# PISTON TAPERED CHECK AUTOMATION, O-RING DETECTION OF GEAR HOUSING AND MAINTENANCE DOWNTIME ANALYSIS DASHBOARD

*Project report submitted in partial fulfillment of the requirement for the degree of*

**BACHELOR OF TECHNOLOGY**

**IN**

**ELECTRONICS AND COMMUNICATION ENGINEERING**

By


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**UNDER THE GUIDANCE OF**

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**JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT**


**MAY 2023**

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# DECLARATION

I hereby declare that the work reported in the B. Tech Project Report entitled **"PISTON TAPERED CHECK AUTOMATION, O-RING DETECTION OF GEAR HOUSING AND MAINTENANCE DOWNTIME ANALYSIS DASHBOARD"** submitted at the **Jaypee University of Information Technology, Waknaghat, India** is an authentic record of my work carried out under the supervision of **Dr. Pardeep Garg & Executive Engineer Debdatta Panda.** I have not submitted this work elsewhere for any other degree or diploma.

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This is to certify that the above statement made by the candidates is correct to the best of my knowledge.

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# ACKNOWLEDGEMENT


Firstly, I express my heartiest thanks and gratefulness to Almighty God for his divine blessing in making it possible to complete the project work successfully.

I sincerely thank my supervisors, **Dr. Pardeep Garg, Assistant Professor,** Department of ECE, Jaypee University of Information Technology, Wakhnaghat, and **Debdatta Panda, Executive Engineer,** Tata Cummins Pvt. Ltd. and express our sincere gratitude to them. My supervisors have extensive knowledge of **"PISTON TAPERED CHECK AUTOMATION, O-RING DETECTION OF GEAR HOUSING AND MAINTENANCE DOWNTIME ANALYSIS DASHBOARD"** and have a keen interest in completing this project. This project has been made possible by their continual kindness, expert assistance, ongoing encouragement, frequent and vigorous supervision, constructive criticism, insightful counsel, reading several substandard versions, and fixing them at every level.

I would like to express our heartiest gratitude to **Dr. Pardeep Garg,** Department of ECE, and **Debdatta Panda, Executive Engineer,** Tata Cummins Pvt. Ltd, for their kind help to finish this project.

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Finally, I must acknowledge with due respect the constant support and patients of my parents.

Mukul Anand (191029)

# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| PLC | Programmable Logic Controller |
| OpenCV | Open Source Computer Vision |
| BI | Business Intelligence |
| LVDT | Linear Variable Differential Transformer |
| OEE | Overall Equipment Efficiency |
| VSM | Value Stream Mapping |
| ATP | Assembly Testing and Painting |
| I/O | Input/ Output |
| ROI | Region Of Interest |
| HULL | A convex curve around an object |
| MIS | Management Information Systems |

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# ABSTRACT

This paper presents a comprehensive solution for engine maintenance and downtime analysis using programmable logic controllers (PLCs), Python, OpenCV, and Power BI. Specifically, the paper focuses on three different aspects of engine maintenance, including engine piston tapered check, engine O-ring detection of gear housing, and a maintenance dashboard.

Optimizing engine performance is paramount for every mechanic tasked with maintaining machinery operations. One crucial task is conducting an engine piston tapered check accurately; otherwise, sub-optimal performance issues can arise. In line with this, we present a practical solution utilizing Programmable Logic Controllers (PLCs) that enables automation of the entire process while ensuring accurate measurement results through automatic report generation.

Engine O-ring detection is another important element that needs consideration during regular maintenance checks since leaks can lead to costly repairs or even worse situations such as accidents or breakdowns affecting operations significantly. Through integrating Python and OpenCV technology solutions towards detecting any irregularities promptly via processing captured images on your camera directly before carrying out corrective measures when necessary without delay.

Considering downtime analysis and periodic maintenance checks requires collating vast amounts of data from diverse sources simultaneously, making analysis cumbersome. This paper, however, proposes that Power BI offers a suitable maintenance dashboard tool towards streamlining the entire process by providing real-time data analytics that can support informed decision-making regarding machine performance, repair, and maintenance schedules. The reliability and longevity of any machine depend significantly on its upkeep and regular monitoring. Engine performance tracking through the use of a comprehensive maintenance dashboard has proven invaluable in preventive care management practices over time, saving companies resources while enhancing productivity. This study explores leveraging Power BI technology to develop such a smart system capable of proactively detecting anomalies in engines' functions for quick resolution before costly breakdowns occur. In conclusion, this paper proposes a comprehensive solution for engine maintenance and downtime analysis using PLCs, Python, OpenCV, and Power BI. The proposed solution is designed to streamline engine

maintenance tasks and improve engine performance. Moreover, the paper highlights the importance of modern technologies in engine maintenance to achieve optimal performance and efficiency.

# CHAPTER 1

# ABOUT THE COMPANY -TATA CUMMINS PVT. LTD.

## 1.1 CUMMINS INC.

Cummins is a global leader in the fields of engines, power systems, generators and components like turbochargers, electronics, and fuel systems etc. It established its first engine manufacturing facility in Pune in 1962 and has pledged not to look back since then on its upward curve. Following are the Mission, Vision, and Values which the form the pillars of the organization:

MISSION: ‘Making people’s lives better by powering a more prosperous world.’

VISION: Vision involves innovating for our customers to power their success

VALUES: Values related to the organization are:

INTEGRITY - Doing what you say you will do and doing what is right.

DIVERSITY AND INCLUSION - Valuing and including our differencesin decision making is our competitive advantage.

CARING - Demonstrating awareness and consideration for the well-beingof others.

EXCELLENCE - Always delivering superior results.

TEAMWORK - Collaborating across teams, functions, businesses and bor-ders to deliver the best work.

## 1.2 TATA CUMMINS PVT. LTD., JAMSHEDPUR


**Figure 1.1**: TATA CUMMINS PVT. LTD., JAMSHEDPUR

Two giants from the world of automobiles - Tata Motors and Cummins India - joined forces back in 1993 to create TATA Cummins. Its primary objective was to manufacture world class diesel engines with an emphasis on quality.

TATA Cummins Jamshedpur today caters to a diverse range of industries such as transportation (buses & lorries) construction machinery as well as emergency backup power systems for hospitals & other critical installations with its line up of 'B' 'C' 'L' series diesel engine models along with several other engine variants. The company boasts three state of the art manufacturing plants with two in Phaltan (Maharashtra) and one at Jamshedpur.

- Manufacturing Facilities: In Jamshedpur, Jharkhand, TATA Cummins Jamshedpur has a manufacturing site. The factory has a yearly production capability of more than 100,000 engines.
- Quality: TATA Cummins Jamshedpur is dedicated to upholding strict standards of quality. The business has put in place several quality management systems, earning

certifications for both ISO 9001 and ISO 14001 in the process.

- Sustainability: Sustainable manufacturing methods are also a priority for TATA Cummins Jamshedpur. The business has put into place programs to cut down on waste production and energy consumption, as well as an extensive system for environmental management.
- Collaboration: To create new technologies and products, TATA Cummins Jamshedpur works in conjunction with a variety of other businesses and institutions. For instance, the business and Bosch worked together to create cutting edge fuel in- ejection systems for diesel engines.

## 1.3 My Role at TATA CUMMINS PVT. LTD.

Roles and responsibilities assigned to me include:

- Attending daily morning meetings.
- Collecting the data I need for my projects, i.e., Automatic Piston Tapered Check and O-Ring Detection.
- Looking out for optimization and digitalization opportunities in the departmentas well as assembly lines.
- Observing all activities performed by the Line operators.
- Reporting my progress with my guide on daily basis.
- Segregating between Value-Added and Non-Value-Added activities to target and work upon loss and waste minimization, alongside improvement of capacity in the production lines.
- Engaging in weekly meetings with the Maintenance Department review the current state of production and defects in the line and reduction in downtime.

## 1.4 VALUE STREAM MAPS

### 1.4.1 CONCEPT

Value stream mapping is a Lean management tool that helps to visualize, evaluate, and improve each step of the supply of a good or service.

A Value Stream comprises the actions (value added and non-value added) currently required to get a product or service to the customer. Value Stream Maps help track the flow of material, information and process in assembly line or supply chain.

