Crane Washington: A Model For Metal Casting

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ABSTRACT

This paper describes activities that occurred over a six-year period at the Crane Valves foundry in Washington, Iowa. The authors believe that the methodology used to achieve energy savings and operating efficiencies can serve as a model for the metal casting industry. Achievements of this study have their roots in the company's commitment to grow its foundry operations despite strong foreign competition. Reducing manufacturing costs while retaining product quality emerged as the key to achieving this goal. In this context Crane-Washington agreed to participate in the first Total Assessment Audit (TAA) performed in the nation. The TAA (1992-93) identified capital and non-capital improvement initiatives, as well as the springboard for the Process Method Management (PM^2) Demonstration Project (1993-95); and three year follow up.

TAA findings indicated that the PM^2 process of improving operations at Crane-Washington focus on a total quality management program to minimize internal scrap rates and associated costs. The PM^2 model for improving foundry efficiencies was integral to the firm's organizational structure and job responsibilities; work instruction and employee training; quality audit and testing procedures; raw materials specifications; and equipment maintenance specifications. The success of a system like PM^2 is the seeking out and gaining control of the variables that impact the basic operations of melting, molding, core making, and finishing.

The results, which follow, are confirmation of the effectiveness of PM^2:

Number Of Foundry Wage Employees	+30%
Good Molds Poured	+66%
Average Tons Poured	+83%
Man Hours Per Ton	-65%
Kilowatt Hours Per Ton	-29%
Cost Of Scrap Per Ton Poured	-28%

Introduction

This model methodology is based on a Total Assessment Audit with a follow on demonstration project conducted by the Metal Casting Center (MCC) at the University of Northern Iowa in conjunction with the Iowa Energy Center. It is being presented so that those wanting to work with small to medium sized metal casters can best understand the activities that have taken place over a 5-year period at a gray and ductile iron foundry in South Eastern Iowa. This model methodology used to achieve energy use efficiencies through productivity enhancements and process management can and should serve as a model for the foundry industry as well as for many other energy intensive industries. It is the intent of this document to further validate this model and the use of the total assessment audit technique. This activity, and the realization of benefits from it, continues today as a wide range of operating and control specifications are continually approved and incrementally adopted.

Certainly, all foundries have much in common. Each, however, has its unique operational aspects, its peculiar strengths and weaknesses. Accordingly, the specific initiatives conducted at the Iowa metal caster may not be appropriate for the foundry industry in general. On the other hand the methodology employed in prescribing and carrying out successful initiatives is appropriate for any foundry where there is a commitment to excellence and a willingness to make positive changes.

Background

The accomplishments that have taken place with the foundry over the last six years have their roots in the company's commitment to grow its foundry operations, even in the face of strong competition from China, South America and Eastern Europe. Reducing manufacturing costs while retaining product quality emerged as the key to achieving this goal, and it was within this context that they agreed to participate in the first Total Assessment Audit (TAA) performed not only in the state of Iowa, but in the nation. Accordingly, this document covers the initiatives and the results of both the TAA (1992-93), the follow-on Demonstration Project (1993-95) and subsequent years (1996-97). The TAA served as a catalyst for many of the capital and non-capital improvement initiatives, but also as the springboard for further process improvements.

The MCC endorses the overall approach taken in which a broad-based team of experts is first assembled to analyze and to make recommendations regarding the operational facets of a selected company. This is then followed by a project designed to implement the key recommendations. The effort is built around a system of productivity and quality program initiatives whose purpose is to build a foundation for long-term competitiveness and growth.

The MCC believes that it is this basic approach that can and should occur for its primary "constituency"-the small-and medium-sized metal casters of the United States. Theoretically, the more the approach is taken, the healthier and more resistant to foreign competition the metal casting industry becomes.

Scope

The scope of the model project dealt with four primary organizations that were integral to the conduct of the TAA and the Demonstration Project.

