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FAILURE ANALYSIS OF PUSHROD IN LOCOMOTIVE DIESEL ENGINE

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Abstract

The project "Failure Analysis of Fuel Injection Pump" used in Diesel Locomotive Engines. The project was carried out at Diesel Loco shed, Golden Rock, and Tiruchirapalli. A detailed study was undertaken in the fuel Injection pump of Diesel Locomotive Engines physically and based on the data collected a failure analysis was done using a Total Quality Management Technique, Failure Mode Effect Analysis (FMEA). The causes of failure of fuel injection pump was found to be the breakage of push rod at its neck position due to high Stress Concentration and increase operating temperature of Internal combustion engine radiation. The improvement could be done on the material characteristics by addition of high strength alloy materials to the high speed steel.

I. INTRODUCTION

Indian Railway is the largest Railway system in the world covering all the states of the nation with its wider spread network of Rails. The railway is also one of the oldest and also the nation takes pride in operating such a large system. The Railways system has come from the earliest steam engine to modern day electric vehicle. It has gone through all kinds of development over than 150 and more years.

The complete manufacturing of all the locomotives and wagon both passenger and freight had been indigenously done in our own factories operated by Indian Railways. Diesel Locomotives are one among the significant drives that is being operated at around 70% of routes even after abundant electrification. These locomotives are manufactured in our country and is being maintained by various Diesel Loco Sheds spread across the country.

One such diesel locomotive shed is situated at Golden Rock, Tiruchirapalli Town in Southern part of India. This project has been carried out at Diesel Loco Shed, Golden Rock, Tiruchirapalli.

The technology used in rail engines is the chemical energy converted to mechanical energy and mechanical energy. As a human being need food & water to live and work smoothly to have energy from eaten food, similarly the engine also needs the fuel and water to develop energy. So to provide fuel in the fuel system, booster pump is provided and to inject through in the combustion chamber, the engine is provided with fuel injection system consisting of fuel injection pump, snobbier valve and the injector.

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The fuel injection pumps used in diesel locomotive engine in Indian railways are of constant stroke variable discharge type. The fuel injection pump has three functions.

- To raise the fuel oil pressure to a value which will efficiently atomize the fuel?
- To supply the correct quantity of fuel to the injection nozzle commensurate with the power and speed requirement of the engine.
- To accurately time the delivery of the fuel for efficient and economical operation of the engine.

The device, which indexes the fuel oil in to tiny particle form in the combustion chamber, is known as injector and the valve, which supplies fuel is known as nozzle valve.

As it was discussed that man needs food to live and survive, to eat energy to work and do day to day work. Similarly the engine needs fuel to start, to run to raise to develop power. But if a man does not chew the food and eat it, he is not going to get energy from the food eaten; more over his stomach up will get up set. In the same manner if the fuel injected to the combustion chamber is not in atomized from the engine will not be in a position to generate the power, due to improper/ in complete combustion.

Hence it is necessary to inject the fuel in the combustion chamber in very tiny particles.

II. BACKGROUND INFORMATION

CONCEPT OF PROJECT:

The failure occurs in the fuel injection pump and it occurs due to following reasons,

- Long Run of Diesel Engines
- Manual Assembling of Fuel Pumps
- Overheating of Pump and its components due to unstopped running of trains for more than 45 hours.
- Breakage of push rod during running.
- Temporarily blocked using a small plate. (One Rupee Coin)

STEP IN PROJECT

- Hardness Testing
- FEA Package
- Micro cam version 4.0

ROCKWELL HARDNESS TEST

The Rockwell hardness test method consists of indenting the test material with a diamond cone or hardened steel ball indenter. The indenter is forced into the test material under a preliminary minor load F0 usually 10kgf. When equilibrium has been reached, an indicating device, which follows the movements of the indenter and so responds to changes in depth of penetration of the indenter, is set to a datum position. While the

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preliminary minor load is still applied an additional major load is applied with resulting increase in penetration. When equilibrium has again been reach, the additional major load is removed but the preliminary minor load is still maintained. Removal of the additional major load allows a partial recovery, so reducing the depth of penetration. The permanent increase in depth of penetration, resulting from the application and removal of the additional major load is used to calculate the Rockwell hardness number.

