Steam Champions in Manufacturing

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ABSTRACT

Traditionally, industrial steam system management has focused on operations and maintenance. Competitive pressures, technology evolution, and increasingly complex regulations provide additional management challenges. The practice of operating a steam system demands the managerial expertise of a "Steam Champion," which will be described in this paper. Briefly, the steam champion is a facility professional who embodies the skills, leadership, and vision needed to maximize the effectiveness of a plant's steam system. Perhaps more importantly, the steam champion's definitive role is that of liaison between the manufacturer's boardroom and the plant floor. As such, the champion is able to translate the functional impacts of steam optimization into equivalent corporate rewards, such as increased profitability, reliability, workplace safety, and other benefits. The prerequisites for becoming a true steam champion will include engineering, business, and management skills.

Introduction

Steam is a significant feature of industrial power. Steam systems account for approximately two thirds of primary fuel consumption in manufacturing. In 1995, this consumption totaled 9.34 billion quads[1], costing $21 billion (Jones 1997). Steam continues to be an ideal medium for applying thermal energy in ways that transform, distill, shape, and cure material works in process.

Usually, plant managers perceive steam to be a utility that supports core process activities. So while plant managers may attribute value of output solely to process applications, no such attribution is given to steam utilities. Regardless of whether that view is warranted, it also implies that plant managers do not think of steam systems as a source of additional value to be captured. In this scenario, the steam manager's job is simply to ensure a reliable supply of steam. At worst, this suggests that some managers are oblivious to the opportunities to control steam system operating costs.

However, the optimization of industrial steam systems is a worthwhile pursuit that returns real value to the asset owners. In order to achieve this, steam systems will require management that is more sophisticated than what was required in the past. The operations aspect of steam optimization will include proper system design, balancing[2], maintenance, and repair procedures. Increasingly, however, business priorities enter the steam management agenda.

Competition and cost pressures demand that manufacturers squeeze value from plant expenses while still generating revenue from marketable products. Meanwhile, new

[1] A "Quad" is one quadrillion (or 10^{15}) Btu.

[2] "Balancing" refers to the continuous process of adjusting the volume of steam to be generated against the loads demanded of the system. A perfectly balanced system experiences no excess or shortage of steam load.

technologies emerge that can enhance steam system productivity. Other technologies pose threats as substitutes to steam applications. At the same time, steam management is made more complicated by the imposition of environmental regulations and operator certifications. A more sophisticated manager—a "steam champion"—is the professional equipped with the skills, leadership, and vision necessary to manage the forces that now characterize industrial steam operations.

Steam Champion: Major Management Functions

The qualities of a steam champion may be best described by an overview of his or her managerial functions and concerns. The steam champion's major activity groups are discussed in the sections that follow. These include:

1. **Performance management:** the strategic evaluation of plant functions relative to industry peers or benchmarks.
2. **Operations management:** the identification and implementation of maintenance and operations processes that ensure reliable steam output.
3. **Personnel management:** the employ and development of human resources as needed to perform system operations.
4. **Business management:** the analysis and communication of steam system performance in relation to business priorities and goals.
5. **Planning:** the anticipation of changes in the business environment, including new technologies, regulations, market conditions, and human resource issues.

Performance Management

Performance management is the first step in optimizing a steam system relative to best-in-class standards. Several key operating metrics[3] allow (1) comparison among systems within the same industry and (2) comparison of one system's performance over periodic intervals. While the sharing of data with competitive firms is usually problematic, professional engineering societies, local utilities, or manufacturing assistance programs may help in this regard. Operations benchmarking may also be accomplished if a plant is one of many belonging to the same corporate group.

