SPC: Should We Keep On Fighting A Lost Battle?

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Abstract

When Walter Shewhart published his famous book "Economic Control of Quality of Manufactured Product" (1) he introduced statistical process control (SPC) and basically started in-process statistical quality control. Until today the technique he introduced is one of the most important ones in quality management.

However, in 80 years many things have changed in industry and in our economy as a whole. In this article we will show that these changes are such that SPC will no longer have an important role to play in quality and quality management of the future. In fact the high importance that is still given to it in certain industries and in quality training courses limits the possibility of developing new and better ways of controlling processes and product quality. Effort is put in applying a methodology that may not be the best suited for quality control or may even be superfluous.

We will describe these changes and their effects on SPC application. We will also point out the alternatives that are needed in order to guarantee quality in the future.

Keywords

Process Control, Error proofing, Technical evolutions.

1. Introduction

Changes in the industrial environment and in our economy as a whole make the application of SPC less and less useful. These changes are related to customer requirements, technological and logistic evolutions, and a major shift in the economy in developed countries towards service industries. Instead of desperately trying to hang on to SPC application for process control it would be much better to focus on other means and methods.

We will treat the various changes one by one but it is clear that they are intertwined. A technical change can have a direct influence on the way we handle our logistic flow.

2. Technological evolutions

Over the years the job content of a machine operator has drastically changed. Originally the operator did most of the production work but gradually the machine took that out of his hands. As the actual work was done by the machine, time became available for other tasks. In fact, it is this evolution that has led to the development of Total Productive Maintenance. The operator now became the first responsible for product quality and process / machine control and maintenance.

But the evolution of machines has not come to a stop. On the contrary, we now have machines that measure the parts and have their own control loop, leading to an extreme accuracy of production. So the machine now is combining the tasks of production and quality control. As our models of processes continuously improve, the quality of the automated control also gets better. It becomes so good that an additional operator control through SPC (or any other method) is no longer needed.

And this automation will continue. Up till now automation was not very intelligent. One of the limitations was the interaction with the outside world allowing a machine to react to changes in the environment. But with the rapid evolution in the development of robots this limitation will soon be overcome. As JamaisCasciosaid “we will have smart robots making stupid robots making parts” (2).

The digitization of our world and our production environment could even make all inline process control superfluous. The program is the part and if the software is correct, so will the part, no matter where it is being produced. This is very clear when we start thinking about 3-D printing that allows us to make a variety of parts in a one-piece flow. We will also refer to this in chapter 3 on logistic evolutions.

All these technological evolutions go in the same direction: the control of the process is more and more taken away from the owner of the process. We are currently developing self-driving cars. These are machines that need to operate in very complex environments with an extreme amount of parameters that can change in any direction at any moment in time. Moreover, the consequences of an error can be very grave: people dying or getting injured, massive traffic jams, et cetera. But the development is such that in the near future we will see these machines on our roads. Knowing this is possible means that any industrial process canbe fully automated.

On top of that and as an additional safety net there is an enormous development of cheap and accurate 100% inspection methods. This is related to changing customer requirements (see chapter 4) but it also has a huge impact on process control. Now you get large automated lines with self-controlling machines that in addition contain 100% inspection methods at different places in the process. On top of that there is an overall monitoring process constantly measuring the Key Performance indices of the process. As an example an online Overall Equipment Efficiency measurement (OEE) compares obtained results with management targets. Instead of reacting to out-of-control signals from a control chart, actions will be driven by deviations from management objectives. In other words business results will directly drive actions in production. “Cut out the middle man” applied to a manufacturing environment.

3. Logistic evolutions

With the introduction of lean and Just-In-Time manufacturing we have seen a drastic reduction in production batch sizes. Processes are continuously interrupted each time a new product has to be produced on the machine. One consequence of this is that changeover time becomes increasingly important (hence the popularity of Single Minute Exchange of Die – SMED) and in some cases this becomes the main source of process inefficiency. Machine flexibility is becoming more important than absolute machine productivity.

Because processes are continuously interrupted it becomes difficult to evaluate their stability over time. In fact, the logistic requirements make us intervene in the process and we are constantly introducing special causes of variation through product changes. This already creates major problems for the application of SPC at this point in time.

Short run SPC (3) is trying to give an answer to this evolution but it makes the application of SPC more complicated and expensive and still requires a certain batch size to operate properly. If after each changeover we can only plot one or two points on our control chart that will not be very helpful in understanding the behaviour of the process, let alone the control of it.

