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Problem Solving and Dok Improvementin in Engine Shop"A“Skoda Auto Volkswagen India Pvt Ltd

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Abstract:

In today’s competitive manufacturing environment, maintaining precision, efficiency, and quality in production processes is critical to achieving organizational success. The automotive industry, particularly in engine assembly, demands adherence to stringent quality standards due to the vital role that engines play in vehicle performance and safety. This project, titled Process and DOK Improvement in Engine Shop by Using Vision System, addresses a significant operational challenge: the incorrect sequencing of engine part fitment during assembly

Additionally, the project serves as a benchmark for leveraging automation and vision systems in manufacturing, paving the way for further advancements in quality control and process optimization. The success of this initiative demonstrates the importance of investing in technology-driven solutions to resolve complex production challenges and achieve long-term operational excellence.

In conclusion, the Process and DOK Improvement in Engine Shop by Using Vision System project highlights the transformative potential of integrating advanced vision systems into manufacturing processes. It underscores the value of innovation in driving cost efficiency, improving product quality, and enhancing overall business performance. The lessons learned from this project can be extended to similar challenges in other production environments, reaffirming the role of technology as a key enabler of success in modern manufacturing.

Keywords:

Assembly, Engine, Operations, Quality, Productivity

Introduction:

This project, titled Process and DOK Improvement in Engine Shop by Using Vision System, focuses on addressing the challenges associated with maintaining the correct sequence of engine part fitment during the assembly process.

Prior to the implementation of this project, the engine assembly process faced significant issues due to the incorrect sequence of part fitment. This oversight went undetected until the end of the assembly line, resulting in engine faults such as damage or seizure. The impact of this issue was substantial, encompassing wasted resources, extended production timelines, increased rework costs, and the potential for customer dissatisfaction.

The traditional methods of manual inspection and reliance on operator accuracy were insufficient to address these challenges effectively. Human error, coupled with the complexity of modern engine designs, made it difficult to consistently ensure proper fitment sequences. As a result, the manufacturing unit experienced frequent disruptions, reduced efficiency, and increased operational costs.

This initiative underscores the importance of leveraging advanced technologies such as vision systems in modern manufacturing environments. It highlights how automation can effectively address operational challenges, enhance process accuracy, and contribute to achieving organizational objectives.Moving forward, the success of this project serves as a foundation for further advancements in assembly line automation and quality control, demonstrating the potential for similar applications across other areas of the production process.

Research Objectives:

- Identifying a system capable of detecting part fitment errors in real-time & Eliminating the possibility of undetected errors progressing through the assembly line.
- Reducing costs associated with rework, scrap, and production delays & Enhancing overall assembly process efficiency and product quality.
- To understand Engine Shop processes & to identify the potential causes of the problem by Fishbone analysis.
- To identify critical issues, this affects the DOK of Engine Shop & analyses the critical issues thoroughly.
- To define actions on potential causes & Plan to implement feasible actions in engine shop processes.
- To implement and execute the actions on floor & to get the desired result once implementation done.
- To sustain the result the result with future plans & to improve the DOK of Engine shop.
- To offer valuable suggestions to improve the process further.

Problem Statement:

Before the implementation of this project, the engine assembly process at the engine shop was plagued by errors in part sequencing. These errors were often undetected until the end of the production process, resulting in engine damage or seizure. This not only compromised product quality but also caused significant financial losses due to scrap, rework, and extended production timelines.

The lack of an effective system for real-time error detection created a dependency on manual inspections, which were prone to human error and inefficiency. As a result, the organization faced the following challenges:

- Increased costs due to rework and damaged components.
- Wasted production time caused by the late detection of sequencing errors.
- Operational inefficiencies that hampered overall productivity and throughput.
- Risks to brand reputation and customer satisfaction due to compromised engine quality

Literature Review:

1. Overview of COGNEX Vision Systems in Manufacturing:
COGNEX Vision Systems are widely recognized for their ability to improve quality control and operational efficiency in manufacturing processes. These systems leverage advanced image processing and machine vision algorithms to detect defects, verify part dimensions, and ensure correct assembly sequencing. The application of such systems in an engine shop addresses critical challenges, such as the prevention of incorrect part sequencing, reduction of manual inspection errors, and improvement in cycle time.

2. Challenges in Engine Shop Operations

Engine shop processes often involve handling a high volume of parts and assemblies with stringent quality standards. Key challenges include:
•Managing a diverse range of part types.
•Ensuring correct part orientation and sequence during assembly.
•Avoiding errors that could lead to costly rework or production downtime.

