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The Application Practice of PDCA Cycle in Improving Product Quality

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Abstract: Under the increasingly fierce competition in the consumer electronics market, product quality has become a crucial element of enterprises' core competitiveness. This study takes "Company A," a small and medium-sized electronic manufacturing enterprise, as a case to address the high defect rate (initially 5.2%) in its smart wristband assembly process. By systematically applying the PDCA cycle for quality improvement, the research identifies core issues such as unstable soldering processes and insufficient standardization of employee operations during the planning phase. Implementation measures include enhanced operator training, equipment calibration, and optimized self-inspection procedures. Verification in the checking phase demonstrates a significant reduction in the defect rate to 2.3%. Effective countermeasures are subsequently standardized into management protocols. The findings reveal that the PDCA cycle enables continuous quality enhancement with low-cost investments, providing a replicable practical framework for quality management improvement in small and medium-sized enterprises.

Keywords: PDCA cycle; Quality improvements; Small and medium-sized businesses.

1. Introduction

Company A is a small and medium-sized enterprise specializing in the production of smart wearable devices. Its flagship product, smart wristbands [1], has gained a certain market share in Southeast Asia due to its high cost-performance ratio. However, in the third quarter of 2023, customer complaint data revealed a notable 12% year-on-year increase in product return rates, with 72% of complaints concentrated on quality issues in the assembly process, such as frequent occurrences of screen display abnormalities and heart rate monitoring malfunctions. Through an in-depth internal investigation, it was found that the defect rate in the smart wristband assembly line had consistently remained at a high level of 5.2%, significantly exceeding the industry average of approximately 3%. This resulted in escalating rework costs, prolonged delivery cycles, and severely constrained the company’s profitability and market expansion efforts.

As a classic quality management tool, the PDCA cycle systematically identifies root causes of issues and drives continuous improvement through its closed-loop mechanism of "Plan, Do, Check, Act" [2]. For individual employees, successful onboarding training can serve to standardize, guide, and integrate, enabling new hires to quickly clarify their job roles and career paths [3]. Compared to relatively complex methodologies such as Six Sigma, the PDCA cycle demonstrates distinctive advantages, including lower operational barriers and reduced resource requirements, making it particularly aligned with the practical needs of small and medium-sized enterprises (SMEs). Through the practical case study of Company A, At present, most of the pre-job training courses do not pay enough attention to the curriculum [3]. this paper thoroughly validates the applicability of PDCA in improving assembly quality for electronic products. The study aims to provide enterprises with actionable and implementable quality management strategies while contributing to enriching empirical evidence for the application of PDCA theory in manufacturing scenarios. PDCA is a relatively scientific management model for continuous quality improvement, which is mainly to summarize the risks and problems existing in the previous management cycle, analyze the reasons for their occurrence, and give targeted solutions, so as to reduce the recurrence of similar or similar problems in the future work [4].

2. Overview of PDCA Cycle Theory

2.1. Definition and Steps of PDCA

The PDCA cycle (Plan, Do, Check, Act) is a systematic improvement methodology proposed by W. Edwards Deming, a renowned expert in the field of quality management. Its core concept revolves around a cyclical iterative process encompassing four stages—Plan, Do, Check, and Act—to achieve continuous problem analysis and resolution (see Figure 1). The specific steps are outlined as follows:

Plan: Clearly define improvement objectives, accurately identify root causes of issues, and formulate actionable countermeasures;

Do: Cautiously implement improvement solutions on a small scale while collecting relevant process data during execution for subsequent analysis;

Check: Conduct a detailed comparison between execution results and predefined objectives, analyze gaps, and evaluate the effectiveness of improvements;

Act: Standardize validated countermeasures into formalized workflows, while transferring unresolved issues to the next PDCA cycle for further resolution.

2.2. Applicability of PDCA in Quality Management

The PDCA cycle is widely adopted in manufacturing quality management due to its logical clarity, operational flexibility, and other advantages. It demonstrates particularly high applicability for small and medium-sized enterprises (SMEs) with limited resources:

Low Entry Barrier: Requires no complex statistical analysis tools; basic methodologies such as fishbone diagrams and the 5 Whys method enable efficient problem diagnosis.

Cost Controllability: Pilot testing within a limited scope (e.g. a single production line) significantly reduces trial-and-error risks and avoids unnecessary cost waste.

Continuous Improvement Capability: Emphasizes cyclical refinement rather than one-time fixes, aligning with the dynamic demands of quality management to ensure sustained quality enhancement.

