Beyond PDCA—
A New Process Management Model

by Praveen Gupta

The plan-do-check-act (PDCA) cycle has been an integral part of quality management for several decades. Today, the ISO 9001 quality management standard specifies use of the PDCA model for managing processes and creating process-oriented thinking.

As I reflect on what I perceive to be the limited success of ISO 9000 standards to date and review the emphasis on inspection and testing in ISO 9001, I have some questions.

For example, why is check included in the cycle when the goal is to reduce the need for verification activities? Several factors related to the cost of poor quality and current demands for quality in terms of Six Sigma and virtual perfection also make me question the role of PDCA.

I therefore decided to investigate its evolution and role and to propose a new process management model I call the 4P’s cycle.

Evolution of PDCA

PDCA’s evolution began with the dawn of the modern tools of quality in the 1920s (see sidebar “PDCA’s Beginnings”).

PDCA is a continuous feedback loop to identify and change process elements to reduce variation. In other words, the objective of PDCA is to plan to do something, manufacture or do it, verify or check it for meeting requirements, and correct the process to maintain the acceptable output performance.

However, literature shows W. Edwards Deming must have realized maintaining or controlling a process was not good enough. He relabeled the feedback cycle of gaining knowledge as the PDSA...
(plan-do-study-act) cycle for continuous improvement, as shown in Figure 1.1

Accordingly, the study of variation in process output is important to continually improving the process. PDCA can be used to identify the need for an improvement, and PDSA can be used to sustain improvement.

PDSA emphasizes study of excessive variation with respect to the acceptable limits and identification of causes of excessive variation for necessary adjustment rather than identifying the root causes of the problem.

It is apparent the PDSA cycle was intended to go beyond Shewhart’s out of control action plan. Deming must have recognized there must be a tendency toward continuous reduction in variation to keep it within customer specified limits.

Somehow, PDSA did not get as much visibility as PDCA, which became a default method to manage a process. As a result, there must be a process to produce a product with specified limits for the process to work, according to the PDCA cycle.

The current version of ISO 9001 is based on the PDCA model in which the input is customer requirements and the deliverable is process output meeting customer requirements. The concept of requirements has been understood as specifications or tolerances. The processes are designed to produce product within these limits, and verification is limited to the established requirements or the tolerance.

Figure 2 shows PDCA’s current implementation in today’s quality management systems (QMSs) in which the product or the process output is checked against the established limits. If the product falls within these limits, it is shipped or sent on to the next process. If the product is out of limits, it is typically sorted, repaired, reverified and dispositioned through a material review board process, scrapped or shipped as is or after repairs.

Sometimes, a form is completed to initiate a corrective action. However, due to lack of time, corrective actions are usually limited to completing the forms instead of taking genuinely corrective action.

One fundamental and unintended error that occurred in transforming from Shewhart’s process control model to Deming’s PDCA version is ignorance of the statistical intent. According to Shewhart’s model, control charts were implemented to determine statistical acceptability of the process, and action plans were specified for out of control situations.

However, in PDCA, the check has been tied to the product specifications instead of the statistical control limits. As a result, intent of process control has been lost, and PDCA began to be used for product management.

**PDCA and ISO 9001**

The current version of ISO 9001 defines PDCA as follows:

- **Plan:** Establish the objectives and processes necessary to deliver results in accordance with customer requirements and the organization’s policies.
- **Do:** Implement the process.
- **Check:** Monitor and measure processes and products against policies, objectives and requirements for the product, and report the results.
- **Act:** Take actions to continually improve the process.
The 1920s can be recognized as the period of industrialization following Frederick Taylor’s work and the dawn of the field of quality. Walter Shewhart of Bell Laboratories invented the concept of control charts, and H.F. Dodge and H.G. Romig developed acceptance-sampling methods.¹

The ’20s also saw the United States enjoying post-war prosperity as one of the victors of World War I. In those days, quality methods were considered trade secrets because they provided a competitive edge. Americans enjoyed the benefits of mass production as the price of goods such as cars came down.

