Process improvement by poka-yoke

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Abstract

Outlines the concept of poka-yoke (as developed by Shigeo Shingo) as a quality methodology, and contrasts it with statistical process control. Highlights the inherent simplicity and the breadth of coverage, and the way it can be used to underpin a policy of zero defect manufacturing.

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It was Toyota, and in particular one of their industrial engineers, Shigeo Shingo, who have been credited with creating the concept of zero defects and the techniques of poka-yoke. poka-yoke (pronounced POH-kah YOH-kay) is Japanese for mistake-proofing and the approach is based around the removal of the causes of defects, or, where this is impossible, the simple and inexpensive inspection of each item to determine that it passes the quality threshold – with no defects.

Thus, a poka-yoke device is any mechanism that either prevents a mistake or defect occurring or makes any mistake or defect obvious at a glance. It is the concentration on removing the causes of defects that is important. The inspection process is a backstop.

Shingo did make a clear distinction between a mistake and a defect. Mistakes are inevitable; people are human and cannot be expected to concentrate all the time, or always to understand completely the instructions they are given. Defects result from allowing a mistake to reach the customer, and defects are entirely avoidable. The goal of poka-yoke is to engineer the process so that mistakes can be prevented or immediately detected and corrected.

Two quotes from Shingo himself explain the simplicity of the logic:

> The causes of defects lie in worker errors, and defects are the results of neglecting those errors. It follows that mistakes will not turn into defects if worker errors are discovered and eliminated beforehand.
>
> Defects arise because errors are made; the two have a cause-and-effect relationship . . . Yet errors will not turn into defects if feedback and action take place at the error stage (Shingo, 1986, pp. 50, 82).

Poka-yoke methods and devices can be – indeed preferably are – very simple. The old-fashioned visual indicators on shelves/storage so that the storekeeper could see replenishment levels (rather than have to wait to be reminded by a card index or sophisticated computer system) are such an example. Following a visit to Yamada Electric, Shingo started to introduce simple, mechanical devices into assembly operations, which prevented parts from being assembled incorrectly and immediately signalled when a worker had forgotten one of the parts. These mistake-proofing or "poka-yoke" devices had the effect of reducing defects to zero.

On his visit to the Yamada plant in 1961, Shingo was told of a problem that the factory had with one of its products. Part of the product was a small switch with two

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push-buttons supported by two springs. Occasionally, the worker assembling the switch would forget to insert a spring under each push-button. Sometimes the error would not be discovered until the unit reached a customer, and the factory would have to dispatch an engineer to the customer site to disassemble the switch, insert the missing spring, and re-assemble the switch. This problem of the missing spring was both costly and embarrassing. Management at the factory would warn the employees to pay more attention to their work, but despite everyone's best intentions, the missing spring problem would eventually re-appear.

Shingo suggested a solution that became the first poka-yoke device (Shingo, 1987, p. 145).

In the old method, a worker began by taking two springs out of a large parts box and then assembled a switch. In the new approach, a small dish is placed in front of the parts box and the worker's first task is to take two springs out of the box and place them on the dish. Then the worker assembles the switch. If any spring remains on the dish, then the worker knows that he or she has forgotten to insert it.

The new procedure completely eliminated the problem of the missing springs.

Many jigs and fixtures now (often unknowingly) incorporate poka-yoke elements – such that, for example, a number of screws to go into an assembly can be first placed in separately identified recesses in the assembly fixture. If each recess takes one of the appropriate type of screw, filling the receptacles controls "input", the visual representation serves as an aide-memoire, and the presence of any remaining screw at the end of the assembly process would indicate a defect. This satisfies both elements of the poka-yoke philosophy. It helps remove the cause of defects – and it provides a simple, visual "inspection" process. Of course, it is common sense and well within the remit of any competent workplace designer. This is no reason not to be reminded of the importance of such simple approaches – nor of the need for a systematic process which ensures that such an approach is always considered. As with all good detection/inspection regimes, it is first, a very simple means of eliminating the kinds of worker oversights and errors that arise from a lack of concentration or an external distraction, and second, it ensures that inspection takes place at a point in the cycle when the cost of recovering from an error is low.

Shingo learned about and made considerable use of statistical quality control (QC) in his early career. Then, in 1977, he observed that the Shizuoko plant of Matsushita's Washing Machine Division had succeeded continuously for one month with zero defects on a drainpipe assembly line with the involvement of 23 workers. He realised that statistical QC is not needed for zero-defect operations. This was achieved principally through the installation of poka-yoke devices to correct defects and control of the manufacturing process to prevent defects occurring.