The whole movement of commodities, materials, or information from the supplier to the client is depicted by VSM, sometimes referred to as material or information flow mapping. The methodology for process improvement is included in both Six Sigma and Lean Six Sigma.

VSM entails drawing up a thorough map of all the crucial elements in your work process that are required to deliver value from beginning to end. You can quickly spot waste, inefficiencies, and areas for improvement by doing this.

By visualizing the value-adding and non-value-adding activities of a process, one can see where one might enhance it. This is the main goal of producing a value stream map.

### 1.4.2 ADVANTAGES

The following are some of the key advantages of value stream mapping:

- **Identifying and eliminating waste:** With the aid of VSM, one may more clearly identify the areas of your process where waste is building up, such as in waiting, overproduction, and pointless processing.
- **Visualizing the entire value stream:** A shared knowledge of the complete workflow is provided by the value stream map, which displays all the steps ina process, including the value-adding and non-value-adding activities.
- **Enabling continuous improvement:** VSM draws attention to the current process while focusing on its potential for improvement.
- **Making processes more efficient:** Efficiency of man, machine, money, energy as well as processes can be defined and engineered by use of Value Stream Maps.There is a concept of Overall Equipment Efficiency which is calculated by the formula:
- OEE= Availability*Performance*Quality of the equipment

Types of Losses can be characterized by the acronym DOWNTIME:

D - Defects

O - Overproduction

W – Waiting

N - Non-utilization of Employees

T – Transport

I – Inventory

M – Motion excess

E – Extra processing

### 1.4.3 ZONES OF VSM

There are broadly 4 zones in a Value Stream Map:

1. Information flow: The flow of information directs each process as to what to produce or perform in the upcoming steps.
2. Process boxes: In a value stream, process boxes depict the stages of product or service delivery. Because drawing a box for each process step would make the map cumbersome, use the process box to designate a single material flow area. When a process is disconnected, the process box pauses, halting the material flow.
3. Process data boxes: Process data boxes detail essential information and metrics about each step, including -
4. Cycle Time - The amount of time required by an operator to complete all work elements before replicating them.
5. Downtime - Time lost in scheduled or unplanned production stoppages.
6. Uptime - the percentage of time a machine is available in production.
7. Changeover time - The time necessary to set up a machine to manufacture a distinct product or part number.
8. Percentage complete and accurate - the proportion of finished goods in a given manufacturing stage that are free of defects and of perfect quality.
9. Availability - the duration of a process operation within a single shift, usually expressed in seconds.
10. Timeline Summary Statistics or Value-Stream Metrics: These are the statistical tools which help in summarizing the various metrics present in the value stream, such as:
    - Lead Time
    - Cycle Time
    - Deployment Frequency
    - Defects

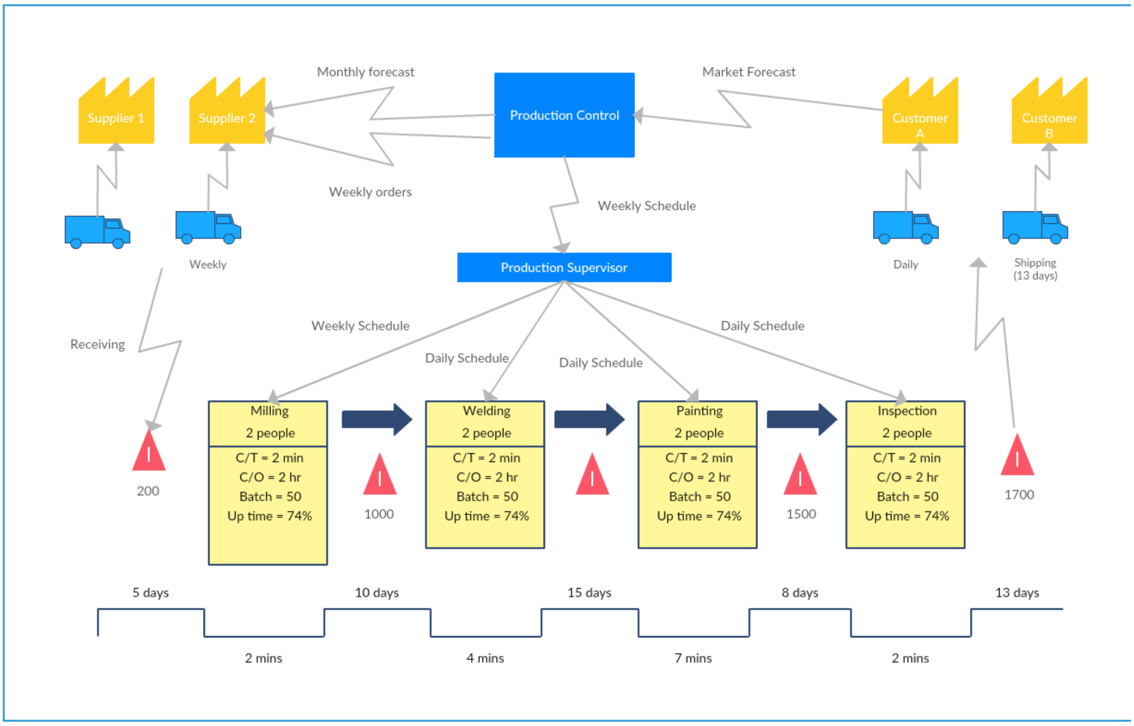



**Figure 1.3:** Sample Value Stream Map

## 1.4.4 VSM SYMBOLS

Standardized symbols are typically used when drawing value stream maps. While some symbols are essentially used everywhere, other elements have different symbols used by various organizations or sources. Different organizations use other identical symbols in different ways. These symbols can cater to three different typesof flow in a value stream:

- **Material Flow -** On top and side of the map.
- **Information Flow -** In the middle lines of the map.
- **Process Flow -** Middle and Bottom boxes of the map.

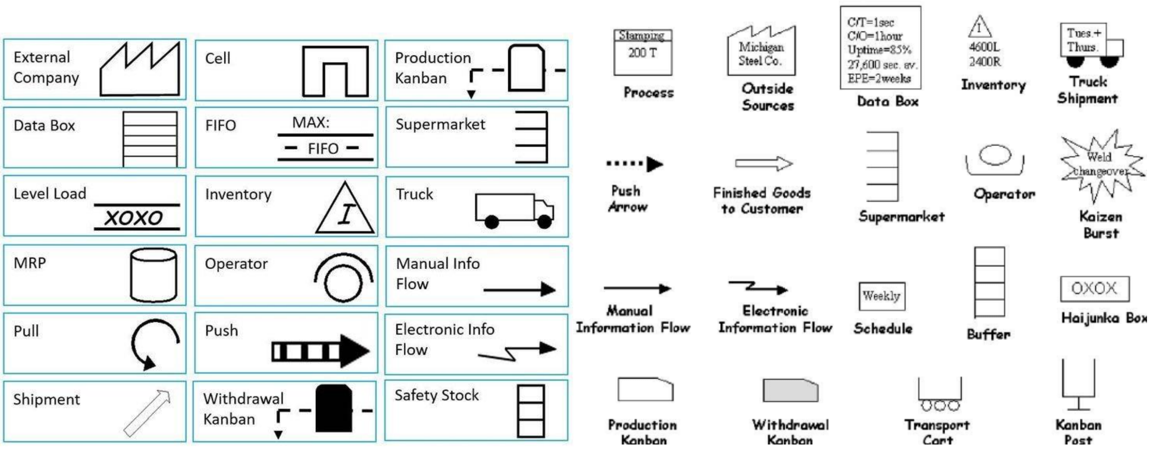


**Figure 1.4:** Value Stream Map Symbol

# Chapter 2

# ABOUT PRODUCT

## 2.1 ENGINE

Fundamentally an internal combustion engine fueled by diesel constitutes what is commonly known as a diesel engine. It involves compressing air inside a combustion chamber under immense pressure and heat before injecting fuel into this highly pressurized space area that eventually ignites due to excessive heat buildup resulting in piston movement which then produces force or power respectively. Diesel-powered machines have various merits attached to them such as higher efficiency rates compared to conventional counterparts alongside greater durability plus reliability when used for extended periods without break or malfunctioning issues arising. Hence forth crucial components constituting an operational diesel motor include: Major Parts of Engine are as follows:

