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Solutions of Cylinder Liner Failures of WDG4 Locomotive

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***Abstract*— A cylinder liner is a cylindrical part to be fitted into an engine block to form a cylinder. It is one of the most important functional parts to make up the interior of an engine. The cylinder liner, serving as the inner wall of a cylinder, forms a sliding surface for the piston rings while retaining the lubricant within. The most important function of cylinder liners is the excellent characteristic as sliding surface and these four necessary points. High anti-galling properties, less wear on the cylinder liner itself, less wear on the partner piston ring less consumption of lubricant. Cylinder liner contains air and diesel, after burning of diesel and air it contains hot flue gases at temperature of 250°C to 350°C. Also, cylinder liners contain water in water jacket and lubrication oil between piston rings and cylinder surface. So, from above we can say that the cylinder liner is a most important part of the engine. So, failure of cylinder liners affects the stoppage of the engine. It is a major problem of failure of cylinder liners in Locomotive Engines. Our aim is to find out causes of the failures and specify the major causes by applying different analysis and observations. By doing this we will try to minimize the failures and increase the life of cylinder liner.**

Keywords: - Failure analysis of liners, Reasons of Cylinder Liner Failures, Type of failures, Modifications in air intake system and lube oil system.

1. INTRODUCTION

GENERAL INTRODUCTION:

Indian Railways is a state-owned railway company, responsible for rail transport in India. It is owned and operated by the Government of India through the Ministry of Railways. It is fourth largest railway network in the world comprising 119,630 kilometers (74,330 mi) of total track and 92.081 km (57,216 mi) of running track over a route of 66,687 km (41,437 mi) with 7,216 stations, IR carried 8.107 billion passengers annually or more than 22 million passengers a day and 1, 101 billion tons of freight annually. Railways first introduced to India in 1833 from Bombay to Thane. In 1951 the systems were nationalized as one unit, the Indian Railways, becoming one of the largest networks in the world. IR operates both long distance and suburban rail systems predominantly on a network of broad gauge. it also owns locomotive and coach production facilities at several places in India, with assigned codes identifying their gauge, kind of power and type of operation, its services cover twenty-six states and three union territories across India, and also international connectivity o Bangladesh (with Bangladesh Railway) and Pakistan (with Pakistan Railways). Indian Railways is the world's eighth biggest employer and had 1.331 million employees at the end of 2015-16. In 2015-2016 Indian Railways had revenues of ₹1.683 trillion (US$26 billion) which consists of 1.069 trillion (US$17 billion) freight earnings and 442.83 billion (Us$6.9 billion) passengers' earnings. Its operating ratio of 90.5%, IR's rolling stock comprises over 251,256 Freight Wagons, 70241 Passenger Coaches and 11,122 Locomotives (39 steam 5,869 diesel and 5214 electric locomotives).

INTRODUCTION OF CYLINDER LINERS:

cylinder liner is a cylindrical part to be fitted into an engine. It is one of the most important functional parts to make up the interior of the engine. cylinder liner is a removable component, cylindrical in shape, inserted into the engine block. It provides the surface for the piston to slide and carry out its compression task. It can be replaced when worn out. Cylinder is commonly made of cast iron. There are two type of cylinder liners are used in engine 1. Wet cylinder liner. 2. Dry cylinder liner. A cylinder liner is a cylindrical part to be fitted into an engine block to form a cylinder. It is one of the most important functional parts to make up the interior of an engine. These are main functions of Cylinder Liners.1.Formation of sliding surface. 2. Heat transfer. 3. Compression gas sealing .4.to form part of the combustion chamber which is compression and combustion of fuel/air mixture take place.

2. LITERATURE SURVEY

- *ANALYSIS OF WDG4 ENGINE: -*
- *YEAR WISE LINER FAILURE ANALYSIS: -*

Year Wise	No. Of Failures
2010-11	1
2011-12	6
2012-13	5
2013-14	4
2014-15	12
2015-16	2
2016-17	16
2017-18	27
2018-19	26
Total	**99**

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- *YEAR WISE LINER FAILURES PIE CHART: -*

