



RESEARCH ON THE APPLICATION ERROR PROOFING THEORY IN THE ENTERPRISES QUALITY MANAGEMENT

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ABSTRACT

Mistake proofing solution are design-based techniques used in industry to prevent errors during the production process. error proofing widely known as Poka yoke is proactive quality management strategy focused on preventing human error before they lead to defect. Originating from the Toyota production system the principle has expanded beyond manufacturing into service and administrative domains as organizations pursue higher quality and operational excellence. The research explores how error proofing integrates into enterprise quality management framework, examines systematic methods for implementing error proofing controls and highlights key application areas demonstrating its effectiveness. Its role in modern quality systems including lean and six sigma, suggest Poka yoke is a foundational error preventive mechanism crucial for sustainable quality improvement. Error proofing system is discussing the operational mechanism of the enterprises quality management error proofing system with the analysis of the process of quality management error proofing.

KEYWORDS: Toyota production system, six sigma, Poka yoke, mistake proofing.

INTRODUCTION

Shigeo Shingo of Japan developed the concept of Poka yoke in the 1960s to prevent human error. Poka yoke is a Japanese term that means mistake proofing (or) error proofing. He distinguished between human mistake and defects that occur during the mistakes (or) to ensure that errors are immediately identified and corrected, thereby avoiding defect formation at the source. It serves as a continuous improvement tool for preventing and defecting defect in manufacturing process with the objective of achieving zero defect performance.^[1] Quality management should control both product quality and the quality of the management process that product it. The purpose of this paper is to investigate the application of error proofing theory and methods in quality management errors, avoid the deterioration of enterprise operation, and enhance the stability of management quality. Because of the cognitive limitations and unreliability of managers and employees.^[2] Error in management is inevitable, these errors may cause increased costs, loss of time, risks, management failures can occur highlighting the need for systematic error proofing in management.^[3] The establishment of a quality management error proofing system supported by scientific management mechanisms enables enterprises to forecast potential departmental failure, reduce errors, and optimize management processes and the design of products (or) services preventing errors at their source, controlling potential risks, and reducing damage caused by failure are forward – looking approaches to improving management quality. This study explores the significance of poke yoke in modern manufacturing, with particular emphasis on its application through the pick-to-light (PTL) system.^[4]

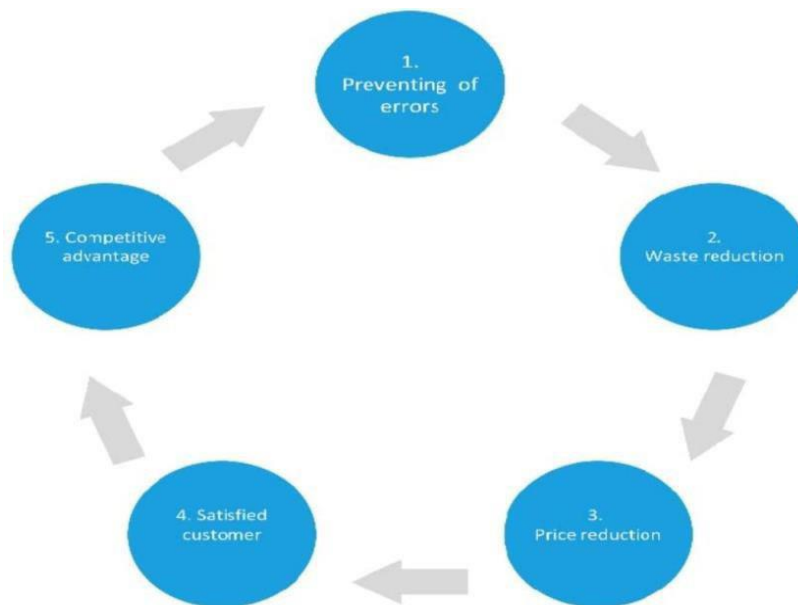
By the end of this introduction, readers will gain a clear understanding of the need for this research, the justification for selecting this model, and the benefits it provides to today's industries. This method is preventive in nature and is based on the principle of achieving zero error in the process.^[6] Control elements are applied at the very beginning of the process, focusing on the inputs before any value-adding activities take place. An error in the production process is defined as any deviation from specified technological, operational, or drawing requirements, as well as any minor variation that affects correct product performance. Most error can be prevented through appropriate preventive measures.^[7]