1. The Foundry

The manufacturing facility in South Eastern Iowa is a leading manufacturer of ball, butterfly, check, gate, and globe valves made from ferrous and nonferrous materials. Operations were established in 1968 primarily to manufacture gray-and ductile-iron valves for industrial, chemical, petroleum, and water-treatment markets. The facility comprises two distinct operations: 1) a metal casting facility (the focus of this document) that produces gray-and ductile-iron castings for valve products and for a variety of customers in the agricultural, machinery, and equipment industries; and 2) a machining, finishing, and assembly facility that produces finished goods for customer delivery.

Foundry operations have a melt capacity of 50 tons per shift. Gray-iron castings fall into Classes 20, 30, and 35 (tensile strength) and meet ASTM 126 specifications. Ductile-iron castings are primarily categorized as 65-45-12 (tensile-yield-elongation), 60-40-18, and 80-55-06. At the heart of the casting operations is a Spomatic greensand, high pressure molding line fed by two Whiting 5-ton electric arc furnaces and two 30-ton Inductotherm holders. The total number of active part numbers manufactured for Crane Valves and for third-party customers exceeds 1200.

2. IES Utilities

The principle subsidiary of IES Industries, Cedar Rapids, IA, is IES Utilities Inc. Created December 31, 1993, by the merger of Iowa Electric Light and Power Company and Iowa Southern Utilities, IES Utilities today serves 325,000 electric and 170,000 natural gas retail customers in more than 550 Iowa communities. IES Utilities and its predecessor companies have provided energy services to Iowans for more than 100 years. The company has been recognized nationally for its broad range of energy-efficiency and environmental programs. Its parent, IES Industries, also owns a variety of energy-service and transportation companies throughout the U.S.

Committed to the economic growth and vitality of Iowa, IES Industries has an aggressive economic development program supporting the expansion of existing businesses and the relocation of new concerns to Iowa. From within this corporate framework and philosophy came the impetus to help fund and to direct the Total Assessment Audit project at Crane-Washington.

3. Iowa Energy Center

Created by the 1990 Iowa Energy Efficiency Act, the Iowa Energy Center (IEC) strives to increase efficiency in all areas of Iowa energy use. The IEC serves as a model for state efforts to decrease the dependence on imported fuels and the reliance on nonrenewable fuels. The IEC fulfills its mission in part by sponsoring a variety of energy-related research and education programs. Currently, the IEC sponsors over 35 projects that address a full spectrum of energy issues including: energy efficiency in the commercial and industrial sectors; lighting research and education; residential and agricultural energy efficiency; biomass conversion; and renewable energy resources. The IEC was responsible for funding the MCC-managed Demonstration Project. IEC leadership recognized early on that the potential savings were substantial in an energy-intensive industry like metal casting. This certainly proved to be the case at Crane.

4. Metal Casting Center

Since its inception in 1990, the University of Northern Iowa's Metal Casting Center (MCC) has remained focused on the needs of the operating metal casting industry. The MCC plays a leadership role in the continued development of strategic initiatives specific to metal casting. In doing so, it has implemented partnerships with industry, technical societies, universities, community colleges, NIST manufacturing centers, and governmental agencies such as the U.S. Department of Energy.

The basic MCC operating concept is to convert theory to practice, with a focus on the demand side of the research cycle. This market-driven approach mandates that the MCC design its programs according to industry needs, as opposed to academic endeavor. Such was the basis for the MCC's active participation in both the TAA and the Demonstration Project. Accordingly, the mission of the MCC is... to improve the productivity and competitiveness of the operating metal casting industry through applied research, technology transfer, education, and assistance to business.

Methodology

Conceived as a "holistic assessment" of a facility or process, the TAA methodology integrates disciplines associated with achieving three objectives: productivity improvement, waste reduction, and energy efficiency. The underlying premise to this approach is that the three objectives are interrelated, and that simultaneous evaluation will produce synergistic results. Ultimately, it is felt that the TAA approach can motivate an industry to make improvements it might not otherwise pursue were it focused on singular objectives. The selection of the facility represented the start of the first TAA to be conducted not only in Iowa, but the nation. It is only fitting that this follow-up study should focus on the results of these activities. The foundry was selected as an energy intensive industry, with a strong working relationship that had already been developed between IES and local Crane management. This relationship provided a foundation that ensured a cooperative effort and beneficial result.

