Dofasco made equipment reliability a strategic issue in the 1980s and has turned their business around to become one of the most profitable North American steel producers. This article highlights a case study of this strategic initiative and how Dofasco aligned equipment reliability with its business objectives.

Utilizing advanced maintenance practices and information technology to achieve maximum equipment reliability

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KNOWING the right maintenance program for company assets is no easy task. One might believe that the longer a company has been around, the more effective its maintenance program. Unfortunately, this is not always true. In fact, the effectiveness of a maintenance program has absolutely nothing to do with the number of years a company has been doing maintenance. For the most part, companies are doing too much maintenance too early, or too little too late, both of which have cost consequences for the organization.

As most organizations are continuously active in attempting to improve their bottom line results through improved maintenance practices, why do only a few ever achieve their objectives? It definitely is not from a lack of trying. On the contrary, trying to improve without the right business process focus, alignment of practices and enabling tools can make matters worse. Interestingly, the required information and know-how generally exist in companies, but are scattered throughout the organizations, leading to inconsistency.

The unfortunate part of taking a silver bullet approach to improvement is that it tends to become very short lived, eventually becoming the flavor of the month. Experience has shown that a strategic and comprehensive approach to physical asset management is the best way to improve equipment reliability.

Dofasco formulated advanced maintenance practices and combined information technology to develop a unique equipment reliability program that has made a significant impact on the company's bottom line.

Background

Dofasco is Canada's second largest steel manufacturer, producing 4.5 million tons of flat rolled steel per year. With revenues of over C$3 billion, Dofasco employs 7000 people at the Hamilton plant (Fig. 1) that has an equipment replacement value of C$5 billion.

Motivation to improve

Early in the 1980s, the steel business prospered. However, in the late 1980s and the early 1990s, things began to change. Globalization was beginning to influence the market; imports started arriving at lower prices with higher quality; residuals from the inflationary period of the 1970s saw costs rising while prices dropped; there was a shift from a seller's to a buyer's market; and shareholder returns were beginning to erode.

Fig. 1 — An aerial view of Dofasco's main plant in Hamilton, Ont.

Dofasco took a step back, evaluated maintenance performance and found that 70% of maintenance work was reactive and only 30% was proactive. The rate of product quality improvement was flat; and average equipment availability was only 78%. At that point, Dofasco realized that equipment reliability was key to improving product quality, production output, lowering costs and improving shareholder return. A strategic project was initiated to research, develop and implement the most advanced maintenance practices and information technologies to achieve maximum equipment reliability.

The project

At the start of the project, four main issues were defined:

- An equipment repair versus an asset management culture existed. The need existed to adopt an equipment reliability business process.
- There were many improvement efforts ongoing in the plant, but they were inconsistent. Dofasco decided to develop a critical few, fundamental business practices.
- Ongoing improvement efforts were typically short lived. Dofasco needed to develop a sound implementation methodology.
- Dofasco had islands of data that were not readily available to maintenance as actionable information. A clear need to integrate data systems with expertise to convert these data into actionable information was identified.

Dofasco quickly discovered that developing an innovative software system to support the first three requirements was fundamental to the strategic initiative.

The practices

Dofasco found a fairly typical situation. Islands of data were scattered throughout the organization in the form of OEM manuals, computer databases, experience and knowledge of their maintenance crafts, and many reports. However, none of the information was easily accessible to people who planned maintenance work and therefore resulted in inconsistent actions. Maintenance planners had no way to know what work they should be planning at what time.

By developing an equipment reliability business process, Dofasco would be able to identify the knowledge/information that needed to be managed. Establishing business practices would ensure consistent behavior to support the business process. A sound implementation methodology would allow for extraction of the required knowledge and make it easily accessible to everyone, resulting in consistent action, or the ability to do the right work at the right time. Finally, Dofasco needed to develop an information infrastructure to turn this data into actionable information.

Dofasco formulated an equipment reliability business process that revolved around the following quality issues:

- Quality planning.
- Quality improvement.
- Quality control.
- Quality assessment.