- HR = E-e

- F0 = Preliminary minor load in kgf
- FI = Additional major load in kgf
- F = Total load in kgf
- e = Permanent increase in depth of penetration due to major load F1 measured in units of 0.002mm
- E = A constant depending on form of indenter: 100 units for diamond indenter,130
- Units for steel ball indenter
- HR = Rockwell hardness number
- D = diameter of steel ball

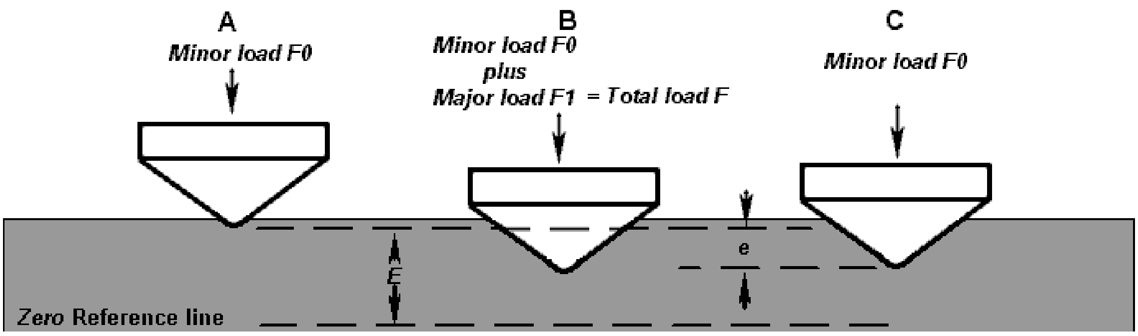

Fig.5.1.Rockwell Principle

Table 5.1 Rockwell Hardness Scales

Scale	Indenter	Minor load F0 kgf	Major load F1 kgf	Total load F kgf	Value of E
A	Diamond cone	10	50	60	100
B	1/16'' steel ball	10	90	100	130
C	Diamond cone	10	140	150	100
D	Diamond cone	10	90	100	100

E	1/8″ steel ball	10	90	100	130
F	1/16″ steel ball	10	50	60	130
G	1/8″ steel ball	10	140	150	130
H	1/8″ steel ball	10	50	60	130
K	1/4″ steel ball	10	140	150	130
L	1/4″ steel ball	10	50	60	130
M	1/4″ steel ball	10	90	100	130
P	1/4″ steel ball	10	140	150	130
R	1/2″ steel ball	10	50	60	130

Scale	Indenter	Minor load F0 kgf	Major load F1 kgf	Total load F kgf	Value of E
S	1/2″ steel ball	10	90	100	130
V	1/2″ steel ball	10	140	150	130

Typical Application of Rockwell Hardness Scales

- HRA….. Cement carbides, thin steel and shallow case hardened steel
- HRB….. Copper alloys, soft steels, aluminum alloys, malleable irons, etc
- HRC….. Steel, hard cast irons, case hardened steel and other materials harder than 100 HRB
- HRD….. Thin Steel and medium case hardened steel and pearlitic malleable iron
- HRE….. Cast iron, aluminum and magnesium alloys, bearing metals
- HRF….. Annealed copper alloys, thin soft sheet metals
- HRG….. Phosphor bronze, beryllium copper, malleable irons
- HRH….. Aluminum, zinc, lead
- HRK….. }
- HRL….. }
- HRM….. }…… Soft bearing metals, plastics and other very soft materials
- HRP….. }
- HRR….. }

- HRS….. }
- HRV….. }

Advantages of the rockwell hardness method include the direct Rockwell hardness number readout and rapid testing time. Disadvantages include many arbitrary non-related scales and possible effects from the specimen support anvil (try putting a cigarette paper under a test block and take note of the effect on the hardness reading! Vickers and Brinell methods don't suffer from this effect).

UTILITY OF FUEL INJECTION PUMP

As it was discussed that man needs food to live and survive, to get energy to work and do day-to-day work. Similarly the engine needs fuel to start, to run to raise, to develop power. But if a man does not chew the food and eats it, he is not going to get energy from the food eaten, more over his stomach up will get up set.

In the same manner if the fuel injected to the combustion chamber is not in atomized form (In very fine tinny particles) the engine will not be in a position to generate the power, due to improper/incomplete combustion.

Hence it is necessary to inject the fuel in the combustion chamber in very tinny particles/in atomized form, to have uniform air and fuel mixture, for complete combustion.