METHODOLOGY

This research employs a mixed methods approach to investigation the integration and impact of error proofing (Poka yoke) techniques in enterprise quality management (EQM). The study

begins with a comprehensive literature review to establish a theoretical foundation on Poka yoke principles and their applications in quality management. This is followed by multiple case studies of organization across various industries that have implemented error proofing techniques in their EQM system. The case studies involve analyzing existing data on quality metrics, process efficiency, and defect rates before and after the implementation of Poka yoke methods. Surveys and interviews and quality management professionals in this organization supplement the case studies, providing insights into the practical aspects of implementing error proofing, benefits realized, and challenges faced. The data collected is analyzed to evaluate the effectiveness of Poka yoke in improving quality metrics such as defect reduction, process efficiency, and their impact is assessed. The findings aim to provide a framework for organization to apply error proofing effectively in their quality management system, enhancing overall quality and operational efficiency.

PRINCIPLE OF POKA YOKE (ERROR PROFFING)



1. Preventing error: Poke- yoke focuses on designing processes and systems in such a way that mistakes are prevented from occurring in the first place or are defected immediately. This reduces human errors and avoids defects at the sources.
2. Waste reduction: By preventing mistakes and defects Poke yoke minimizes waste caused by rework, scrap, reinspection, and rejected products. This leads to better utilization of materials time and resources.

3. Price reduction: When defects and waste are reduced, production costs decrease, lower costs of rework, repairs, and warranty claims allow enterprises to reduce product price or improve profit margins.
4. Satisfied customer: Error free products and consistent quality increase customer satisfaction customers receive reliable products that meet their expectation, leading to trust and long-term relationships.
5. Competitive advantage: Organization that implements poke yoke effectively achieve higher quality, lower costs, and better customer satisfaction. This combination provides a strong competitive advantage in the market.^[5]

TYPES OF POKA YOKE (ERROR PROOFING)

1. Prevention type: In prevention poke yoke systems processes are designed to make errors impossible. This approach removes the chance of mistakes occurring in the first place. Human errors can be avoided by using elimination, production, replacement, and facilitation techniques.
2. Detection type: In this type of poke yoke system mistakes or errors are quickly defected and corrected at the source or at the next workstation. This ensures that mistakes do not develop into defect or reach the customer. In simple terms, detection - based poke yoke allows errors to occur but provides effective mechanisms for their detection, alerting, and correction. The impact of human errors can be minimized through detection and corrective or mitigating actions.^[8,9]

EQUIPMENTS USED IN ERROR PROOFING THEORY

1. Contact/physical devices

Jigs and fixtures

Guide pins and blocks

Go/on-go Gauges

2. Sensor-based equipment

Proximity and limit sensors

Vision system (AI cameras)

Torque sensors

3. Warning and signaling systems

Andon lights

Digital interlocks/software controls

1. CONTACT /PHYSICAL DEVICES

These devices work by physically preventing incorrect actions or ensuring that components are in the right place. They rely on the physical shape, size, or presence of an object to guide the process.

- Jigs and fixtures

These custom – designed tools that hold a workpiece in a specific, correct position during manufacturing or assembly. If a part doesn't fit the jig, it's the wrong part or oriented incorrectly.



Fig. 02

- The operator places the component (shown in hand) onto the fixture.
- The fixture is designed exactly to the shape and dimensions of the correct part.
- The component can be inserted only in the correct orientation.
- If the parts are upside down, reversed, wrong model, incorrect size it will not fit into the fixture.
- Locating pins and guides align the Part precisely.
- All holes, slots, and surfaces must match the fixture profile.
- Even a small dimensional error prevents proper seating.
- When the correct part is placed sits fully inside the fixture. The process continues (inspection or next operation).

- When the part is incorrect to fixture blocks movement process stops immediately.
- Wrong parts are physically rejected no dependence on operator judgment defects are stopped at the source.