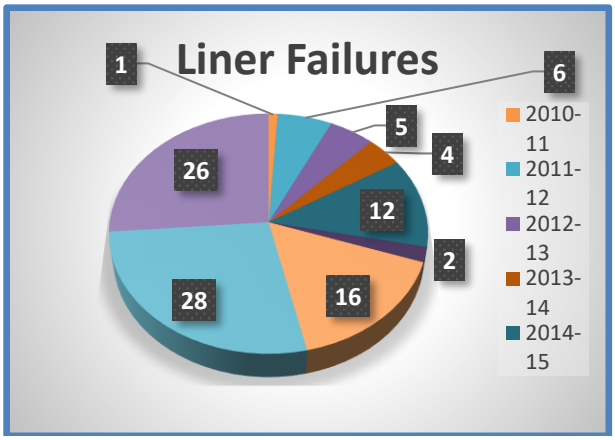

Figure 1: - Pie Chart of Liner Failures

- *REASON WISE FAILURES ANALYSIS: -*

Liner Cracked at Air Inlet Port	21
Liner Bottom Part Broken	8
Pocket Welding	3
Liner Cracked	50
Scratches in Internal Surface	14
Liner Wear	3
Total	**99**

- *REASON WISE LINER FAILURE PIE CHART: -*

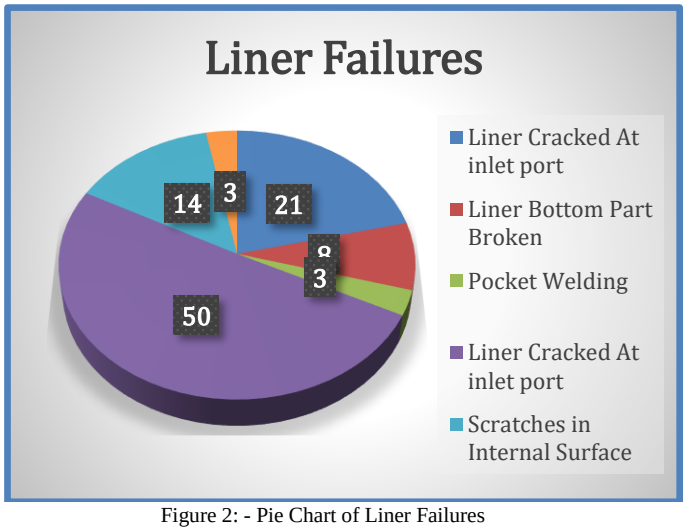

Figure 2: - Pie Chart of Liner Failures

- *FINAL CONCLUSION AND COMMENTS: -*

  - The failure is not due to any material/manufacturing defect of the liner.
  - Hence this does not qualify replacement of liner under warranty.
  - Recommend to get the defective cylinder liner providing a replacement on good will basis.
  - There is no need of change liner material.
  - The failure of liner is due some other reasons.

- *LUBE OIL CHARACTERISTICS ANALYSIS:*

OIL IOC MULTIGRADE OIL 606

- *CHARACTERISTICS OF FRESH OIL: -*

Viscosity = 15.5 µpa to 16.5 µpa at 100°C
Water content = nil
PH value = above 9
TBN (Total Base Number) = up to 12
Flash point = 200°C to 220°C
Density = 0.89 Kg/m^3 at 15°C

QUALITY PLAN FOR ENGINE LUBE OIL AS PER ROSO GUIDE NO 6 VERSION JANUARY 2017: -

Sr No.	Elements with Their Codes	Limits for WDG4 (EMD)		
		Normal ppm	Border Line ppm	High ppm
1.	Lead (Pb)	0-50	50-75	Above 75
2.	Aluminum (Al)	-	0.5	-
3.	Copper (Cu)	0-75	75-155	Above 150
4.	Silicon (Si)	0-15	15-20	Above 20
5.	Iron (Fe)	0-75	75-125	Above 125
6.	Chromium (Cr)	0-10	10-20	Above 20
7.	Sodium (Na)	-	-	-
8.	Tin (Sn)	0-20	20-40	Above 40
9.	Boron (B)	0-10	Above 10	Above 20
10.	Zinc (Zn)	0-10	Above 10	Above 20

ANALYSIS RESULT: -
FRESH OIL: -
In fresh oil after analysis on spectrometer we get all properties and number of atoms of all elements in lube oil. From this analysis we get all the oil properties in balanced condition / as per standard table. From this we can say that there is no problem in fresh lube oil properties. So, we can use this oil as a lube oil.

SYSTEM LUBE OIL: -
In this oil after analysis on spectrometer we get the all properties and number of atoms of all elements in lube oil. From this analysis we get the result in which we seen that the atoms of silicon are more compares to fresh oil. This silica in lube oil is affects the failure of liner.