Together these techniques constitute zero quality control, which, Shingo argues, can achieve what may have been impossible using statistical quality control methods.

Shingo himself categorised three different types of inspection:

- judgement inspection;
- informative inspection; and
- source inspection.

Judgement inspection is the traditional inspection process of identifying products that are defective before they are released for distribution. This is sometimes referred to as "inspecting in quality". Modern quality thinking, quite rightly, suggests that this is an inappropriate and expensive way of maintaining acceptable product quality.

Informative inspection uses data gained from inspection to modify the process and prevent defects. Traditional statistical process control (SPC) is such a form of inspection. The kinds of checks built into zero-defect approaches can also often be informative inspection, since they are used to subsequently modify the manufacturing process.

Shingo built successive checks – where each operation inspects the quality of the previous operation – into his methodology, fearful of leaving inspection to a point where it was either ineffective or resulted in excessive scrap and re-working. Successive checks also allow the precise points at which errors occur to be identified – this allows faster and easier modifications to manufacturing processes and working methods. It also makes each area both a production stage and an inspection stage. If handled correctly, this can also increase responsibility and commitment of the workforce. Also, if handled correctly, so that the inspection is part of the operational activity, the actual cost of inspection can be made to be very low. As against typical sample inspection processes, it also means that every

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item is inspected (several times) and all defects should be identified.

An alternative (and one commonly used in poka-yoke devices) is to allow self-checking of work by the operators who complete it. This provides even faster feedback! Where the nature of the process can cause or contribute to defects (heating conditions, machine speeds, etc.) it also allows the operator, who should be aware of the process environment, to identify and isolate possible causes.

Both self-checking and next station checking are "after the event" checks – they determine that something that has been produced is defective. This means the product has to be scrapped or reworked.

Source inspection determines "before the event" whether the conditions necessary for quality production exist. Shingo comments: "It had dawned on me that the occurrence of a defect was the result of some condition or action, and that it would be possible to eliminate defects entirely by pursuing the cause" (Shingo, 1986, p. 50). He goes on to identify that the checking of operating and working conditions before an operation commences may be a means of elimination of defects.

Poka-yoke devices use source inspection to ensure that proper operating conditions exist prior to actual production. In some cases, devices are designed to actually prevent production from occurring until the necessary conditions are satisfied. This is a common process within automated manufacturing systems where a manufacturing cycle cannot start until all components are detected as being in place. At a simple level, it is represented by the fact that no domestic microwave cooker will work unless the door is properly closed.

Source inspection, self-checks, and successive checks are used together to gain maximum feedback in the shortest time so that the manufacturing process is both understood and managed. Although the immediate result is that defects are identified and prevented from progressing, the real aim is to modify the process so that future defects are designed out. Source checking is preferable because it eliminates defects but is often not possible. Then, self-checking is preferable since it provides information faster – and enables more accurate identification of defect sources.

Shingo refers to his control process as "zero quality control" this is something of a misnomer since there is a high degree of quality control in the poka-yoke methodology. However, the building in of these inspection mechanisms should result in the inspection process being an integral part of the production process. In that sense it is not an "overhead" on production and is thus at zero cost. Shingo took exception to the popularity of SPC, decrying it as providing only partial (sample) inspection and being an "afterthought". He suggested that it merely identified defects and that, in fact, it allows for the same number of defects to occur in future production runs; there was no element of prevention built in. (This is probably a little harsh, since SPC is often used as the basis of process analysis and review: the prevention may simply be one more step removed, and less automatic in its inclusion.)

It is reasonable to suggest that since SPC usually involves significant intervals between the sampling of batches, feedback will be faster with source inspection and informative inspection than under traditional SPC-based inspections. However, this does not necessarily mean that Shingo's methods are systematically faster than SPC at ensuring corrective actions are undertaken. The willingness and ability to take corrective action is a function of the attitude and commitment of both managers and workers, not an intrinsic attribute of a particular approach to inspection or quality management.

Shingo advocated the practical application of zero defects by good engineering and process investigation, rather than the slogans and exhortations that have been associated with the quality campaigns of many American and Western companies. Shingo, like Deming and Juran, argued that such American approaches of displaying defects statistics were misguiding and demoralising. Instead, the positive results of improvement should be announced and displayed. The culture follows the engineering and is a by-product of it, rather than cultural change being the process by which improvements are realised.

The much vaunted Japanese quality miracle arose from the application of many thousands of simple poka-yoke devices. Each one is relatively simple – but together their effect is enormous.

References

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