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How big data can improve manufacturing

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Manufacturers taking advantage of advanced analytics can reduce process flaws, saving time and money.

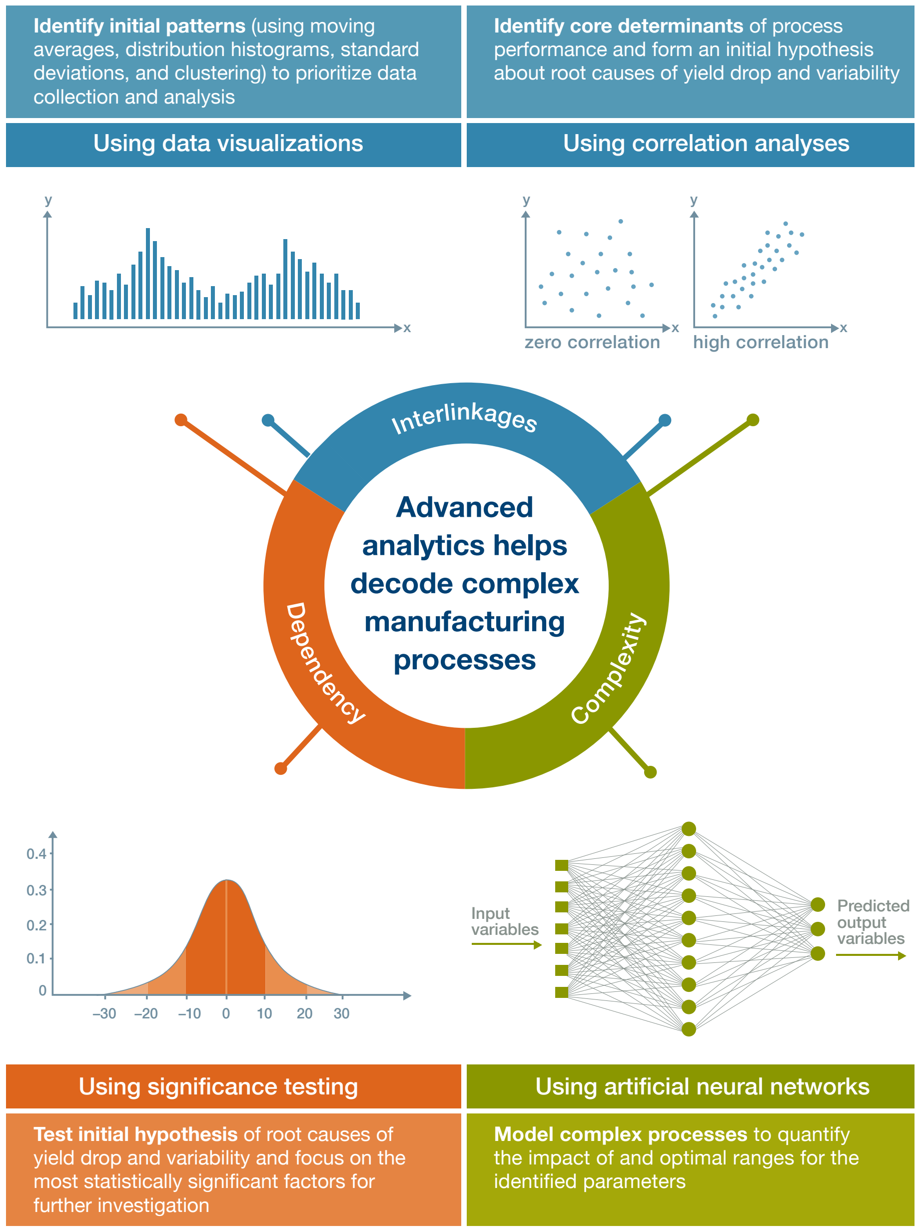
In the past 20 years or so, manufacturers have been able to reduce waste and variability in their production processes and dramatically improve product quality and yield (the amount of output per unit of input) by implementing lean and Six Sigma programs. However, in certain processing environments—pharmaceuticals, chemicals, and mining, for instance—extreme swings in variability are a fact of life, sometimes even after lean techniques have been applied. Given the sheer number and complexity of production activities that influence yield in these and other industries, manufacturers need a more granular approach to diagnosing and correcting process flaws. Advanced analytics provides just such an approach.

Advanced analytics refers to the application of statistics and other mathematical tools to business data in order to assess and improve practices (exhibit). In manufacturing, operations managers can use advanced analytics to take a deep dive into historical process data, identify patterns and relationships among discrete process steps and inputs, and then optimize the factors that prove to have the greatest effect on yield. Many global manufacturers in a range of industries and geographies now have an abundance of real-time shop-floor data and the capability to conduct such sophisticated statistical assessments. They are taking previously isolated data sets, aggregating them, and analyzing them to reveal important insights.