3. PROPOSED METHOD:

- *AIR INTAKE SYSTEM WITH CYCLONE SEPARATOR*
  - Engine Air intake system takes care of the amount of oxygen required for complete combustion of fuel injected in the cylinders in various operating conditions. Air intake system consists of the following components. 1.Turbo charger, 2. Inertial air intake filters , 3. Baggie type fiber glass air intake filters , 4. After cooler.

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- In order to supply the required quantity of air for complete combustion of injected fuel, this loco is provided with a turbo charger. The turbo charger is primarily used to increase engine horse power and provide better fuel economy through the utilization of exhaust gases.
- The turbo charger used here is a single stage turbine with a connecting mechanical gear train also through over-riding clutch.
- The connecting gear train is necessary for engine starting, light load operation and rapid acceleration. Under these conditions, there is insufficient exhaust heat energy to drive the turbine fast enough to supply the necessary air for combustion, and the engine actually driving the turbocharger through the gear train assisted by exhaust gas energy.
- When the engine approaches full load, the heat energy in the exhaust gases reaches temperatures up-to 100°F (538°C) is sufficient to drive the turbocharger without any help from the engine.
- At this point, an overrunning clutch in the drive train disengages the mechanical drive and the turbocharger is mechanically disconnected from the engine gear train.
- After turbocharger air enters air cyclone separator. Cyclone separator separates dust from the air.
- The engine inlet air is initially filtered through cyclonic filters and finally filtered in baggie filters and enter turbo impeller casing. The intake air is compressed by the turbo impeller & the outlet air from turbo enters both bank after coolers, where the heat generated in the compressed air is cooled by after coolers. Compressed air after cooling in after coolers enters both bank air boxes of the engine. Always, pressurized air is filled in the air boxes by turbo. This pressurized air rushes into cylinders through 18 air inlet ports provided on each cylinder according to the engine timing.

- *LUBE OIL SYSTEM WITH CENTRIFUGAL OIL CLEANER*

The complete engine lubricating oil system is a combination of 04 oil systems.

These are:

1. Scavenging oil system
2. Main lubricating oil system
3. Piston cooling oil system
4. Centrifugal Separator
5. Soak Back or turbo lube system

- Lubricating oil system consists of Engine sump scavenging pump, Main lube oil pump, Lube oil strainer housing, Filter assembly, Lube oil cooler assembly, Turbo oil filter.
- Oil from the engine sump is drawn by gear driver scavenging pump through a coarse mesh lube oil strainer element and is filtered in lube oil filter tank in which 5 filters elements are housed. Oil from the filter tank flows to main lube oil pump through a lube oil cooler and fine mesh lube oil strainer element.
- A lube oil bye pass valve is provided across lube oil filter tank which is set at 40 psi. This valve is responsible for continuous oil supply to engine moving parts when filters are choked. A filter condition gauge is provided across the filter tank and is in parallel with bye pass valve to continuously indicate the condition of lube oil filters inside the filter tank.
- Pressurized lube oil supplied by scavenging pump is further pressurized by a main lube oil pump. Main lube oil pump is basically having two pumps in one housing. One for the piston cooling and the other for the complete engine moving parts including turbo charger. Piston cooling pump supplies pressurized oil to all the pistons through headers and piston cooling pipes on both banks. Oil supplied from piston cooling pipe cools the piston crown from the bottom and lubricate cylinder liners and piston rings while dropping down to the sump.
- Pressurized oil from Main lube oil pump passes through a pressure relief valve set at 125 psi, lubricate all 10 main bearings, 8 connecting rod bearings, both end engine gear trains, stub shafts, all cam bushes through drilled oil passages in cam shafts, valve lever mechanism, bridge assembly, Lash adjusters & exhaust valves etc.
- Centrifugal separator separates silica from the lube oil and cleans the oil.
- Oil pipeline from the cam gear end lube oil main header taken to engine Governor to shut down the engine in case of low lube oil pressure
- One 55V AC Electrical Motor (3/4 HP) driven pump (Turbo soak back pump) circulates engine lube oil to turbo before cranking and after shutting down the engine to protect the turbo running without oil and to cool turbo after the engine is shut down.
- Working time of this Turbo soak back pump is decided by EM 2000. Turbo lube pump works for 15 minutes after engine shut down, if loco was working below 4th notch before shutting down of the engine and runs for 35 minutes after engine shut down, if loco was working above notch before shutting down of the engine.
- Oil for the Turbo is taken from cam gear end lube oil main header through a paper type spin on filter.

