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Cold Test Rejection Analysis and Quality Improvement

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ABSTRACT: On manufacturing process of Engines, the Engine assembly line consists of 32 machines that perform various activities that contribute to production of engines. Our project involves the identification of the major problem in those machines and choosing one of the best problems (cold test) and improving the pass ratio of that particular machine. After the in-depth analysis of the cold testing we infer five basic problems like the crank and cam issue, oil leak, fuel leak, vibrations and breakaway torque. Out of these problems the crank and cam issue was chosen and various techniques were performed to reduce the rejection count in order to reduce the rejection in the overall cold testing. Each problem is entitled around the production line of the engines, and involves out of the box solution for complex problem. Solving these problems would eventually improve the quality of the manufacturing process by 80%.

KEYWORDS: Cold test, Crank and Cam, GEMS, Crimping, Rejection analysis, Pass ratio

I. INTRODUCTION

The quality of a machine is improved by performing some improvement activities. The rejections in the machines are analysed and the various causes, its impact on the society is also taken into consideration and then the idea to control the rejections in the machines is proposed. The rejections were maximum in the cold testing machines. The “cold test” is the end of line test and it is mainly used to check the quality of the machines. Productivity and quality are two important aspects have become great concerns in today’s competitive global market. Every production/manufacturing unit mainly focuses on these areas in relation to the process as well as product developed [5]. There is a trend in the automotive industry towards eliminating mechanical and hydraulic control systems and replacing them with electronic controls. The rise of electric vehicles (EV) is beginning to look like slowly developing tsunami [12]. The overall objective of the project is to improve the Pass Ratio of the assembly of machine. Each individual machine undergoes different testing routines and mechanism to check its operational feasibility and maintenance status at the assembly line. The testing process reports the point of failure and position of failure in the machines during different manufacturing phases. We primarily focus on the problem which causes failure of the machine and analyse the process which machine and analyse the process which causes the problem. It’s causes and effects are gauged with the illustration of the PARETO CHART, which effectively streamline the problem solving. The Pass Ratio of all the machine in the Assembly line are monitored for months and reported for analysis over the period of time

II. METHODOLOGY

Fig.1 represents the flow of the process in order to achieve the final outcome. At first we start with the data collection process, in this process we collect the data by using a software called GEMS. We put the Pareto chart and find the machine issue. Then the issue is reduced by various techniques which will improve the quality of the engine



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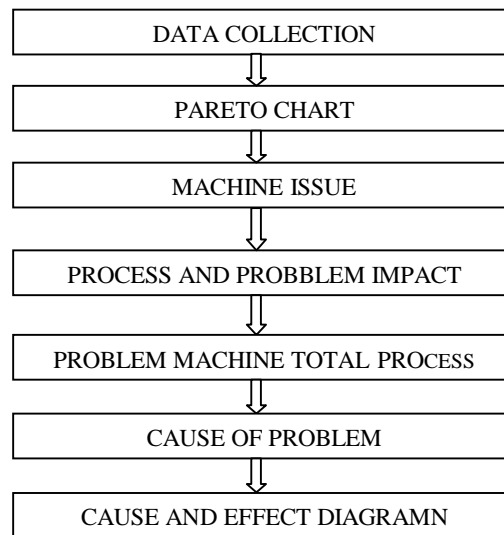


Fig. 1 Flow chart

III. DATA COLLECTION

MACHINE	SEPT	OCT	NOV	DEC
ST1-COLD TEST	262	96	956	778
ST2-COTTER CHECK	99	125	883	723
ST1-COLD TEST	178	68	536	439
ST-13 TIMING CHAIN VISION CHECK	96	60	412	195
ST-11 FINAL VISION CHECK	29	18	201	157
ST-14 CONROD LOOSEN N/R	10	17	293	155
ST-55 OIL PAN SEAL G AND VISION C	16	19	47	147
ST-3 VALVE SPRIN G VISION CHECK	20	9	136	140
ST-6 PISTON CONROD VISION BACKU	35	53	301	100
ST6-4PT#2 TEST	38	11	180	88
ST-20 MANUAL MLA AND HLA RECHE	46	22	135	88
ST-9 FAWHEEL AND D/PULLEY CHEC	0	6	197	83
ST-21 CAM CAP AND SWING ARM VIS	133	136	704	76
ST-1B/PLATE SEAL G AND VISION CH	46	0	181	65
ST -11 END PLAY TEST	39	25	114	51
ST-12 TOUCH PROVE CHECK	8	1	67	49
ST 12-1 MLA RECHECK	58	0	277	45
ST-12 OIL SEAL PRESS	0	0	44	41

Table 1 Rejection Analysis

Table 1 refers to the number of rejections in each machine for various months. From this we find the machine with the highest amount of rejections and then we correct it.

