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Study and failure analysis of BS-III engine's fuel system and cooling system

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Abstract: The project under the 'STUDY AND FAILURE ANALYSIS OF BS-III ENGINE'S FUEL SYSTEM AND COOLING SYSTEM' has been thoroughly studied and disciplined in this project work. Diesel engine is use in various field for the different application, the performance of engine is depending on the engine system & components. The cooling system is one the important systems for diesel engine. The results are shows mean time between failure, failure rate and failure density. This is helpful for designing & manufacturing of components and modification. During engine operation, the fuel is supplied by gravity from fuel tank to the primary filter where coarse impurities are removal. From the primary filter, the fuel is drawn by fuel transfer pump and is delivered to fuel injection pump through the second fuel filter. The fuel injection pump supplies fuel under high pressure to the injectors through the high-pressure pipes.

KEYWORDS: Engine, BS-III Engine, Fuel System, Cooling System.

INTRODUCTION

As per the study and failure analysis of BS-III engine's fuel system and cooling system, it has been observed that the BS-III engine are equipped with a common rail fuel injection system that operates at high pressure to deliver fuel to the engine cylinders. The fuel system comprises of various components such as fuel tank, fuel filter, fuel pump, common rail system provides better fuel efficiency and lower emission compared to the conventional fuel injection system. However, the BS-III engine face certain issues related to their fuel system such as injector clogging, fuel leakage and pressure drop. Injector clogging occurs due to the accumulation of dirt and debris in the injector nozzles, which affects the fuel spray pattern and leads to poor engine performance. Fuel leakage can occur due to damaged or worn-out seals and gaskets in the fuel system components. Pressure drop can occur due to malfunctioning pressure regulator or a faulty fuel pump.

Apart from the fuel system, the cooling system of BS-III engine is also crucial for their efficient operation. The cooling system comprises of various components such as radiator, water pump, thermostat, hoses and coolant. The cooling system maintains the engine temperature within an optimal range by dissipating excess heat generated during combustion. However, the BS-III engine face certain issues related to their cooling system such as overheating, coolant leakage and pump failure. Overheating can occur due to a malfunctioning thermostat or a clogged radiator. Coolant leakage can occur due to damage hoses or a faulty water pump, pump failure can occur due to worn-out bearing or a defective impeller.

In conclusion, the study and failure analysis of BS-III engine's fuel system and cooling system highlight the importance of regular maintenance and timely repairs to ensure their efficient operation.

LITERATURE REVIEW

Rok Vihar et al. (2015), A tire pyrolysis oil (TPO) produced from waste tires was tested in a 6-cylinder, compression ignition, turbocharged, 6.9 L heavy- duty engine. Experiments were conducted in two operating modes, with and without intercooler, at two different engine speeds and at various loads. Impact of thermodynamic and engine performance parameters on combustion process were systematically analyzed in terms of cause and effect phenomena through mechanisms initiated by the fuel properties. Results indicate that TPO can be efficiently used in turbocharged non-intercooled CI engines at high loads, which opens its use in power generation.

Mr. Dhananjay H Joshi et al. (2012) an experimental has been carried out for pyrolysis oil blended with diesel used in single cylinder engine. In this study, the effects of parameters like. The results of the taguchi experiment identifies that 5% blend ratio, injection pressure 180bar and engine load 20kg are optimum parameter setting for highest mechanical efficiency.

Hilditch et al, (2003). CO and UHC emissions, resulting from low combustion temperature, particularly at lower load conditions, and from crevices and boundary layer. The world's first functional supercharged engine was made my Dugald Clerk, which was used in two-stroke engine in 1878. Daimler received a German patent for supercharging an IC engine in 1885. In a supercharger the loss can be up to 15% of engine output. To reduce the loss of power, later on the compressor was driven by a turbine using the exhaust gas energy. Then this technology became popular by the name as Turbo charging during early 1980's.

P.Spring et al [2007], In this paper we are going to discuss about the exhaust gas recovery using pressure-wave supercharger. In pressurewave supercharger energy is transferred between two gaseous fluid streams by bringing them together for a short time in a narrow channel. Pressure-wave mechanism uses the physical that if two fluids of different pressures are brought into contact, pressure equalization is faster than mixing. This device uses unsteady waves to produce a steady flow of gas to the engine.

ENGINE

ENGINE: Generally, Engine is a power producer. Engine is a device which transforms the chemical energy of a fuel into thermal energy and further converted to mechanical energy.

