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PERFORMANCE EXCELLENCE
IN THE WOOD PRODUCTS INDUSTRY

STATISTICAL PROCESS CONTROL

Part 4: Flowcharts

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Part 1 in this series introduced the reader to Statistical Process Control, and Part 2 provided an overview of how and why SPC works. Part 3 began the step-by-step process of building the practical skills necessary for hands-on implementation of SPC. It discussed Pareto analysis, a tool to help decide where to focus initial efforts.

Part 4 discusses flowcharts. Part 5 in the series will continue building implementation skills by discussing cause-and-effect diagrams. Future publications in the series will discuss case histories of wood products firms using SPC, providing real-world evidence of the benefits of SPC and examining pitfalls and successful approaches.

What's the next step in implementing SPC?

After achieving top management's commitment to using SPC, the next step in beginning an SPC program is to determine where to focus initial efforts to get the "biggest bang for the buck." In Part 3, we presented Pareto analysis as a tool to locate the primary causes of nonconformities and therefore where to focus initial efforts. Now we need to know which specific activities in the process cause the nonconformity and which quality characteristic(s) to monitor.

An example will help to clarify the above discussion and the objective of this report. The Pareto analysis conducted in Part 3 of this series revealed "size out-of-specification" as the major nonconformity, from the standpoint of both frequency and relative cost to scrap or rework. We now need to know:

- The specific step or steps in the process (e.g., dry kilns, rip and chop, moulding) responsible for causing size out-of-specification
- The quality characteristic (e.g., moisture content, width, thickness, motor amps, or proportion of nonconforming parts) to measure

Cause-and-effect diagrams are commonly used to identify specific activities responsible for causing nonconformities. However, we have chosen to discuss flowcharts first, postponing a discussion of cause-and effect diagrams until Part 5 in

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this series. Our choice is based on the fact that flowcharts have been found to be valuable tools for initiating discussion during cause-and-effect analysis and for ensuring that everyone understands and agrees on what really happens—rather than what's supposed to happen—in the manufacturing process.

Flowcharts

Flowcharts graphically represent the steps in creating a product or service. The process of creating a chart is often beneficial because personnel may be unaware of all the "nitty-gritty" details involved in producing the product. Also, people often are surprised to learn of the differences between the ideal process flow and what actually occurs in the mill. This is particularly true when the team developing the chart includes representatives of all departments of the plant, not just production personnel.

In addition to understanding processing steps, flowcharts provide other benefits. If detail is sufficient, flowcharts can help to reveal non-value-added activities such as inspection, rework, redundant steps, movement, unnecessary processing loops, and bottlenecks. From the standpoint of SPC, flowcharts also help to reveal the stages in the process where data may be collected. Flowcharts are also excellent tools for training new hires.

Brassard and Ritter (1994) list six steps to flowchart development.

1. Determine the start and stop points the chart will cover.
2. List the major steps (inputs, decisions made, activities, inspection, delays, and outputs) in the process.
3. Put the steps in the proper order.
4. Draw the flowchart.
5. Test the flowchart for accuracy and completeness.
6. Look for opportunities to improve the process (i.e., reduce non-value-added activities).

Developing a flowchart: An example

We will demonstrate flowchart development using a secondary wood products manufacturer as an example.

Background

XYZ Forest Products Inc. produces wooden handles for push brooms. Their customers produce finished brooms by adding a rubber grip to the top of the handle, inserting a threaded metal ferrule to the bottom of the handle, and attaching the broom head.

Last year, business began to fall off for XYZ; orders dropped 40 percent in just 6 months. Several customers stated that the competition's quality was better. A few customers had begun asking XYZ to provide documentation of process performance—namely histograms, control charts, and process capability indices (see Part 2 in this series for an overview of these subjects). Therefore, XYZ was inspired to use SPC.

Because customers reported several different quality problems (fuzzy grain, size out-of-spec., warp, etc.), XYZ personnel did not know precisely how and where to start their quality improvement program. They conducted the Pareto analysis, as presented in Part 3 in this series, to help them decide where to focus initially. Size out-of-specification was found to be the primary quality problem. Following the Pareto analysis, the general manager of XYZ convened a team of personnel from engineering, sales, production, quality control, and management to develop a flowchart for their process. We will summarize their activities using the six steps described above.

