A DISSERTATION-2 REPORT ON

Maintenance Practices for performance enhancement of Indian Railway diesel engine

MASTER OF TECHNOLOGY
IN
MECHANICAL ENGINEERING

SUBMITTED BY

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TOPIC APPROVAL PERFORMA

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Qualitative Assessment of Proposed Topic by PAC		
Sr.No.	**Parameter**	**Rating (out of 10)**
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2	Project Feasibility: Project can be timely carried out in-house with low-cost and available resources in the University by the students.	7.33
3	Project Academic Inputs: Project topic is relevant and makes extensive use of academic inputs in UG program and serves as a culminating effort for core study area of the degree program.	7.00
4	Project Supervision: Project supervisor’s is technically competent to guide students, resolve any issues, and impart necessary skills.	7.00

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6	Future Scope: Project has potential to become basis of future research work, publication or patent.	7.00

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Final Topic Approved by PAC: **Innovative Maintenance Practices for Performance Improvement of Indian Railway Locomotives**

Overall Remarks: Approved

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CERTIFICATE

I hereby certify that the work being presented in the dissertation entitled "___________________________" in partial fulfillment of the requirement of the award of the Degree of Master of Technology and submitted to the department of Mechanical Engineering of Lovely Professional University Phagwa, is an authentic record of my own work completed under the supervision of Mr. Gaurav Vyas, Assistant Professor Department of Mechanical Engineering Lovely Professional University. The content of this dissertation has not been submitted in part or full to any other University or Institute for the award of any Degree.

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This is to certify that above statement of declaration made by student is correct to the best of my Knowledge.

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The external viva-voce examination of the student was held on successfully _______________

Signature of Examiner

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I would like to express my sincere thanks and gratitude to my Supervisor Mr. Gourav Vyas Assistant Professor Mechanical Engineering Department of Lovely Professional University for his consistent support, valuable and timely guidance and motivation.

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DECLERATION

I hereby declare that dissertation work entitled “The maintenance practices an**d improvement in Indian railway locomotive”** is an authentic record of my own work carried out as requirement of Dissertation-2 for the award of degree of M.Tech in Mechanical engineering from Lovely Professional University, Phagwara, under the guidance of Mr. Gaurav Vyas during January to Dec, 2016

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CHAPTER 1: INTRODUCTION

1.1 History of Locomotives

First rolling stock was introduced in the year 1550 for the transportation of ore tubs from the mines; initially it was started and introduced in the German railways. This maneuver was first exemplified in the year 1556 by Georgiou Agricola. He has initially used "H und" wagons with maneuvers on the timber planks and a plumb pin on the truck fitting in to the gap between the planks, and it get going. The first true railways were introduced and have been manufactured between Bossley and Shropshire, and also spread in the England in the year 1605.The sae trams and railway was used by James Clifford for carrying coal from mines to riverside towns and furthered transported to other areas. On this first documentary was recorded and its construction have been proceeded the Wollaston Wagon and completed in the year 1604 which has been regarded as an earliest british installation This Wagon ran in between Strollen to near Nottingham afterwards another early carriage way was noted between headlong to huntingdon Beaumo, Mining was major concerned at that time due to mining at Strelley. Broad wooden railway was also laid down near Newcastle upon Tyne.

In the 18th century and such carriage and tram ways and are spreader in the many areas of the England, The constructed a carriage ways for transporting stones for the supply in to the local areas to meet the supply needs of the construction areas and the builders of the Georgian and traces of bath. The Battle of Preston pans was held in the Jacobite rebellion of the 1745 and was fought between astride wagon ways, this type of transport was spread in sufficient amount of areas and the areas of coalfield, largest number of railway lines has been made near the coal field near Newcastle upon Tyne, which were mostly used in the transportation of coal and chaldron wagons on the banks of river so that they could be shipped to London by coiler brigs. The Wagon ways was technophile so that trains carrying coal wagon can be descended to the scathe by gravity effect. The wagon ways on less steep can be regarded by allowing the wheel to bind the curves

1.1.2 High-Speed Rail

High Speed rail come in the existence with the establishment of the first line between Tokyo and Osaka in Japan in the year 1964, further it was followed by Spain, France and Germany. Italy and republic of china and many other nations built the high-speed train having Top speed of 300Km/Hrs., construction of these high speed and semi high speed trains considerably reduces the train traffic between major cities.

India’s first railway engine powered by Steam introduced in England in the year 1832, Thereafter in the year 1843 it was shipped to India. Thereafter on the first august 1849 this was the mile stone in the history of Indian railway on this day Indian peninsular railway company was established and then a contract between the Indian peninsular railway and east India Company. Because of this contract a railway tracks of 56 Kms between Bombay and thane. The construction of this means transport system which spread all over India and in the end of the 19^{th} century 24752 Kms .In the year 1960 can be considered as a transformation phase of the Indian railway started conversion of steam power to diesel powered locomotive, this conversion was done by the General Motors EMD Division and the American Locomotive Company (ALCO) were asked to submit the proposals and quotation for new diesel powered locomotives.. Indian Railways and WDM-4 class prototype was given to railway for the trail purpose. Indian railway asked for the technology sharing and that was denied by general motors and then the ALCO design has been approved and selected for production. First factory for manufacturing of diesel locomotive was constructed in Varanasi and production of the locomotives began in India. Since then 2800 WDM-2 locomotives have been manufactured by this DLW plant in India.