- **Engine Block:** An engine block, also known as a cylinder block, is the main component of an internal combustion engine. It is typically made of cast iron oraluminum and houses the cylinders, which are responsible for converting fuel into mechanical energy. The engine block also contains various other components, including the crankshaft, camshaft, pistons, and connecting rods, all of which work together to create power.
- **Engine Head:** In an internal combustion engine, the cylinder head sits above the cylinders and forms the roof of the combustion chamber. In side-valve engines, the head is a simple sheet of metal; whereas in more modern overheadvalve and overhead camshaft engines, the cylinder head is a more complicated block often containing inlet and exhaust passages, coolant passages, valves, camshafts, spark plugs and fuel injectors.
- **Connecting Rod:** A connecting rod is a component of a piston engine that connects the piston to the crankshaft. It is typically made of steel or aluminum. It has a specific length and shape that allows it to transfer the motion of the pistonto the crankshaft. In a four-stroke engine, the connecting rod is responsible for converting the reciprocating motion of the piston into the rotational motion of the crankshaft.
- **CAM Shaft:** The camshaft is a mechanical component of an internal combustion engine. It opens and closes the inlet and exhaust valves of the engine at the right time, with the exact stroke and in a precisely defined sequence. The camshaft is driven by the crankshaft by way of gearwheels, a toothed belt ora timing chain. With a

transmission ratio of 2:1, the rate of rotation of the camshaft is half that of the crankshaft.

- **Crankshaft:** A crankshaft is a component in the transmission system which changes the reciprocating motion of the piston into rotational motion. This helps in achieving the rotational Power output from the reciprocating input given by the piston.

**Figure 2.1:** Engine

## 2.2 ENGINE BLOCK

The part responsible for housing indispensable aspects such as cylinders in an internal combustion machine is referred to as its engine block. Previous models were constructed using a separate cylinder case attached to another casing holding its crankshaft; however, current designs feature integrated parts where both are built together into one structure known as an "engine" or "block." These constructions often offer additional amenities like coolant fluid pathways or oil galleries for lubrication purposes within said structure's confines.

**Figure 2.2:** Engine Block

## 2.3 ATP Finish Line

ATP (Assembly, Testing, and Painting) is a crucial process in the manufacturing of various products, especially in the engine industry. Assembly involves putting together different components to create a finished product, while testing involves checking for functionality and quality assurance. Painting is the process of applying a protective and aesthetic coating to the finished product.

In the Engine industry, ATP is critical to ensuring that vehicles meet quality standards and are safe to operate. During the assembly phase, specialized machinery and skilled workers are utilized to fit various components together, transmissions, and engine block. After assembly, the finished engine undergoes rigorous testing to ensure that it meets safety standards and functions properly.

Once the Engine has passed testing, it undergoes the painting process, where a protective and aesthetically pleasing coat of paint is applied. This not only protects the Engine from environmental factors such as rust and corrosion but also improves its visual appeal.

Overall, ATP is an essential process in manufacturing, ensuring that the final product is of high quality, safe, and visually appealing.

# Chapter 3

## Piston Tapered Check Automation: PLC

## 3.1 Introduction

### 3.1.1 Background

Guaranteeing top-quality products is essential for manufacturers striving to meet industry standards. In automotive production, the engine piston serves as an indispensable component contributing to optimal vehicle performance. Its primary purpose involves transferring combustion pressure from fuel into energy by means of connected rotatory parts like crankshafts. To achieve peak engine efficiency demands correct placement and dimensions of pistons in relation to other engine elements such as blocks. Motor specialists traditionally used manual checks involving bore gauges; however, this system was inefficient due to errors induced by human factors and time constraints it imposed. Our proposed solution deploys LVDT sensors with PLC technology based on mutual induction principles aimed at addressing these drawbacks.

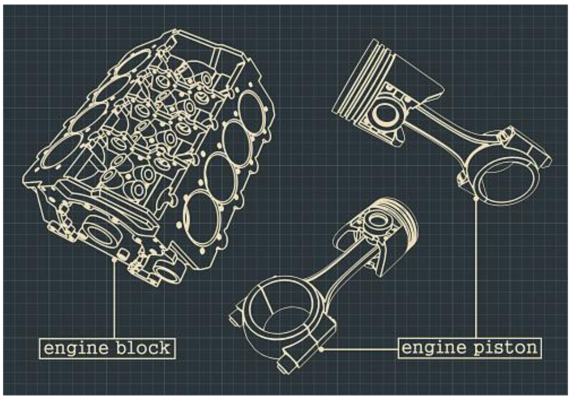



**Figure 3.1:** Engine Block & Piston

### 3.1.2 Problem Statement

**3.1.3** Manually gauging the distance between an engine block and its corresponding piston using a bore gauge dial presents significant drawbacks in terms of efficiency and accuracy. Notably this methods inability to accurately measure sub-10-micron distances makes it inherently flawed for high-precision work. Given these limitations, its evident that continuing with such manual practices will ultimately result in lower quality engine pistons.

### 3.1.4 Scope of the Project

The project's scope is to design and implement a system that uses an LVDT sensor to check the distance between the engine block and the piston. The system will be able to measure distances less than 10 microns accurately, making it more efficient than the manual process of using a bore gauge dial.

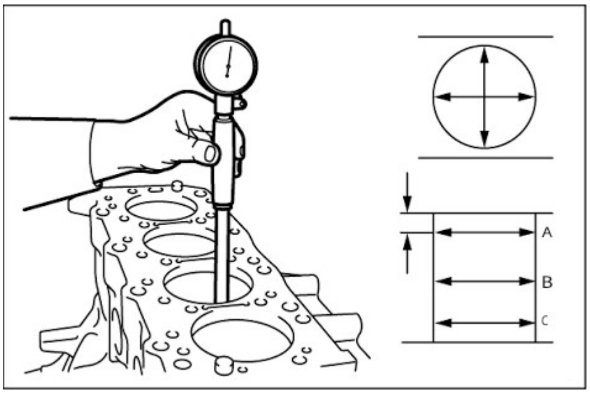



**Figure 3.2:** Checking With Bore Gauge Dial

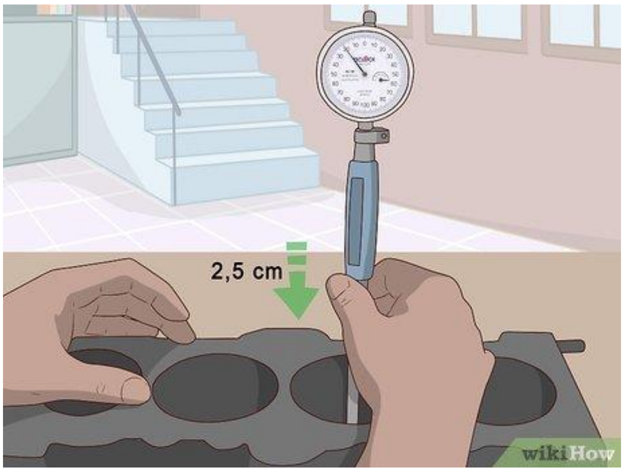



**Figure 3.3:** Checking for depth of block.

## 3.2 OBJECTIVE

To construct and implement an innovative system using an LVDT sensor for evaluating the space between the engine block and piston is what this initiative endeavors toward. The specific goals include:

- Initially creating an improved precision approach than utilizing bore gauge dials manually;
- In addition, fabricating equipment capable of computing distances greater than or equal to ten microns accurately;
- Additionally producing customer-friendly machinery which anyone can easily use;
- Finally developing dependable tools that have consistent outcomes.

## 3.3 IMPLEMENTATION

### 3.3.1 System Architecture:

Efficiency meets innovation thanks to our non-contact LVDT sensor working on mutual induction technology that measures distances between vital engine components such as blocks and pistons with remarkable accuracy essential for reliable readings during various procedures.

Acting as "the brains" of this system is our PLC, receiving LVDT sensor-generated signals before activating motorized actuators to perform specific movements repositioning engine components that are crucial for accurate measurement and testing purposes.