Figure 1 shows the migration of manufacturing from a craft to process control.², ³ The craftsmen’s process looks more like a service in which the customer participates throughout—from specifying to verifying the custom product.

Taylor separated the craftsman’s work into specialized series of tasks, removing the customer from several tasks. Then sampling plans were developed to verify performance against some limits before making the decision about disposition.

Building on the knowledge gained from sampling, Shewhart experimented to observe patterns in the process output and developed statistical methods to characterize the product output. Figure 1 illustrates how statistical methods—so-called control charts—were developed to control the process.

The figure shows Shewhart really developed control charts to plot the process output and adjust the process appropriately. Shewhart’s approach appears to be a method to manage the product output through process control using his out of control action plans. Functionally, the Shewhart cycle consisted of four actions: plan, do, inspect (sample inspection) and act.

The Shewhart cycle of process control was revisited by W. Edwards Deming. The Shewhart cycle was eventually named the plan-do-check-act (PDCA) cycle, as shown in Figure 2.⁴ Deming’s revised version of Shewhart’s cycle of process control was a means to reduce variation between the desired and actual performance.

REFERENCES
You can see check implies acceptability of the product in meeting requirements. In my experience working with more than 100 companies, when PDCA is used as a product or process management tool against the specification limits, the focus becomes acceptability or mediocrity.

The act then becomes a means to keep the process within limits or the product within its tolerances without any consideration to the statistical nature of the performance, as originally intended by Shewhart.

So far, ISO 9001 has not been credited for significant process improvements because organizations have been certified for their systems’ ability to supply products and services meeting customer requirements.

Statistical Intent Overlooked

At this point we can conclude Shewhart developed the process control paradigm to statistically maintain a process within specified limits. With the current use of PDCA as a process management tool, the statistical intent has been overlooked.

In both Shewhart’s model for managing product and Deming’s model for managing process using PDCA, the focus of process control has been to produce process output within specified limits, leading to some marginal products and mediocre processes. As a result of building a product meeting specified limits, organizations have utilized preinspections, inspections, reinspections, tests or retests, leading to increased cost of poor quality.

Had PDCA been implemented using statistical tools to aim at the target performance, the cost of poor quality could have been much lower much earlier. The quality profession also would have looked very different today—we would not be working on reducing the cost of quality but instead might be working to ensure quality of process and product designs.

Any organization building to limits will find continuous improvement a difficult journey because it provides a fuzzy target at best and limited pass/fail information.

My audits of several QMSs identified corrective action as a weak area and an opportunity for improving the effectiveness of the QMSs. I found organizations repeatedly issue corrective actions, and the problems remain. As a result, process engineers or quality professionals are busy solving problems or fighting fires because the problems just do not go away.

Use of statistical techniques has been ignored, and the opportunity has been missed for improvement with proper application of statistical tools. Since the understanding of statistical control is lost, Shewhart’s control charts—statistical process control (SPC)—has been used incorrectly and rendered ineffective.

The need for improvement continues because of increasing customer demands. Flavor of the year programs have been launched since the 1980s—quality circles, statistical process control, pre-controls, just-in-time manufacturing, benchmarking and design of experiments have come and gone in organizations.

Enter the Japanese

To solve product quality problems, in the 1960s Kaoru Ishikawa introduced the concept of cause and effect analysis using the fishbone diagram, as shown in Figure 3. The fishbone diagram is a wonderful tool for listing potential causes to create an effect under investigation.

Ishikawa grouped various causes in four categories: material, machine, method and manpower (4M’s). The fishbone diagram is a nonstatistical tool universally accepted for identifying the root cause of a problem.

These four M’s must be made available before performing a process. Due to lack of motivation for gaining process knowledge, people perform process activities right away without getting ready. So, while performing the root cause analysis using the fishbone diagram, people identify those causes that normally are inputs to the process—the flaw in the plan phase of PDCA.

In the 1980s Genichi Taguchi introduced a different method of measuring quality—the loss function as shown in Figure 4. Accordingly, the loss function is a financial measure of the consequences of a product’s performance as it deviates from its designed target value, thus emphasizing improving process and product performance with respect to targets and limits.