The next step was to develop practices to support this process. Practices involved in the quality planning process were designed to ensure that employees understood their business unit goals and how their assets would contribute to these goals. With this understanding, employees could target their equipment reliability efforts on assets that contributed to business unit goals.

Dofasco analyzed the practices that would be part of the quality improvement process. Practices put in place were designed to ensure that proper maintenance programs were identified for its assets. Work identification is key to equipment reliability—if the proper work is not identified, then the practices are irrelevant.

Quality control includes practices for the actual work to be done. These practices address the efficiency of the maintenance department. Again, it must be stressed that without proper work identification, the quality control process does not matter—all that is being accomplished is the wrong work being done more efficiently.

The last step, quality assessment, is extremely important. This is where work done is assessed to determine if the proper maintenance programs were identified in the first place. This process provides the opportunity to continuously improve work identification practices.

At this point, Dofasco identified a process and practices to support that process, but the next step was the most difficult—implementation of the process and practices. Dofasco developed an implementation methodology involving 10 steps. Dofasco has since partnered with Ivara Corp. to make this methodology commercially available as a product called Ivara.ERS (equipment reliability strategy). An implementation step was also developed by Dofasco to address each of the defined business processes, including reliability-centered maintenance (RCM) analysis, predictive maintenance (PdM) needs assessment, criticality analysis and hierarchy development.

The technology

Once the practices were in place, Dofasco recognized the need for a computerized system to assist them in ensuring that these new practices would be easy to follow. One of the first things Dofasco did was define content versus computer. Dofasco recognized that their business process, practices and implementation methodology all ensured the content of what maintenance did was effective at achieving equipment reliability. The role of the computer system was to enable the business process and practices to be conducted in the most efficient manner. In other words, Dofasco was not trying to design a computer system with the idea that it was going to solve their problems. Instead, Dofasco recognized that the best use of the computer was to efficiently manage processes and practices.

Dofasco already had a computerized maintenance management system (CMMS) in place, but determined that it could not satisfy all of their needs. A CMMS is work order based and functions to improve the efficiency of how maintenance executes its work. Therefore, the CMMS addressed the quality control aspects of Dofasco's processes (work planning, work scheduling and work execution). However, Dofasco also needed something to identify what work needed to be executed and the right time to do it.

Dofasco quickly realized that the data necessary to improve equipment reliability were already available, but were not being put into a central repository where they could be analyzed and turned into actionable information. There were OEM specifications and manuals, operator checksheets hung on the wall, expertise in the minds of employees and many databases containing useful data that Dofasco could use.

Dofasco did an exhaustive search to find a commercially available package that could satisfy its needs, but found nothing available. Dofasco then decided to develop the technology themselves. It was not a goal to develop technology for technology's sake; rather, Dofasco had very specific business objectives that needed to be satisfied and wanted to use technology to help achieve those objectives.

The result was a software package Dofasco called the intelligent condition monitoring system (ICMS), which has been commercialized and marketed by Ivara Corp. (Fig. 2) under the name Ivara.EXP (expert maintenance program). This software supported the quality planning and quality improvement processes that Dofasco had in place. In other words, it helped Dofasco to manage the effectiveness of maintenance operations and complimented its CMMS, which manages efficiency of work performance.

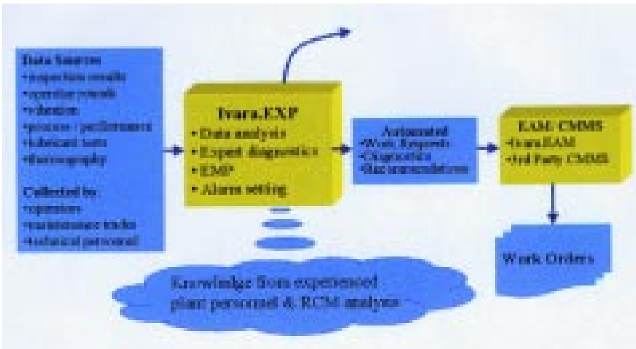

Fig. 2 — Dofasco's ICMS system (commercially known as Ivara.EXP) collects data from a variety of sources and integrates to the CMMS to ensure that the right work is executed at the right time.