The true effectiveness of steam operations can be evaluated with a couple of fundamental metrics. The cost per thousand pounds of steam produced is one comprehensive measure of steam system operating expense. Steam's contribution to plant output is another potential metric, and can be expressed as pounds of steam required per unit of production. When possible, the comparison of these metrics to industry standards provides a relative measure of a steam plant's operating condition. An alternative approach is to benchmark a plant's performance to its own initial energy audit profile. Success is then a function of subsequent performance relative to the initial profile. Knowledge of the steam plant's

[3] A *metric* is a variable or a ratio of variables that records the performance of a chosen feature for each of many different observations. For example, *boiler efficiency* compares the Btu content of a boiler's steam output to the Btu content of the fuel consumed to produce that steam. Boiler efficiency is a metric because it can be recorded and compared (1) for many boilers, or (2) repeatedly for the same boiler at regular intervals.

relative performance is a prerequisite to implementing an ongoing optimization program. Table 1 suggests the steam champion's checklist of performance management items.

Table 1. Steam Champion's Performance Management Checklist: Suggested Elements

Steam Costs	▪ Monitor fuel cost to produce steam in ($) per 1000 lbs. of steam ▪ Calculate and trend fuel cost to generate steam
Steam/Product Benchmarks	▪ Measure steam/product benchmark: lbs. steam required per unit of production ▪ Trend steam/product benchmark with periodic measurements
Steam System Critical Parameter Measurements	▪ Steam production rate ▪ Fuel flow rate ▪ Feedwater flow rate ▪ Makeup water flow rate ▪ Blowdown flow rate ▪ Chemical input flow rate ▪ Intensiveness of steam flow metering (by plant, building, process unit, etc.)

Adapted from (Wright 2001)

Operations Management

Operations management involves the identification and implementation of improvement opportunities. Some activities are remedial or reactive in nature, such as fixing leaks. Others are routine, such as monitoring and recording performance data. Still others are proactive, requiring the investment in new equipment that will enhance productivity. Optimized steam systems deliver thermal resources with a minimum of loss from the boiler to the plant's process applications. Best-in-class or benchmark comparisons help to identify the features of an optimized system. Reference to such comparisons should lead directly to the formulation of an operations management program, having system optimization as its goal.

The steam champion's operations management program requires diligent monitoring and maintenance. This provides system reliability and also ensures that potentially dangerous anomalies are discovered and corrected before personnel are harmed. Disciplined operations preclude down-time, allowing the plant to demonstrate greater productivity. Proper combustion, water treatment, condensate control, insulation and refractory, and leak repair all ensure that the thermal transfer of steam is maximized. If any of these functions are compromised, the ensuing thermal loss usually requires more fuel to compensate. That, of course, means additional operating costs. Finally, as fuel consumption increases, so do combustion emissions and the liabilities associated with them.

More intensive operations and maintenance will cause certain steam plant O&M[4] costs to rise. The steam champion understands that over the boiler's lifetime, expenditures for fuel alone will dwarf other costs as well as the capital outlay for the boiler itself. The rise in incidental O&M costs expended to optimize the steam system can be more than compensated by fuel cost savings.

System optimization is an ongoing process. Continuous improvement, or judiciously maintained optimization, is the rule. Many plant managers make the mistake of

[4] "O&M" refers to operations and maintenance costs, which are routine or at least clearly driven by hours of operation or volume of production. O&M costs typically include labor and consumables such as cleaning supplies, uniforms, lubricants, waste collection, space heat and lighting, and communication and documentation expenses.

implementing a one-time, comprehensive system improvement only to let the efficiency gains erode over time through inattentive maintenance.

Table 2 offers the monitoring and maintenance duties on the steam champion's operations management checklist.