The loss function is a quadratic function of deviation from the target. It implies that when a performance of a product deviates from a target value, it
costs money irrespective of its compliance with meeting the intended limits. Building to the specified limits implies a certain cost of quality, while building to target minimizes the cost of quality.

The deviation from target within acceptable limits may be attributed to uncontrolled sources of variables. The use of loss function also allows users to minimize the product cost while maximizing its perceived value due to higher quality.

Taguchi’s emphasis on target and tolerance guided the effort for continual improvement in the design engineering phase rather than in the process control phase. This effort was called offline control and led to the design for manufacturability models.

Accordingly, if the product is designed to the process capability, defects would be less likely to occur. This eventually may lead to lack of product innovation with maximum utilization of manufacturing resources—therefore keeping the prices of mature products low.

**Motorola and Six Sigma**

In 1981, Motorola recognized it could not compete with the prices of semiconductor chips produced in Japan. The lower price of chips was due mainly to superior manufacturing skills or the compatibility of design and manufacturing.

Motorola leadership had launched an initiative to undo the existing management style and accelerate continuous improvement. An environment of urgency and fear of extinction led to the application of any available improvement methods, including aggressive goal setting for improvement, statistical methods or precontrol, Pareto charts, Ishikawa diagrams, histogram, design of experiments and Dorian Shanin’s variability reduction methods.

Searching for better improvement methods, Motorola scientist and engineer Bill Smith developed a vision to achieve virtually perfect or closer to target product. Six Sigma was first introduced as a target for achieving superior performance and a plan to achieve a higher rate (68% per year) of improvement.

The original Six Sigma methodology consisted of the following steps:

1. Define products or services.
2. Identify customers and their critical needs.
3. Determine your needs to achieve and meet customer requirements at Six Sigma levels.
4. Establish the process to do the work.
5. Measure and verify the performance if less than 3.4 parts per million (ppm) or $C_p$ and $C_{pk}$ are less than 2.0 and 1.5 ppm, respectively.
6. Improve the capability to achieve Six Sigma level performance.

The Six Sigma methodology heightened the need for doing well or achieving the target performance. In my work, it also enabled me to link root cause analysis to the process needs to do well. Today, the Six Sigma improvement approach has been packaged into define, measure, analyze, improve and control—generally known as the DMAIC methodology—which is used to improve a process but still misses the significance of achieving the target performance.

Implementations of Six Sigma accentuate limitations of control charts and the PDCA model. The required defect rate for a Six Sigma level process performance is 3.4 ppm, which is difficult to achieve.
with Shewhart’s control charts designed to produce a product with a defect rate no more than 2,700 ppm beyond 3-sigma control limits. Thus you cannot achieve Six Sigma level performance of 3.4 ppm using the current implementation of PDCA or control charts.

**From Process Control To Process Management**

Looking into an underlying source of problems in current manufacturing facilities—the culture of fighting fires, acceptability mind-set and uncertainty in expected performance—we need to change the concept of process control to the concept of process management.

Process management implies establishing expected target performance, developing a plan, providing necessary resources, ensuring superior execution of a sound methodology and taking care of exceptions with appropriate process controls. Applying this understanding of process management to PDCA, you can see gaps.

The main differences between control and management approaches are listed in Table 1. When you apply the process management model to the PDCA cycle, consider opportunities for improvement, look for broken pieces of management systems and examine the unchanged management principles for achieving dynamic growth and profitability. The following gaps will become visible:

- You are guided by ineffective planning for necessary resources.
- You are limited by ineffective use of statistical thinking.

During the last several decades, well-known quality experts have arrived at their own unique twist to improving corporate performance. Besides Shewhart’s control charts and model for process control, Joseph M. Juran emphasized execution or project management, Taguchi strived for performance on target to minimize losses, Deming heightened awareness of variability, and Ishikawa used the four M’s.

All appear to have improved the four specific elements of PDCA that equate to the four states of a process:

- Juran demanded superior performance throughout with better execution.
- Deming replaced check with study, which implies understanding the nature of variation.
- Taguchi highlighted the need for a target to minimize losses or enhance value.
- Ishikawa guided us to better preparation of inputs to minimize defect occurrence in the process.