The ICMS software collects islands of data and analyzes them using expert systems technology. It can predict potential problems and trigger an alarm. After identifying an alarm condition, ICMS recommends the corrective action needed to avoid a functional failure on the equipment.

As shown in Fig. 2, a variety of information is collected by the ICMS system, such as visual inspection results, operator rounds, vibration characteristics, process parameters, lubricant test results, electrical diagnostics, thermographic images and trends, etc. Data are collected in a variety of ways. Where possible, data are captured electronically by integrating predictive maintenance devices and data historians. Where data cannot be obtained on-line, handheld data loggers (Fig. 3) allow personnel to conduct inspections accurately and efficiently and download/upload information.

Fig. 3 — View of an operator using a handheld data logger to capture data about an asset for analysis in the ICMS system.

The ICMS system then analyzes the data based on rules that have been defined and can trigger alarms as necessary. The alarms alert maintenance planners to potential problems. The system can also identify the nature of the problem based on data (both stored and received) and recommend corrective action. Planners have the ability to drill down into information provided and review trending graphs for the asset. Planners then send out a work request to trigger a work order in the CMMS system. Work is then planned and scheduled for maintenance crafts to execute.

Key concepts that the ICMS system addresses are:

- Consolidating a variety of maintenance and operating plant data and distilling it into actionable information.
- Capturing plant expertise in a comprehensive equipment maintenance program (EMP) that includes preventive, predictive and corrective activities.
- Providing visibility of equipment condition and problems, and traceability back to the plant data that triggered the alarm.
- Integrating with the CMMS, thereby avoiding duplicate efforts in two systems.

The EMP is the interface where all activities that need to be performed on an asset are first identified. As mentioned above, this includes preventive, predictive and corrective activities. Inspection templates, PM routines and standard jobs are created in the system to make setup easier. The computer captures all relevant information about the EMP for an asset (Fig. 4), including what activities to perform, how often and when they were last performed.

The EMP also allows Dofasco to set up equipment condition indicators. These indicators can come from metered or predictive technology readings such as temperature, mileage, pressure and vibration as well as from visual inspections that allow for the capture of information such as clogged, cracked, normal, etc. Once

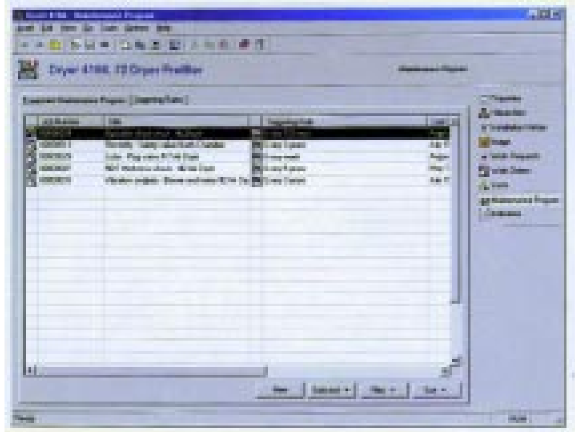

Fig. 4 — The EMP stores all information about the activities that need to be performed on an asset, how often, what maintenance crafts are needed and when it was last performed.

the condition indicators have been specified to track on an asset, rules must be to set up to trigger alarms and recommend actions to take when alarms are triggered. Rules can include calculations, such as engineering computations as well as failure modes, which combine multiple indicators. An example (Fig. 5) is given for how condition indicators can be combined into a failure mode, in this case an excessively dirty after-filter.

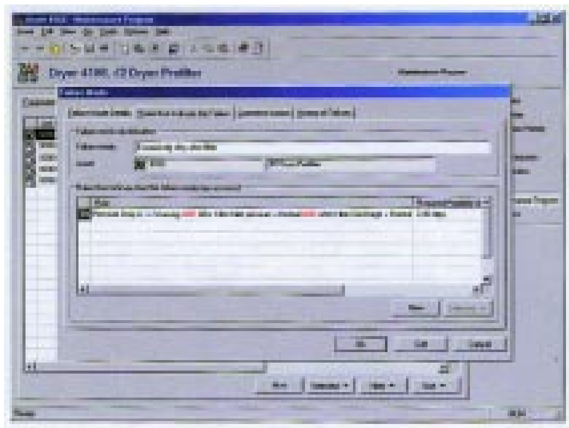

Fig. 5 — By combining condition indicators failure modes are predicted and appropriate corrective actions are recommended.

