Six Sigma Boosts the Bottom Line

Dow Chemical Co.'s (Midland, MI) six sigma quality-improvement program is expected to increase the firm's cumulative earnings before interest and taxes by over $1 billion by 2003, chairman of the board William Stavropoulos told analysts last November. Du Pont's (Wilmington, DE) six sigma champion Don Linsenmann claims a similar scale of annual benefit, even though Du Pont's chairman Chad Holliday says "savings are just beginning" from the company's first two years of six sigma. Add to these two majors the likes of Honeywell, GE Plastics, W. R. Grace, GlaxoSmithKline, Air Products, and Praxair — all proclaimed devotees of six sigma — and the steady growth of this statistical-based technique in the chemical process industries (CPI) becomes clear.

The surprise, though, is that the methodology has been so long coming to the CPI. Not many of the above-mentioned companies have had six sigma programs in place for longer than a few years (Dow announced its corporate-wide commitment in September 1999, for example), yet it was in 1988 that Motorola (Tempe, AZ) received the Malcolm Baldrige National Quality Award for its work with the then relatively new quality control program. And, ironically, it was General Electric chairman and CEO Jack Welch, himself a chemical engineer by training, who was one of six sigma's leading proponents throughout the 1990s. At the time of last November's agreement for GE to acquire Honeywell for $45 billion, Welch said Honeywell (or rather its own then-recent acquisition AlliedSignal) was "the company who taught us how to do six sigma … we speak the same language."

Fundamental statistics

But just how do you teach six sigma? Unlike many modern management methods, you have to start with some pretty basic and rigorous statistical analysis. According to Pradeep Deshpande, founder and CEO of Simulation and Advanced Controls (SAC, Louisville, KY), and professor and former chair of the department of chemical engineering at the Univ. of Louisville, "it takes a while to figure out what is different about six sigma relative to the many quality approaches of the past. Some may view it as yet one more quality initiative, a fad of the day, and so one that will disappear shortly. It needs to be understood that six sigma is based on sound fundamental principles and the laws of nature. It is here to stay."

Those fundamentals have been explained previously in some detail in *CEP* (Sept. 1999, pp. 65–70) by Deshpande, his SAC colleague Sohan Makker, and Mark Goldstein, president of Go Global LLC (Louisville, KY). As they said then, "six sigma is neither new, nor is it rocket science." It is, they maintain, "an elegant collection of tools for problem-solving that, when properly exploited, will lead to handsome returns and globally competitive positions."

Six sigma's statistical basis sets the goal of achieving a defect rate of 3.4 parts per million or less in whatever activity to which it is applied. Now, engineers well-versed in the math of statistical analysis will be quick to spot that if you look up a 6σ variation on a normal distribution curve, what you actually get is 2 ppb for a double-sided test. That, however, assumes normality. What Motorola decided — and what has been subsequently accepted by all six sigma followers — was that in reality the product or process mean might vary from the nominal target by up to 1.5σ. Taking this into account on the distribution curves translates into the 99.99966%, or 3.4 ppm, defect rate now cited as six sigma.

The belts

That is the concept behind the six sigma philosophy. But putting the theory into practice goes far beyond dry statistics. At Dow, for instance, last year was the first full year of implementation, but the company already has in place "1,000 trained 'black belts,' more than 90 'master black belts,' and over 1,500 'process owners, local champions, and business champions' across all businesses and all geographies," says Jeffery Schatzer, Dow's communications leader for six sigma.

Six sigma work processes have led to significant cost savings in manufacturing and better performing membrane modules at Dow's FilmTec membrane module manufacturing plant in Minneapolis, MN. Photo courtesy of Dow Chemical Co.

Similarly, Du Pont now boasts 1,139 black belts who have completed or are working on 3,500 projects aimed at reducing costs and increasing production capacity. According to the company, about 15,000 employees are, or have been, in six sigma training or serve on black belt teams.

The terminology might be arcane, but these "master black belts," "black belts," and "green belts" are at the core of all six sigma programs. According to Tony Bendall, professor of quality and reliability management at the Univ. of Leicester in the U.K., they are the people trained, to differing levels, in the appropriate methods, tools, and techniques to enable them to manage the program and guide improvement projects.

"Typically," he says, "a black belt will have undertaken a training program lasting a minimum of 20–25 days, and carried out an improvement project over a 3- to 6-month training period. A green belt will have undertaken around 10 to 15 days of training. When fully trained, a black belt will work full-time on improvement projects, while green belts spend at least 20% of their time on projects. Master black belts are site experts and trainers of black and green belts."

That somewhat begs the question: who trains the trainers? How important is it for companies to bring in outside help at the early stages of implementation? Speaking as one whose company can offer such help, Pradeep Deshpande has no doubts. "I don't know that there is a choice here," he says, "especially in the process applications of six sigma where the expertise is limited to just a few."

But while acknowledging the need for outside help in the early stages, Deshpande highlights one of the defining features of successful six sigma programs, such as that at GE under the leadership of Jack Welch. "If there isn't total commitment from top management, six sigma should not be adopted," he says. "Third-party professionals can help, but the people inside understand their processes and transactions best, so they must be intimately involved throughout all phases of six sigma implementation to ensure success."