Our motorized actuator guarantees high-precision movement capabilities in its design, ensuring optimal positioning accuracy of critical engine parts such as pistons and blocks when measuring or testing.

Last but not least, our HMI interface delivers exceptional usability through an intuitive user experience delivering ease of use while being accessible even for novice operators allowing them to effortlessly interact with the sophisticated system interface.

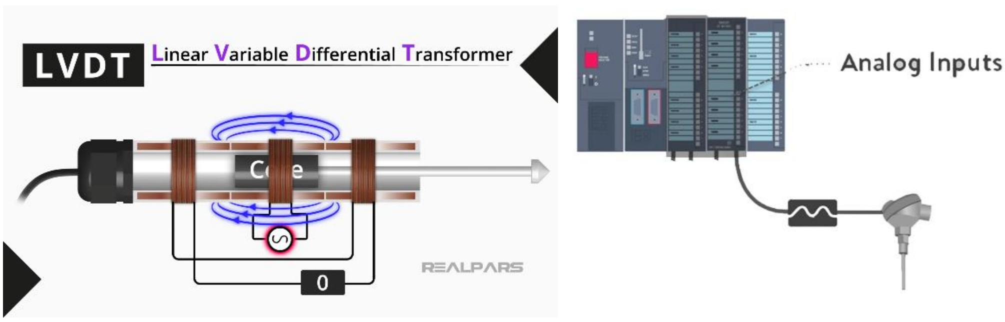



**Figure 3.4:** LVDT Sensor


**Figure 3.5:** PLC (S7 315-2PN/DP)

### 3.3.2 System Design:

1. LVDT Sensor: We selected an LVDT sensor that could measure distances less than 10 microns accurately.
2. PLC: Integrated the PLC into the system to control the motorized actuator and receive signals from the LVDT sensor.
3. HMI: We integrated the HMI into the system to provide a user-friendly interface for the operator.

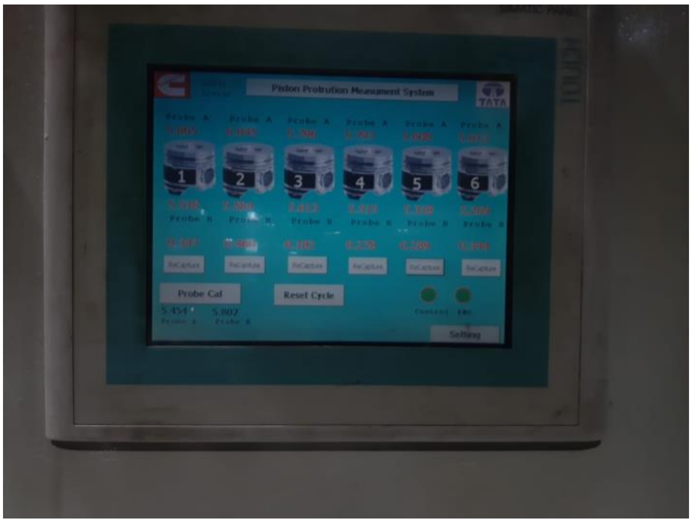



**Figure 3.6:** HMI

### 3.3.3 System Operation

Measuring engine piston displacement is made easy using an LVDT sensor: placed by operators onto the piston, it moves both it and the engine block into place for optimal measuring precision. The distant between them is then measured and sent as a signal to a PLC, which in turn directs a motorized actuator to appropriately adjust engine block positioning.

## 3.4 Result & Discussion:

The engine piston tapered check using an LVDT sensor which works on mutual induction through PLC was successfully implemented. The system automatically checks the distance between the engine block and piston and ensures it is less than 10 microns, eliminating the need for the manual process of bore gauge dial. The LVDT sensor accurately measures the piston taper and sends the data to the PLC for processing. The system is efficient and reliable, providing consistent and accurate measurements every time.

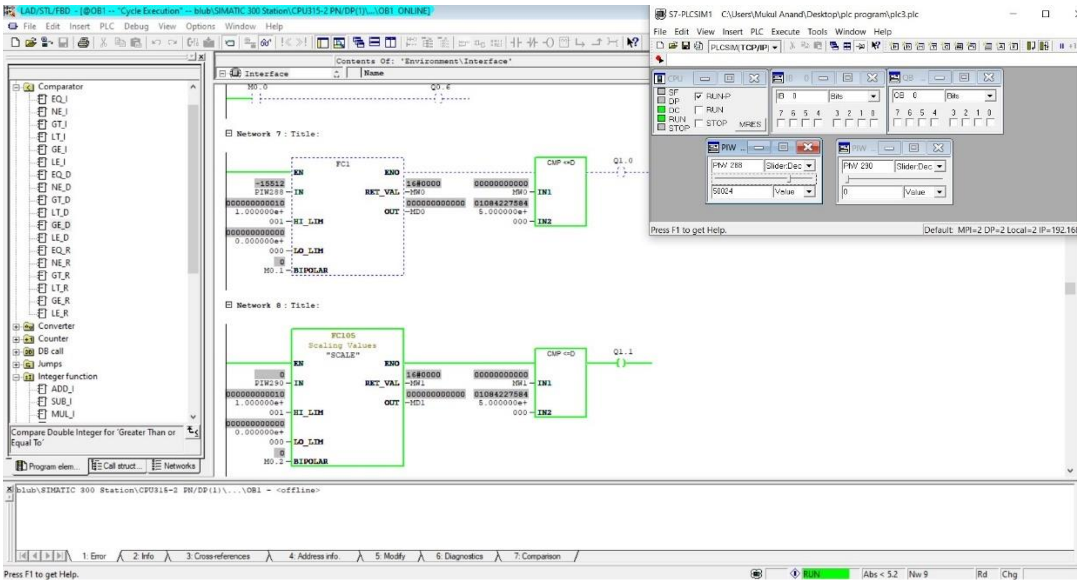


**Figure 3.7:** Ladder Logic

| Piston no. | Dial A | Dial B | Difference |
|---|---|---|---|
| 1 | 20 | 18.5 | 1.5 |
| 6 | 21.6 | 30 | 8.4 |
| 2 | 22 | 16.5 | 5.5 |
| 5 | 17.3 | 18 | 0.7 |
| 3 | 14.3 | 16.5 | 2.2 |
| 4 | 11 | 14.5 | 3.5 |
| | | | |
| 2 | 35 | 35 | 0 |
| 5 | 35 | 39 | 4 |
| 3 | 34 | 35 | 1 |
| 4 | 34 | 36 | 2 |
| 6 | 35 | 39 | 4 |
| 1 | 35 | 38 | 3 |
| | | | |
| 2 | 30 | 30 | 0 |
| 5 | 31 | 34 | 3 |
| 3 | 34 | 35 | 1 |
| 4 | 35 | 36 | 1 |
| 6 | 30 | 30 | 0 |
| 1 | 31 | 32 | 1 |

**Table 3.1:** Manual Process using Dial Gauge

| Automatic Process(LVDT) | | | |
|---|---|---|---|
| Piston no. | Probe A | Probe B | Difference |
| 1 | 5.518 | 5.865 | 0.347 |
| 2 | 6.045 | 5.584 | 0.461 |
| 3 | 5.613 | 5.796 | 0.183 |
| 4 | 5.515 | 5.793 | 0.278 |
| 5 | 5.787 | 5.521 | 0.266 |
| 6 | 5.781 | 5.469 | 0.312 |
| | | | |
| 1 | 2.219 | 5.83 | 3.611 |
| 2 | 2.28 | 5.885 | 3.605 |
| 3 | 2.28 | 5.813 | 3.533 |
| 4 | 2.24 | 5.859 | 3.619 |
| 5 | 2.292 | 5.877 | 3.585 |
| 6 | 2.35 | 5.784 | 3.434 |
| | | | |
| 1 | 2.234 | 5.741 | 3.507 |
| 2 | 2.257 | 5.784 | 3.527 |
| 3 | 2.251 | 5.845 | 3.594 |
| 4 | 2.269 | 5.906 | 3.637 |
| 5 | 2.147 | 5.761 | 3.614 |
| 6 | 2.216 | 5.706 | 3.49 |

