

“Study and Quality Analysis of Tail Light Assembly, Cluster Sub-Assembly and Production Assembly Line for Electric Scooters and Bikes:of Kinetic India Pvt Ltd, Ahilyanagar.”

Shreyash Rajendrakumar Sulakhe¹, Gaurav Rajendra Shahane², Dr. Ramesh Suryabhan Gadakh³

¹ Student, Department of Mechanical Engineering Sau Sundarbai Manik Adsul Polytechnic, Chas, Ahilyanagar, India

²Guide, Department of Mechanical Engineering Sau Sundarbai Manik Adsul Polytechnic, Chas, Ahilyanagar, India

³Principal Sau Sundarbai Manik Adsul Polytechnic, Chas, Ahilyanagar, India

Abstract

The electric two-wheeler industry is rapidly developing in India due to increasing demand for energy-efficient, low-emission and economical transportation. Manufacturing electric scooters and bikes involves several precision assembly operations in which production efficiency and quality control play an important role. This research paper presents a case study of selected assembly operations associated with electric two-wheelers at **Kinetic, Ahilyanagar**, with particular emphasis on **tail light assembly, cluster sub-assembly, quality inspection and the vehicle assembly line**.

The study examines the sequence of operations, material handling, component fitment, fastening, electrical connections, inspection procedures and final quality verification. Tail light assembly requires correct positioning, connector engagement, fastening and functional testing. Cluster sub-assembly requires proper mounting of the instrument cluster, electrical connector connection, display verification and dimensional alignment. The assembly line integrates these sub-assemblies with other vehicle systems such as the chassis, battery, motor, wiring harness, brakes, suspension and body panels.

Quality-control techniques such as **Poka-Yoke, visual inspection, torque control, functional testing, first-pass inspection, defect analysis and traceability** can be used to reduce assembly defects. The study identifies important quality parameters and suggests improvements in workstation ergonomics, standardized work instructions, error-proofing, digital traceability and end-of-line testing.

Keywords: Electric Scooter, Electric Bike, Kinetic, Ahilyanagar, Tail Light Assembly, Cluster Sub-Assembly, Assembly Line, Quality Control, Poka-Yoke, Production Management.

1. Introduction

Electric vehicles have become an important part of the modern automotive industry. Electric scooters and bikes require integration of mechanical, electrical and electronic components. Unlike conventional two-wheelers, electric vehicles contain additional systems such as batteries, Battery Management Systems, motor controllers, electric motors and electronic instrument clusters.

The manufacturing process therefore requires accurate assembly and systematic quality inspection. Kinetic Engineering has a manufacturing facility at Ahilyanagar with capabilities associated with two-wheelers and automotive components. The company has also reported modernization of its manufacturing operations, including automation and robotic systems. These developments make the facility a relevant industrial case for studying production and quality practices.

This research focuses specifically on:

1. Production assembly line
2. Tail light assembly
3. Cluster sub-assembly
4. Quality inspection
5. Assembly-line productivity
6. Defect prevention

2. Objectives

The main objectives of this study are:

1. To study the production assembly line of electric scooters and bikes.
2. To understand the sequence of vehicle assembly operations.
3. To study the tail light assembly process.
4. To study the cluster sub-assembly process.
5. To identify critical quality parameters in these operations.

6. To study inspection and testing methods.
7. To identify common assembly defects.
8. To study the application of Poka-Yoke in assembly operations.
9. To suggest methods for improving production efficiency and quality.
10. To develop a systematic quality-improvement approach for electric two-wheeler assembly.

3. Organization Profile – Kinetic, Ahilyanagar

Kinetic Engineering Limited has a manufacturing presence in Ahilyanagar, Maharashtra. The manufacturing infrastructure supports automotive and two-wheeler-related production activities.

The facility includes manufacturing and assembly capabilities supported by various production machines, fixtures, inspection equipment and quality systems.

The manufacturing environment involves activities such as:

- Component manufacturing
- Fabrication
- Welding
- Painting
- Sub-assembly
- Vehicle assembly
- Inspection
- Testing
- Quality control

For electric two-wheelers, the manufacturing system requires integration of mechanical and electrical assemblies.