Table 2. Steam Champion's Operations Management Checklist: Suggested Elements

STEAM SYSTEM OPERATING PRACTICES		
Steam Trap Maintenance Program	▪	Select proper trap for application
	▪	At least annual testing of all traps
	▪	Maintain a steam trap database
	▪	Repair/replace defective traps
Water Treatment Program	▪	Ensure that water treatment system functions properly
	▪	Measure conductivity and blowdown rates for boiler and mud drum
Steam Insulation	▪	Ensure that boiler refractory and insulation on pipes, valves, flanges, etc. are in good condition
	▪	Ensure that steam distribution, end use, and recovery equipment insulation is in good condition
Steam Leaks	▪	Record frequency of leaks
	▪	Establish an order of loss magnitude for leaks
	▪	Establish system and timetable for repairing leaks
Water Hammer	▪	Note frequency of water hammer episodes
	▪	Ability to remedy water hammer
Periodic Inspection and Maintenance for Steam Systems	▪	Generation: Boiler, deaerator, feedwater tank, chemical treatment equipment, blowdown equipment, economizer, combustion air preheater, clean boiler's fireside or waterside deposits, etc.
	▪	Distribution: Piping, steam traps, air vents, valves, pressure reducing stations, etc.
	▪	End-use: Turbines, piping, heat exchangers, coils, jacketed kettles, steam traps, air vents, vacuum breakers, pressure reducing valves, etc.
	▪	Recovery: piping, valves, fittings, flash tanks, condensate pumps, condensate meters, etc.
BOILER PLANT OPERATING PRACTICES		
Boiler Efficiency	▪	Determine ratio of Btu heat absorbed by steam to Btu energy input from fuel
	▪	Measure flue gas temperature, oxygen content, and carbon monoxide content
	▪	Select type of excess air control (none, manual, automatic)
Heat Recovery Equipment	▪	Use feedwater economizer and/or combustion air pre-heater
	▪	Perform blowdown heat recovery
Quality of Steam	▪	Monitor boiler output to ensure "dryness" of steam
General Boiler Operation	▪	Use automatic controller for continuous blowdown
	▪	Investigate common system faults (patterns of alarm signals) to determine remedies
	▪	Reduce frequency of steam pressure fluctuations beyond +/- 10 percent of boiler operating pressure
STEAM DISTRIBUTION, END USE, & RECOVERY OPERATING PRACTICES		
Minimize Steam Flow Through PRVs	▪	Analyze pressure reduction options: none, use boiler controls or PRVs, use backpressure turbines
Recover & Utilize Available Condensate	▪	Maximize volume of condensate recovered and utilized
Use High Pressure Condensate to Make Low Pressure Steam	▪	Maximize volume of flash steam recovered and utilized

Adapted from (Wright 2001)

Personnel Management

It is immediately evident that the duties demanded by the operations management program will make intensive use of well trained, motivated, and disciplined manpower. Plant technicians will need to apply mechanical as well as record-keeping skills. The steam champion must ensure that staff are adequately trained to understand the "big picture" (i.e., the steam load's relationship to process demands). But equally important is the knowledge needed to monitor and remedy operating features of the steam system itself. In addition to training, the steam champion will be tasked with designing and scheduling a monitoring and maintenance routine. This routine will facilitate the planning of staffing levels and man-hours to be applied. In addition, it helps the steam champion to better plan the purchase of consumables related to operations needs.

Motivation is key to staff serving effectively. While it is critical for staff to understand the purpose and means for achieving plant optimization, the motivation to carry out the necessary operations routine will be enhanced if staff also share in the savings that optimization provides. Rewards also create the incentive for staff to look for improvement opportunities above and beyond the scheduled operations duties.

Training is the prerequisite to effective staffing. The steam champion seeks training resources and organizes a training regimen that develops each staff member in stages. Initial training introduces basic operational concepts and safety. Intermediate training is intended for staff with some operational experience who are prepared to improve their range of technical abilities. Advanced training presents the use of industry standards and benchmarks, introduces operating liabilities related to resource management and emissions control, and perhaps the fundamentals of human resource management.

The steam champion also has his or her own training agenda. Business principles are important, while new technology development, energy market functions, and regulatory policies are worthy of repeat study.

Membership in a professional engineering society is a worthwhile commitment for key staff as well as the steam champion. These societies have excellent resources for training and development. The provision of such membership and its perquisites are also a way to reward staff.

Training culminates in the ability to fully realize the goals of an operations program. The result—the ongoing optimization of the steam system—provides savings that accrue to the plant's bottom line.