IV. ENGINE QUALITY CONTROL

The objectives of the engine quality control are as follows:

- To ensure best quality engine.
- To reduce part rejection.
- To achieve a salvage PPM of 80 in plant 1
- To achieve 10 PPM local part quality.
- To achieve CS-10000

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V. PROBLEM IDENTIFICATION

The fig.2 shows the maximum amount of rejection happens during the cold test check. By using the Pareto analysis the following listed operation contribute 80% of process rejection. The background of the problem is analysed and the improvement is done.

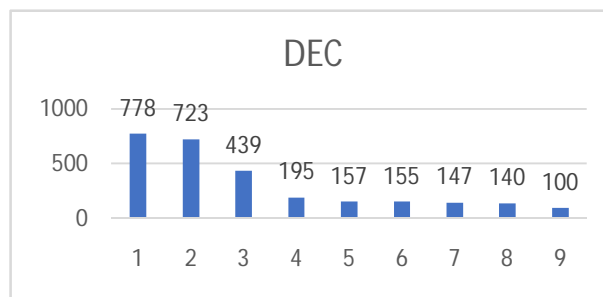


Fig. 2 Pareto Graph

VI. COLD TEST SYSTEM CHECK



Fig. 3 Cold Test Machine

The cold test monitoring i.e. the final test after the assemble line and before shipping the engine to the customers, consists the final control of engine in order to access its state of health [1]. Cold Test System finds issues introduced during the final engine assembly stages and includes high-speed tests, low speed tests and static tests with operator inspection. It detects low vacuum, bad oil pump, EGR valve functionality, incorrect engine timing, leaking fuel rail, damaged fuel injectors, knock sensors, missing/damaged gaskets. Examples of the main tests:

1. **Oil system** - To test the oil system, the crankshaft is rotated by an electric motor at a fixed speed.
2. **Fuel system**- To test the system test will identify missing or damaged gaskets and oil pumps not meeting specifications of the fuel system, the engine is rotated
3. **Vibrations**-To test for unwanted vibration in the engine, the crankshaft is rotated by the electric motor at a fixed speed.
4. **Crank and cam**-The crank and cam are used for finding the engine's exact timing. The crank and cam are used in both kappa engine and the U-engine
5. **Breakaway torque**-The torque which is given as a sign of a process completion is checked at a given rpm



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COLD TESTING ISSUES:

The different components which are checked by Cold Test are: - Oil Pump, Oil Pressure Regulating \ Relief valve, Intake Valves, Exhaust valves, Camshaft, Valve Drive, Crankshaft & Balancer Shaft (for excess vibration), Main Bearings, Connecting rod Bearings, Pistons, Piston Rings, Head Gasket, Ignition System, Spark Plugs and Spark duration, Injector Valves, RPM Sensor & RPM Sensor wheel, Coolant etc[2].

PROBLEMS	TOTAL
COUNT OF FUELLEAK	46
COUNT OF BREAKAWAY TORQUE	65
COUNT OF CRANKAND CAM	125
COUNT OF OIL RELIEF	104
COUNT OF VIBRATIONS	65

Table 2 Basic Issues of Cold Test

The designer could develop software based 3D models and it could be tested many number of times at different working conditions. The ANSYS software is used for this purpose [3].

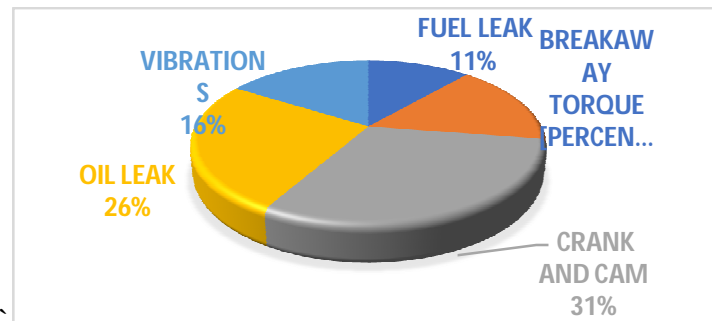


Fig. 4 Pie Chart representing the rejection percentage

From the pie chart as shown in the Fig. 4 when compared to all the problems, THE CRANK AND CAM ISSUE has the most rejection percentage. By decreasing the rejections in the crank and cam we will be able to decrease the total number of rejections in the quality line.

