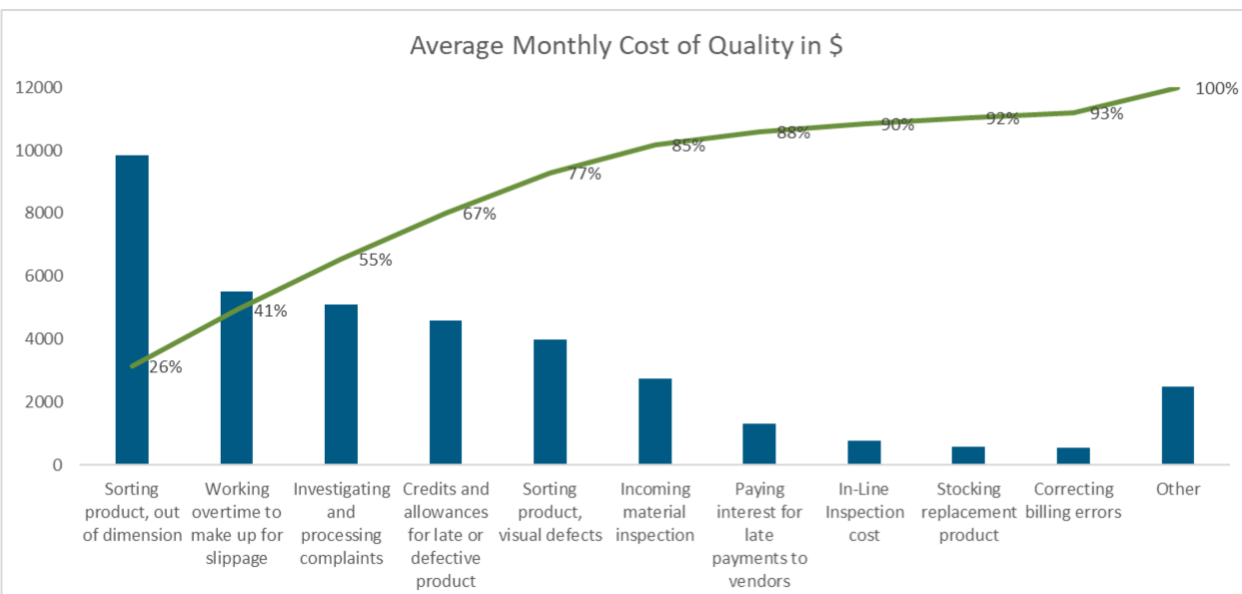
Using Statistical Process Control to Reduce Inspection Costs

Abstract or summary

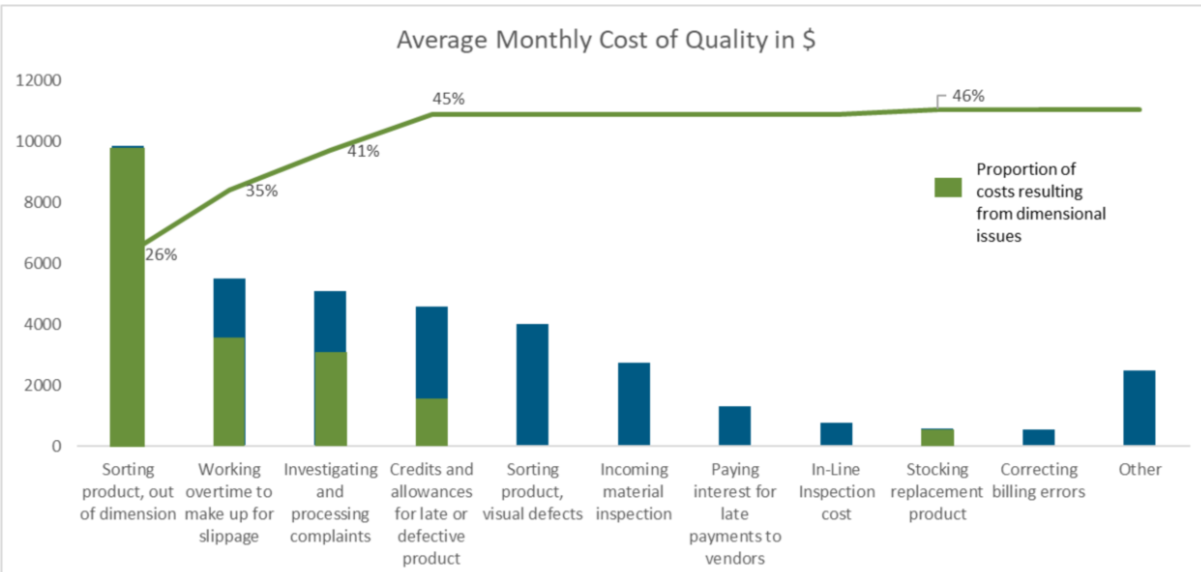
- Statistical Process Control (SPC) can significantly reduce or eliminate the need for product sorting, reducing warehouse space requirements, improving efficiency, meeting demand, and freeing up employee hours to allocate to value added activities. We demonstrate how control limits and run rules through the implementation of SPC can dramatically reduce the overall cost of quality by detecting process issues very quickly.