The TAA offered :

- An unbiased, expert evaluation of productivity, waste reduction, and energy efficiency
- A final report of the findings;
- Confidentiality of all information; and
- No regulatory disclosure.

In return, industry responsibilities included:

- Management support;
- Adequate responses to requests for data;
- An adequate and appropriate support staff;
- TAA cost support;
- A willingness to pursue recommended capital projects; and
- A willingness to participate in follow-up activities through December 1997.

IES's work plan for the TAA included seven major tasks, as shown :

1. Client selection – industrial client
2. Total assessment team – productivity, environmental, energy management
3. Pre-audit data collection – energy usage, productivity, waste information, plant layout
4. On-site team visit – plant tour, break out, closure meeting
5. Data analysis – individual analysis, team analysis, report generation
6. Report presentation – executive summary, presentation to client
7. Post TAA – pursuit of projects, rebates/grants, biannual reporting

Following the Pre-Audit Data Collection (Step 3), the On-Site Team Visit (Step 4), and the Data Analysis (Step 5), the information from each of the team members' reports was distilled into a list of "Opportunity Ideas." The collection of ideas comprised 63 statements (short paragraph format), each of which captured a specific improvement recommendation. These ideas were then categorized as follows:

Category	Count	Category	Count
Energy Efficiency/Management	15	Core Operations	03
Waste Management	11	General	03
Quality Management	06	Marketing Operations	02
Information/Engineering Systems	06	Cleaning and Grinding	01
Patterns	06	Pouring	01
Marketing	04	Production Scheduling	01
Molding Operations	04		

TAA Major Outcomes

The opportunity ideas were further refined into a series of "major focus comments," effectively summarizing the ideas within broad disciplines. The comments are further condensed for presentation within this document.

Major focus comment: quality management. Improving the quality of operations began with the adoption of a total quality management program. The TQM program should include: formalized and documented testing and inspection of materials, processes, and product; a continuous improvement philosophy active and applicable in all foundry operating procedures; an upgrading of housekeeping measures; and an increase in employee empowerment, interaction, and participation. Statistical process control was viewed as a valuable tool that should be taught and practiced as the quality program matures to an appropriate level.

The TQM program was believed to offer an opportunity to significantly reduce its internal scrap rates and associated costs. As with all companies, employees saw adopting a successful program as requiring a comprehensive re-engineering of methods and processes, a solid management commitment, and an acceptance.

Major focus comment: synchronous manufacturing. Integrated with a total quality management program is the concept of synchronous manufacturing. This idea includes real-time inventory control and scheduling of materials, production, patterns, and cores. In the foundry's case, improvements in pattern and core box storage, as well as in core quality, would permit schedules to be made farther in advance, yet also would allow the flexibility necessary for short production runs. The TAA team also viewed the management information system, as then configured and utilized, to be difficult to use with synchronous manufacturing demands on the delivery and scope of information, especially in the area of production control. Whether a new MIS or a modified version of the existing MIS, extensive employee training on its correct utilization was viewed as necessary.

Major focus comment: waste management. The waste management system was firmly in place. Suggestions were primarily focused on their taking a proactive stand in dealing with increasing production volumes. For instance, scrap reductions would extend the life to the landfill where waste sand is currently disposed, but other efforts to reuse foundry sand and to incorporate a sand reclamation unit would also serve to lengthen landfill life. Additionally, methods of reducing the volume of wastewater were suggested, as were several practical ideas (e.g., paper recycling and waste exchange) that were felt to be appropriate for the foundry.

Major focus comment: energy management. The energy management review focused on two general categories of projects: capital projects that produce energy savings; and noncapital projects (such as rate and schedule changes) that result in lower utility costs. Capital project suggestions included lighting retrofits, compressed air system improvements, a paint booth heat recovery system, and foundry ventilation / heat recovery system. Cash incentives in the form of rebates were offered by IES for capital projects that would meet selected utility program requirements. Noncapital projects were suggested to take advantage of time-of-day options and of lowering firm demand on the interruptible rate. Suggestions included lowering the arc furnace firm demand (500 KW to 250 KW), exercising the time-of-day option for the SPO, and forming an effective energy management team.