**4P’s Cycle**

I propose a new cycle for process management which is different from control. The proposed 4P’s cycle consists of:

- Prepare.
- Perform.
- Perfect.
- Progress.

The 4P’s cycle, as shown in Figure 5, is again based on the closed loop feedback model. It incorporates the wisdom of Shewhart, Ishikawa, Juran, Taguchi and Deming.

**Prepare** represents ensuring good inputs to the process. The inputs consist of Ishikawa’s 4M’s (material, machines, methods and manpower or people). The objective is to ensure these four M’s are delivered well as inputs to the process.

**Perform** implies the process steps are well defined, mistake proofed, lean and understood for consistent and effective execution.

**Perfect** means assessing whether the process performed as planned and the process output is on
target. If the process output is not on target, the gap from perfection must be analyzed for continual reduction.

**Progress** leads to improvement in the process and its output based on the reduction of variation from the target.

By continually applying the 4P’s cycle, you can reengineer the process to achieve the results desired by the customer through better process management instead of increased inspection.

Table 2 shows the difference between PDCA and the 4P’s cycle. The main difference lies in moving from control to engineering. The limits dependent mind-set produces average performance, while a target driven process produces excellence. Because design affects most of the cost factors, it makes sense to better control the process and product designs.

You can therefore see the 4P’s cycle as a natural evolution of the Shewhart and Deming approaches to process control or product management (see Table 3, p. 52). If you reflect on expected performance levels, you cannot achieve virtual perfection with PDCA or through problem solutions. Instead, you must apply the 4P’s cycle to prevent problems from recurrence.

### Examples Using the 4P’s

To institutionalize the process thinking required by ISO 9001 standards, I incorporate the 4P’s model in procedures. Each procedure includes prepare, perform, perfect and progress to force the process owner to address these issues, including specifying targets.

Preparation requires reviewing the 4M’s to identify needs and gather necessary items to get ready for performing an operation. For example, if a maintenance technician goes to repair a machine and forgets a tool, the repair cannot be completed unless the technician goes back and picks up the tool.

The objective of sound preparation is to acquire necessary resources to do a good job. Addressing needs to do a good job is typically a weak area in designing processes because most root cause analysis leads to one of the preparation items as a source of problems.

For a precision manufacturing process, machines were set up and parts made and inspected according to specifications and then shipped to the customer. But the internal reject rate was very high—in fact, for some dimensions, the defect rate was 100%. Process analysis demonstrated setup was practically aimed at the lower or the upper specification limits as a general practice or to accommodate for tool wear and tear.

When $C_p$ and $C_{pk}$ analyses were performed, some processes had acceptable $C_p$ but low $C_{pk}$. This implies a shift in the process caused by setups being too close to the specification limits. The reasons for
building everything with respect to limits happened to be because the specifications had no target values. When the process was centered, and specifications were modified to aim at the designed target values, the reject rate dropped significantly, as expected, as much as 98%. To sustain such an improvement, the engineer had to establish procedures to verify setup against the target values and variation from it rather than acceptability of parts within specified limits.

When parts are built to specification limits and are marginal in performance, parts depend too much on measuring devices. Instead, if parts are built to targets, the process output is more robust and less dependent on measuring system capability. Similar experiences highlighted the need to question the presence of a mind-set of building to limits and not the targets. This led me to the PDCA philosophy of checking the product against limits and not verifying against targets.

### Reducing Variation

Progress represents movement in process performance toward the intended target. To get closer to target, you must analyze causes for variation and implement necessary changes to reduce variation. Different improvement techniques are deployed to reduce variation for assignable or random causes.

I have seen the 4P’s model work well at small (25 employees) companies to large (about 1,000 employees) organizations. It is making process owners think carefully about their needs or preparations to do well and establish right in-process controls and performance targets to achieve excellence rather than acceptability within specifications. Progress also ensures analysis and improvement of less than excellent performance instead of handling defects or rejects.

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### REFERENCES AND NOTES