Problem Definition

- Rising overtime costs and customer complaints have driven ACME Corporation's plant manager to investigate the costs of quality in the plant. A Pareto of the data (see figure 1) reveals that sorting for dimensional defects alone accounts for 26% of expenditures related to quality. When the process runs well, it is highly capable and produces a very low rate of out of spec parts, but when issues occur, holds can be large and costs high.



Acme's procedure is to hold all product made to the last good check whenever an issue is identified (often through routine inspections). The suspect product is 100% sorted. Pallets prior to the last good check are also sampled to contain the issue. Depending on the severity of the issue, a significant amount of overtime is required to make up for the lost production. However, because 100% sorting is not 100% effective, a portion of the complaints and customer credits bars are also due to these quality issues. In total, the costs resulting from these dimensional issues account for 46% of all costs of quality.



High-Level Solution

Implementing statistical process control in this case will have a significant positive impact on the Cost of Quality by detecting quality issues quickly. Operators continue to do the same dimensional inspections but use SPC to identify statistically improbable conditions, either on paper or using SPC software. This identifies a process issue much quicker without additional inspection.

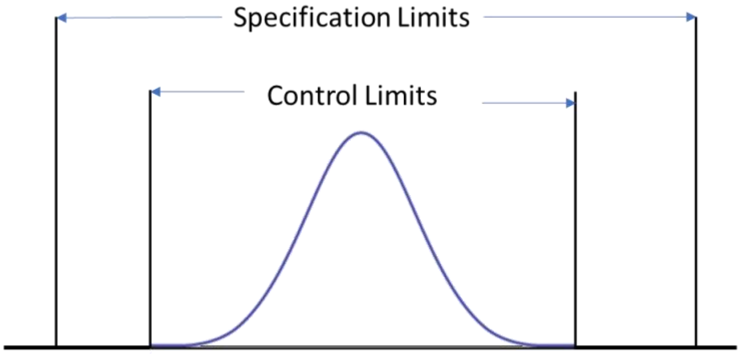
SPC uses control limits and run rules to estimate the population and alert the operator of any statistically unlikely shifts that indicate a problem.

Solution Details

All processes are subject to variability. This variability accounts for differences in product dimensions or attributes. A capable process and measurement system ensure that the production and measurement processes can reliably meet the customer requirements.

Defects primarily occur when special causes of variation enter a process. Special causes of variation are sporadic and typically attributable to a particular event. This can be a different lot of material, adjustment to equipment, change in environmental factors, etc.