In order to accelerate its implementation of six sigma, Dow did use outside consultants to help in the design and delivery of six sigma training. "This outside assistance allowed us to have the 1,000 black belts trained by year-end 2000," says Schatzer. "However, our internal resources are taking over a larger proportion of the training task … giving the consultants more opportunity to consult rather than 'do.' In that way, everybody wins."

Six sigma in practice

One recent example of where six sigma has won benefits for Dow is at its FilmTec membrane manufacturing operation in Minneapolis, MN. Used in water purification applications, FilmTec membranes are tested prior to shipping to ensure that they meet the flow requirements prescribed by the customer. If they do not meet the spec, they are not shipped. This policy protected the customer, but rejects were costing FilmTec around $500,000 a year. A six sigma program was therefore implemented to improve product quality, measured in terms of flux, or the flow through the membrane per unit area per unit time.

The resulting improvements are "significant," according to Dow. For one of FilmTec's standard brackish-water membranes with a target flux of 45 gal/ft^2/d, the standard deviation of the manufacturing process had been running as high as 4.46 gal/ft^2/d — the equivalent of 14.5% of the product being out of spec. The six sigma program reduced this standard deviation by 1.83 gal/ft^2/day, so only 2.2% of product is now out of spec.

This might be some way short of the 3.4 ppm six sigma "holy grail," but Dow says the savings to its customers will be considerable, by way of better performing membranes being made available faster than before.

What this example further demonstrates is the way in which the six sigma implementation brought about what Dow calls "a strategic shift in thinking and participation by all FilmTec employees." Using systematic breakthrough methods, manufacturing managers had to measure, analyze, improve, and control the membrane manufacturing processes to effect the required changes. These are the basic steps in any six sigma program.

Specifically, FilmTec's six sigma team identified a problem with the delivery of a particular chemical component to the process. Feed was continually interrupted, while empty batch containers were being replaced with full ones. The problem was simply solved by fitting level alarms on the containers and installing an inexpensive hold-up reservoir to maintain feed while containers are swapped.

That, however, was not the end of FilmTec's six sigma program. It could be argued that six sigma is for life, a constant striving for incremental improvements in quality and performance. To sustain its gains from the project, for example, FilmTec's team came up with additional changes to the way in which the processes are monitored. Before six sigma, data used to track trends in membrane flux were displayed in tabular form. The tables were hard to read and had little impact on process monitoring. Now, the measurements are displayed on Excel spreadsheet charts that better illustrate trends in the finished product.

According to Dow's Schatzer, "software is a very interesting arena." He agrees with the suggestion that there is a growing industry support around six sigma — consultancies, training organizations, software suppliers, etc. "Dow initially used an outside source to provide software for tracking six sigma results," he says. "However, we found that the outside software did not meet our data management and reporting needs. Subsequently, Dow has adopted and adapted a software package that allows us to track project value performance, as well as project metrics. Reliable storage and retrieval of accurate project data are critical to measuring progress and timely reporting."

It's probably no coincidence that the uptake of six sigma in the CPI has been strongest among a relatively small number of very large, multinational operators. As Schatzer says, "One of the strengths that Dow has in terms of its implementation of six sigma is the fact that the company has one global IT platform. This gives us the opportunity to leverage project ideas and information globally at Internet speeds."

According to Steve Phelan, senior vice president and co-founder of Formation Systems (Southborough, MA), for major players like Dow, GE, and Du Pont, the benefits of six sigma "dramatically outweigh the costs." The potential for mid-size companies, "particularly those with a healthy growth trajectory," is also strong, but Phelan cautions modest-growth, mid-tier, and smaller companies to carry out a careful cost analysis before embarking on a six sigma initiative.

"A primary cost of six sigma," he says, "is the personnel charge involved in identifying and training black belts. Initially, because six sigma was so new, the supply of trainers was very limited, making training extremely expensive." Today, though, he says there are numerous organizations offering advice, usually owned and staffed by black-belt-level veterans of the early six sigma efforts.

Despite Phelan's note of caution, SAC's Deshpande believes that six sigma can benefit all businesses. "I am 100% confident that every organization, no matter what size, will benefit significantly from six sigma," he says. "The list includes process industries, discrete-parts manufacturers, service companies, financial organizations, government departments, universities, and so on — all would have to follow six sigma practices to achieve globally competitive positions. Since six sigma was pioneered in Motorola, a manufacturer of discrete parts, some wonder if the concepts apply to the process industries. It needs to be clarified that six sigma applies to *all* processes — discrete or continuous, manufacturing or transactional, static or dynamic."

In the description of the AIChE short course he is offering later this year, Deshpande expands on his views: "Let us remember that manufacturing companies, including those in the process sector, have benefited from automation, but transactional processes have not. Since defect rates in transactional operations can be as high as 50%, the impact of six sigma here can be tremendous. Some process companies, mainly the refinery and petrochemicals sector, have gone beyond automation and realized the benefits of optimization, a subset of six sigma. But most others have not and so even in the manufacturing side of the process industries, the potential of six sigma remains very large."

[AIChE's course No. 611, Six Sigma for Global Competitiveness, will be offered April 23–24 in Houston, August 15–16 in New York, and November 8–9 in Las Vegas. For more information, call 1-800-AIChemE (1-800-242-4363). — Editor]

— Tom Noble