Creating the flowchart

Step 1. Determine the start and stop points that the chart will cover.

Because XYZ had never developed a flowchart for the process, the team decided to chart the process from start to finish. The start point was green lumber receiving, and the stop point was finished product storage. The team agreed to create a macro-flowchart; that is, a chart showing only the general flow of the process with minimal detail. The team decided that once they'd created a cause-and-effect diagram for the problem, and had determined the specific steps in the process most likely responsible for the problem, they would then create a flowchart with a narrower focus and more detail.

Steps 2 and 3. List the major steps in the process, and put the steps in the proper order.

The team brainstormed (see Brassard and Ritter for a discussion of brainstorming) to develop the steps involved in the process. Then, they put the steps in the proper sequence. (Brassard and Ritter list steps 2 and 3 separately because, in a group setting, people usually name the activities most familiar to them, which

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generally leads to a list of steps that is out of sequence). In our example, the team identified these steps.

- Receive rough green lumber; tally.
- Sticker lumber.
- Move stickered lumber to green storage.
- Move lumber to dry kilns.
- Kiln dry lumber.
- Unsticker, tally, and stack dry lumber.
- Move lumber to dry storage.
- Move lumber to planer.
- Unload and plane lumber.
- Crosscut surfaced lumber.
- Rip lumber to handle blank widths.
- Tally handle blanks.
- Shape broom handles from blanks.
- Inspect handles with go/no-go gauge; tally and scrap no-go.
- Load and move good handles from shaper to taperer.
- Taper ferrule end.
- Round grip end of handles.
- Inspect handles for appearance; tally and send nonconforming to scrap and rework.
- Load and move handles to sander.
- Sand handles.
- Load and move handles to packaging.
- Package.
- Move packaged handles to finished product storage.

Note: It is imperative to list what actually happens during production versus the ideal for the process. For example, if lumber leaving the planer goes to storage, as opposed to going directly to the crosscut saws as listed above, this should be specified.

Step 4. Draw the flowchart.

Symbols are used in flowcharting to identify different categories of activity. For example, ovals may be used to indicate inputs/outputs, and boxes indicate a processing step (Figure 1).

It is important to maintain a consistent level of detail in the flowchart. Brassard and Ritter suggest the amount of detail to include in a flowchart. Macro-level flowcharts show key action steps but no decision boxes. Intermediate-level flowcharts show action and decision points, and micro-level flowcharts show intricate details.

Each step in the process should be labeled. Arrows should be used to indicate the flow of steps. To make the chart easier to read, it is helpful when using yes/no decision boxes to have the “yes” boxes branch down and the “no” boxes branch to the left. This will, of course, depend on the amount of space available. For future reference, names of team members, the date, and the purpose for creating the chart should be included (Figure 2, page 6).

Step 5. Test the flowchart for accuracy and completeness.

The team should make certain that symbols are used correctly, process steps are identified clearly, and that process loops are closed (that is, every path flows to a logical end). Also, if the chart contains any process boxes with more than one output arrow, the team may wish to consider adding a decision diamond. As a final check, someone outside the team should be asked to verify the chart’s accuracy and completeness.

Step 6. Look for opportunities to improve the process (reduce non-value-added activities).

This is where the team seeks opportunities to optimize the process. An ideal process flowchart should be made and compared to the actual process flowchart. The team should then examine the non-value-added activities, which might include the following.

- Unnecessary redundancy. (Two machines performing the same operation might be necessary redundancy if they increase throughput without creating bottlenecks; multiple inspection points for the same quality characteristic are often unnecessary redundancy.)
- Inspection
- Delay
- Many movements (for example, movement to a staging area, then to storage, then to another holding area, and then to production).

Montgomery suggests several ways to eliminate non-value-added activities.