3. Analysis of the Current Situation and Problems of The Case Enterprise

3.1. The Status Quo of the Assembly Link of The Enterprise

Company A's smart wristband assembly line operates in a semi-automated production mode, with its key production processes encompassing the following critical stages:

Component Soldering: Utilizing reflow soldering equipment to complete the soldering of critical components such as circuit boards, sensors, and display modules;

Casing Assembly: Manual installation of batteries, securing of motherboards and casings, followed by airtightness testing to ensure structural integrity;

Functional Testing: Comprehensive final inspections of core functionalities including heart rate monitoring, touchscreen responsiveness, and Bluetooth connectivity to verify compliance with performance standards.

Currently, the assembly line achieves a daily output of 2,000 units. However, according to Q3 2023 statistical data, its average defect rate remains as high as 5.2%, significantly exceeding the industry average of 3%. Additionally, only 60% of assembly line workers have received standardized operational training, and the calibration cycle for soldering equipment is limited to quarterly intervals. These issues collectively reflect inefficiencies in the company's operational management practices.

3.2. Performance of Quality Problems

According to the defect data statistics of Company A in Q3 2023 (based on a daily production benchmark of 2,000 units), the total number of defective products reached 104 units per day, resulting in a defect rate of 5.2%. The specific distribution is as follows:

Poor Soldering Issues: 47 units/day, accounting for 45%. The primary manifestation is insufficient bonding between circuit boards and sensors, leading to heart rate monitoring failures. Further analysis revealed that 65% of these defects occurred during midday temperature fluctuations in equipment (11:00–13:00).

Component Misinstallation: 31 units/day, representing 30%. Common issues include reversed battery polarity, missing screws, or insufficient fastening. Correlation analysis of personnel operations indicated that 78% of these errors were attributed to employees with less than 3 months of tenure.

Functional Test Failures: 26 units/day, comprising 25%. Among these:

Screen abnormalities (18 units/day, 70% of functional failures): Issues such as bright spots and color deviations;

Touchscreen malfunctions and others (8 units/day, 30%): Primarily caused by screen damage due to compression during assembly.

Equipment-related factors also contributed significantly, with 40% of test failures resulting from insufficient sensitivity of testing equipment.

4. Specific Applications of the PDCA Cycle

4.1. Planning Phase (Plan)

4.1.1. Goal setting

Based on the current reality of Company A, the following improvement objectives were clearly set:

Short-term goal: Reduce the defective rate of the assembly line from 5.2% to less than 3% within 3 months; Priority issues: Prioritise and focus on solving the two types of problems that occur more frequently, namely, soldering false soldering (45% of the total) and misassembly of parts (30% of the total).

4.1.2. Analysis of causes

Personnel factors: new employees accounted for 40 per cent of the workforce and there was a significant lack of operational training (only 1 day of basic training); during lunchtime hours, employees were prone to fatigue, which led to excessive welding speeds and consequent neglect of process standards.

Equipment factors: reflow soldering equipment temperature control system there are fluctuations (± 10 ℃), which seriously affects the stability of the welding; calibration of the functional test equipment lags behind, so that the rate of misjudgement is high.

Management factors: the lack of perfect self-inspection process, quality problems mainly rely on the final inspection link to find, which undoubtedly increases the difficulty of quality control.

4.1.3. Countermeasure development

In response to the above core issues, the following improvement programmes were elaborated: in terms of operation training, a standardised operation manual was compiled and a practical assessment link was added to enhance the operation skills of the staff; in terms of equipment management, the calibration cycle of the welding equipment was adjusted from a quarterly to a monthly basis and a temperature monitoring device was added to ensure the stable operation of the equipment; in terms of the self-checking process, it was designed to add a staff In terms of the self-inspection process, we designed to add employee self-inspection forms at the welding and assembly stations to record key parameters so that problems can be identified and corrected in a timely manner.

4.2. Implementation Phase (Do)

4.2.1. Implementation response

Employee training and assessment: organise and carry out a 2-week special training activities, the training content comprehensively covers the welding temperature control, component installation sequence and other key knowledge points; through the simulation of practical tests to screen qualified employees, for employees who do not meet the standard resolutely be eliminated (elimination rate of 8%).

Equipment calibration and monitoring: Before starting work every day, carefully record the temperature profile of the welding equipment, and immediately stop the machine for maintenance once abnormal conditions are found; increase the calibration frequency of the function test equipment from 1 time per month to 1 time per week in order to improve the accuracy of the test.

Self-inspection process on the ground: welding station employees need to carefully fill in the "welding parameters of the self-inspection form" for every 50 pieces of products; in the assembly station to set up a misassembly problem illustration Kanban, assisting employees to quickly identify the error, improve work efficiency.

4.3. Inspection Phase (Check)

4.3.1. Effectiveness verification

After 1 month of implementation of improvement measures, the key data has changed significantly: the defective rate has been successfully reduced from 5.2% to 2.3% (the average number of defective items per day has been reduced from 104 to 46); the percentage of soldering problems has been reduced from 45% to 20%, with the defective rate in the lunchtime period reduced by 72%; and in terms of the problem of misassembly of parts, the operation error rate of new employees has been reduced from 78% to 35%.