Major focus comment: future marketing. The marketing plan had two phases, first, to increase foundry productivity and cash flow in the short term, while strengthening long-term viability through well planned initiatives and sound marketing practices. Secondly, developing strategic marketing planning was included: an assessment of current and future target markets; identification of characteristics (sizes, weights, types, etc.) of the most profitable castings for foundry operations; a program of communicating marketing ideas to corporate personnel; and the pursuit of ductile-iron product niches.

Demonstration Project PM^2

Although metal casting is one of manufacturing's most efficient approaches to near-net-shape material forming, the average efficiency of all the equipment used in a typical foundry is less than 45 percent. Appropriately, it was the ultimate goal of the TAA, and the "working" goal of this Demonstration Project, to improve the efficiency of foundry operations. The improved efficiency, in turn, was projected to reduce substantially the energy cost of producing gray-and ductile-iron products.

In pursuit of its goal, the Metal Casting Center focused its quality management efforts on Crane's internal scrap rate. This focus was considered to be in harmony with the TAA's findings, as well as with the fact that, the external scrap rate- the percentage of products rejected or scrapped by its customers- has been extremely low.

Equally the focus, and projected beneficiary, of the MCC's efforts was the metal casting industry itself. With the publication of this document, the MCC delivers to that industry its model for improving foundry efficiencies through process management and quality program initiatives. The MCC model-termed Process Management Method, or PM$^2_{TM}$ is integral to:

* Organizational structure and job responsibilities;
* Quality audit and testing procedures;
* Raw materials specifications; and
* Work instructions and employee training

Eighteen months into the Demonstration Project, the dramatic increase in tons-poured-per-day and the ***dramatic decrease of scrap-cost-per-ton*** *are adequate testimony to the efficacy of the PM^2, the TAA, and management / marketing initiatives.*

To some degree or fashion, all ferrous and nonferrous foundries share four operations that are fundamental to the industry: *1. Melting ; 2. Molding; 3.Core Making; 4. Finishing.* Even in modern, competitive foundries, each of these operations tends to be energy and labor intensive, and each tends to require specialized and expensive processing equipment. To be successful, any system of managing processes must seek out and gain control of the "variables"-i.e., the materials, tooling, equipment, and personnel-that impact these basic foundry operations.

This seeking out and gaining control were precisely the strategy of the PM^2 as it was conceived by the MCC. During the Demonstration Project, the PM^2 evolved successfully as the result of the partnership between the MCC and the foundry. Appropriately, references in this document to the "Project Team" reflect this combination of MCC and foundry personnel. As it evolved, the PM^2 was able to "dovetail" with the results of the TAA, enveloping the TAA's Opportunity Ideas within a formal structure of quality management principals. In summary, the PM^2 comprised six major components.

PM^2 component 1: specification development guidelines. The Project Team established development guidelines that exhorted specification originators to:

* Write the specifications, to whatever extent possible, within the context of a participative management philosophy (analogous to a "flat" organizational structure.)
* Make the specifications comprehensive, covering any topic that directly or indirectly could influence the quality of a process or product.
* Write the specifications in a manner that fits directly into a certification program-in this specific case, and ISO 9000 program, as directed by the foundry corporate management.
* Write the specifications for use by operators and supervisors, in a manner that is user friendly.
* Specify performance responsibility -adopting the premise that specifications assume significance only when there is ownership and accountability.

PM^2 component 2: specification development procedure. The Project Team instituted essential procedures to be followed as specification development takes place. Developers were to:

Write the specification per the development guidelines (PM^2 Component I).

* Involve appropriate wage, supervisory, and management personnel in the review of the specification.
* Revise the specification as necessary.
* Put the specification into operation to prove its validity.
* Make any additional revisions and revalidate the specifications as necessary.
* Train the supervisors to operate in accordance with the validated specification.
* Oversee the supervisors' training of their employees.