- Rearrange the sequence of worksteps.
- Rearrange the physical location of the operator in the system.
- Change work methods.
- Change the type of equipment used in the process.
- Redesign forms and documents for more efficient use.
- Improve operator training.

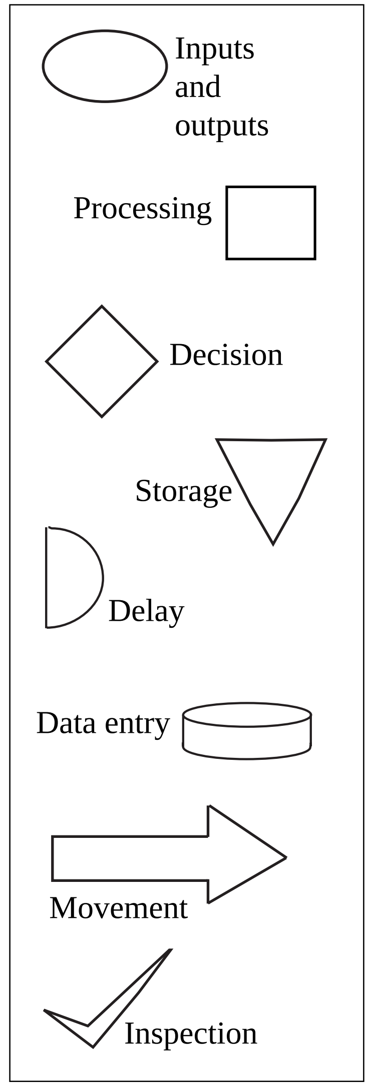

Figure 1.—Flowchart symbols.

- Improve supervision.
- Identify more clearly the function of the process to all employees (flowcharts are good visual aids for explaining the process to employees).
- Eliminate unnecessary steps.
- Consolidate process steps.

A macro-level flowchart (Figure 2) lacks the necessary detail to identify non-value-added activities. Once XYZ team members have constructed a cause-and-effect diagram for the defect category, they will know the step(s) in the process for which they need a more detailed flowchart. Consider, for example, that the team determines shaping through sanding as the processing steps that deserve a closer look for size out-of-specification troubles. Their flowchart for this part of the process may look like the charts in Figures 3 and 4.

