus.

Analyzing the 90% for significant cost savings and other operational benefits

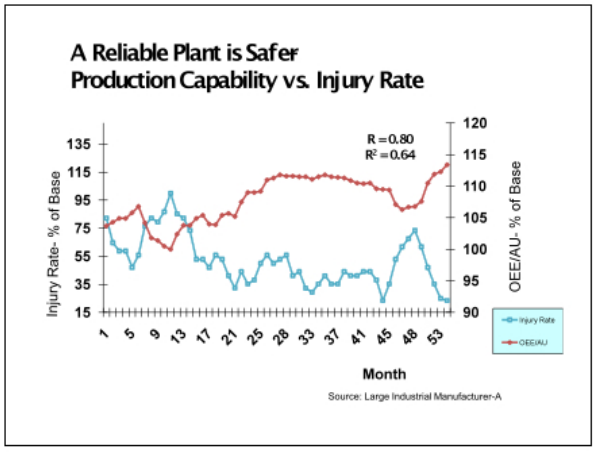
For those in a plant environment interested in identifying new, deep, untapped wells of cost-cutting opportunities, the "90/10 rule" is an observation of potentially major consequence. With the proper guidance and expertise, the typical mid- to large-size multi-pump operating manufacturer can reclaim hundreds of thousands or even millions of dollars each and every year by optimizing their pumps along their entire life cycle. In addition, by applying many of the

improvements to neighboring rotating equipment—smaller, but still significant cost-saving opportunities and relatively easy when expertly done in tandem—they can even further increase and accelerate the significant return to be realized.

Once systems are optimized, savings come quickly from many areas, including lower energy costs, lower maintenance costs, lower consumption of parts and equipment, and lower inventory costs.

And in addition to cost savings, the other benefits to manufacturers when successfully implementing life cycle optimization can be huge as well. In our consulting practice, ITT Plant Performance Services, a knowledge services-focused offering of pump manufacturer ITT Corporation, we have seen our clients experience improvements including, but not limited to:

- Increased product consistency and quality, driven by reduced variability in processing
- Higher plant productivity with decreased downtime, and/or the ability to run longer or at higher outputs with more robust systems and less fear of failure
- Increased safety performance; since there is a strong positive relationship between the number of corrective/reactive work orders and the number of injuries, reducing the former reduces the latter, often significantly
- Improved labor efficiency, with personnel more frequently performing high value activities, and avoiding reactivity



A new breed of consultants, working the top floor *and* the shop floor

Where can plant leaders turn to assist them in tapping into these benefits? Unfortunately, the (over) leaning of the work force has made it even less likely that the expertise currently resides in-house. And, as many manufacturing operations have discovered, an engagement with a traditional management consulting company can not only be a lengthy endeavor necessitating a major upfront investment, but also is frequently of limited practical usefulness when it comes to hands-on analysis of plant machinery. Indeed, traditional consultants—with their expertise in business systems, finance and accounting—tend to focus their efforts on the *top floor* boardrooms and offices and shy away from the nitty gritty of the *shop floor*, an environment in which many tend to be neither knowledgeable nor comfortable.

Further, "the 90/10 rule" is often misunderstood and ignored even by engineering consultants designing a new plant or line. One way that we frequently see expensive inefficiencies built right into the system, hamstringing the potential productivity of the operation from Day 1, is the common tendency to oversize pumps. In fact, a composite of our studies suggest that pumps are oversized 25% on average. The typical thinking is "I estimate this process requires pumping at 1100 gallons per minute, so I'll spec a 1350 gallons per minute model just to be on the safe side."

Although the customer will pay more to buy the larger pump, this cost difference appears modest—until one understands that this extra upfront cost is only a small fraction of what it will cost the plant every day for years or decades when overall lifecycle costs are considered. In fact, this oversizing can lead to a 20% higher energy bill, month in and month out. And adding insult to this injury is the fact that not only is this extra energy wasted, it will actually be going to pay for *destructive* forces that will be continuously sabotaging reliability every minute the pump is running.

That is, when a pump is oversized, the resulting need to throttle it down in operation, forcibly restricting flow with a control valve, means that the plant is paying for energy that does not go into constructive flow, but in fact pays for excessive vibration, heat and wear that lowers service life and foments inefficiency throughout the system. In fact, our extensive operational database suggests that an over-sized pump system can generate *10 times* greater maintenance costs than one that is right-sized.

While traditional types of consulting organizations certainly have their place and their proven strengths, the fact is that new types of consultancies have emerged and are being substantially

driven by customer observations that traditional efforts in providing specific hands-on recommendations and services regarding pumps and other types of rotating equipment are often lacking. In our offices, it has become a cliché to relate a call from a plant manager with a story such as "the consultant told us to change pump system from x to y and now it's running even worse." Just as frequently, we go into a plant and find several over-sized pumps or other "built-in" efficiency robbers installed in the design phase, presumably by consultants unfamiliar with their ongoing detrimental effects in real-world plant operations.