PM^2 component 3: specification list. Specifications were developed as applicable to the four basic foundry operations: melting, molding, core making, and finishing. Assembled by the Project Team, the list includes all of the areas that need to be addressed in connection with a foundry's quality program certification process. Included are approximate time frames, expressed in "months after project start," within which both specifications development and personnel training activities can be scheduled to take place in a typical foundry application.

PM^2 component 4: specification development. Specification development provided for the generation of Crane-Washington's Quality Control Plan-the tangible result of PM^2 development and implementation. Generated by the Project Team, the Plan contains all of the flow charts, key control points, specifications, work instructions, laboratory procedures, and audit procedures developed for the foundry at the time of this document's publication.

PM^2 component 5: audit procedure. The Project Team also generated an audit procedure that provides guidance for quality assurance personnel to:

* Select and train an audit team consisting of both wage and salaried employees.
* Perform audits.
* Review audit results and retain personnel as necessary.

PM² component 6: quality certification procedure. The Project Team established a plan for achieving certification status within a quality-standards program. The plan guides management in:

* Generating responsibilities, assignments, and timetables for the development of certification procedures.
* Developing certification procedure in a manner and format in harmony with ISO 9000 and ANSI standards.
* Performing a mock certification procedure audit.
* Applying for certification.

Results

As shown in the accompanying graphs, outstanding results have been achieved since the start of TAA and Demonstration Project activity. A new spirit of optimism is alive in the plant and office, and the prospect for long-term profitability is being actualized. The statistics on these graphs represent the benefits realized by management initiatives, the TAA, and the Demonstration Project. As the PM² process and quality initiatives continued in subsequent years operational performance improvements and statistical gains are evidenced.

The figures used for the purpose of graphing the data are a statistical manipulation, which provides numeric values as a function of the standard deviation, the mean, and the actual values. This manipulation of data was required to provide anonymity for the foundry, but the values provide a standard score, which allows for comparison between groups

Figure 1.Gross Tons Poured Expressed as Standard Units

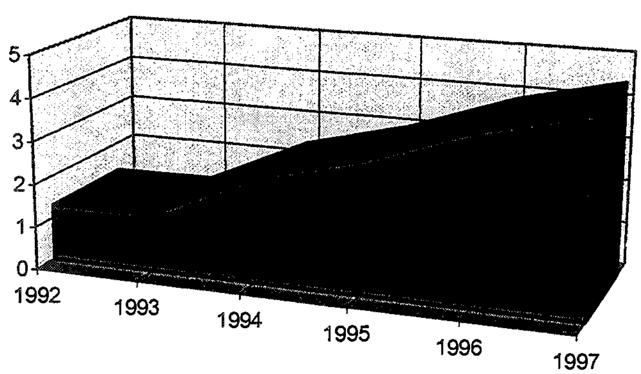


Figure 2. Scrap Cost per Ton Expressed as Standard Units

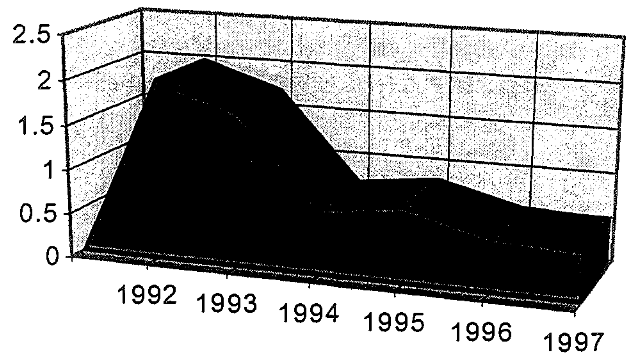
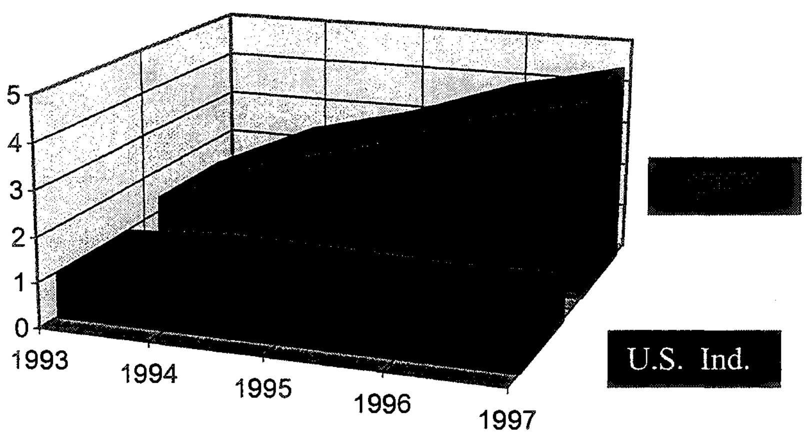