TYPES OF IC ENGINE
TATA ENGINES:

BS- I	SA1212C
BS- II	SA1212C
BS- III	SA1212C
BS- IV	
BS- VI	

LEYLAND ENGINE

- HINO
- L6.65(P)
- LEY HA6
- LEY 400

MAHINDRA ENGINES

- MDI 3000
- MDI 3200
- MDI 3200TC
- PGO
- S4

CLASSIFICATION OF ENGINE

- Internal combustion engine (IC)
- External combustion engine (EC)

SA1212C:

S- SEMI FORWARD
A- 4X4(AUXILIARY DRIVE) 12- 120HP
12- 12TON GROSS WEIGHT
C- CUMMINS ENGINE

E.C.G MEANS:

E - ENGINE
C-CLUTCH
G-GEAR BOX

WORKING PRINCIPLE OF ENGINE:

If an engine is to work successfully then it has to follow a cycle of operation in a sequential manner the sequence is quiet not changed. Though spark ignition (SI) and compression ignition (CI) engine have much in common behaviour, there are certain fundamental differences between them.SI engine was invented by NICOLAS A. OTTO CI engine was invented by RUDALPH DIESEL.The most used engine is reciprocatory internal combustion engine and gas turbine in rotary engine.

FOUR STROKE COMPRESSION ENGINE:

- Suction stroke/Intake stroke Compression stroke.
- Power stroke Exhaust stroke.

FOUR STROKE IGNITION ENGINE:

- Suction stroke/Intake stroke Compression stroke
- Power stroke Exhaust stroke

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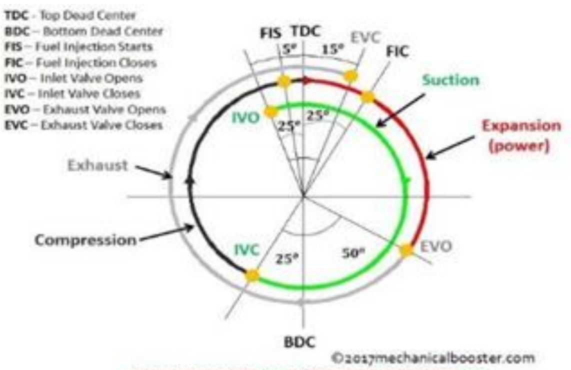
VALVE TIMING DIAGRAM



Valve Timing Diagram of 4 Stroke Diesel Engine

NORMS ENGINE CLASSIFICATON:
BS-III

6 CYLINDERS, ROTARY PUMP, 24 VAVLES, BATTERY – 24 V, STARTER – 24 V, VALVE DOOR – 1 nos, CO EMISSION – 2g/km

BS-III
BS-III regulation was first rolled out in 2005 and their sale was made mandatory across the nation 2010. The introduction of the more stringent norms led to a remarkable reduction in emissions from petrol powered passenger vehicles, with a maximum permissible Carbon Monoxide emission of 2,3g/km, Hydro Carbon + Nitrogen Oxides discharges of 0.35g/km, and Respirable suspended particular matter discharge of 0.05. The diesel models emitted a peak carbon monoxide of 0.64g/km, a nitrous oxide of 0.50g/km. Furthermore, the Sulphur content in the Bharat Stage III-compliant fuels was restricted to 100 PPM. Automobile markers achieved compliance with the BSIII emissions by installing a catalytic converter that curbed the discharge of Carbon Monoxide and Hydrocarbons. In the BS-III engine the catalytic converter is used to reduce the formation of the hydrogen and carbon mono oxide.

Fig.no.3.2 BS-III ENGINE

FIRING ORDER:
In diesel engine the firing order is the order in which the fuel is injected into each cylinder
For 6 cylinder the sequence is **1-5-3-6-2-4**
For 4 cylinder the sequence is **1-3-4-2**

DEAD CENTER:

TDC – Top Dead Centre is the position of an internal combustion engine's piston when it is at the very top of its stroke.

BDC – Bottom Dead Centre is the opposite when the piston is at the very bottom of its stroke.

Fig.no.3.3 TDC AND BDC

FAILURE:
Failure in Head occurs in

1.Valve
Bending or breaking because of contact with the pistons

2.Rocker arm
Improper lubrication of the bearings causing them to seize up.

3.Push rod
It is caused by the rocker arms ball jumping out of the push rods cup.

4.Spring
Can cause, excessive valve noise, compression loss and severe internal engine damage.

FAILURE IN CYLINDER BLOCK OCCURS IN

1.Liner
Excessive ingress of oil into the combustion chamber due to defective components.

2.Piston pin

Piston pin fractures are caused by excessive loads.

3.Connecting rod

Common causes of connecting rod failure are tensile failure from high engine speeds, the impact force when the piston hits a valve due to incorrect installation of the connecting rod.

4.Piston ring

Failure caused due to the abrasive particles entering the space between the piston and cylinder. This is due to operation in a dusty environment with poor air filtration.