But what has happened so far is nothing in comparison with the evolutions that lie ahead of us. Production techniques are evolving in such a way that we are truly arriving at a one part lot size. The best-known example of this is 3-D printing as we already referred to in chapter 2. If each consecutive product is different, with different settings and parameters, applying SPC will be virtually impossible.

4. Customer expectations

The industry that has been pushing the hardest for the application of SPC by its suppliers has been the automotive industry. In fact, they define minimum capabilities to be achieved in contractual requirements. At the same time the allowable amount of defective product has gone down drastically. It is not uncommon to have requirements of maximum 50 ppm defects or even 5 ppm defects, for instance for safety-related products.

For a supplier it is impossible to guarantee these low levels of defects when only using statistical process control based on regular sampling.

To illustrate this a small simulation was made in Minitab 17 software. 20 samples of 300 parts were randomly selected out of a population that in relation to the specifications would lead to a process performance of 1.33. The population is perfectly centred on the process target, so we would expect a theoretical ppm out-of-spec of 63.

For each sample the performance and the expected ppm out of spec were calculated. In this example the only variation is sampling variation so it is a situation of an extremely stable and capable process that is sampled regularly. This is clearly a much better situation than you would ever have in reality where there would undoubtedly be disturbances and process changes. In figures 1 and 2 we show the best and worst sample result.

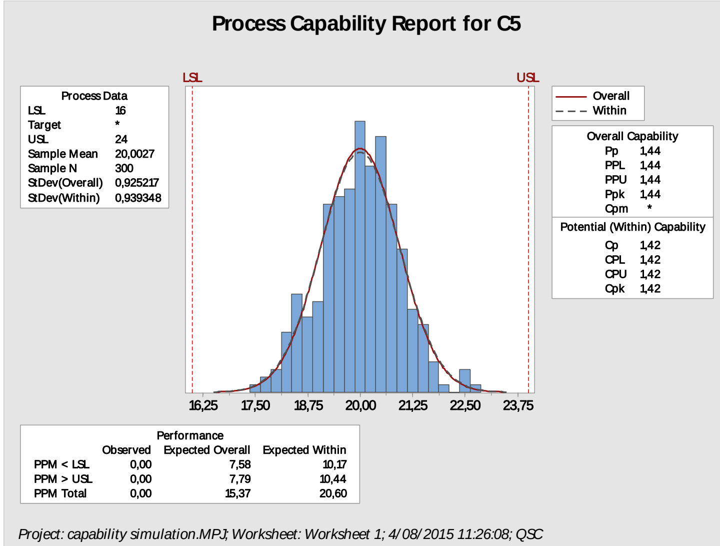

Figure 1: Best sample result (ppm = 15.37)

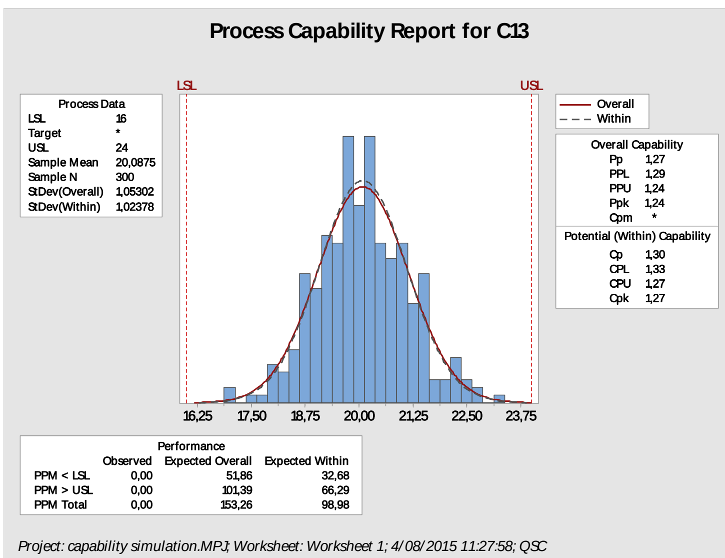

Figure 2: Worst sample result (ppm = 153.26)

The graphs show changes in ppm out of spec from 15 to 153. This clearly shows how difficult it is to guarantee extremely low defect levels even with a controlled and capable process.

So in order to fulfil these extreme customer requirements, companies have introduced other methods. Typically error proofing or Poka-Yoke methods are introduced and in a lot of cases in combination with 100% control methods (see chapter 3). Very often these 100 % control methods will be described as Poka-Yoke which in theory they are not. They allow errors to occur but avoid that they pass through the process or to the customer.However, suppliers know that this is what they ultimately will be judged on.