- **APPLICATIONS:**

- Used for correct assembly of engine parts, manifolds, cylinder heads, etc.
- Ensures correct PCB placement and component insertion.
- Prevents wrong orientation of gears, shafts, or housings.
- Used in packaging lines to prevent wrong labeling or filling errors.
- Ensures correct part alignment in high-precision assemblies.
- Used in jigs and fixtures to maintain dimensional accuracy.
- Applied in assembly lines for high-volume production.

- Guide pins and blocks

These are simple physical features that ensure parts align correctly. For instance, connectors often have asymmetric shapes or guide pins to prevent them from being plugged in upside down or into the wrong port.

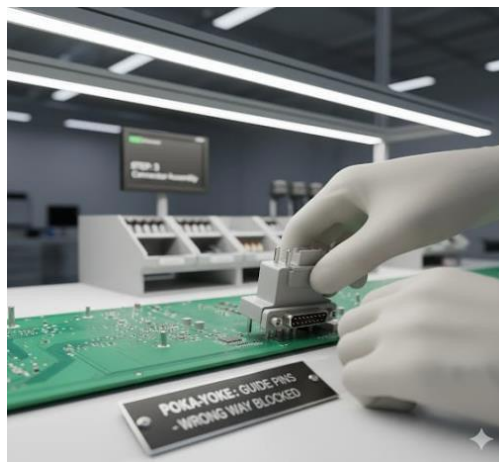


Fig 0.3

- This connector and fixture are designed with guide pins and symmetric slots.
- This ensures the connector fits only in the correct orientation.
- If the operator tries to insert the connector in the wrong direction or position, the guide pins do not align and physical blockage occurs, stopping insertion completely.
- When the connector is aligned correctly, the guide pins match the holes on the PCB and the connector fits smoothly without force.

- The error is prevented at the source, before electrical connection or soldering, avoiding damage to PCB tracks or pins.
- No skill or judgement is required from the operator -the fixture itself ensures correctness
- **APPLICATIONS:**
- Electronics Manufacturing Used in PCB assembly lines to guide connectors and ICs.
- Automobile Electronics Ensures correct wiring harness and ECU connector fitting.
- Computer Hardware Production Prevents incorrect installation of ports and cables.
- Telecommunication Equipment Used in router, modem, and server board assembly.
- Medical Devices Ensures correct electronic module assembly in diagnostic equipment.
- Aerospace Electronics Used in high-precision circuit board installations.
- Industrial Control Panels Prevents wrong wiring or module placement.
- **Go/No-Go Gauges**
- These are tools used for quick dimensional checks. A Go side allows a correct part to pass, while a No-Go side prevents an incorrectly sized part from passing, instantly identifying out-of-spec items.



Fig 0.4

- The GO gauge is tried on /into the component (shaft, hole, pin, diameter). If the component is within the correct size (tolerance), the GO gauge fits smoothly.
- The NO-GO gauge is the tried. If the component is correct, the NO-GO gauge must NOT fit.
- GO fits +NO-GO does not fit=Accept

- GO does not fit or NO-GO fits=Reject
- The operator gets an immediate physical result without measurement reading or calculations.
- **APPLICATIONS:**
- Checking shafts, engine components, bolts, and bushings.
- Inspecting drilled holes and turned parts.
- Precision component tolerance checking.
- Checking connector pin sizes and housing dimensions.
- Mass production quality control.
- Checking machine parts for dimensional accuracy.
- Checking internal and external diameters.

2. SENSOR BASED EQUIPMENT

- These utilize electronic or optical sensors to detect the presence, absence, position, or characteristics of components and processes. They often integrate with automated systems to stop a process or trigger an alarm if an error is detected.
- Proximity and limit sensors
These sensors detect the presence or absence of an object without physical contact (limit sensors). They ensure a step isn't skipped or that a part is correctly loaded.