Dofasco uses reliability-centered maintenance (RCM), thus a system was devised to have full support for the RCM methodology, linked directly to the EMP. This structure allows Dofasco to see if the task being performed is based on RCM analysis.

This system has enabled Dofasco to leverage plant data, collected in a variety of ways, into actionable maintenance information. Data from operator checksheets, which prior to this system were kept on clipboards near the equipment and rarely used, are entered in the computer. Similarly, inspection data from maintenance crafts and technical staff are collected. Inspection checksheets are downloaded to dataloggers (Fig. 3) with a configurable list of inspection outcome choices. This ensures that uniform data are collected so that the data can be used for equipment condition analysis. Personnel performing the inspection also receive immediate feedback on any alarms triggered while entering data. This enables them to ensure valid data are entered and also provides an opportunity for immediate corrective action if possible. Condition indicator values from predictive technologies such as thermographic peak and vibration resonance are also able to be extracted. Other condition indicator values are collected from plant floor data collectors such as data historian, PLC and DCS equipment. By utilizing all of these methods, Dofasco collects real-time data with integrity to track equipment performance.

Once data are collected and entered, they can be turned into actionable information used to make informed maintenance decisions. This is achieved by processing data with rules defined in the EMP. These rules trigger alarms (Fig. 6) and recommend corrective actions when equipment is performing outside of desired operating parameters. This ensures that all abnormal equipment status is readily visible to maintenance personnel. Trends can be examined and analyzed (Fig. 7) to facilitate informed decisions. If necessary, corrective actions can then be taken to return equipment to the desired operating state.

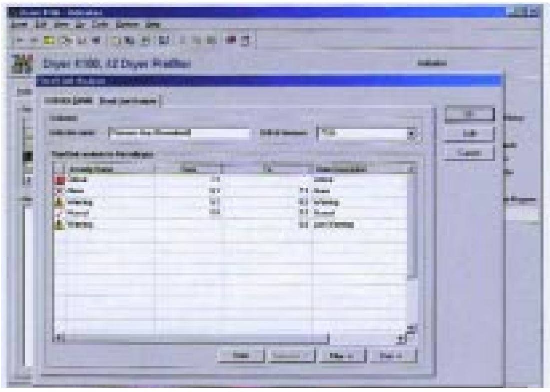

Fig. 6 — Various alarm levels available in ICMS.

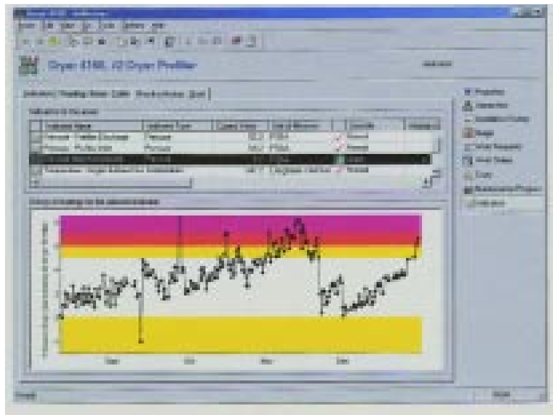

Fig. 7 — Trend for the pressure drop across the prefilter for the No. 2 dryer at Dofasco.

Summary

As a result of implementing these innovative practices and technologies, Dofasco completely changed how maintenance departments operate, resulting in millions of dollars in savings. Proactive maintenance work has increased from 30 to over 75%; equipment availability increased more than 10%; and product quality yield rose from 76 to 91%. In addition, Dofasco reduced the maintenance workforce, through voluntary attrition, from 3678 down to 1734. Spare parts inventory was reduced from $110 million to $70 million, with a goal to get to $50 million by the end of 2001. ▲