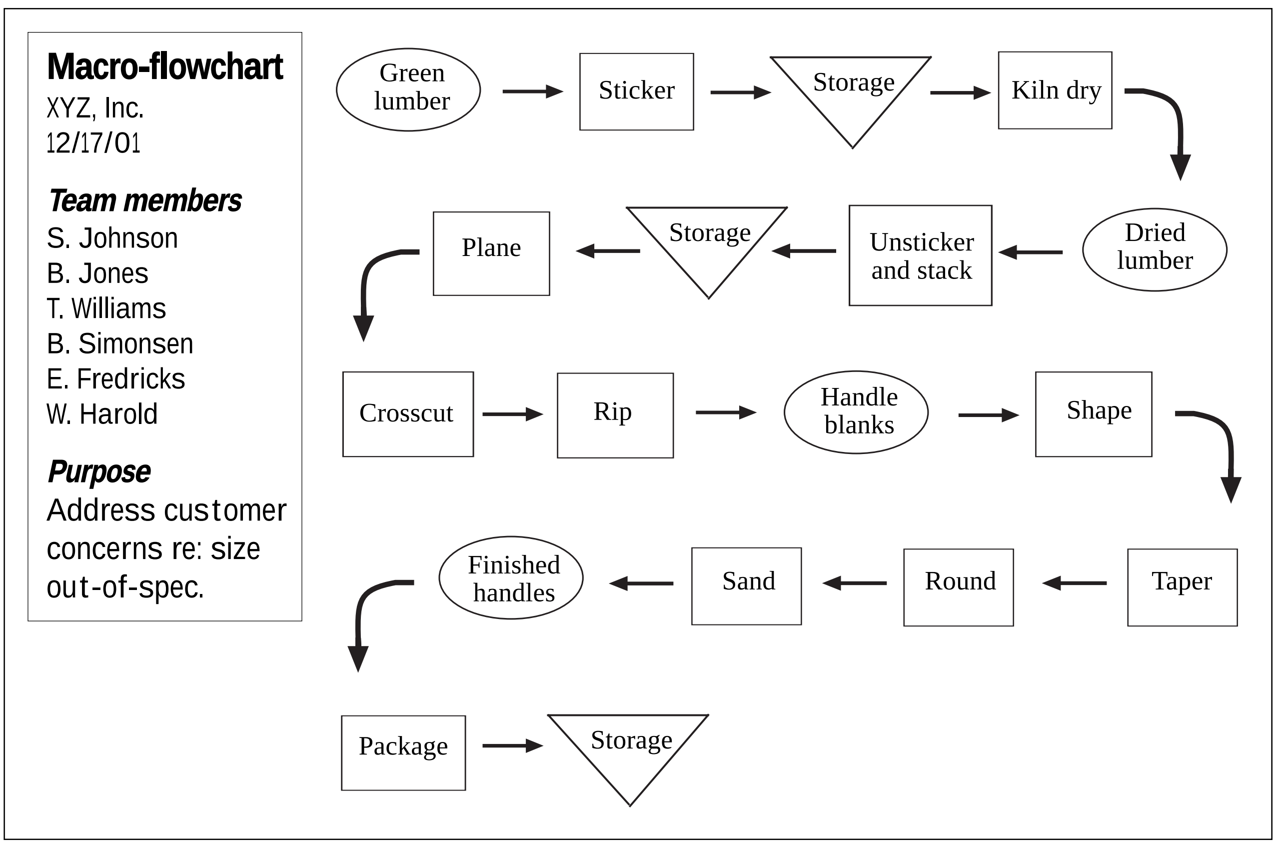

Figure 2.—Sample macro-flowchart.