FAILURE ANALYSIS OF BS-III ENGINE:
CALCULATIONS:

- F.D – FITMENT DATE
- R.D – REMOVED DATE
- DURATIONS IN km
- ENIGNE NUMBER

FORMULA:
LET'S TAKE,

- X- REMOVED DATE
- Y- FITMENT DATE
- Z- DURATION OF km
- Consider the equation, X – Y = Z

DATA AND MODEL CALCULATIONS:

1. ENGINE NO:62900521
F.D - 21/9/2021
R.D – 7/9/2022
Km – 36,000
X1 – Y1 = Z1 [Note: Convert year into month]
7/9/2022 – 21/9/2021 = 1 Year
Z1 = 36,000 / 12
= 3,000 km/month
= 36,000 km/year.

2. ENGINE NO: 31K63347568
F.D – 29/7/2022
R.D – 13/12/2022
Km – 15,000
X2 – Y2 = Z2
13/12/2022–29/7/2022=5months
Z2 = 15,000 / 5
= 3,000 km/month
=36,000 km/year.

3. ENGINE NO: 51A 63418876
F.D – 24/9/2015
R.D – 19/11/2022 Km – 312,000
X3 – Y3 = Z3
19/11/2022 – 24/9/2015 = 7 years
Z3 = 312000 / 84
= 3714 km/month
= 44,568 km/year.

CALCULATION TABLE

S.NO	ENGINE NUMBER	KILOMETER PER MONTH	KILOMETER PER YEAR	GRADE
1.	62900521	3,000	36,000	VERY GOOD
2.	31K 63347568	3,000	36,000	VERY GOOD
3.	51A 63418876	3,714	44,568	EXCELLENT
4.	31J 63343964	3,027	36,324	VERY GOOD
5.	61G 63535946	3,000	36,000	VERY GOOD
6.	51B 63425446	3,200	38,400	VERY GOOD
7.	51B 63425284	3,000	36,000	VERY GOOD
8.	11F 63143058	3,000	36,000	VERY GOOD
9.	31K 63347979	3,058	36,708	VERY GOOD
10.	61L 63555538	3,000	36,000	VERY GOOD

RATING TABLE:

RATING	GRADE
50-40	EXCELLENT
39-30	VERY GOOD
29-20	GOOD
BELOW 20	POOR

FUEL SYSTEM

The function of a fuel injection system is to meter the appropriate quantity of fuel for the given engine speed and load to each cylinder, each cycle, and inject that fuel at the appropriate time in the cycle at the desired rate with the spray configuration required for the combustion chamber employed.

The fuel tank is a reservoir that holds the fuel supply and helps maintain its temperature at a level below its flash point. The fuel tank also serves as an important means of dissipating heat from the fuel that is returned from the engine.

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4.1 FUEL TANK AND ITS FAILURE:

Fig.no.4.2 FUEL TANK

Failure can be caused by a range of issues. Weakening welds on seams and corrosion of walls can contribute to so called pinhole leaks. Total roof collapse of a tank is also a risk associated with corrosion of support beams due to a build- up of acids and salts.

4.2 FEED PUMP:

A feed pump is a pump that moves a fluid such as a fuel at a controlled rate. A low-pressure feed pump ensures that the injection pump receives a continuous flow of filtered fuel. The fuel feed pump operates only when the engine is running.

Fig.no.4.2 FEED PUMP

FEED PUMP FAILURE:

The most common is improper lubrication when the incorrect lubricant is used or not enough is applied. Bearings also fail in extreme temperatures. Another cause of failure is bearing overload, e.g., a pump cavitating from lacking the proper flow will increase pressure on the impeller's front.

4.3 FUEL FILTER:

The fuel filter keeps fuel running smoothly to the engine Instead of creating a fine spray of fuel that burns completely, they start to produce a stream that doesn't completely ignite. Changing the fuel filter keeps the injectors clean longer, which means more power and better gas mileage.

Fig.no.4.3 FUEL FILTER

The most common sign of a clogged fuel filter is trouble starting the car, since it depletes the oil supply going to the engine. Although a dirty fuel filter leads to ignition difficulty, a fully-clogged filter will fail completely, and the engine won't start at all.

4.4 FUEL INJECTION PUMP AND ITS FAILURE:

In a mechanical system, the fuel charge is accurately metered and pressurised by the fuel injection pump and passed to the high-pressure injectors via pipes before being sprayed into the combustion chamber, where it ignites. The resulting combustion gasses then drive the piston down to produce the power stroke.

Fig.no.4.4 FUEL INJECTION PUMP

One of the major reasons for injector pump failure is an excessive build-up of deposits. There are two types of deposits internal injector deposits and external injector deposits. External injector deposits are caused by fuel that's not wholly burned that often builds up around the injector holes.

4.5 HIGH PRESSURE PIPE:

Pressure-piping is a set of pipes which are used to contain fluid at high pressure. High-pressure gases were transported through pressure-piping. High-pressure vapor should be carried through pressure-piping to a storage bank. Pressure-piping is a set of pipes which are used to contain fluid at high pressure.