VII. CRANK AND CAM SHAFT

CAM SHAFT:

The cam shaft and its associated parts control the opening and closing of the two valves [8]. 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. Camshaft is used in the engine for transfers'

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Fig. 5 Camshaft

motion to inlet & exhaust valve [9]. The camshaft is driven by the crankshaft by way of gearwheels, a toothed belt or a timing chain. With a transmission ratio of 2:1, the rate of rotation of the camshaft is half that of the crankshaft. The camshaft is driven by the crankshaft through timing gears cams are made as integral parts of the camshaft and are designed in such a way to open and close the valves at the correct timing and to keep them open for the necessary duration.[10]The camshaft structure is shown in the fig.5 .

CRANKSHAFT:

Crankshaft is large volume production component with a complex geometry in the Internal Combustion (I.C) Engine[6]Crankshaft is a large component with a complex geometry in an engine which converts the reciprocation displacement of a piston to a rotary motion with four link mechanism [4] . Crankshaft experiences large forces from gas combustion. This force is applied to the top of the piston and since the connecting rod connects the piston to the crank shaft, the force will be transmitted to the crankshaft[7]A crankshaft—related to *crank*—is a mechanical part able to perform a conversion between reciprocating motion and rotational motion. In a reciprocating engine, it translates reciprocating motion of the piston into rotational motion; whereas in a reciprocating compressor, it converts the rotational motion into reciprocating motion. The crankshaft and its structure are shown in fig.6.

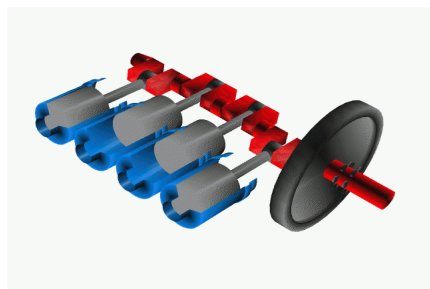


Fig. 6 Crankshaft

CRANK AND CAM ISSUES:

The crank and cam are used for finding the engine's exact timing. The crank and cam are used in both kappa engine and the U-engine. During the cold testing of a machine there occurs different issue at different RPM

AREA OF THE PROBLEM (BLOCK DIAGRAM)

The rejection of the crank and cam NG does not depend on the quality of the engine. The ODU which is present in the bullhead of the engine is the female type OD7U. When the engine fits itself inside the COLD TESTING MACHINE

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that consists of the male type ODU the necessary power for the engine to be tested is provided. The pin number 26, 27,28 of the ODU gets activated when the flywheel rotates at 500 rpm, these pins activate the input line of the crank and cam. When the input line is connected more crank and cam NG occurs due to the following problems

1. Wiring harness cable frequent damage and wire cut issues
2. Wire directly routed to ODU unit resulting the ODU terminal to frequently come out while machine masking
3. Rough handling of the wires
4. Wear and tear of the cable is only 2 months
5. Wire gets damaged due to handling
6. Lock clip may get damaged during the assembly process

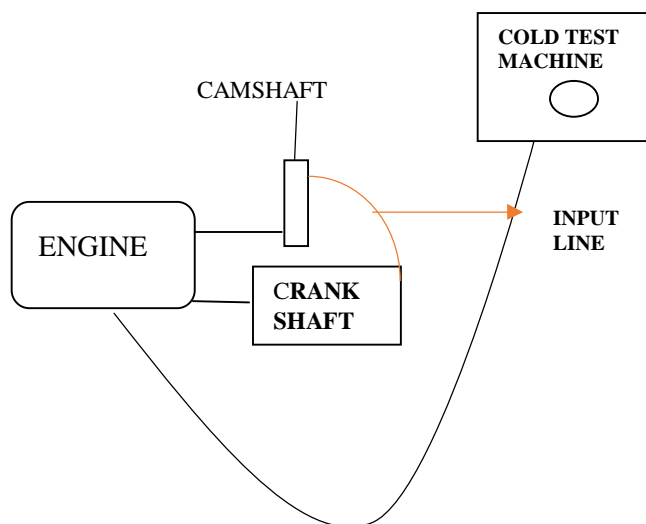


Fig.7 Block diagram

BEFORE:

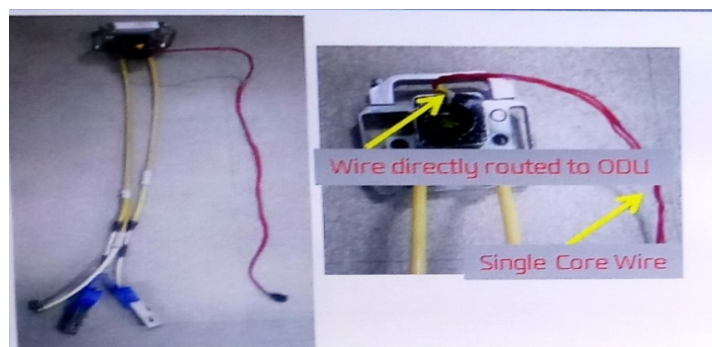


Fig. 8 Before Improvement

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PROPOSED IDEA AND IMPROVEMENT:

AFTER:

1. Cable is changed from single core to 3 wire
2. Crimping of the wire
3. Additional connector with match plate is provided
4. Crank and cam NGs are reduced

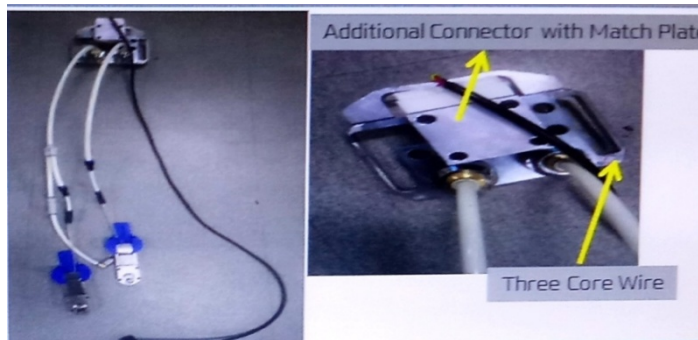


Fig. 9 After Improvement

VIII. RESULT AND DISCUSSION

The bar graph shows the variation in the number of rejections before and after the implementation. The number of rejections in the crank and cam is reduced from 125 machines to 20 machines and hence the total NG count for the cold test bud is reduced from 778 to 278. Therefore, we are able to improve the quality and reduce the rejection of an engine

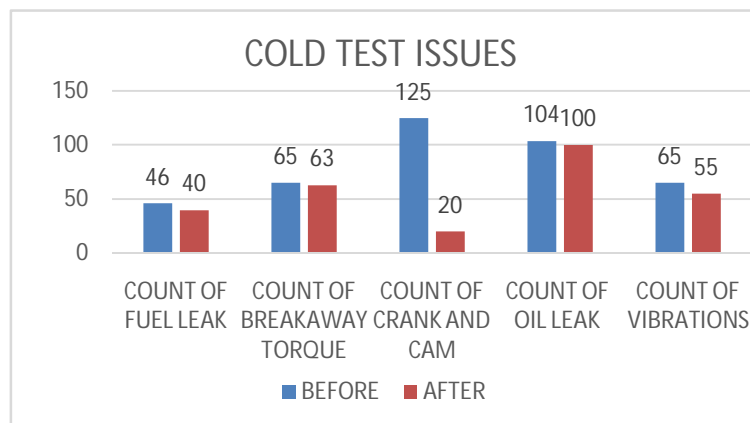


Fig.10 Bar graph of the improvised results

IX. CONCLUSION

The cold test monitoring, i.e. the final test after the assembly line and before shipping the engine to the customer, consists in the final control of engine in order to assess its state of health the cam after the implementation of modification. We can observe the variation of rejection in the graph before and after implementation. By minimizing



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rejections, the quality of the engine will increase thus saving a lot of time. Hence the primary objective of this project is fulfilled by carrying out all these changes mentioned below:

1. Increasing the process efficiency
2. Improved quality
3. Reduction in the rejection
4. Reduction in the wastage of scrap
5. Stability in the manufacturing

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