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PERFORMANCE EXCELLENCE
IN THE WOOD PRODUCTS INDUSTRY
STATISTICAL PROCESS CONTROL

Part 5: Cause-and-Effect Diagrams

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Our focus for the first four publications in this series has been on introducing you to Statistical Process Control (SPC)—what it is, how and why it works, and then discussing some hands-on tools for determining where to focus initial efforts to use SPC in your company. Experience has shown that SPC is most effective when focused on a few key areas as opposed to the shotgun approach of measuring anything and everything. With that in mind, we presented check sheets and Pareto charts (Part 3) in the context of project selection. These tools help reveal the most frequent and costly quality problems. Flowcharts (Part 4) help to build consensus on the actual steps involved in a process, which in turn helps define precisely where quality problems might be occurring and what quality characteristics to monitor to help solve the problems.

In Part 5, we now turn our attention to cause-and-effect diagrams (CE diagrams). CE diagrams are designed to help quality improvement teams identify the root causes of problems. In Part 6, we will continue this concept of root cause analysis with a brief introduction to a more advanced set of statistical tools: Design of Experiments.

It is important, however, that we do not lose sight of our primary goal: improving quality and in so doing, improving customer satisfaction and the profitability of the company.

We've identified the problem; now how can we solve it?

In previous publications in this series, we have identified the overarching quality problem we need to focus on and developed a flowchart identifying the specific steps in the process where problems may occur. We now need to narrow our focus so that we know what is *causing* the problem—and therefore how it can be solved.

Continuing our example from Parts 3 and 4, we determined that "size out of specification" for wooden handles was the most frequent and costly quality problem. The flowchart showed that part size/shape was inspected with a "go/no-go" gauge at the infeed to a machine that tapers the handles. The results of go/no-go inspection are either that the shape is acceptable ("go"), in which case the parts were loaded into the tapering machine, or that the shape is not acceptable ("no go"), in which case the parts are scrapped. However, customers are still indicating that the sizes of the handles are not meeting their specifications.

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In short, our prior efforts have helped us identify *what* the problem is and *where* it might be occurring in the process. We still do not know, however, what to do to *solve* the problem because we do not know what might be causing the problem. Once we identify and confirm a solution, we can take steps to closely monitor the situation such that the solution is maintained over time.

Cause-and-Effect Diagrams

A cause-and-effect (CE) diagram is a graphical tool for organizing and displaying interrelationships of various theories of the root cause of a problem. CE diagrams are also commonly referred to as fishbone diagrams (due to their resemblance to a fish skeleton) or as Ishikawa diagrams in honor of their inventor, Kaoru Ishikawa, a Japanese quality expert.

Like flowcharts, CE diagrams are typically constructed as a team effort; and as with many team efforts, the process is often more important than the end product. When a team is brought together to study potential causes of a problem, each member of the team is able to share their expertise and experience with the problem. The team approach enables clarification of potential causes and can assist with building consensus for most likely causes. By empowering the team to identify the root cause and its solution, the team gains ownership of the process and is far more motivated to implement and maintain the solution over the long term.

Perhaps most importantly, using a team to develop a CE diagram can help to avoid the all-too-common challenge of pet theories. Pet theories might arise when someone asserts that he or she already knows the cause of a problem. The person(s) presenting this theory may well be right, and if they are in a position of authority, chances are their theory will be the one that gets tested! There are risks, however, in simply tackling the pet theory. If the theory is in fact wrong, time and resources may be wasted, and even if the theory is correct, future team efforts will be stifled, since team members may feel their input to problems is neither needed nor valued. Further, the theory may be only partially correct: It might address a symptom or secondary cause rather than the actual *root* cause.

CE diagrams, instead, bring the team together to identify and solve core problems.

Brassard and Ritter (1994) list two common formats for CE diagrams:

- Dispersion analysis: The diagram is structured according to major cause categories such as machines, methods, materials, operators, and environments.
- Process classification: The diagram is structured according to the steps involved in the production process such as incoming inspection, ripping, sanding, moulding, etc.

We will discuss the developing a CE diagram via an example.

Developing a cause-and-effect diagram

XYZ Forest Products Inc. produces wooden handles for push brooms. Company representatives visited a customer facility and examined the contents of the scrap and rework bins. Through the use of a check sheet and a Pareto chart, they were able to identify "size out of specification" as the most frequent and costly quality problem. A flowchart helped build team consensus on the actual (vs. ideal) steps involved in the manufacturing process and enabled the team to identify points in the process where the problems might occur, as well as where measurements were currently being taken.

To be able to address this problem, the team members must now identify the root cause and then determine and test potential solutions. For the long term, they will need a plan to ensure that their solution to the problem becomes standard operating procedure.