**Table 3.2:** Automatic Process using LVDT

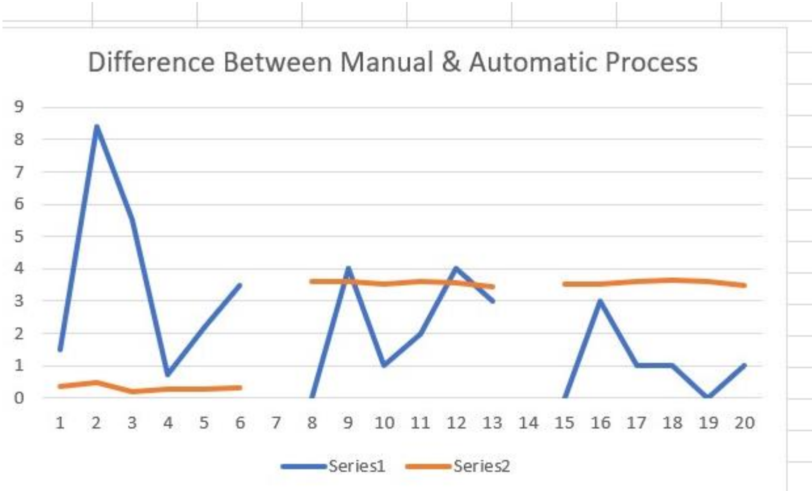



**Table 3.8:** Result Series1- Manual & Series2- Automatic

As Shown Above manual process has human error and has spikes in the graph whereas Automatic process is more promising and smoother.

## 3.5 Conclusion:

The utilization of an LVDT sensor alongside a PLC has emerged as an effective and dependable solution for conducting engine piston taper inspections. This approach negates potential human errors while delivering uniform and accurate outcomes. Conversion from manual bore gauge dialling to automatic means has improved time efficiency significantly while promoting increased productivity at lower expenses. Making use of acronyms like LVDT or PLC contributes to simplifying terminology within the framework, improving clarity of understanding while facilitating effective communication between relevant stakeholders. Without a doubt, integration between an LVDT sensor compatible with a PLC facilitates superior results for streamlining engine piston tapered checks.

# Chapter 4

# O-Ring Detection Of Gear Housing: OpenCV

## 4.1 INTRODUCTION

### 4.1.1 Background

When it comes time to stop liquids and gases from escaping various mechanical pathways throughout engines - whether due to transportation or other mechanisms- theres no better tool than an O ring sealant component . Designed specifically for this purpose these tiny yet mighty gaskets are essential for preserving important subsystems like oil distribution channels or coolant lines within any given engine compartment . Utilized by fitting snugly within a small groove between two mating surfaces they provide an impenetrable barrier to keep fluids where they belong even during the most vigorous activity . Clearly detecting the presence of these crucial O ring components is vital for any manufacturer, mechanic or repair technician - ensuring both quality assurance and proper functioning across all engine systems.

### 4.1.2 Problem Statement

To identify whether or not there is a black coloured O ring present within an engines gear housing, our task involves devising an intricate computer vision solution utilizing both Python and OpenCV. Our ultimate goal for this project is creating an efficient high accuracy real time O ring detection system through careful engineering processes.

### 4.1.3 Scope of the Project

The scope of this project is limited to detecting the presence of a black-coloured O-ring in the gear housing of an engine. The implement will be done by using Python and OpenCV.

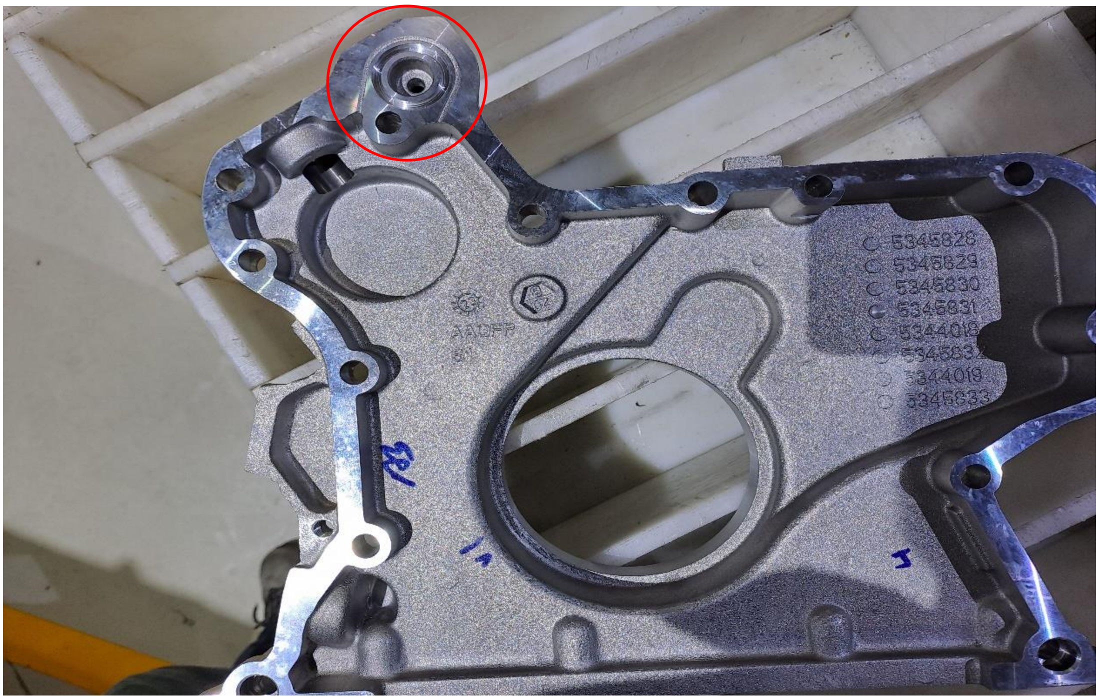



**Figure 4.1:** Gear Housing Without O-ring

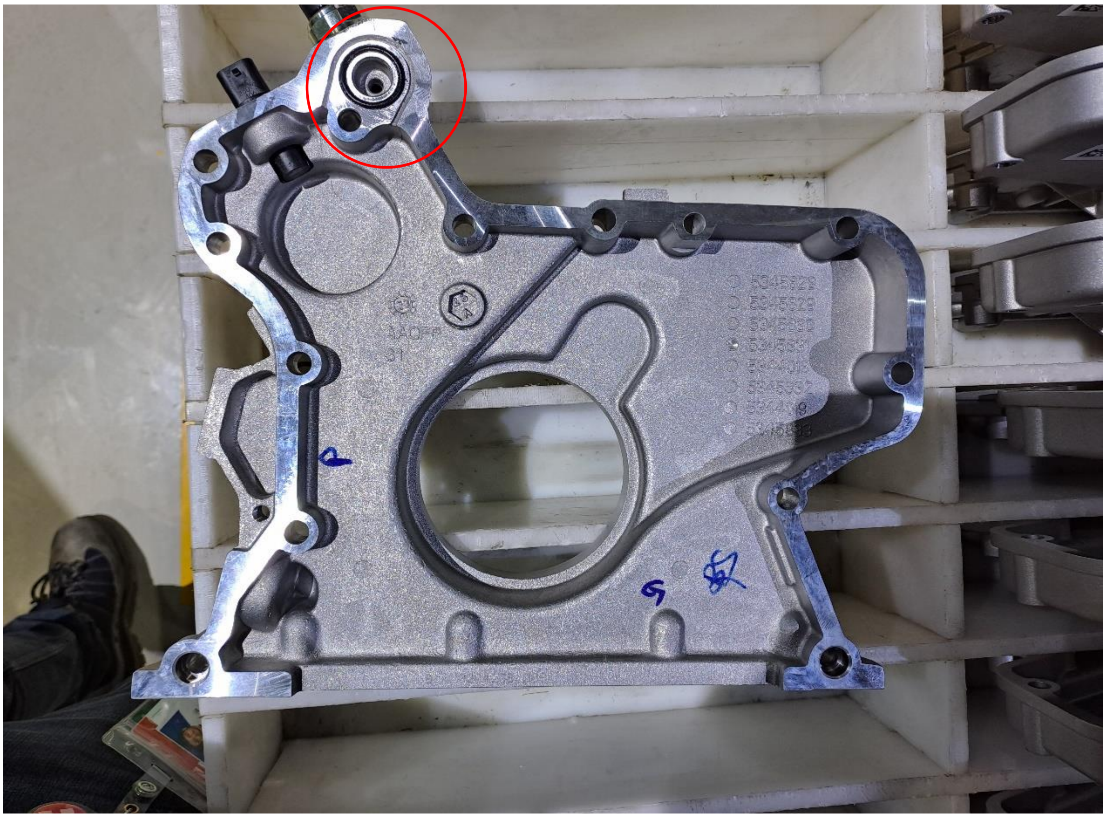


**Figure 4.2:** Gear Housing With O-ring

## 4.2 OBJECTIVE

Detecting whether a black-coloured O-ring exists in an engine's gear housing is our key objective for this project. We have set out with distinct targets aligning with this goal: first and foremost, identifying precisely where within the image does one find such an object - or more commonly called as locating its region of interest (ROI).