Past studies highlight the risks of human error in manual operations and the need for automation to ensure consistent performance.

3. DOK in Engine Shop Operations

The concept of DOK emphasizes the extent of knowledge required to perform specific tasks in manufacturing. Improving DOK involves:
•Standardizing processes to minimize variability.
•Using technological aids to augment operator decision-making.
•Enhancing training programs to increase proficiency in operations.
The integration of COGNEX Vision Systems supports DOK improvement by providing real-time feedback and error-proofing mechanisms.

4. Vision Systems in Sequence Validation

One of the critical applications of COGNEX Vision Systems is sequence validation, where the system ensures that parts are assembled in the correct order. Literature highlights:
•Error-proofing (Poka-Yoke): Vision systems act as a safeguard against incorrect assembly sequences by identifying anomalies in real time.
•Process Traceability: By capturing and storing images of each stage, these systems improve traceability and support quality audits.
•Cost Efficiency: Studies show a significant reduction in costs associated with defective assemblies and customer returns when vision systems are implemented.

5. Benefits of Vision-Based Automation

Numerous case studies in manufacturing domains have shown measurable benefits of vision-based automation, such as:
•Improved throughput by reducing manual inspection bottlenecks.
•Enhanced consistency and reliability in process outcomes.
•Faster detection and resolution of defects or process deviations.

6. Limitations and Considerations

Despite the advantages, challenges in implementing COGNEX Vision Systems include:
•Initial cost of equipment and software integration.
•Calibration and maintenance requirements to ensure accuracy over time.
•The need for skilled personnel to manage and interpret data from the system.

7. Case Studies and Industrial Applications

•Automotive Sector: Successful implementations in engine shops have demonstrated how vision systems reduce error rates in sequencing and improve overall process efficiency.
•Aerospace and Electronics: These industries use vision systems for high-precision assembly and quality assurance, providing insights into best practices applicable to engine shop operations.

8. Future Directions

The integration of COGNEX Vision Systems with IoT and AI technologies is an emerging trend. Predictive analytics, combined with real-time vision data, can further enhance process efficiency and quality control.

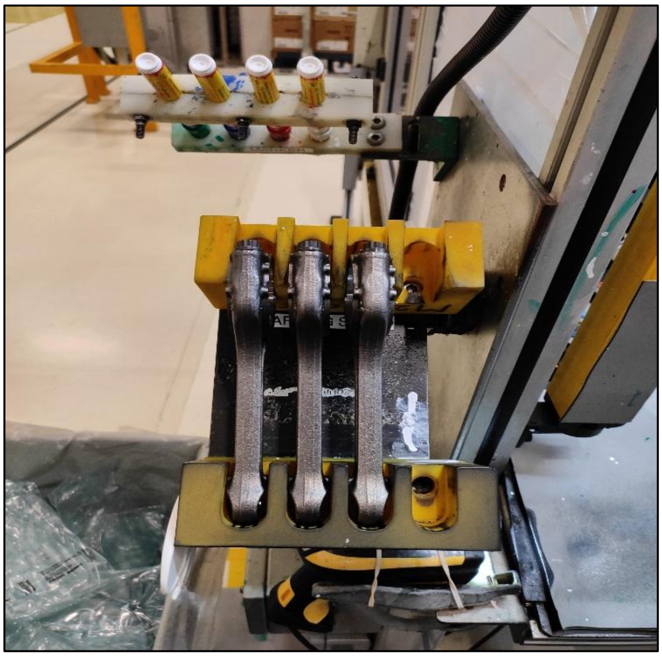
Collaborative robots (cobots) equipped with vision systems are also gaining traction for complex assembly tasks.

Research Methodology:

PROBLEM SOLVING AND DOK IMPROVEMENT IN ENGINE SHOP

Introduction:
The project is assigned by my project guide Mr. Bharat Patil & it is aimed to eliminate wrong sequencing or assembling the engine parts by implementing automation in the production process. The project is situated in zone 1 of the engine assembly, where the mechanical assembly is done that mainly includes engine piston assembly with connecting rod (con rod) and con rod cap. The piston assembly and subassembly area is the bottle neck area of the assembly line. As it is very important part of engine for smooth working.