Fig.no.4.5 HIGH PRESSURE PIPE

FAILURE OF HIGH PRESSURE PIPE:

- Corrosion.
- External Corrosion.
- Internal Corrosion.
- Stress Corrosion Cracking (SCC)
- Selective Seam Corrosion (SSC)
- Excavation Damage.
- Natural Force Damage.
- Other Outside Force Damage.

4.6 INJECTOR:

Injector, a device for injecting liquid fuel into an internal-combustion engine. The term is also used to describe an apparatus for injecting feed water into a boiler. In diesel engines fuel must be in a highly atomized form for proper combustion.

Fig.no.4.6 INJECTOR

FAILURE OF INJECTOR:

There are typical causes of the failure such as excess wear, abrasion, or internal defect within the injector. There are also symptoms the vehicle presents which are warning signs of what's going on under the gasket and these are things you can help your customers can look out for.

COOLING SYSTEM

A water-cooling system for an internal combustion engine cools the engine by circulating water into the water jackets provide in the cylinder head and cylinder block of the engine. The system is comprised of a radiator, a water pump, a cooling fan and a thermostat as main parts

5.1 RESERVOIR

A reservoir is a holding receptacle for liquid. The most important reservoir in your car is the container that holds your coolant for the radiator natural or artificial lake or large tank used for collecting and storing water, esp for community water supplies or irrigation. a receptacle for storing gas, esp one attached to a stove.

Fig.no.5.1 RESERVOIR

FAILURES OF RESERVOIR:

- Constantly low on coolant.
- Coolant leaks.
- Engine overheating.
- Corrosion.

5.2 RADIATOR

A radiator is the key component of the engine's cooling system. Its main role is to disperse a mix of antifreeze and water throughout its fins, which releases some of the engine's heat while taking in cool air before continuing to pass the rest of the engine.

Fig.no.5.2 RADIATOR

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FAILURE OF RADIATOR

Rust is usually the greatest reason for a radiator to fail over time. There are various chemical reactions that can cause rust to start forming, salt and humidity are other factors. When rust starts to form, it will slowly decrease the radiator's capabilities until it finally breaks down completely.

5.3 CYLINDER HEAD AND ITS FAILURE:

Cylinder head is the part of an engine that closes the upper ends of the cylinders. When I removed the cylinder head, I found the tops of the pistons and inlet valves covered in a shiny substance. The cylinder head is an intricate casting mated to the top of the cylinder block.

Fig.no.5.3 CYLINDER HEAD

Failure of the engine cylinder head is caused by the thermal fatigue. The most common reason for cylinder head failure is overheating caused by coolant loss, head gasket failure or restricted flow of coolant.

5.4 THERMOSTAT:

The thermostat is like a valve that opens and closes as a function of its temperature. The thermostat isolates the engine from the radiator until it has reached a certain minimum temperature. Without a thermostat, the engine would always lose heat to the radiator and take longer to warm up.

Fig.no.5.4 THERMOSTAT

FAILURE OF THERMOSTAT

- High temperature readings.
- Erratic changes in temperature.
- Leaking coolant.
- Increased fuel consumption.
- Unusual noises

CALCULATION

FORMULAE USED:

- PROFIT (Z) = ORIGINAL RATE (X)-RECONDITIONING RATE (Y)
- Z=X-Y
- PROFIT GAINED BY NLC THROUGH RECONDITIONING OF FUEL PUMP PER YEAR SERVICE PUMP PROFIT BY RECONDITIONING
- TOTAL AMOUNT OF PROFIT=Z1+ Z2 + Z3+ Z4 + Zs

SINGLE PUMP PROFIT:

1. BHARATH STATE-11 (337)
   PROFIT (Z) = ORIGINAL RATE (X)-RECONDITIONING RATE (Y) Z1= X-Y
   = 99200-9920
   PROFIT (Z1) = 89280

2. BHARATH STATE - III (472)
   PROFIT = ORIGINAL RATE-RECONDITIONING RATE
   = 129500-12950
   Z2 = 116550

3. MDI 3200 TCA (251,255)
   PROFIT = ORIGINAL RATE-RECONDITIONING RATE
   = 98750-9875
   PROFIT Z= 88875

4. PGO (408)
   PROFIT = ORIGINAL RATE-RECONDITIONING RATE
   = 85000-8225
   PROFIT ZA = 76775

5. HENO (421)
   PROFIT = ORIGINAL RATE-RECONDITIONING RATE
   =112500-11250
   PROFIT Z, = 101250

CONCLUSION

1. The experience that We learned from the study and failure analysis of the IC engines is actually a lot. With the help of my guide, we gained a lot of knowledge about IC Engine practically.
2. We thoroughly studied about the entire IC engine components and its different failures occur in it. And various solutions like how we can reduce the occurrence of failure in the IC engine components.

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