Building upon that knowledge base comes developing an algorithm programmed explicitly to recognize 'black' coloured O-rings within said ROI when sighted and consequently producing output images for utilization.

To give some practicality towards our ideas entails installing such functionality into Python and OpenCV applications so it may undergo testing before finally analysing how accurate it performs.

## 4.3 IMPLEMENTATION

### 4.3.1 Methodology

Python language with OpenCV technology has been selected as an effective approach for implementing the O-ring detection system. Below-mentioned steps will be performed by us to accomplish this task:

• Image acquisition: To begin with, quality images of gear housing will be captured using cutting-edge camera techniques.

• ROI selection: Following completion of image acquisition, we plan on selecting specific regions-of-interest (ROIs) by utilizing advanced camera focusing methodologies

• Image processing: Proper noise reduction from acquired ROIs followed by precise segmentation techniques targeting colour-based thresholding will get carried out in detail under image processing

• O-ring detection: Post image processing; our team aims towards analyzing each segmented ring's potential properties for determining its presence within ROIs effectively

• System evaluation : Set benchmarks would get accomplished based on precision measurement procedures along with contours-related analyses.

### 4.3.2 Software Architecture

- The software architecture of the O-ring detection system is shown below:
- Image Acquisition Module: Captures images of the gear housing.
- ROI Selection Module: Allows the user to select the ROI.
- Image Processing Module: Pre-processes the ROI to remove noise and performs colour-based thresholding to segment the O-ring.
- O-ring Detection Module: Analyses the segmented O-ring and determines its presence.
- User Interface Module: Displays the results of the O-ring detection system to the user.

## 4.4 Result:

Engineers have successfully built an automated system for detecting O-rings within the gear housing of engines. Using Python and OpenCV frameworks combined with image processing techniques, this innovative solution accurately identifies black-coloured O-rings responsible for blocking any pathways that may facilitate liquid or gas escape. Rigorous testing of this promising technology shows high levels of precision when applied across a diverse range of images featuring different gear housings with their respective O-rings.