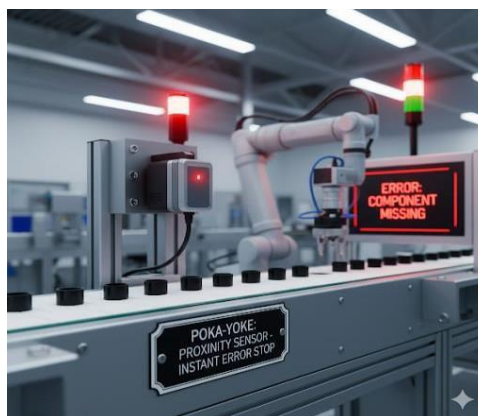


Fig: 5

- A proximity sensor (inductive / capacitive / photoelectric) is installed at a fixed point on the conveyor or workstation. It continuously checks whether the required component is present.

- If the component is present the sensor sends a correct signal to the PLC. If the component is missing or wrongly positioned -the sensor sends an error signal.
 - When an error is detected: red warning light turns ON, error message appears on the display (e.g: ERROR: COMPONENT MISSING) conveyor or machine stops immediately.
 - The process cannot continue until the missing component is corrected, preventing defective products from moving to the next stage.
 - Once the component is correctly placed, the sensor detects it and the system allows the process to resume.
- **APPLICATIONS:**
 - Detects missing bolts, nuts, or engine components.
 - Checks presence of PCB components.
 - Ensures product is placed before sealing.
 - Detects missing tablets or bottles in packaging lines.
 - Checks presence of caps or labels.
 - Ensures proper part placement before next operation.
 - Used for precision component verification.
- **Vision system (AI cameras)**
Advanced camera system combined with AI can perform complex inspections, detecting defects, verifying assembly, reading labels, or ensuring correct color and orientation much faster and more reliably than the human eye.
 - On detecting a defect: conveyor or machine stops, or defective PCB is automatically rejected from the line.



Fig. 0.6

- A high -resolution industrial camera captures images of each product (PRINTED CIRCUIT BOARD) as it moves on the conveyor.
 - The captured image is compared with a pre-programmed reference (golden image) stored in the system software.
 - If the product matches specification -OK signal (green indicator). If any mismatch is found-ERROR DEFECT DETECTED message appears on the screen and red light turns ON.
 - On detecting a defect: conveyor or machine stops, or defective PCB is automatically rejected from the line.
- **APPLICATIONS:**
 - PCB inspection, solder joint checking, component verification.
 - Checking assembly alignment and part presence.
 - Inspecting labels, packaging, and tablet defects.
 - Detecting contamination, shape, or packaging defects.
 - High-precision component inspection.
 - Ensures strict quality standards compliance.
 - Checking barcode, print quality, and labeling errors.
- Torque sensors
 - Used primarily in assembly, these sensors ensure that fasteners (screws, bolts) are tightened to a precise torque specification. If the torque is too low (loose) or too high (stripped), the system halts the process.
 - The required torque (minimum and maximum limit) is pre- programmed into the controller.



Fig 0.7

- The required torque (minimum and maximum limit) is pre-programmed into the controller.
- The electric screwdriver or robotic tool tightens the fastener while the torque sensor continuously measures applied torque.
- If torque is within the specified range operation is accepted. If torque is below (loose) or above (over-tightened) system detects an error.
- When torque is out of range: display shows ERROR: TORQUE SPECIFICATION FAILED. Red warning light turns ON. Tool or conveyor stops automatically
- The process cannot proceed until the fastener is correctly tightened, preventing loose or damaged assemblies.

- **APPLICATIONS:**
- Automotive Industry:
 - Engine assembly
 - Wheel lug tightening
 - Chassis and suspension bolts
 - Airbag and safety component fastening
- Two-Wheeler
 - Manufacturing
 - Frame assembly
 - Brake system fastening
- Heavy Machinery
 - Structural bolt tightening
 - Hydraulic system assembly
- Electronics Industry
 - PCB mounting screws
 - Laptop/mobile assembly
- Medical Devices
 - Surgical equipment assembly
 - Precision instrument fastening

- Aerospace
Aircraft structural fastening
Critical component assembly

3. WARNING AND SIGNALING SYSTEM

Feedback and warnings to operators or management. These systems aim to make errors visible as soon as they occur, enabling prompt corrective action. While some error-proofing systems physically prevent error, others provide immediate.