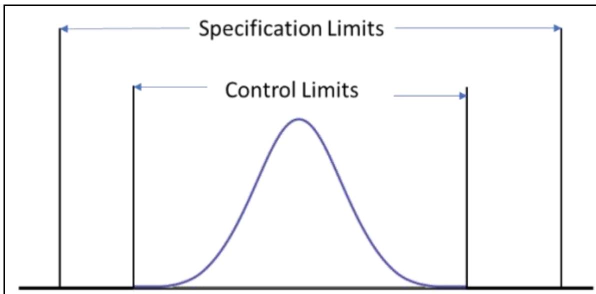
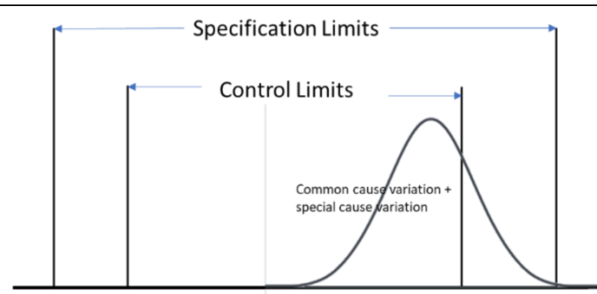
Using SPC we can separate (based on a chosen level of probability) normal process variation (common cause variation) from special causes of variation. The sooner an issue is detected by detecting the special cause variation, the sooner the issue can be fixed and the lower the cost of quality.



ACME's production line is capable, meaning that it produces a very low defect rate when it is running well. The common cause variation present in this process is bounded by the control limits. When the process is centered, it will make almost no parts out of spec. In Figure XX we see that the control limits are tighter than the specification limits. This means we will almost never get out of spec parts from this process when only common cause variation is present.

However, if a special cause is introduced, the process will drift or become more variable. The sooner this unexpected variation can be identified, the quicker the root cause of the variation can then be identified and corrected, keeping products in spec and costs down.

Let's consider the situation where there's an abrupt process shift due to an issue, for example a bad lot of material or a broken chuck or fixture. This will introduce special cause variation into the process and cause it to shift.

	
In-Control Process: Only common cause variation is present	Out-of-Control process: Common cause + special cause variation
Defective rate: 6 ppm	Defective rate: 50,000 ppm

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Instead of making 6 parts per million out of spec, the process is now making 50,000 parts per million (or 5%) out of spec. If we measure one sample every 20 minutes and the process runs 100 parts per minute, we only have a 5% chance of identifying the issue each time we sample against the specification limits. In this case, it would take approximately 524 samples before we have a 95% chance of detecting this issue. By this point, we have made 174 hours of production with a 5% defect rate, totaling 1,048,000 parts that will need to be dispositioned.

CONTROL LIMITS

If, on the other hand, we use control limits, the samples will be compared to the control limits instead of the specification limits to identify if statistically unlikely measurements are detected. About 46% of the parts are now outside of the control limits, giving us a much higher probability of detecting the issue with a single sample. Now, it will take approximately 6 samples before we have a 95% chance of detecting the issue. In this case, 120 minutes of production were made with a 5% defect rate, totaling 12,000 parts to be dispositioned.
Table X summarizes the difference between these two cases.

	Chance of detecting the problem with a single sample	**# of samples to get 95% chance of detection**	**Time before 95% chance of detection (min)**	**Parts to Sort**
Using Spec Limits	5.70%	524	10480	1,048,000
Using Control Limits	46.40%	6	120	12,000

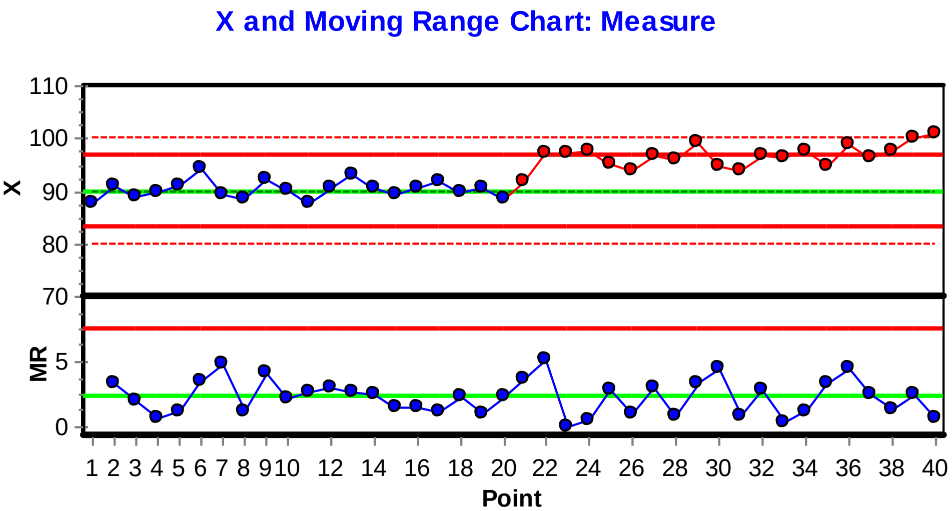
In this case, the use of control limits alone results in a 98% average reduction in the number of parts to be dispositioned.