CE diagrams are often developed via a brainstorming exercise. Brainstorming can be either a structured or unstructured process. In a structured process, each member of the team takes a turn in presenting an idea. In unstructured brainstorming, people simply present ideas as they come. Either approach may be used, however the advantage of the structured approach is that it elicits ideas from everyone—including more shy members of the team.

The following steps are taken to develop a CE diagram:

1. Clearly define the problem (effect): Ensure the problem is clearly stated and understood by everyone. In the example here, it would be good to ensure that everyone understands specifically what "size out of specification" means.
   In this case, the team might create a definition such as, "The diameter of the broom handle measured at the bottom tip is either too large or too small to meet our customers' specifications of ± x inches." The bottom line for CE diagrams is that there is only one clearly defined effect being examined. The process focuses primarily on the causes—of which there will likely be far more than one.
2. Decide on format: The team should determine if the dispersion analysis or process classification (described above) is most appropriate for the situation. Either approach is acceptable. The primary concern is which format works best for the group and the problem being explored. For our purposes, we will focus on the dispersion analysis approach.
3. Draw a blank CE diagram: The diagram should look like Figure 1. The effect or problem being studied is entered in the box on the right-hand side. The main backbone is then drawn, followed by angled lines for the various cause categories. In this case, we have entered the common dispersion analysis categories of machine, methods, materials, operator, and environment.
4. Brainstorm causes: The team can now begin brainstorming potential causes of the problem. It is typical for causes to come in rapid-fire fashion unrelated to categories on the diagram. The meeting facilitator will have to enter the causes in the appropriate place on the diagram. If ideas are slow in coming, however, the facilitator might address each of the categories one at a time with questions such as, "Could our machinery be leading to handle size being outside the specifications?"
5. "Go for the root" (cause): As the team discusses some of the causes, it will become apparent that there are underlying causes for some items. For example,

under materials, someone might mention wood moisture content (MC). Within this item, there could be a problem of MC variation within a wood species as well as differences between species. There may also be MC variation due to mixing purchased materials (dried by a vendor) with material dried in-house. In addition, MC could be explored further with regards to the other categories such as incoming inspection failing to check MC (an issue involving both operators and methods) and/or extended storage of the material in areas without temperature and humidity control (related to environment). The basic idea is to ensure that causes are explored in enough depth such that the fundamental or root cause(s) is identified.

Of course, at some point, the process will come to a natural conclusion. This can happen either when the team has exhausted all possibilities, or some consensus is reached that the root cause has been identified.

The completed CE diagram might look like the one in Figure 2. Due to space limitations, many of the items listed here are quite cryptic. When working on a flipchart or whiteboard, a team would want to use more detail in describing potential causes. As discussed in Step 5 above, notice that some causes appear in multiple categories. For example, causes related to moisture appear in "materials," "methods," "environment," and "operator." This is to be expected, since the issues themselves are multidisciplinary. Moisture content of wood, for example, is a material property that is influenced by the environment, and proper control requires the right methods as implemented by the operator.

Also notice the secondary branches. For example, under operator, "size checks" is listed, with potential causes including "frequency" (i.e., the operator checks the part size but not often enough) and "skipping" (i.e., the operator doesn't do the checks at all.)