4. Research Methodology

The research methodology consists of the following stages:

Industrial Study

↓

Process Observation

↓

Identification of Assembly Operations

↓

Tail Light Assembly Study

↓

Cluster Sub-Assembly Study

↓

Quality Inspection Study

↓

Defect Identification

↓

Production & Quality Analysis

↓

Improvement Recommendations

The study can use both primary and secondary information.

4.1 Primary Data

Primary information may be collected through:

- Industrial observation
- Discussions with production engineers
- Discussions with quality engineers
- Operator interaction
- Workstation observation
- Inspection-process observation
- Assembly-line study

4.2 Secondary Data

Secondary information can be collected from:

- Company publications
- Technical papers
- Automotive standards
- Research journals
- EV manufacturing literature
- Quality-management references

5. Electric Two-Wheeler Production Assembly Line

A generalized electric scooter/bike assembly sequence is:

Chassis → Battery → Motor/Powertrain → Suspension → Wheels → Wiring Harness → Tail Light → Cluster → Body Panels → Seat → Controls → Final Assembly → Electrical Inspection → Functional Testing → End-of-Line Inspection

The actual sequence may vary according to the vehicle model and production-line layout.

5.1 Major Assembly Stations

Station Assembly Operation

- Station 1 Chassis preparation
- Station 2 Suspension assembly
- Station 3 Wheel and tyre assembly
- Station 4 Motor/powertrain assembly
- Station 5 Battery installation
- Station 6 Wiring harness installation
- Station 7 Tail light assembly
- Station 8 Cluster sub-assembly
- Station 9 Body-panel assembly
- Station 10 Seat and accessories
- Station 11 Electrical connection
- Station 12 Functional inspection
- Station 13 End-of-line testing
- Station 14 Final quality inspection

6. Tail Light Assembly

The tail light is an important safety component of an electric two-wheeler. It provides visibility to vehicles approaching from the rear and may incorporate:

- Tail lamp
- Brake lamp
- Turn indicators
- Reflector
- Housing
- Lens
- Electrical connector
- Mounting screws/fasteners

6.1 Tail Light Assembly Process

The general assembly sequence is:

Tail Light Housing



LED/Lamp Module Installation



Lens Installation



Connector Connection



Mounting on Vehicle



Fastening



Visual Inspection



Electrical Functional Test

6.2 Tail Light Assembly Operations

Step 1 – Component Verification

The operator verifies:

- Correct part number
- Correct model
- Housing condition
- Lens condition
- Connector condition

Step 2 – Lamp Module Installation

The LED/lamp module is correctly positioned inside the housing.

Step 3 – Lens/Housing Assembly

The lens is assembled with the housing.

Important checks include:

- Proper seating
- No gap
- No crack
- No deformation

Step 4 – Connector Connection

The electrical connector is connected to the vehicle wiring harness.

The connector should be completely engaged.

Step 5 – Mounting

The tail light assembly is positioned on the rear portion of the vehicle.

Step 6 – Fastening

Specified fasteners are tightened using the appropriate tool.

Torque control is important to prevent:

- Loose assembly
- Excessive tightening
- Component damage
- Vibration-related failure

Step 7 – Functional Testing

The tail light is checked for:

- Tail-light operation
- Brake-light operation
- Indicator operation, where applicable
- Illumination
- Connector function

7. Tail Light Quality Parameters

Parameter	Quality Requirement
Housing	No cracks or deformation
Lens	No scratches/cracks
Mounting	Correct position
Connector	Fully engaged
Fastener	Correct torque
Illumination	Uniform
Brake light	Correct operation
Indicator	Correct operation
Wiring	Proper connection
Appearance	No visible defect

8. Common Tail Light Assembly Defects

Possible defects include:

1. Wrong component fitted
2. Loose connector
3. Improper lamp positioning
4. Lens damage
5. Incorrect fastening
6. Loose mounting
7. Light not functioning
8. Wiring connection error
9. Misalignment
10. Gap between housing and body

8.1 Defect Prevention

These defects can be reduced through:

- Poka-Yoke fixtures
- Part-number verification
- Connector-specific design
- Torque-controlled tools
- Visual work instructions
- Functional testing
- Operator training
- First-piece inspection

9. Cluster Sub-Assembly

The instrument cluster is an important electronic interface between the vehicle and rider.