Consider the production of biopharmaceuticals, a category of healthcare products that includes vaccines, hormones, and blood components. They are manufactured using live, genetically engineered cells, and production teams must often monitor more than 200 variables within the production flow to ensure the purity of the ingredients as well as the substances being made. Two batches of a particular substance, produced using an identical process, can still exhibit a variation in yield of between 50 and 100 percent. This huge unexplained variability can create issues with capacity and product quality and can draw increased regulatory scrutiny.

One top-five biopharmaceuticals maker used advanced analytics to significantly increase its yield in vaccine production while incurring no additional capital expenditures. The company segmented its entire process into clusters of closely related production activities; for each cluster, it took far-flung data about process steps and the materials used and gathered them in a central database.

Exhibit



A project team then applied various forms of statistical analysis to the data to determine interdependencies among the different process parameters (upstream and downstream) and their impact on yield. Nine parameters proved to be most influential, especially time to inoculate cells and conductivity measures associated with one of the chromatography steps. The manufacturer made targeted process changes to account for these nine parameters and was able to increase its vaccine yield by more than 50 percent—worth between $5 million and $10 million in yearly savings for a single substance, one of hundreds it produces.

Developing unexpected insights

Even within manufacturing operations that are considered best in class, the use of advanced analytics may reveal further opportunities to increase yield. This was the case at one established European maker of functional and specialty chemicals for a number of industries, including paper, detergents, and metalworking. It boasted a strong history of process improvements since the 1960s, and its average yield was consistently higher than industry benchmarks. In fact, staffers were skeptical that there was much room for improvement. “This is the plant that everybody uses as a reference,” one engineer pointed out.

However, several unexpected insights emerged when the company used neural-network techniques (a form of advanced analytics based on the way the human brain processes information) to measure and compare the relative impact of different production inputs on yield. Among the factors it examined were coolant pressures, temperatures, quantity, and carbon dioxide flow. The analysis revealed a number of previously unseen sensitivities—for instance, levels of variability in carbon dioxide flow prompted significant reductions in yield. By resetting its parameters accordingly, the chemical company was able to reduce its waste of raw materials by 20 percent and its energy costs by around 15 percent, thereby improving overall yield. It is now implementing advanced process controls to complement its basic systems and steer production automatically.

Meanwhile, a precious-metals mine was able to increase its yield and profitability by rigorously assessing production data that were less than complete. The mine was going through a period in which the grade of its ore was declining; one of the only ways it could maintain production levels was to try to speed up or otherwise optimize its extraction and refining processes. The recovery of precious metals from ore is incredibly complex, typically involving between 10 and 15 variables and more than 15 pieces of machinery; extraction treatments may include cyanidation, oxidation, grinding, and leaching.

The production and process data that the operations team at the mine were working with were extremely fragmented, so the first step for the analytics team was to clean it up, using mathematical approaches to reconcile inconsistencies and account for information gaps. The team then examined the data on a number of process parameters—reagents, flow rates, density, and so on—before recognizing that variability in levels of dissolved oxygen (a key parameter in the leaching process) seemed to have the biggest impact on yield. Specifically, the team spotted fluctuations in oxygen concentration, which indicated that there were challenges in process control. The analysis also showed that the best demonstrated performance at the mine occurred on days in which oxygen levels were highest.

As a result of these findings, the mine made minor changes to its leach-recovery processes and increased its average yield by 3.7 percent within three months—a significant gain in a period during which ore grade had declined by some 20 percent. The increase in yield translated into a sustainable $10 million to $20 million annual profit impact for the mine, without it having to make additional capital investments or implement major change initiatives.

Capitalizing on big data

The critical first step for manufacturers that want to use advanced analytics to improve yield is to consider how much data the company has at its disposal. Most companies collect vast troves of process data but typically use them only for tracking purposes, not as a basis for improving operations. For these players, the challenge is to invest in the systems and skill sets that will allow them to optimize their use of existing process information—for instance, centralizing or indexing data from multiple sources so they can be analyzed more easily and hiring data analysts who are trained in spotting patterns and drawing actionable insights from information.

Some companies, particularly those with months- and sometimes years-long production cycles, have too little data to be statistically meaningful when put under an analyst's lens. The challenge for senior leaders at these companies will be taking a long-term focus and investing in systems and practices to collect more data. They can invest incrementally—for instance, gathering information about one particularly important or particularly complex process step within the larger chain of activities, and then applying sophisticated analysis to that part of the process.

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The big data era has only just emerged, but the practice of advanced analytics is grounded in years of mathematical research and scientific application. It can be a critical tool for realizing improvements in yield, particularly in any manufacturing environment in which process complexity, process variability, and capacity restraints are present. Indeed, companies that successfully build up their capabilities in conducting quantitative assessments can set themselves far apart from competitors. □

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