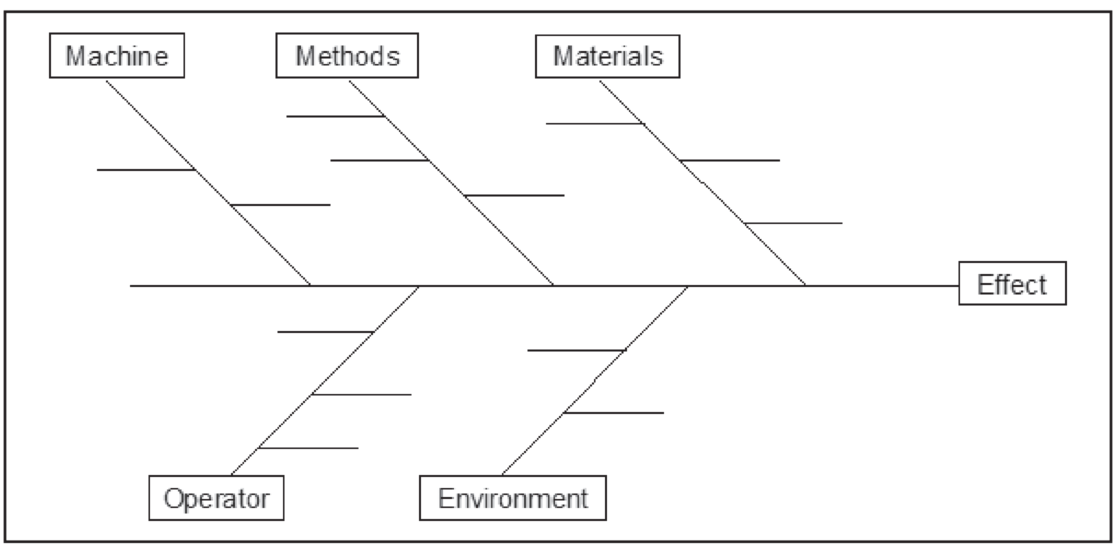

Figure 1. Blank cause-and-effect diagram

Conclusion

Now that the team has completed the diagram, how do they know which cause is the root cause? As stated above, the process is as important as the end product. It is not the diagram per se that tells the team what the root cause might be, but rather the discussion while constructing the diagram that will help lead the team to a cause or two worthy of further exploration.

In this case, the fact that "moisture content" appeared in so many places on the diagram might lead us to speculate that the team spent a fair amount of time discussing this issue. That fact, combined with a basic knowledge of wood (i.e., wood shrinks and swells with changes in moisture content) might lead the team to decide to collect data and/or conduct an experiment to verify one or more of the items on the diagram. For example, the team might decide to gather baseline data—measure the moisture content within species and between species and construct a histogram. They could then conduct an experiment to examine the impact of changes in moisture-check methods on moisture content variability and verify the effect of these changes by constructing additional histograms. If the changes appear to work, they would then need to ensure that the changes become standard practice (and of course, are followed). If the changes do not seem to work, however, the team might then move to the next most likely cause.

In that regard, it should be noted here that merely reaching consensus on the cause of a problem certainly doesn't guarantee accuracy. In fact, the team's decision on the root cause might be wrong. In some situations, more advanced statistical tools may be needed to identify causes and conduct and interpret the results of experiments. Design of experiments (DOE) is a set of statistical methods and tools for ensuring the efficient and effective conduct of experiments. Our next publication in this series will present a brief overview of DOE. Using DOE, however, requires more advanced statistics than are within the scope of this series. We will

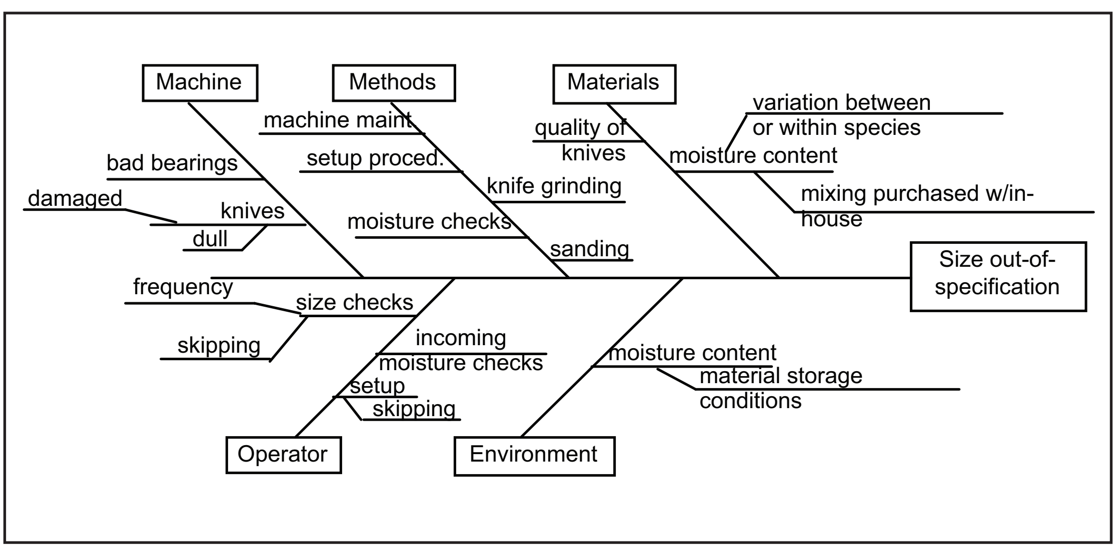

Figure 2. Completed cause-and-effect diagram

merely introduce DOE to give you some familiarity with the topic and to help you decide if you want to pursue formal training in the subject.

For more information

Brassard, M. and D. Ritter. 1994. T*he Memory Jogger II: A Pocket Guide of Tools for Continuous Improvement & Effective Planning* (Methuen, MA: Goal/QPC). http://www.goalqpc.com

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ABOUT THIS SERIES

This publication is part of a series, *Performance Excellence in the Wood Products Industry*. The various publications address topics under the headings of wood technology, marketing and business management, production management, quality and process control, and operations research.

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