Piston assembly Process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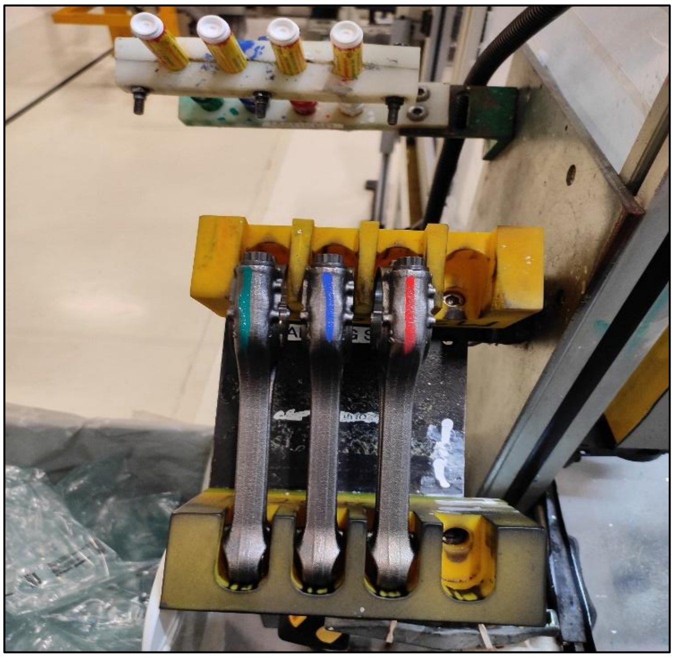

2.

In the context of **engine assembly** (before piston assembly), the breaking mechanism for the **con rod and con rod cap** is a critical step in preparing these components for installation. This process ensures that the rod and cap are perfectly mated and aligned when reassembled around the crankshaft journal.

Here's how this mechanism works step-by-step:

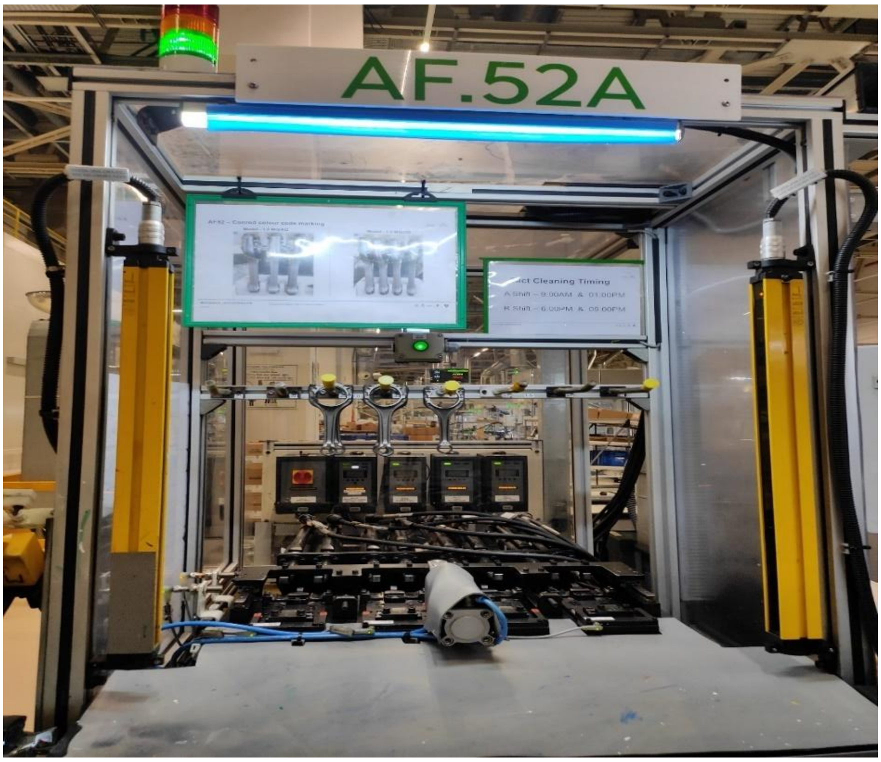
1. Post-Fracture Preparation: The connecting rod is initially manufactured as a single solid piece (Picture 1)

•Marking each rod and cap pair is marked to avoid mismatches during final assembly (Picture 2).

•A planned fracture method, typically fracture splitting, is used to separate the connecting rod into: Con Rod & Con Rod Cap

1. Fracture Splitting Mechanism (Pre-Piston Assembly)

Before assembling the piston, the connecting rod and cap must be separated through a controlled breaking process. We receive pre Grooved or notched connecting rod from supplier. The stress risers (small grooves or notches) are introduced at the desired fracture line. These grooves are precisely machined to create a pre-defined breaking point.