Indeed, this need to drill down deeper into *the actual machinery* of plant operations to find "the next generation" of untapped cost-cutting opportunities has led to the emergence of this new breed of consultant who is as at home on the shop floor as on the top floor, and not afraid to investigate the hidden complexities of heavy equipment operation and get fingernails dirty in the pursuit of cost-savings opportunities previously generally avoided by the consulting industry as a whole. ITT Plant Performance Services, as an offshoot of a pump company, can effectively leverage decades of hands-on, real world pump development and operational knowledge, data and experience, and make it available as a turn-key, highly valuable service, filling a void and meeting a timely need voiced by manufacturers of all kinds.

Glimpses into a life cycle-optimized plant

With the right hands-on assistance, a life cycle-optimized plant begins to look and operate very differently than one that operates in a less efficient manner. Although every plant is different, this section will provide some examples of improvements that have been implemented in our clients' plants along the entire life cycle—including design, inventory, operations and repair stages.

In general, the end state of a fully optimized plant can include:

- A database of installed equipment that is continuously updated with each purchase, installation, repair, or upgrade
- Real-time visibility of inventory levels (including those on site, at sister facilities, or in the supply chain), generating confidence that there is constant access to the spare parts needed to support the operation
- Immediate knowledge of the location and status of every asset including those in the repair loop (onsite and offsite)

- The ability to scan a bar code on a piece of equipment and know its current condition, maintenance history, performance history, replacement parts, and associated inventory levels
- Knowledge of Key Performance Indicators by machine and location, including mean time between failure, bad actors, top failure modes, efficiency rating and more
- Insight into the root cause, the corrective action plan, and the financial impact of every major source of inefficiency in the plant
- The ability and resources to implement corrective action plans and establish a continuous cycle of identification and elimination of inefficiencies over time

Life Cycle Optimization: Design Stage

Life cycle optimization can and should begin in the design and sourcing stage. It should bring to the process the insight that the decisions made at this stage impact not only the relatively modest up-front investment in equipment that accounts for about 10% of life cycle costs, but the efficiency, productivity and bottom line cost of operating the plant going forward, where the vast majority of life cycle costs lie. Plants save money on their initial equipment bill by right sizing specifications, and also move forward with built-in efficiencies, ensuring cost-effective operation right from start-up.

Whether it begins at the design stage, or within a plant already in operation, key to a quality life cycle optimization effort is the application of a bar code to every pump and other piece of equipment, and the creation of an attached record that ultimately includes every available detail about the unit's history—locations of use, repairs, replacement parts onboard, upgrades and more. Once this database is created, it is a key to tracking every piece of equipment for maximum reliability and productivity throughout its lifecycle, from inventory to operations to repair and back. And, it allows access to a running history of the asset, including information such as mean time between failure, common failure modes, bad actors and other information that can be mined to help diagnose problems or identify less than optimum operating situations.

Life Cycle Optimization: Inventory Stage

For plants already past their design stage, life cycle optimization efforts often find their foundation in inventory procedures. While most plants can reduce inventory levels by removing obsolete and redundant parts, these one-time savings pale in comparison to the ongoing reductions that can be achieved by first having a more reliable, efficient and predictable operation. In fact, bloated

inventory is itself often a *symptom* of plant unreliability, with increased need for repairs, longer repair cycles and lack of confidence in the predictability of plant operations driving the accumulation of parts. Further, if the plant is unreliable, then an arbitrary slashing of inventory can serve to decrease reliability even further if the needed back-up parts are not at hand. In addition, it is an effort that will quickly back-slide toward initial levels if inventory strategies, procedures and systems are not addressed, such as, for example, ensuring that there are procedures in place to continually remove obsolete items from inventory going forward.

That's why overall plant optimization efforts call for *rationalizing* inventory, not merely reducing it. While investing the appropriate amount of effort based on the plant's relative risk/reward situation, the right type of consulting organization will analyze the installed base of machinery, common failure modes, reliability metrics, the criticality of each part, their ready availability in the supply chain and other key aspects of real-world need to determine an optimum, strategic inventory of parts and equipment. And, they will put procedures in place to keep inventory at the leanest strategically apt levels so that they won't "re-bloat" over time.

In addition, efforts are made to reduce the number of parts by taking advantage of available alternatives. For example, replacing the 36 individual parts needed to repair a power end with a single subassembly pre-built to exacting tolerances not only lowers inventory costs, but saves repair time and improves the reliability and productivity of the equipment going forward. All of this serves to minimize the parts that need to be purchased, and, as our clients have discovered, the cheapest part is the one that you never have to buy.