Business Management

Steam production is ultimately conducted for business purposes. The steam champion's business management agenda is two-fold: contribute to plant output while demonstrating steam's contribution in meaningful business terms. Success on both counts will get the attention of upper management, who will ultimately decide how much financial and material support are available to steam operations.

The advent of submetering technologies helps the steam champion to track steam's contribution to different process lines within a plant. That metering data is a primary input for demonstrating business results.

Why do operations data need to be translated into business terms? Unfortunately, few chief executive or finance officers have an understanding or interest in the engineering functions and measurements that define operations management. It is usually a waste of everyone's time if a plant manager describes steam optimization impacts in terms of Btus, pounds per hour, or efficiency ratios. Meaningful communication describes impacts in terms of increases in net income, return on assets, and addition to shareholder equity. The steam champion discusses the impact of steam optimization in these terms.

Central to business dialog is the improvement of net income, or the "bottom line." All other financial impacts depend on this measure. The preceding discussion of system operations management describes how optimization reduces fuel expenditures. Those expense savings translate directly into new income. A thorough discussion of steam system efficiency's financial impacts, with examples, is already available (Russell 2000). The following is a select review of the financial impacts of steam optimization.

Return on assets (ROA). As a financial variable, ROA is simply the ratio of *net income for an accounting period* to the *average value of plant assets in place for that period.* A corporate decision-maker uses ROA as a measure of how hard assets work. To illustrate, consider two plants, both with $10 million in assets. One produces an annual income of $1 million (a 10% ROA), while the other produces $2 million (20% ROA). This is clearly a difference worthy of investigation.

Production cost per unit. Competition in some industries forces managers to focus on cost. This is especially true for high-volume commodity processes such as refining, primary chemicals, and pulp and paper production. The marketplace usually dictates prices; profitability will then depend on cost containment. A steam champion is prepared to document and communicate the results of optimization in terms of a reduction in cost per unit of product. The corporate audience often responds better to this measure than to a statement of aggregate costs saved. Sometimes, a few pennies saved in the per-unit production cost have a meaningful impact on the product's marketability. A steam champion can identify the increment of per-unit cost savings attributable to steam optimization.

Addition to shareholder equity. The holding companies that own manufacturing concerns are keenly interested in the performance of their stock, as well as the opinions of that stock as issued by Wall Street analysts. Accordingly, company executives place a priority on the company's performance in terms of the variables tracked by equity analysts.[5] The holding company's cumulative goal, however, is to grow shareholder equity. The steam champion can translate an improvement in net income into incremental growth in equity. For example, assume that a holding company stock sells at a price of ten times earnings.[6] If a steam optimization initiative realizes $1 million in savings, shareholder wealth is increased by an increment of $10 million ($1 million times the P-E ratio of 10).

The steam champion serves his or her own interests in contributing to the firm's financial and corporate priorities. Steam managers compete with process and other managers for a share of the firm's capital budget. Those managers who can demonstrate superior returns on their capital investment proposals will get greater corporate support.

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[5] Some examples of financial variables tracked by equity analysts include inventory turnover, debt ratios, profit margins on sales, and rate of return on assets. Many other creative variables exist.

[6] Stated alternatively, the stock's P-E ratio is 10.

Planning

As implied by the previous discussion, the industrial steam plant manager's agenda encompasses more than mechanical concerns. Regulation, human resource considerations, and technology evolution impact steam management to varying degrees over time. The steam champion monitors these forces and makes plans for accommodating change.

Emissions control. These regulations impact most large-scale combustion processes. Current output restrictions limit sulfur dioxide and nitrous oxides. Emerging legislation in response to global warming concerns will focus on carbon emissions. Industrial steam managers must contain emissions output with alternative fuel selections, proper combustion techniques, and abatement technologies. The acceptable thresholds for emissions production are subject to constant revision. Professional and industry associations have excellent resources for interpreting U.S. Environmental Protection Agency regulations as well as the technologies and practices that facilitate compliance.[7] The steam champion uses these resources to adjust the operations management plan accordingly.