Figure 3. Crane-Washington Performance Vs. U.S. Gray and Ductile Iron Industry Performance



Conclusion

When the foundry facility began operations in 1968, product demand was high and the U.S. foundry industry was healthy. Over the next two decades, however, the strength of foreign metal casters grew dramatically, and the increased competition forced the closure of many U.S. foundries. By 1990, the survival of foundry was clearly in jeopardy. Management recognized that reversing the trend had become a matter of greatly improving manufacturing efficiency and drastically reducing costs.

But how to do so? To its credit, the foundry did the right thing: it embraced the TAA and PM^2 projects described in this report, cooperating fully as partners in their conduct. Today, it can safely be said that the foundry willingness to self-invest-to pursue the principals of total quality management and continuous improvement-was directly responsible not only for the success of this Demonstration Project, but for the current operating profits (and open doors), of a healthy Iowa business.

Implementation of the PM^2 coincided with a variety of successful foundry management initiatives, many of which were planned or started during the periods immediately preceding and concurrent with the TAA. As such, and as stated previously, the significant performance improvements realized since the start of the Demonstration Project are the result of a combination of factors. A significant factor in the improvements was an effective marketing initiative that secured a targeted third-party account providing high-volume components that fit well with foundry operations. This, in addition to a management initiative to out source selected low-volume components, provided a strong base upon which to improve the rest of the operations.

A participative management approach was followed during PM^2 development. Wage and supervisory personnel remained heavily involved throughout all phases of the TAA and Demonstration Project. They participated in the development, approval, implementation, and auditing of all operating procedures and specifications integral to the PM^2. Foundry supervising personnel, were responsible for training their own wage personnel to follow the PM^2 procedures and specifications, themselves received technical and managerial training from:

* The UNI Metal Casting Center staff and consultants;
* Foundry equipment and materials suppliers; and
* Foundry corporate personnel staff.

As the Operations Close-Ups accompanying this paper show, a great deal of progress was made in relation to foundry equipment and tooling. Melting, molding, core making and finishing equipment was repaired, modified, or tuned as necessary foundry personnel (the Maintenance Department, for example, made significant modifications to the Spomatic molding line) and by technicians representing equipment manufacturers. State-of-the-art replacement equipment was purchased, including such items as charge crane scales, dust collectors, core sand mixers, and a sand moisture and moldability controller. In addition, the Project Team wrote effective equipment operating and controls specifications that served to reduce the frequency and scope of repairs.

Foundry management is to be credited for making sure that levels of authority and areas of responsibility were clearly defined within the framework of a flat organized structure. The bulk of the responsibility and authority to conduct day-to-day PM^2 functions resided with wage and supervisory personnel.

Also key to performance improvements and a successful Demonstration Project was the addition of skilled personnel to the staff. Beginning prior to the TAA, these personnel additions include: supervisory and management personnel, such as process and tooling engineers, a core supervisor, a molding supervisor, and a foundry manager; and wage personnel, such as chip-and-grind workers.

While the foundry had its unique operational challenges, it was not all that different from other Iowa foundries in its need for possessing a competitive posture in a global marketplace. Fortunately, the approach taken is sound, and it is repeatable:

1. Convene the caliber of industry specialists;
2. Allow the specialists to evaluate, thoroughly and professionally, a foundry's operations; a
3. Assemble the appropriate technical talent to support local management in conducting improvement initiatives that get results.