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4. IMPLEMENTATION DETAILS:

1. *MODIFIED AIR INTAKE SYSTEM BY ADDIING CYCLONE SEPARATOR : -*

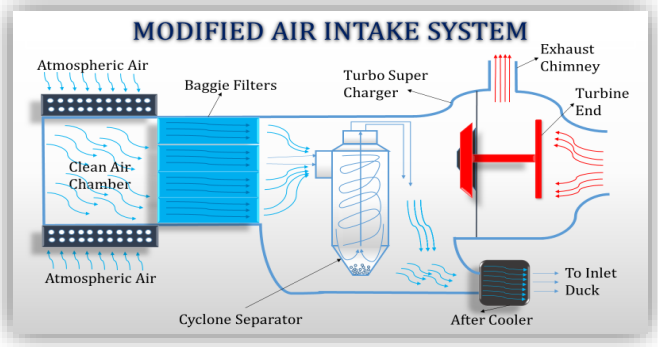

Figure 3: - Modified Air Intake System

➢ *CYCLONE SEPARATOR*

Cyclone separators provide a method of removing particulate matter from air or other gas streams at low cost and low maintenance. Cyclones are somewhat more complicated in design than simple gravity settling systems, and their removal efficiency is much better than that of settling chamber. Cyclones are basically centrifugal separators, consists of an upper cylindrical part referred to as the barrel and a lower conical part referred to as cone (Figure). They simply transform the inertia force of air particle flows to a centrifugal force by means of a vortex generated in the cyclone body. The particle laden air stream enters tangentially at the top of the barrel and travels downward into the cone forming an outer vortex. The increasing air velocity in the outer vortex results in a centrifugal force on the particles separating them from the air stream. When the air reaches the bottom of the cone, it begins to flow radically inwards and out the top as clean air/gas while the particulates fall into the dust collection chamber attached to the bottom of the cyclone. Cyclones have no moving parts and available in many shapes and sizes.

2. *MODIFIED LUBE OIL SYSTEM BY ADDING CENTRIFUGAL SEPARATOR: -*

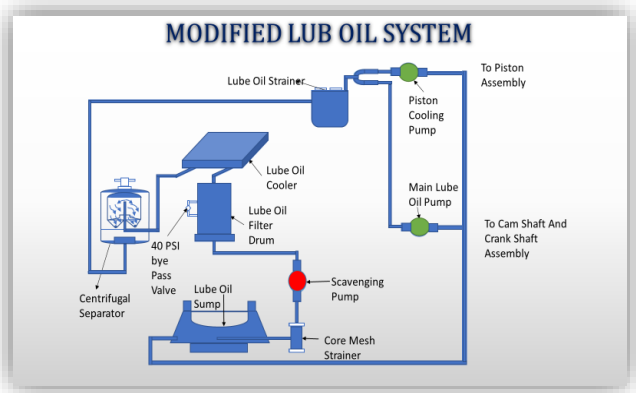

Fig 4: - Modified Lube Oil System

➢ *CENTRIFUGAL SEPARATOR*

Vehicles and equipment repeatedly come across contamination that may cause excessive wear, unreliable operation or complete failure. These destructive contaminants consist of particulate debris from swallowed dust, water, lubricating oil, dirt and wear and microbiological development. Lubricating oil is deteriorated resulting in formation of sludge, lacquer and carbon with use. Additionally, it is contaminated by different byproducts of combustion of fuel, water, acids, unborn fuel. In addition to these fine particles of dust and rust formed in engine are other impurities present in the oil. The oil after passage through the strainer and pump passes through the strainer and pump passes through the oil filter whose purpose is to remove any impurities which might damage the engine bearings.

5. CONCLUSION AND FUTURE SCOPE

To put in a nutshell, Impurities and the dust particles of the environment would be affacting more on the liners surface . On the other hand, impurities in the lube oil would also damage the engine parts. By adding cyclonic separatore in air intake system and centrifugal separator in lub oil system reduce the failures and damages of liners.

In the future with this modification of air intake and lube oil systems will directly impact on the indian railways growth and also help to its development. Morever, Reduction in failures and demage parts quantity will improve the finance budget of railways. Maintenance and replacement of parts would be less .

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