4.3.2. Non-compliance

Despite the remarkable results achieved, there are still some problems that do not meet the standards: there is still a 5% test failure rate in the screen assembly link of complex models of bracelets; some employees are not standardised enough to fill in the self-inspection form, which leads to difficulties in data traceability work.

4.4. Processing Phase (Act)

4.4.1. Standardised measures

Institutionalise training: extend the training cycle for new employees to 1 week, and incorporate it into the performance appraisal system to ensure the effectiveness of training; standardise equipment maintenance: formulate the Welding Equipment Daily Inspection Form, which is supervised and implemented by the team leader to ensure that the daily maintenance of the equipment is carried out in practice; solidify self-inspection process: electronically integrate the self-inspection form into the enterprise MES system to achieve real-time monitoring and to improve the management efficiency.

4.4.2. Legacy issues carried forward to the next cycle

In response to the problems in the screen assembly process, the second round of PDCA cycle was immediately launched, focusing on optimising the design of the screen mounting fixtures and actively introducing the anti-dumbness and error prevention mechanism, in order to further improve the product quality and solve the legacy problem.

5. Conclusion

Through the systematic application of PDCA cycle in the assembly link of smart bracelet in Company A, we have achieved significant implementation results, and also brought a lot of inspiration for quality management of small and medium-sized enterprises.

5.1. Effectiveness of Implementation

5.1.1. Significant improvement in quality

After the continuous improvement of PDCA cycle, the defective rate of the assembly line has been successfully reduced from the initial 5.2% to 2.3%, which is much lower than the industry average, effectively solving the key quality problems such as soldering false soldering and misassembly of parts. This not only reduces rework costs, but also shortens the delivery cycle, improves customer satisfaction, and injects a strong impetus to Company A's competitiveness in the Southeast Asian market.

5.1.2. Employee empowerment

Through intensive operation training and practical assessment, employees' operation skills and quality awareness have been significantly improved. After the training cycle for new employees was extended to 1 week and included in the performance appraisal, the standardised operation level of the employees was greatly improved and the operation error rate was significantly reduced. In addition, the implementation of the self-inspection process enables employees to identify and correct their own problems in a timely manner, further improving production efficiency and product quality.

5.1.3. Management upgrades

In terms of equipment management, the adjustment of the calibration cycle of welding equipment and the addition of temperature monitoring devices have effectively guaranteed the stable operation of equipment. The increase in calibration frequency of functional testing equipment has reduced the rate of misjudgment and improved the accuracy of testing. At the same time, the self-test table was electronised and incorporated into the MES system, which realised real-time monitoring and tracing of data and improved the level of management refinement.

5.2. Revelations

5.2.1. Universality and Practicality of the PDCA Cycle

As a classic management tool, the PDCA cycle has wide applicability in the quality management of small and medium-sized enterprises (SMEs). It has a low threshold for operation, is cost-controlled, and can identify the root causes of problems and promote continuous improvement through a systematic approach. The successful practice of Company A has shown that the PDCA cycle can effectively solve the quality problems faced by small and medium-sized enterprises, and improve the quality of products and the level of management.

5.2.2. Emphasis on personnel training and management

Employees are the key executors of quality improvement, and their operational skills and quality awareness directly affect product quality. SMEs should pay attention to employee training, develop a systematic training plan, through hands-on assessment and performance incentives, to enhance the operation level and quality awareness of employees. At the same time, the establishment of a perfect self-inspection process, so that employees involved in quality management, can find and solve problems in a timely manner to improve the efficiency and effectiveness of quality control.

5.2.3. Enhanced equipment management and maintenance

The stability and accuracy of equipment is an important guarantee of product quality. Small and medium-sized enterprises should strengthen the management of production equipment, establish a scientific equipment calibration and maintenance system, and conduct regular equipment inspection and maintenance to ensure that the equipment is in the best operating condition. For key equipment, monitoring devices can be installed, real-time monitoring of equipment operating parameters, timely detection and resolution of equipment anomalies, to reduce quality fluctuations caused by equipment problems.

5.2.4. Importance of continuous improvement

Quality management is a dynamic process that requires continuous improvement and optimisation, and the PDCA cycle emphasises "cyclical" rather than "one-time" improvement, and achieves continuous quality improvement by constantly identifying and solving problems. Small and medium-sized enterprises should integrate the PDCA cycle into their daily management, form a culture of continuous improvement, and continuously improve product quality and management level to meet the demands of market competition.

In summary, the successful application of PDCA cycle in the assembly of smart bracelet in Company A provides valuable practical experience for quality management of SMEs. By paying attention to personnel training, strengthening equipment management and establishing a continuous improvement mechanism, SMEs can achieve effective quality improvement and enhance market competitiveness under the condition of limited resources.

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