Depending on the vehicle model, the cluster may display:

- Vehicle speed
- Battery state of charge
- Warning indications
- Turn indicators
- Headlight indication
- Charging information
- Riding mode

- Error/warning codes
- Odometer/trip information

9.1 Cluster Sub-Assembly Process

Cluster Housing

↓

Display/PCB Assembly

↓

Lens Installation

↓

Connector Installation

↓

Bracket/Fastener Assembly

↓

Vehicle Mounting

↓

Electrical Connection

↓

Display Testing

10. Cluster Quality Inspection

Important inspection parameters include:

Mechanical Inspection

- Housing condition
- Lens condition
- Mounting alignment
- Fastener condition
- Gap and flushness

Electrical Inspection

- Connector engagement
- Power supply
- Display operation
- Indicator operation
- Warning indication
- Communication with vehicle controller

Visual Inspection

The following defects should be checked:

- Scratches
- Cracks
- Dust
- Display defects
- Misalignment
- Loose components
- Uneven gaps

11. Cluster Sub-Assembly Defects

Possible defects include:

Defect	Possible Cause
Display not working	Electrical connection problem
Flickering display	Loose connector
Wrong display information	Communication/software issue
Scratched lens	Improper handling
Misalignment	Incorrect mounting
Loose cluster	Incorrect fastening
Warning indication failure	Electrical/electronic fault

12. Quality Control on Assembly Line

Quality should be controlled at three levels:

12.1 Incoming Quality Control

Components are inspected before entering production.

12.2 In-Process Quality Control

Quality is checked during assembly.

Examples:

- Connector check
- Torque check
- Component orientation
- Visual inspection
- Functional test

12.3 End-of-Line Quality Control

The completed vehicle is inspected and tested.

13. Poka-Yoke Applications

Poka-Yoke means **mistake-proofing**.

Possible applications include:

Tail Light

- Connector mismatch prevention
- Fixture-based positioning
- Part-presence sensors
- Torque confirmation

Cluster

- Model-specific mounting fixture
- Connector orientation control
- Barcode verification
- Display functional test

Assembly Line

- Component identification
- Digital work instructions
- Sensor-based confirmation
- Automatic torque recording

14. Quality Control Tools

14.1 Check Sheet

A check sheet can be used to record assembly defects.

Example:

Defect	Quantity
Loose connector	___
Wrong part	___
Improper torque	___
Light failure	___
Cluster display problem	___
Scratches	___
Misalignment	___

Actual production data should be entered from authorized industrial records.

15. Pareto Analysis

If defect data are available, Pareto analysis can identify the major causes of quality problems.

For example:

Total Defects → Classification → Ranking → Major Defect Identification → Corrective Action

The objective is to focus improvement efforts on the few defect categories responsible for the largest proportion of total defects.

16. Fishbone Analysis

A fishbone diagram can investigate assembly defects under:

Man

- Operator skill
- Training
- Fatigue

Machine

- Tool condition
- Fixture condition
- Torque-tool calibration

Method

- Incorrect sequence
- Inadequate work instructions

Material

- Wrong component
- Damaged component

Measurement

- Incorrect inspection
- Uncalibrated instrument

Environment

- Lighting
- Workplace arrangement
- Temperature/dust

17. Production Efficiency

Production efficiency can be evaluated using:

$$\left[\frac{\text{Production} \backslash \text{Efficiency}}{\text{Production} \backslash \text{Planned}} \times 100 \right]$$

For assembly-line quality:

$$\left[\frac{\text{Rejection} \backslash \text{Rate}}{\text{Vehicles} \backslash \text{Total} \backslash \text{Vehicles} \backslash \text{Produced}} \times 100 \right]$$

First Pass Yield:

$$\left[\frac{\text{Vehicles} \backslash \text{Passing} \backslash \text{First} \backslash \text{Time}}{\text{Vehicles} \backslash \text{Total}} \times 100 \right]$$

These calculations should be performed using actual production data collected with permission from the organization.

18. Assembly Line Balancing

Assembly-line balancing is important for maintaining smooth production.

The basic objective is:

Balanced Work Content → Reduced Waiting → Improved Line Efficiency → Higher Productivity

If one workstation requires significantly more

time than the other stations, it can become a bottleneck.