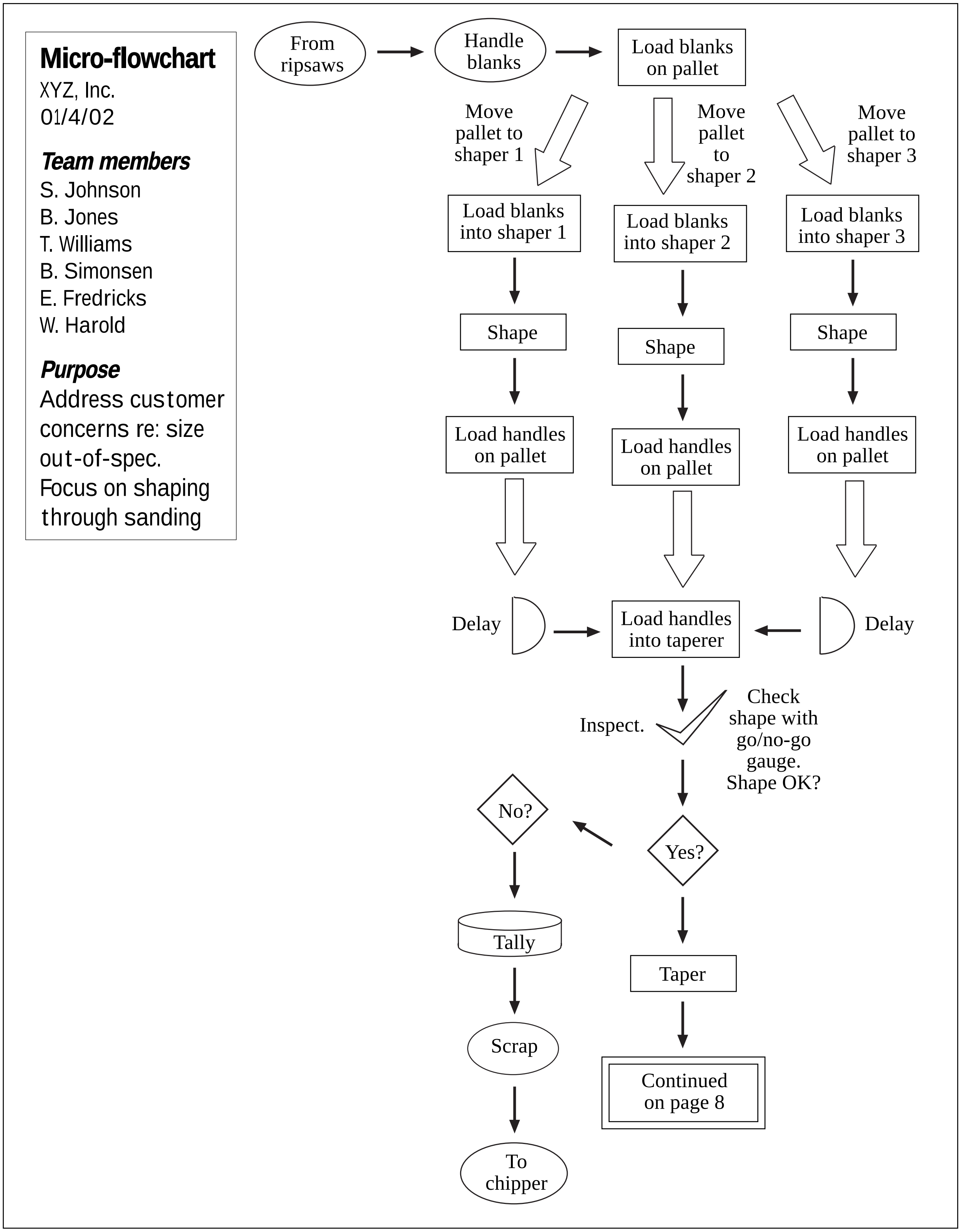

Figure 3.—Sample micro-flowchart, part 1.