Professional certifications. Safety and emissions regulations shape the personnel certification requirements for steam system operations. The cost of acquiring certifications, as well as the cost of compensation required by properly certified personnel, is a challenge for human resource management. Under-trained apprentices are easier on the payroll, but a corresponding loss in productivity is the trade-off. It is desirable to develop these personnel, assuming they can be retained after completing their training.

The steam champion has tough choices for sustaining acceptable levels of certified labor. Depending on labor market conditions and the plant manager's tolerance for continuous hiring and staff development, the choice is between outsourcing operations to a certified energy performance contractor, or managing a staff with a few key professionals and a complement of apprentices who essentially learn on the job. In the best of circumstances, the steam champion can plan staffing needs in response to statutory certification requirements. But in practice, this human resource challenge may defy planning. The steam champion will need executive-level commitment to training and compensation as the means for attaining system optimization.

Technology evolution. New technologies are in part relevant to the preceding discussions about emissions control and professional certification. But technology development is also relevant to plant and process design. Certain control, monitoring, and automation technologies are emerging that will boost the productivity of steam systems. Other technologies emerge as substitutes for steam. The steam champion monitors development on both these fronts and uses this knowledge to influence asset selection for the plant.

Monitoring technologies rely on data flows over time to determine a steam system's operating norms. This data has value on a daily operational level as well as at a more strategic plant management level. With respect to daily operations, monitoring reports warn the operator when a data snapshot captures operating results out of the ordinary. Combustion, boiler operations, distribution elements, and end-use applications can all be monitored in this fashion. Additional value can be captured from such data if it is used for

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[7] The American Gas Association and the American Petroleum Institute are two good examples.

on-going efficiency and productivity trend analyses. It is this strategic use of data that distinguishes the steam champion from other plant managers.

Automation technologies perform a variety of functions, from signaling the failure of key hardware components to controlling the mixture of fuels used simultaneously for combustion. The steam champion monitors the implementation of these innovations and employs them to the extent that such technologies are compatible with available human resources. To elaborate, it is theoretically possible to monitor every component of a steam system; this could be a problem if there is insufficient staff to interpret all the data that the monitors generate.

New technologies also bring substitutes to steam. Infrared applications, both electric and natural gas fired, have supplanted steam in the drying of paper coatings in some plants. Sonic vibrators, in combination with membrane sifters, are emerging as a non-thermal method for distilling liquids. Countless electric applications have been devised to provide thermal energy with pin-point accuracy in product fabrication processes.

The steam champion monitors technology developments for those that are relevant to his or her industry. In some instances, steam champions may determine that a substitute technology is ultimately superior to steam. The true criteria in making such a choice is the degree to which a technology option will add value—either through cost reduction or product enhancement. Steam champions in certain industries or facilities may have to evolve professionally with the prevailing technology. But in the industries featuring large scale, continuous thermal energy, steam is not unlikely to be supplanted. The need for steam champions to support these systems will continue for the foreseeable future.

Conclusion

The fundamental premise of steam system optimization is that some investment of resources is required to accomplish fuel savings. Projects to be implemented will be those with the most attractive savings and return on investment. Manufacturers that choose to pursue optimization will have (1) a sufficient time horizon to realize benefits that are especially large in the long term, and (2) top level executive commitment to achieving optimization goals. In short, the appropriate corporate culture is a prerequisite for allowing a steam champion to emerge and thrive.

Steam champions already exist, serving their employers and perhaps entire industries with their expertise. Many are senior, which is not surprising given the volume of expertise they have amassed. But by the same token, senior champions eventually retire, and replacements are not always available. Energy policy, as well as industry leaders at the trade association level, might want to support the development of new steam champions. The steam champion management agenda—performance, operations, personnel, business, and planning—is one that needs adequate support from the training community.

Given industry's appetite for energy, as well as the energy supply concerns that are resurfacing in 2001, the rationale for developing and retaining steam champions is compelling. The business impacts of doing so should be all the incentive needed for industry to act accordingly.

References

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