The role of SPC is to evaluate process stability and natural process variation. When an out-of-control situation occurs we need to intervene and remove the special cause so the process performs to the best of its ability. It is not aimed at reaching a certain ppm level. But when an organization has an automated self-regulating production line with an accurate 100 % product control (see chapters 2 and 3) what role does SPC play? Why would a company invest in an extra control system?

Despite all the efforts of quality specialists over the years we have to admit that in production the most important thing is still that products are within specifications. Very often out-of-control signals from control charts are neglected as long as products are still within specifications. In fact a lot of the so-called control charts that we see on the factory floor are actually nothing more than registration cards or as one person once called it: Show Process for Customers. We may regret this but with the evolutions that we see we must accept that the role of SPC will continually be reduced. For the quality world the question is: should we keep on fighting this battle or is it not better to focus on other elements of quality management?

5. From an industrial economy to a service economy

In production environments the application of SPC is very often focused on machining processes. A lot less control charts can be found in assembly departments. The reason of course is that assembly processes are much more people driven and as such more difficult to stabilise and to control using statistical methods. Service processes and very much so the front-end service providing processes are in that respect even worse.

The quality of the service process lies in the direct interaction between the service provider and the receiver of that service. It is extremely difficult and not advisable to standardise a process like that. A German friend of mine very often refers to the service industry as “Customer Created Chaos”. One could say that each customer is a different “part” and that our process is a continuous stream of special causes. In fact, the pressure for standardisation of service processes may have an adverse effect on the quality. We could find ourselves optimising a process for the average customer to later on discover that there is no such thing as an average customer. We should aim at treating the customer the way he or she wants to be treated rather than the way we want to treat him or her.

Quality management has been developed in a mass manufacturing environment. The tools and methods that we use come from this environment and this is also very clear in the language that we use. But while 70% of our body of knowledge has been tuned for operation in manufacturing, we currently have an economy that is driven for 70% by service. There is a clear mismatch between what we have learnt and teach and what the world currently looks like.

One of the negative effects of this is that we always look for application of the tools that we know in an environment that we do not know. So you see quality improvement projects that desperately try to introduce statistical techniques into service operations. Students following a Six Sigma course have to have a designed experiment in their project for certification. Whether this is really useful or not does not seem to matter. I think it is time that the quality world puts a stop to this if we want to have a meaningful presence in the largest part of our economy.

6. Consequences for process control

In addition to the various evolutions that have been explained in the previous chapters, there is one additional evolution to be noted: the reduced life-cycle of products. Many companies today are driven by innovation and they know that their continued success will be dependent on the speed with which they can introduce new products onto the market. This has a dramatic effect on one of the most important aspects of quality and quality management: continuous improvement.

We are approaching a situation where continuous improvement during the production of a product will become unacceptably costly. Adapting a released product may no longer be worthwhile if the next product is already underway. Can we afford to launch a product, subsequently invest money in improving it and then seeing it withdrawn from the market before we have even finished the improvement?

Genichi Taguchi made the distinction between off-line quality engineering and online quality engineering. By investing more in off-line quality engineering, meaning investing more in product and process design and optimization prior to production, we can reduce the need for online quality engineering. If products and processes are truly robust by design the need for process control and improvements during production can be heavily reduced.

Unfortunately this message of Dr Taguchi has not been understoodvery well. Like many other, in essence preventive methods, the Taguchi methods have also been used mainly to solve problems. This will be too late in tomorrow’s world. We will need to come to a production environment where errors become impossible through preventive techniques. This means that for the quality professional of the future there are enormous possibilities in the area of product and process development. We need to focus much more on techniques like QFD (Quality Function Deployment), TRIZ (Theory of Inventive Problem Solving), FMEA (Failure Mode and Effects Analysis), Axiomatic Design, Poka-Yoke, and etcetera. This will prepare the Quality specialist of the future much better for the environment of the future.

7. Conclusions

Statistical process control has been and still is a very valuable tool in controlling processes and helping us raise them to a higher level. However, in view of developments in technical, economic and logistic aspects, the time may have come to leave it behind.

Because of technological evolutions the control of the quality of production processes will no longer be in the production. Product quality will be controlled in the design of the product and the associated processes.

Companies will have to invest much more in the quality of their design department than in the quality of the production. Young professionals that are interested in a career in quality should be focusing on methods applicable in design and development. The quality community should reduce its emphasis on problem-solving and in process quality control and increase its efforts in off-line quality engineering.

Maybe we should even go one step further. If we believe in quality maybe we need to get rid of "quality engineers" altogether. Our biggest contribution could be in making sure that the above mentioned philosophy and techniques become part of the curriculum of all engineering studies. Only then will we have achieved our quality mission.

8. References

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