AF. 52 A Fracture Splitting Mechanism

The fracture splitting process typically involves the Hydraulic or Mechanical Press. A hydraulic or mechanical tool applies a sudden, controlled force at the con rod's weak points. The force causes the rod to fracture cleanly along the groove.

The mechanism ensures the fracture occurs cleanly without damaging the mating surfaces. The irregular, jagged fracture surface created ensures a perfect, unique fit between the rod and cap.

Connecting Rod & Cap after getting separate by Fracture Splitting Process

Benefits of Fracture Splitting Before Piston Assembly (as shown in the above images) The irregular fracture ensures the rod and cap can only be assembled in the correct orientation & with unique fit. It eliminates the need for additional machining of the mating surfaces. The jagged surface increases the mechanical strength of the joint, preventing slippage during operation.

Connecting Rod & Cap Bearing Fitment: Once the rod and cap are fractured and the bolts are loosen the next step is bearing insertion. Here for bearing installation the semi automatic machine is used with Pick to light mechanism.

The piston is then assembled to the upper part of the connecting rod using the Retaining clips or Cir Clips for locking the pins in place.

2. Pre Piston Assembly:
The piston is attached with con rod & the pre assembly setup is aligned for final piston assembly. After the piston assembly is complete, the con rod cap is unbolted again for installation around the crankshaft journal.

The Pre-assembled Piston and Con Rod with Cap set Is Kept in a way to identify the correct sequence for assembly. It is visually identified by checking the colour marking.

Pre Assembled Piston and Con Rod with Cap set Is Kept For Final assembly

Final Piston Assembly in the Engine

Piston & Con Rod Insertion and Con Rod Cap Tightening

The cap is then reattached with high-precision bolts and torqued to specification to ensure proper alignment and secure connection

3. Axial Play & Friction Test

This Process is done after piston assembly to measure the axial movement or clearance between the piston and its associated components (e.g., crankshaft, connecting rod, or bearing surfaces) and to assess the frictional resistance between the piston and its mating surfaces, such as the cylinder bore, under operating. The system moves the piston through its stroke while measuring axial displacement and frictional resistance using integrated force and displacement sensors. Real-time data acquisition and comparing with standard measurement. This method is ideal for quality control in manufacturing, enabling rapid testing with consistent results.

Data Analysis and Key Metrics:

This Process is done after piston assembly to measure the axial movement or clearance between the piston and its associated components (e.g., crankshaft, connecting rod, or bearing surfaces) and to assess the frictional resistance between the piston and its mating surfaces, such as the cylinder bore, under operating. The system moves the piston through its stroke while measuring axial displacement and frictional resistance using integrated force and displacement sensors. Real-time data acquisition and comparing with standard measurement. This method is ideal for quality control in manufacturing, enabling rapid testing with consistent results.
The study analyzed the impact of the COGNEX Vision System implementation using both quantitative and qualitative data.
Key Findings:

1. Quantitative Analysis:

- Error Rate Reduction: Errors decreased by 83%, from 12 to 2 per 100 assemblies, indicating significant accuracy improvement.
- Cycle Time: Average cycle time reduced by 16.7%, from 90 to 75 seconds per assembly, reflecting enhanced efficiency.
- Rework Instances: Daily rework instances dropped by 75%, from 20 to 5, minimizing downtime.

- Throughput: Production increased, demonstrating improved process performance.
- Cost-Effectiveness: The pre identification of defect has saved rework cost of engine.

2. Qualitative Analysis:

- Operator Feedback: 90% found the system user-friendly, 85% reported increased confidence, and initial challenges (10%) were resolved post-training.
- Supervisor Observations: Enhanced traceability and a 50% reduction in intervention due to streamlined workflows.
- Training Effectiveness: Correct sequencing rates improved from 65% pre-training to 95% post-training.

10. Interpretation:

- Error Reduction and Efficiency Gains: The system significantly reduced errors and rework while improving cycle time, throughput, and process quality.
- Knowledge Improvement: Training and real-time guidance improved operator competency and accuracy.
- Cost-Benefit: Financial analysis supports the system's cost-effectiveness and sustainability.
- User Satisfaction: Positive operator and supervisor feedback confirms acceptance and long-term feasibility.