RUN RULES

SPC looks for statistically unlikely conditions within data. As we've seen, points outside control limits are statistically unlikely when only common causes of variation are present. Similarly, patterns such as 6 consecutive points increasing, or decreasing, are also highly improbable. SPC also looks for these patterns, called run rules, to indicate the presence of special cause variation.

SPC uses both control limits and run rules to detect changes to a process. Chart X shows the control chart before and after the process shift at ACME. The top chart indicates the measurement of each data point. The bottom chart uses a measure of the variation in the data to look for unlikely patterns in the spread of the data. The first 20 points are prior to the introduction of the special cause.

In this case, the shift is detected within 2 samples when multiple unlikely statistical patterns are observed. The software indicates this change by highlighting the points in red. The operator is alerted of the change immediately and only 40 minutes of production must be sorted.



The above example highlights what happens when an abrupt change is made to the process. However, if the shift occurs over time, for example, due to wear, the use of SPC run rules would likely detect the increase prior to the process making any parts out of specification. This allows the operator to stop the process and address the root cause without having to hold and inspect any parts.

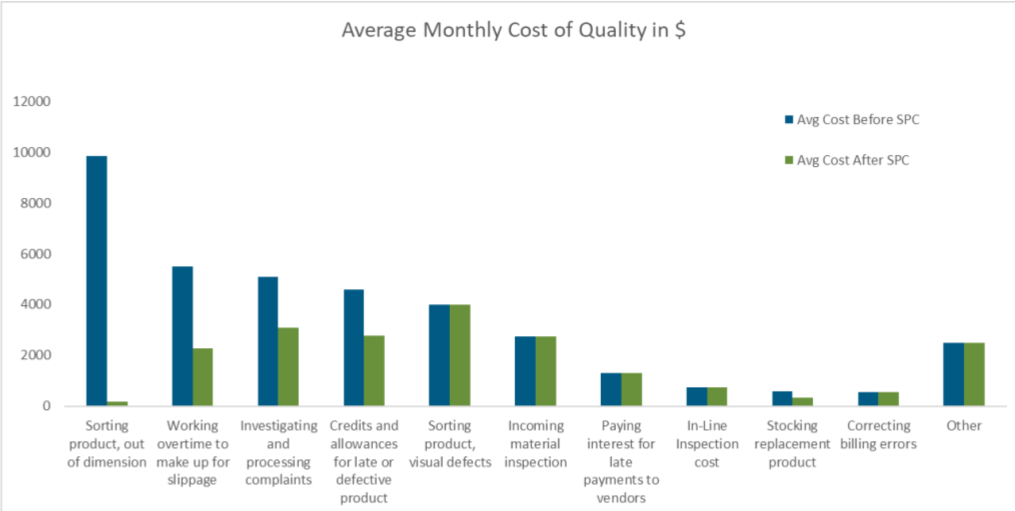
Business Benefits/Summary

While every case is unique, effective SPC implementation eliminates unnecessary adjustments to the process and allows for much earlier identification of problems so issues can be addressed at lower cost.

Statistical Process Control commonly reduces the overall cost of quality by:

- Reducing risk of quality escapes, complaints, and recalls
- Reducing material to be held
- Reducing scrap
- Reducing overtime and sorting costs
- Improving overall customer satisfaction and retention
- Reduce time to train new personnel

In the above example, through the application of SPC to ACME's process, 98% of costs due to sorting were eliminated, reducing the overall cost of quality by over 45%. Sorting for dimensional defects has gone from the main contributor to Cost of Quality to a relatively insignificant cost. ACME can now focus on the next highest contributor to further reduce quality costs.



SPC can be implemented at low cost and can be implemented using software or on paper. SPC should be considered as part of the solution in a combination with other appropriate quality tools whenever there is a desire to make data-based decisions about when to adjust a process or to catch quality issues early in the process.