For example:

Workstation	Operation	Cycle Time
WS1	Chassis preparation	___ sec
WS2	Battery installation	___ sec
WS3	Wiring	___ sec
WS4	Tail light assembly	___ sec
WS5	Cluster assembly	___ sec
WS6	Body assembly	___ sec
WS7	Testing	___ sec

Actual cycle-time values should be measured during the industrial study rather than assumed.

19. Quality Improvement Recommendations

The following improvements are recommended:

1. Use standardized work instructions at every workstation.
2. Use torque-controlled fastening tools.
3. Introduce connector Poka-Yoke.
4. Use barcode/QR-based component traceability.
5. Implement 100% functional testing of critical electrical components.
6. Maintain inspection check sheets.
7. Perform regular fixture inspection.
8. Calibrate measuring and torque equipment periodically.
9. Implement first-piece approval.
10. Record defects digitally.
11. Conduct Pareto analysis periodically.
12. Apply 5S at assembly workstations.
13. Improve operator ergonomics.
14. Use visual management boards.
15. Implement Kaizen for repetitive assembly problems.

20. Proposed Quality Improvement Model

The proposed model is:

Component Inspection

↓

Standardized Assembly

↓

Poka-Yoke

↓

Torque Verification

↓

Electrical Functional Test

↓

Visual Inspection

↓

End-of-Line Test

↓

Defect Data Collection

↓

Pareto/Fishbone Analysis



Corrective Action



Continuous Improvement

21. Expected Results

Implementation of systematic production and quality-control practices is expected to provide:

- Reduction in assembly defects
- Reduction in rework
- Reduction in rejection
- Improved first-pass yield
- Improved assembly consistency
- Better electrical reliability
- Improved traceability
- Reduced operator error
- Improved production efficiency
- Improved customer satisfaction

The actual percentage improvement should be calculated only from genuine before-and-after production data.

22. Discussion

Tail light and cluster assemblies may appear to be relatively small operations compared with the complete vehicle assembly process; however, both are important for vehicle safety, functionality and customer perception.

The tail light requires correct mechanical positioning and reliable electrical connection. The cluster requires both mechanical assembly accuracy and electrical/electronic functionality. Therefore, inspection at the workstation can prevent defects from moving to subsequent assembly stations.

A combination of **standardized work, Poka-Yoke, torque control, visual inspection and functional testing** can provide an effective quality-control system.

For an industrial research study at Kinetic, Ahilyanagar, actual production-line data can further strengthen the analysis by comparing cycle time, defect rate, rework, rejection and first-pass yield before and after implementation of improvement measures.

23. Conclusion

This research presents a study of production and quality practices associated with electric scooters and bikes, focusing on **tail light assembly, cluster sub-assembly and the vehicle assembly line** at Kinetic, Ahilyanagar.

The study demonstrates that quality cannot be achieved only through final inspection. It must be built into every stage of the production process. Correct component identification, standardized assembly, controlled fastening, connector verification, functional testing and end-of-line inspection are essential for reliable

electric two-wheelers.

Tail light assembly requires particular attention to mounting, connector engagement, fastening and illumination testing. Cluster sub-assembly requires accurate mechanical mounting and verification of electronic functionality.

The integration of **Poka-Yoke, 5S, Kaizen, standardized work, torque monitoring, digital traceability, SPC and systematic defect analysis** can help improve both production efficiency and product quality.

Future research should use actual Kinetic production data to quantify improvements in **cycle time, rejection rate, first-pass yield, rework, defects per vehicle and assembly-line efficiency**.

References

1. Kinetic Engineering Limited, manufacturing and infrastructure information.
2. Kinetic Engineering Limited, company publications and investor information.
3. Automotive Industry Action Group, *Advanced Product Quality Planning (APQP)*.
4. Automotive Industry Action Group, *Production Part Approval Process (PPAP)*.
5. ISO, *ISO 9001 – Quality Management Systems*.
6. IATF, *IATF 16949 – Quality Management System Requirements for Automotive Production and Relevant Service Parts Organizations*.
7. Automotive and electric-vehicle manufacturing research literature.
8. Technical literature on electric two-wheeler production and battery-electric vehicle systems.