Findings and Observations:

This section will try to highlight and discuss the results and the findings based on the analysis done on the data collected from Engine assembly line. The offline engine data collected, defect wise analysis done. This research focuses on the defects affecting DOK of engine assembly line in selected manufacturing company. The action has taken in the form of implemented project. Following are the findings during Research in Skoda Auto Volkswagen India Pvt. Ltd.

Most of the engines are offline after engine testing stations due to wrong sequence fitment of parts.

Only dependency of single source for ensuring quality and process is not sufficient. Process data must me saved to cross check the information if any failure observe in fiture.

Engine assembly process is the most important and sensitive part of whole automobile company & that needs to addressed carefully.

Maximum automation results in minimizing hardworking and maximizing smartness in the process.

Overall DOK is improved and Defects also reduced at satisfactory level during problem solving.

Implementation of fully new concept for the first time added lots of knowledge about various technologies.

By integrating this automated solution, the manufacturing unit achieved:

Early detection of errors: Faulty sequences were identified in real-time, preventing them from escalating into major issues. Cost savings: The elimination of end-of-line rework and scrap significantly reduced operational expenses. Improved efficiency: The streamlined process minimized downtime and enhanced productivity. Enhanced quality assurance: The system ensured compliance with assembly standards, leading to more reliable engine performance. Time Savings: Faults were addressed in real-time, preventing production delays and increasing through output. The implementation of the COGNEX vision camera system resulted in transformative improvements in the engine assembly process.

What does it mean by DOK?

DOK is mean by Direct Ok Product from unloading stations.

In this method without online or offline rework engine directly goes to car assembly line.

The KPI of Engine Shop is to achieve 95%+ DOK by December 2024.

DOK reduces the overall rework cost of Engine Shop.

Highest the DOK, efficient overall processes.

Formula of DOK:

DOK = Number of OK Components

Total Components Produced

How Automation Improves DOK Rates

Automation plays a significant role in enhancing DOK production rates through precision, consistency, and real-time feedback. That is:

1. Error Reduction: Automated systems, like vision inspection or robotic assembly, eliminate human error, ensuring parts are manufactured to exact specifications consistently. Example: Machine vision systems detect defects in real time, preventing faulty parts from progressing down the line.

2. Consistency: Robotics and automated machinery maintain uniformity across all products, significantly reducing variability that can lead to defects. Example: Robotic system ensures precision & improving part quality.

3. Process Optimization: Automation monitors and adjusts manufacturing parameters dynamically, ensuring optimal conditions for production. Example: Sensors in CNC machines automatically correct deviations in dimensions or surface finish.

4. Data-Driven Improvements: IoT-enabled devices collect data from every stage of production, identifying trends and areas of improvement for increasing DOK rates. Example: Predictive maintenance ensures machines are always in top condition, avoiding part failures caused by wear.

5. Enhanced Speed: Automation accelerates production cycles while maintaining or improving quality. Example: Automated conveyors and pick-and-place systems streamline the movement of parts to inspection areas.

Recommendations:

Though problem is resolved at some extent, still there are some suggestions and process recommendations I could able to find.

- Update the system software and firmware periodically for optimal performanceRebalancing of lines, work contents area sometimes necessary to strengthen the processes.

- Line side employee rotation, calibration is to be planned for skill up gradation.
- Systematic problem solving is to be carried out by team leaders and group leaders on daily basis.
- Perform routine calibration of the vision system to prevent drifts in accuracy. Clean cameras, lenses, and sensors regularly to avoid errors due to dirt or smudges.
- Consider utilizing Cognex systems for other assembly line checks, such as bolt tightening or gasket placement, for comprehensive quality control.Quick process audits are to be conducted internally to strengthen processes.
- Documentation part is to be improved to record even small improvements on shop floor processes which help to improve Productivity and Quality both.
- AP, SWS must be followed by employee on daily basis.
- This project has given me the opportunity to emerge as a result of this study and it has also helped me to bridge the gap between the theoretical knowledge and practical application at "SKODA AUTO VOLKSWAGEN INDIA PVT. LTD."

Conclusion:

Incorporating COGNEX Vision Systems into engine shop operations offers a robust solution for preventing wrong part sequences, enhancing DOK, and streamlining manufacturing processes. While initial implementation challenges exist, the long-term benefits in terms of quality, efficiency, and cost savings outweigh these concerns. Future research could explore further integration with Industry 4.0 technologies to unlock new levels of automation and intelligence in manufacturing processes.

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