- Andon lights
Originating from the Toyota production system, Andon lights are visual signaling systems on the production floor. Different colors indicate the status of a workstation (e.g. green for normal, yellow for attention needed, red for problem/ stop).
- The production line is continuously monitored through sensors, machines, or manual inputs for quality or process abnormalities.
- When a defect, quality issue, or abnormal condition occurs, the system is triggered automatically or by the operator.

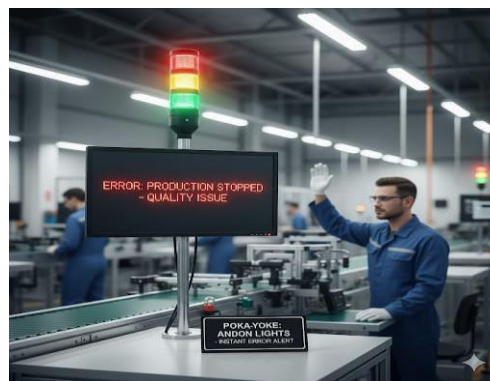


Fig 0.8

- The screen shows a clear message such as ERROR: PRODUCTION STOPPED-QUALITY ISSUE, making the problem visible to everyone on the shop floor.
- The line stops (or slows), supervisors and maintenance teams are alerted, and corrective action is taken before production resumes.

APPLICATION

- Assembly lines for engines, parts fitting, welding.
- PCB assembly, component placement.

- Detects missing labels or improper sealing.
- Alerts for contamination or machine malfunction.
- Ensures correct dosage and packaging.
- Detects thread breakage or machine stoppage.
- Indicates tool wear or process failure.

- Digital interlocks / software controls

In modern manufacturing, software plays a crucial role. Digital interlocks prevent an operator from proceeding to the next step or completing a task until specific data is entered, a barcode is scanned, or a previous step is confirmed as complete.



Fig 0.9

- The system is programmed so that each component or product must be scanned (barcode/ QR code / RFID) at a specific stage.
- The operator scans the component using a handheld barcode scanner.

The scanned code is sent to the system controller or EMS (manufacturing execution system).

- The system checks: correct part number, correct sequence / model, lot or batch validity
- Correct scan- system unlocks the process and allows the conveyor or machine to run.
- Wrong / missing scan -screen shows ERROR: BARCODE SCAN REQUIRED, red light turns ON, and the process remains locked.
- The line cannot proceed until the correct barcode is scanned, preventing wrong part usage or mix-ups.

• APPLICATIONS:**• Automobile Industry**

Engine assembly verification

Part number confirmation

• Electronics Manufacturing

PCB component validation

Serial number tracking

• Pharmaceutical Industry

Batch number verification

Correct packaging confirmation

• Food Processing Industry

Label verification

Expiry date validation

• Warehouse & Logistics

Inventory tracking

Shipment verification

• Medical Device Manufacturing

Component traceability

Compliance verification

Advantages:

- Error is detected and corrected immediately, preventing defective products from moving to the next stages.
- Consistent processes lead to fewer defects and higher quality output.
- Early error detection minimizes material loss and reprocessing costs.
- Less time is spent on inspections, corrections, and customer complaints.
- Delivering defect free products builds trust and long-term customer relationships.
- Error proofs system reduces human mistakes that can cause accidents.
- Simple, foolproof systems reduce dependence on highly skilled labor.^[9,10]

Applications:

- Fixtures and guides prevent incorrect part placement or wrong orientation.
- Sensors detect missing, extra, or wrongly assembled components.
- Interlocks ensure operations are performed in the correct order.
- Vision systems and sensors automatically detect defects in real time.
- Barcoding, QR codes, and RFID prevent wrong material usage.^[11,12]

CONCLUSION

Error proofing (Poka yoke) is a vital approach in enterprise quality management that correcting them immediately, organizations can ensure consistent product quality, reduce waste, and improve operational efficiency. Error proofing systems enhance customer satisfaction, improve workplace safety and empower employees by making processes simpler and more reliable. Overall, the application of error proofing supports continuous improvement, cost reduction, and long-term competitive advantage, making it an essential element of effective enterprise quality management.

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