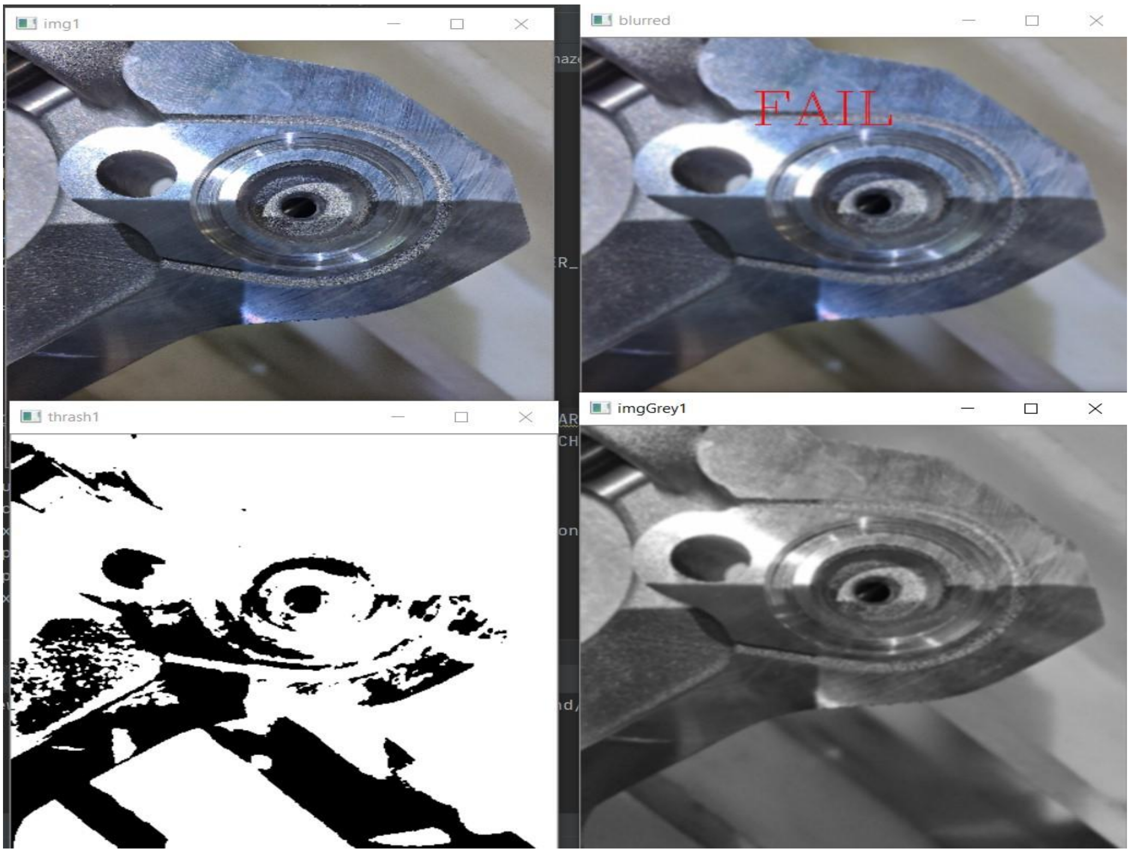



**Figure 4.3:** Gear Housing Without O-ring ‘FAIL’

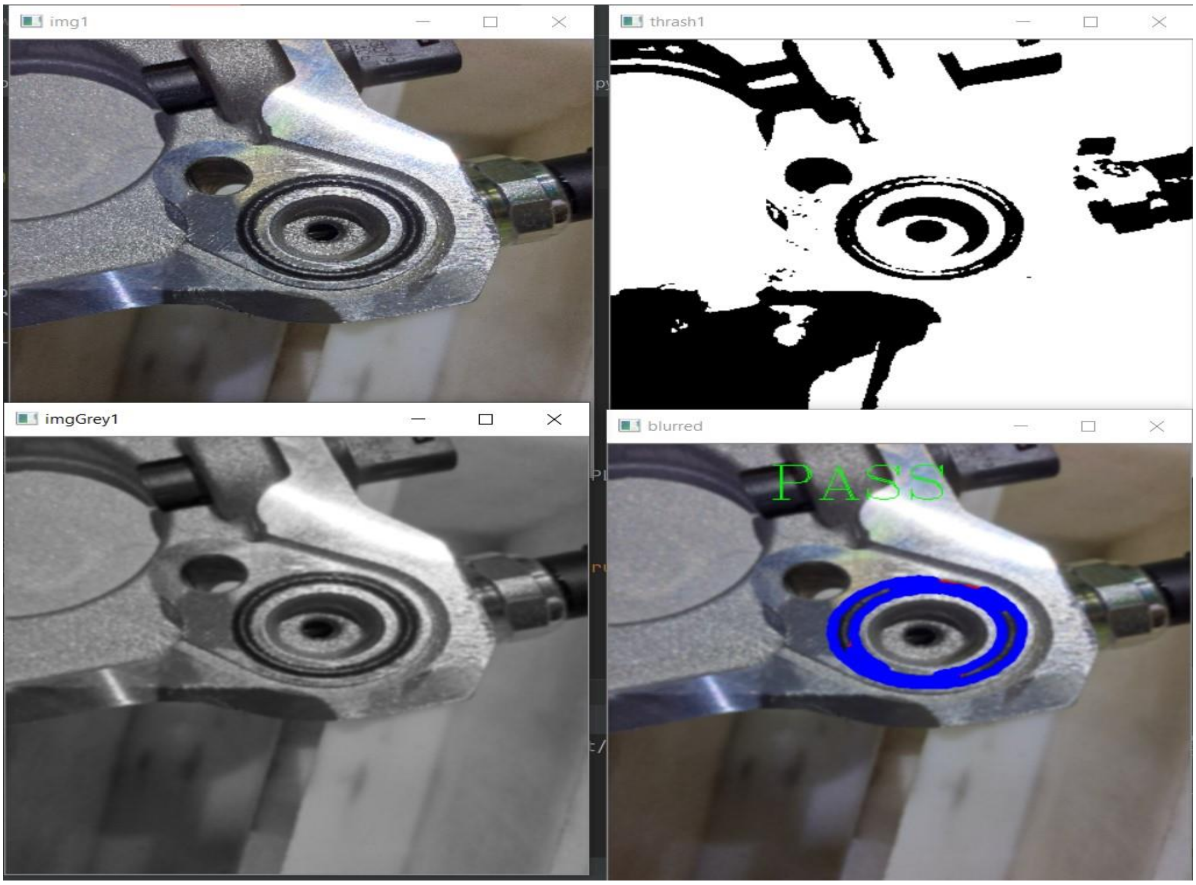



**Figure 4.4:** Gear Housing with O-ring ‘PASS’

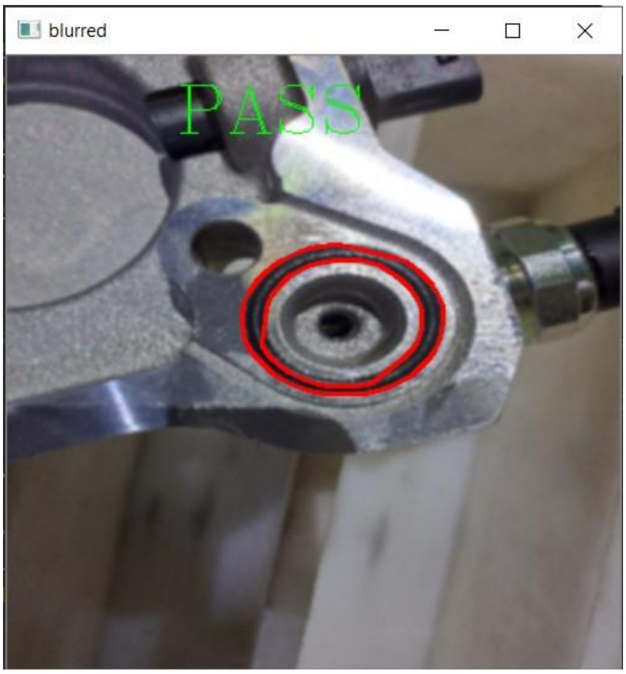



**Figure 4.5:** Gear Housing with O-ring using HULL

## 4.5 Conclusion:

Overall, through the integration of Python and OpenCV technologies into our advanced detection system for black-coloured O-rings in gear housings has proven effective. With automation capabilities embedded within our system-manufacturing processes are improved by ensuring accurate installation procedures that significantly improve overall engine performance reliability. The scalability offered by python language allows maintenance-friendly imaging-processing activities quickly customizable on a case-by-case basis all while providing flexibility across different industries. This technology can be further developed and implemented in various industries to improve product quality and efficiency while reducing the risk of product failure.

# Chapter 5

# Maintenance Downtime Analysis Dashboard: Power BI

## 5.1 Introduction:

Cummins is a leading manufacturer of diesel and natural gas engines, generator sets, and related components and technologies. The maintenance department is a critical part of Cummins manufacturing, responsible for ensuring that all production equipment runs smoothly and efficiently. To facilitate this process, the maintenance department requires an effective MIS report and downtime analysis system that can provide real-time information on equipment performance, maintenance requirements, and downtime.

The Power BI dashboard project was initiated to develop a comprehensive MIS report and downtime analysis system for the Cummins maintenance department. The dashboard provides a centralized platform that enables maintenance staff to monitor equipment performance, identify maintenance needs, and optimize downtime management.

## 5.2 Objective:

The objective of this project was to design and develop a Power BI dashboard that would help the Company maintenance department to:

1. Track equipment performance in real-time
2. Identify maintenance needs and prioritize maintenance tasks.
3. Monitor equipment downtime and optimize downtime management.
4. Generate periodic maintenance reports.

## 5.3 Implementation:

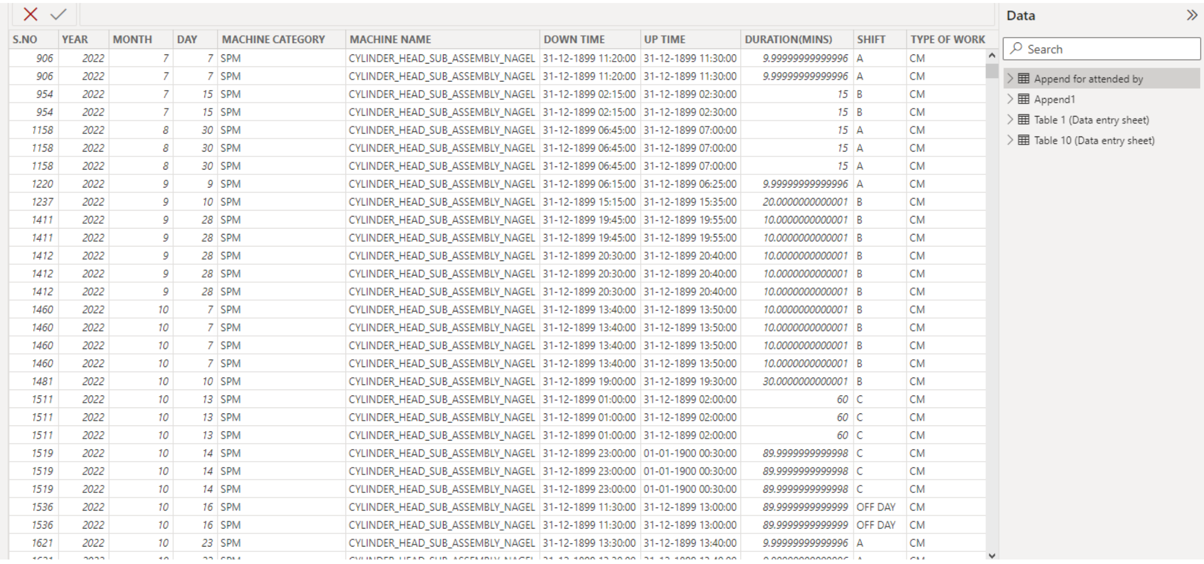
The implementation of the Power BI dashboard project involved the following steps:

We began our project by gathering essential requirements from the maintenance department regarding their need for valuable insights related to equipment performance and maintenance history along with downtimes issues. Once these requirements were finalized along with outlining key data sources needed for effective visualization of this information - we moved ahead with integrating various datasets together in one consolidated model which is essential to provide detailed accurate analysis of every aspect critical aspect captured in these datasets.

To ensure that everyone can understand this consolidated dataset model effortlessly without any confusion - We transformed all such critical data sets effectively into an interactive format which can be easily used by anyone regardless of technical expertise or background knowledge within a few clicks.

Our next phase then focused on creating insightful dashboards utilizing Power BI combined with various visualizing tools like bar graphs,line charts . These graphical presentations were used primarily only after ensuring their accuracy by conducting proper testing before delivering them as part of the final deliverables.