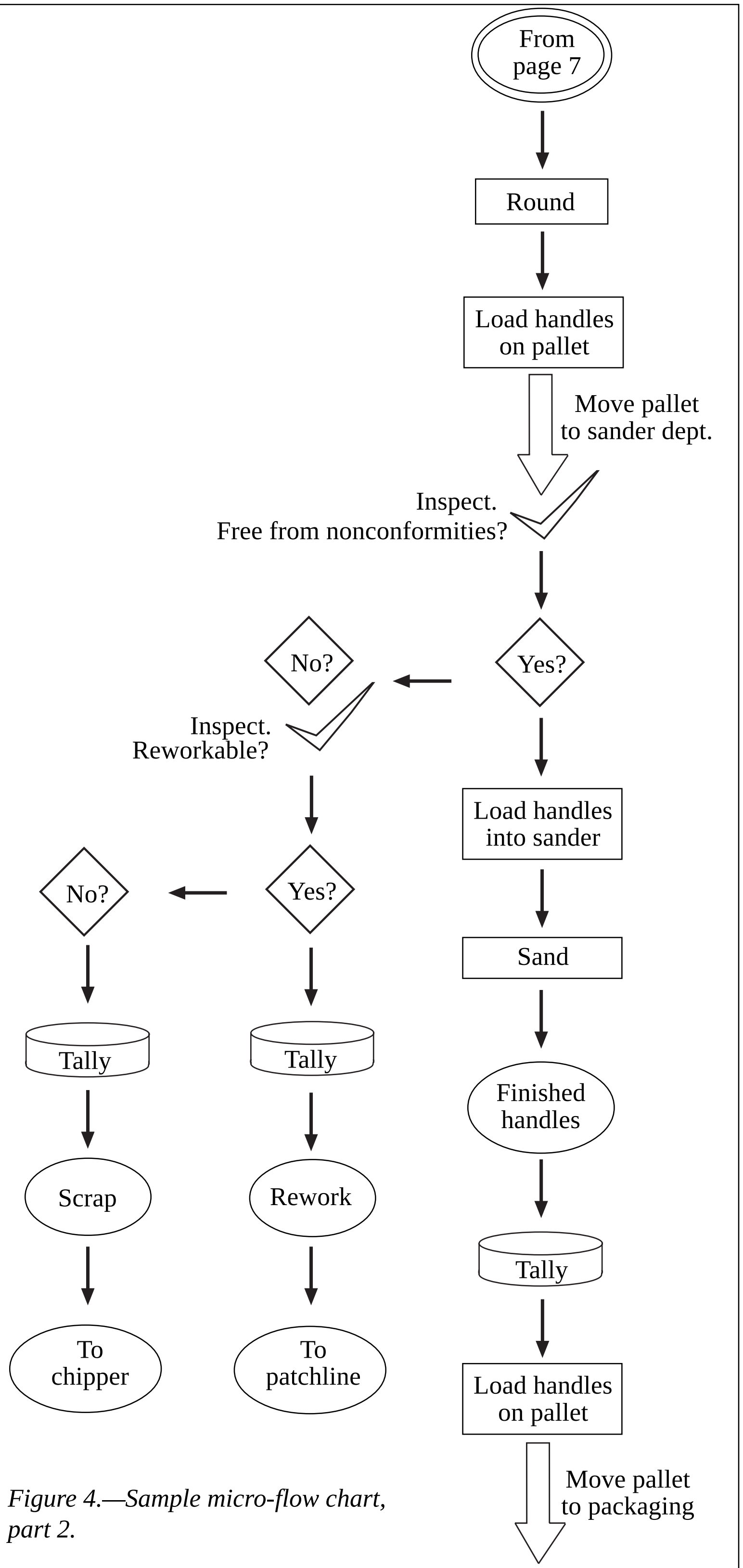

Figure 4.—Sample micro-flow chart, part 2.

Potential areas for improvement are revealed in Figure 3. Notice the delay at the taper machine. Three shapers feed one taper machine which appears to lead to a bottleneck. More detailed data (downtime, throughput, costs, etc.) would need to be collected to determine a solution.

Another area to examine is the two inspection points, one before the taper machine and the other before the sander. Handles are inspected for conformance to size specifications at the infeed to the taper machine and are checked for appearance at the infeed of the sander. The team might address numerous questions, including:

1. Are both inspection points necessary? Could the product be inspected for both size and appearance before the taper machine?
2. Could appearance be checked earlier in the process? It probably isn't cost effective to check for conformance to appearance specifications **after** significant value has been added to the product.
3. If there is a problem with conformance to size specifications before the taper machine, can it be determined which of the shapers is the likely source of the problem? Are size data fed back to the operators?

4. Can the handles be checked with calipers instead of go/no-go gauges? Much more information is obtained using measurement data than go/no-go information. For example, a go/no-gauge might reveal that handles are “small” after they go out of specification. Charting data obtained with calipers, on the other hand, would enable the operator to detect trends and make corrections **before** the product went out-of-spec.

Let’s examine one more potential area for improvement. Notice all the movements in Figure 3. This company probably has a fleet of forklifts. Product is loaded on pallets, moved, and unloaded many times. How might throughput increase if the process flow were improved by, for example, using *just in time* (JIT) or *lean manufacturing techniques* such as work cells, which are groups of machines dedicated to producing a particular product or part.

That question can be addressed by creating another type of flowchart known as a *value stream map*. These maps track the flow of value and information from customer order all the way back to first-tier suppliers. Value stream maps add a dimension—time—that flowcharts don’t cover. By tracking process cycle times, equipment uptimes, and inventories, companies can estimate the amount of time they spend doing things the customer would not be willing to pay for (movement, queues, delays due to large batches, problems related to the scheduling system, rework, etc.) versus time spent altering the product in ways the customer *will* pay for (generally, those are process cycle times). The current value stream map is used to redesign the process to reduce non-value-added time (thus eliminating waste) and reduce customer lead time.

A detailed discussion of value stream mapping is beyond the scope of this report. For more information, see Rother and Shook.

Conclusion

We now have graphical representations of the steps involved in creating the product. In the process of creating the chart, we have had the opportunity to increase company personnel’s understanding of “how we do things around here” and perhaps also to streamline the process and reduce non-value-added steps. We now also have a valuable tool for initiating discussion during cause-and-effect analysis, the next step in beginning an SPC program.

For further information

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