Life Cycle Optimization: Operations Stage

As suggested, keeping inventory levels consistently low for the long term requires optimizing the reliability and predictability of plant operations. Indeed, the operations stage is where most of the lifecycle costs of plant equipment are spent, and it is in this area that a life cycle-optimized plant can find significant savings by identifying and correcting issues that constantly sap performance and productivity, both known and unknown.

The goal of optimization is to maximize the plant's Overall Equipment Effectiveness (OEE), which we define as rate x quality x uptime, at the lowest possible cost. Key to this are reducing energy consumption, identifying and eliminating bad actors, identifying and eliminating waste,

and increasing mean time between failure, often to new, unprecedented levels, as the plant taps into the ability to plan and make decisions based on factual data.

The ability of specialized plant optimization consultants to examine, in great detail, the physical operation of the pumps and rotating equipment often brings quick improvements as chronic problems are uncovered. Of vital importance is the fact that pump system expertise allows the pinpointing of the *source* of inefficiencies when diagnosing complex problems. Many investigations by more generalized consultants or in-house professionals uncover and continually treat symptoms and stop there, lacking the knowledge to drill deeper to uncover the root cause. This is key in life cycle optimization efforts. Very frequently, we find, for example, plants experiencing repeated seal failure and continuously replacing seals or trying to bolster seal performance, and not realizing that chronic seal failure is not a root cause but most often a symptom of another, less apparent issue.

Life Cycle Optimization: Repair Stage

In life cycle optimization, the repair stage gets the attention it deserves. First of all, repair tracking is initiated to ensure the fastest and most accurate repairs, with full knowledge of where every piece of equipment is, its status, and when it will be ready to be put back to service or inventory. Further, with awareness of the "90/10" rule in mind, only OEM parts are used, understanding that the potentially enticing upfront savings of using third party parts is dwarfed by the resulting losses in ongoing efficiency and costly erosion of mean time between failure.

But perhaps even more important is the realization that every repair event presents a valuable opportunity to improve plant performance. Should the goal be to attempt to return the system to the way it was, or is there a repair/replace/upgrade decision to be made that will ensure that the returned equipment makes the operation a little bit *better*? In an optimized plant, managers, at their fingertips, have the life cycle data and analysis that will enable these vital decisions. Sometimes it may be investment in a new piece of equipment, but sometimes it may be a small tweak to the system, such as uncovering the opportunity to trim the impeller by a quarter of an inch to reduce energy consumption and improve reliability. When there is specific understanding of intrinsic pump behavior and hydraulic issues at your disposal, these opportunities are frequent and of significant value.

The elements required

Taking a bird's eye view of the life cycle optimization process, and looking across all stages, from design to inventory to operations to repair and back, there are four critical elements necessary for making a lifecycle optimization vision a reality in most contemporary plants. These should be offered as a turn-key solution by the consulting operation charged with bringing the vision off of the page and into the plant:

- Reliable access to accurate, meaningful data—tracking all equipment to collect the most valuable, most actionable information, always mindful of the relative costs of collection vis-à-vis the specific opportunities for data driven decision-making that exist in the particular plant
- Analysis to identify opportunities—data is of limited value on its own, and must be translated into actionable knowledge by experts with hands-on experience in what the data is communicating and how to act on it; this allows the uncovering of trends that may be obscured in a forest of data, including the identification of bad-actors and problem installations, Pareto analysis of failure modes based on an installed base of pumps, the comparison of efficiency rates, and much more
- Expertise to diagnose the source of problems and their solution—problems uncovered may suggest a self-evident fix, or, through expert eyes, they may just point in the right direction toward one, suggesting that additional information be gathered through a root cause analysis, machine health analysis, skills assessment or other study, as well as help justify its value and need
- Resources to implement change and deliver savings—readily deployable, onsite resources expert in implementing cost-saving initiatives and establishing a continuous cycle of identification and elimination of inefficiencies, with strong project managers and embedded specialists coordinating efforts such as equipment modification, procedures and standards rewriting, skills training, change management initiatives, inventory management, parts programs, repair programs and whatever else might be indicated to reach the life cycle optimization goals

An effort that doesn't cost—it pays

Obviously, every plant is at a different stage on its cost-cutting journey. But, being that optimizing equipment over its life cycle is an area that has been grossly overlooked, most any plant operating more than a handful of pumps and other pieces of rotating equipment will readily uncover significant savings in these operations when they tap into the proper expertise. Indeed, it is rare that consultants specifically expert in pump and rotating equipment cannot find

opportunities to save energy, reduce repair and maintenance expense and boost operating efficiencies fairly readily, with relatively low levels of investment required and fast ROI.