So, these are the comprehensive yet straightforward steps we followed to help maintenance departments understand the equipment performance and maintenance requirements with a focus on reducing downtime. Our main objective was to verify the dashboard's precision, dependability and performance capacity. Upon achieving this goal, we proceeded to promptly implement the dashboard within our maintenance department.



| S.NO | YEAR | MONTH | DAY | MACHINE CATEGORY | MACHINE NAME | DOWN TIME | UP TIME | DURATION(MINS) | SHIFT | TYPE OF WORK |
|---|---|---|---|---|---|---|---|---|---|---|
| 906 | 2022 | 7 | 7 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 11:20:00 | 31-12-1899 11:30:00 | 9.99999999999996 | A | CM |
| 906 | 2022 | 7 | 7 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 11:20:00 | 31-12-1899 11:30:00 | 9.99999999999996 | A | CM |
| 954 | 2022 | 7 | 15 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 02:15:00 | 31-12-1899 02:30:00 | 15 | B | CM |
| 954 | 2022 | 7 | 15 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 02:15:00 | 31-12-1899 02:30:00 | 15 | B | CM |
| 1158 | 2022 | 8 | 30 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 06:45:00 | 31-12-1899 07:00:00 | 15 | A | CM |
| 1158 | 2022 | 8 | 30 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 06:45:00 | 31-12-1899 07:00:00 | 15 | A | CM |
| 1158 | 2022 | 8 | 30 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 06:45:00 | 31-12-1899 07:00:00 | 15 | A | CM |
| 1220 | 2022 | 9 | 9 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 06:15:00 | 31-12-1899 06:25:00 | 9.99999999999996 | A | CM |
| 1237 | 2022 | 9 | 10 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 15:15:00 | 31-12-1899 15:35:00 | 20.0000000000001 | B | CM |
| 1411 | 2022 | 9 | 28 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 19:45:00 | 31-12-1899 19:55:00 | 10.0000000000001 | B | CM |
| 1411 | 2022 | 9 | 28 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 19:45:00 | 31-12-1899 19:55:00 | 10.0000000000001 | B | CM |
| 1412 | 2022 | 9 | 28 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 20:30:00 | 31-12-1899 20:40:00 | 10.0000000000001 | B | CM |
| 1412 | 2022 | 9 | 28 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 20:30:00 | 31-12-1899 20:40:00 | 10.0000000000001 | B | CM |
| 1412 | 2022 | 9 | 28 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 20:30:00 | 31-12-1899 20:40:00 | 10.0000000000001 | B | CM |
| 1460 | 2022 | 10 | 7 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 13:40:00 | 31-12-1899 13:50:00 | 10.0000000000001 | B | CM |
| 1460 | 2022 | 10 | 7 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 13:40:00 | 31-12-1899 13:50:00 | 10.0000000000001 | B | CM |
| 1460 | 2022 | 10 | 7 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 13:40:00 | 31-12-1899 13:50:00 | 10.0000000000001 | B | CM |
| 1460 | 2022 | 10 | 7 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 13:40:00 | 31-12-1899 13:50:00 | 10.0000000000001 | B | CM |
| 1481 | 2022 | 10 | 10 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 19:00:00 | 31-12-1899 19:30:00 | 30.0000000000001 | B | CM |
| 1511 | 2022 | 10 | 13 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 01:00:00 | 31-12-1899 02:00:00 | 60 | C | CM |
| 1511 | 2022 | 10 | 13 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 01:00:00 | 31-12-1899 02:00:00 | 60 | C | CM |
| 1511 | 2022 | 10 | 13 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 01:00:00 | 31-12-1899 02:00:00 | 60 | C | CM |
| 1519 | 2022 | 10 | 14 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 23:00:00 | 01-01-1900 00:30:00 | 89.9999999999998 | C | CM |
| 1519 | 2022 | 10 | 14 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 23:00:00 | 01-01-1900 00:30:00 | 89.9999999999998 | C | CM |
| 1519 | 2022 | 10 | 14 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 23:00:00 | 01-01-1900 00:30:00 | 89.9999999999998 | C | CM |
| 1536 | 2022 | 10 | 16 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 11:30:00 | 31-12-1899 13:00:00 | 89.999999999999 | OFF DAY | CM |
| 1536 | 2022 | 10 | 16 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 11:30:00 | 31-12-1899 13:00:00 | 89.999999999999 | OFF DAY | CM |
| 1621 | 2022 | 10 | 23 | SPM | CYLINDER_HEAD_SUB_ASSEMBLY_NAGEL | 31-12-1899 13:30:00 | 31-12-1899 13:40:00 | 9.99999999999996 | A | CM |



**Figure 5.1:** Raw Data

## 5.4 Result:

The project to deploy the Power BI dashboard was executed flawlessly, resulting in its current usage by the Cummins maintenance department. Thanks to the up-to-the-minute insights it delivers on equipment functioning, upkeep essentials, and downtime supervising, this dashboard is proving essential. Below are some of its key advantages:

1. Real-time monitoring of equipment performance - The dashboard provides maintenance staff with real-time data on equipment performance. This enables them to identify potential issues before they become major problems.
2. Prioritization of maintenance tasks - The dashboard helps maintenance staff to prioritize maintenance tasks based on equipment performance data. This ensures that critical maintenance tasks are performed first.
3. Optimization of downtime management - The dashboard provides data on equipment downtime, which enables maintenance staff to optimize downtime management.
4. Generation of periodic maintenance reports - The dashboard generates periodic maintenance reports, which provides a comprehensive view of maintenance activities.

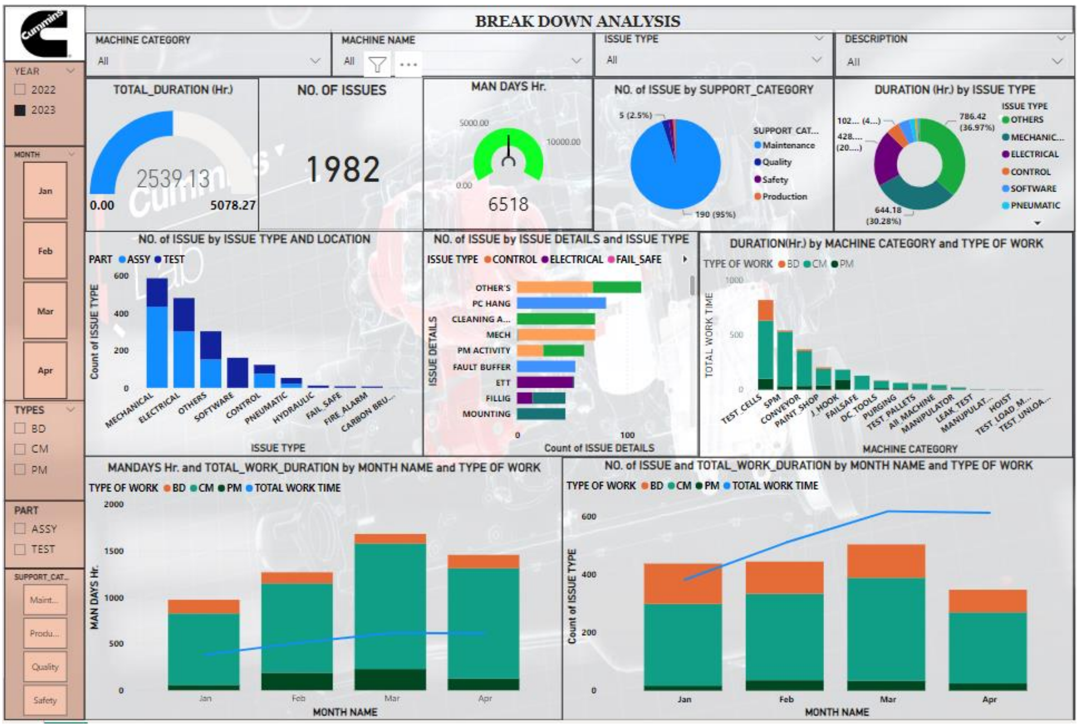



**Figure 5.2:** Dynamic Dashboard


**Figure 5.3:** Detailed Analysis

This will automatically change as per the selection and easy to analysis the issue in the machine and downtime so that we can work and improve the production timing.

## 5.5 Conclusion:

The Power BI dashboard project has provided the Cummins maintenance department with a comprehensive MIS report and downtime analysis system. The dashboard provides real-time data on equipment performance, maintenance needs, and downtime management, which enables maintenance staff to optimize equipment performance and downtime management. The project has been a success, and the dashboard is now being used by the maintenance department to manage maintenance activities effectively.

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