The Header rod is of cylindrical in shape. It is divided into three parts to total length of the rod is 133mm. The rod is of about 20mm diameter in the top end this diameter of the rod is maintained up to 30mm in length, after this there was a grooving of about 1.3mm (approx) and it has a distance of about 3mm. The use of this grooving is to lock the header cup.

The rod is further extended up to 100mm in length vice it has the diameter of about 30mm uniformly throughout the length. In the top and bottom of the rod there is a dot to determine the center point of the road.

SPECIFICATION OF THE PUSH ROD

Table 2.1 Specification of push Rod

S.NO	PARTS	DETAILS
01	MATERIAL WEIGHT	250g
02	RAW MATERIAL USED	HIGH SPEED STEEL
03	MANUFACTURER	MICO
04	LENGTH OF THE ROD	133mm
05	GROOVING DEPTH	1.3mm

(The above specifications are approx values)

2.4. INJECTOR

The device, which indexes the fuel oil in the tiny particle form in the combustion chamber, is known as **injector** and the valve, which supplies fuel, is known as **nozzle valve.**

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2.5 NOZZLE HOLDER

The fuel injection nozzle holder conducts fuel from the pump, snobbier valve and high-pressure discharge tubing to fuel injection nozzle and provides a means of adjusting the nozzle valve opening pressure. The nozzle atomizes the fuel and directs it, in a definite spray pattern into the engine combustion chamber. The major components of the nozzle holder body (1), pressure adjusting spring (4), shims (compensating washers(2), guide bush(3), intermediate disc (6) and nozzle cap nut (7).

To adjust nozzle valve opening pressure shims are used between nozzle holder body and guide bush (spring cap), above the spring. The lower end of nozzle

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➢

holder is ground and lapped to provide leak proof and pressure tight seal with the lapped upper surface of intermediate disc(6). The lower surface of intermediate disc is also lapped to provide a pressure tight sealing with the lapped surface of nozzle body.

Nozzle

The fuel injection nozzles are the closed, hydraulically operated, differential type, consisting of two parts-nozzle body and nozzle valve (pin). Both these parts are made out of special heat treated alloy steel to minimize wear.
The nozzle valve and nozzle body are matched to from an assembly. These parts should not be exchanged individually but replaced only as an assembly.
At the tip of nozzle body are 9 spray holes through which fuel passes into the combustion chamber. The spring-loaded nozzle valve controls the flow.

2.6 SPECIFIED PERIOD FOR MAINTENANCE SCHEDULE

The Complete Overhauling of Fuel Injector Nozzle is to be carried out in every Quarterly and half year (M-9), and Yearly schedule (M-19) and when there is some specific trouble like dribbling, spray hold choking and in case of fuel dilution etc

FUTURE SCOPE

METALLOGRAPHY IMAGEING STATION

MICROCAM Ver 4.0 is new generation image analysis software meant for metallurgist to do analysis in the simplest way. This is a single screen window based system. The system is flexible, independent to adopt any capture card, camera and microscopes.

III. RESULTS

STAGES OF FMEA

FMEA is an analytical technique that combines the technology and experience of people in identifying foreseeable failure modes as product or process and planning for its elimination. Can be explained as a group of activities intended to

- Recognize and evaluate the potential failure of a product or process and its effects.
- Identify actions that could eliminate or reduce the chance of potential failures.
- Document the process.

- FMEA – before the event action – team effort – inexpensively alleviate.
- Changes in design and production.
- Broadly classified as Design FMEA, and Process FMEA
- Design FMEA: identify foreseeable failure modes.
- Process FMEA: identify process failure modes.

IV. CONCLUSION

The frequent failure of header rod in the fuel injection pump has been studied and analyzed in detail. The results have been published and discussed.

The main cause of failure is the material characteristic. The material needs to be hardened to withstand high impact loads and temperature during running of the locomotives. A detailed FMEA chart has resulted in the following causes.

a. Stress concentration.
b. Prolonged utility of fuel injection pumps during continuous running of drain over long distances.

The corrective suggestions are to add alloying materials that would improve the strength of the push rod and also take care of the high temperature and thermal stresses. Addition of Molybdenum or vanadium or tungsten is recommended for increased strength. Molybdenum also would cater resistance over increasing thermal stresses

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