After there number of modification has been made per the demand and the requirement of the railway and hence there is modified version WDM-2 was introduced and their sub version has been released as follows. WDM-2A, WDM-2B and WDM-3A.

Figure 1. Diesel Engine (dsl shed ldh)

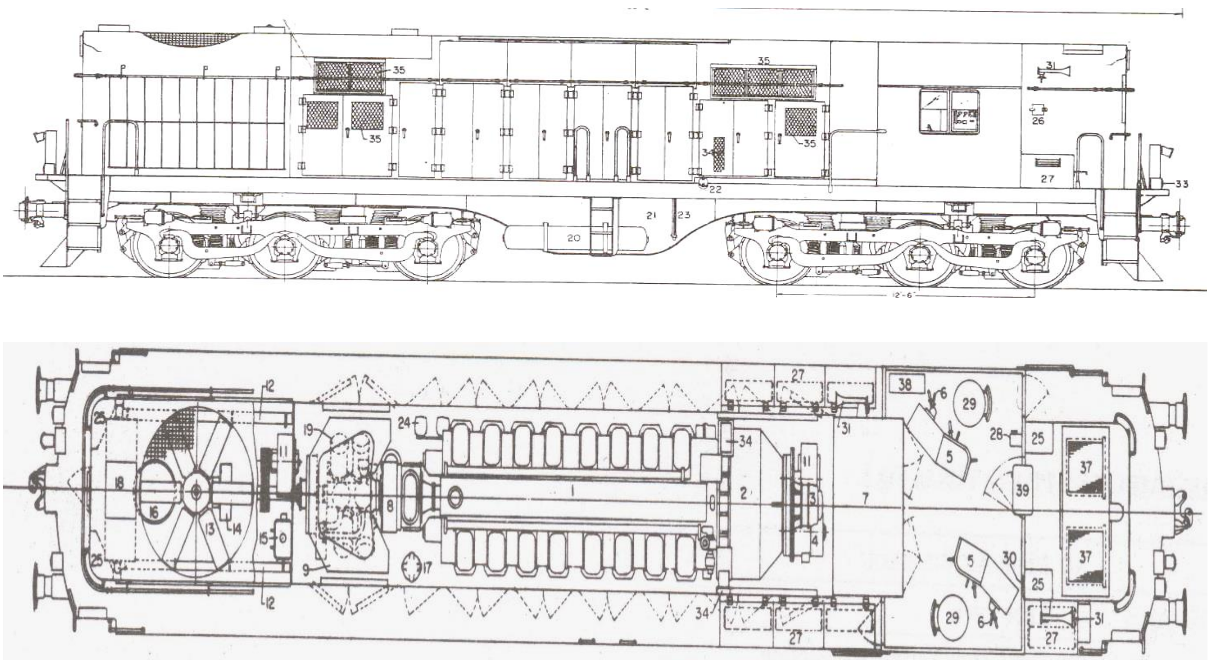


Figure 2. Layout of Diesel Engine (Courtesy: STC LKO)

1.2 Classification of locomotive:

Locomotives are mainly classified based on their motive power and track gauge. Name of class consist of information about locomotives which is normally designed of four to five letters where first letter denotes the track gauge and the second letter denotes the motive power (Diesel or electric) and third letter designates the traffic condition, it is suited for like Goods, passengers, mixed or shunting and fourth letter designates the locomotive and time based model number. New classification has been arrived in 2002 and it has been adopted and practiced. In this new system has been implemented for the locomotives developed after 2002, and in this system only change in the fourth letter and this designates the Horsepower range. This classification and designation is not valid for the electric locomotives and all locos are not covered.

Locomotive sometimes consist of fifth letter also and this fifth letter denotes a technical variant or subclasses and types. The fifth letter also indicates and gives information about for the smaller modification in basic model and series and even different manufactures motors. The new method and designation rules of locomotives classify diesel locomotives. The fifth term refrain the horse power indication and there is an increment of 100 hp from A, B, C respectively. So according to this rule WDP-3A means the engine is capable of producing 3100 hp.

They retained their original class names such as WP class or M class.

W- Wide gauge 5ft 6 in of Indian broad gauge

1. Y – yard gauge or meter gauge 3ft or 1000 mm
2. Z – z stands for narrow gauge 2ft 6 in
3. N – narrow gauge (toy gauge) (2 ft.)

The second notation denotes motive power

1. D – Diesel
2. C – D C electric can run under dc overhead line
3. CA –run both dc and ac overhead line
4. B – battery electric locomotive

Letter third denote job type

1. G – for goods
2. P – for passenger
3. M– for both mixed goods and passenger
4. S – shunting loco used in yards
5. U – Dmu emu multiple unit
6. R –for Rail cars

WDM 3A”

1. W means broad gauge
2. D stands diesel motive power
3. M stands mixed run for both goods and passenger
4. 3 stands locomotive horse power (3000 h.p)

WAP 5

1. W stands broad gauge
2. A stands a.c electric traction motive power
3. P stands for passenger
4. Stands for that this locomotive is chronologically the fifth electric locomotive model used by the railways for passenger service

   WDM wide gauge mixed loco

   WDP stands wide Diesel passenger WDG – stands Wide Diesel Goods

   WDS- wide diesel shunter

   WCDS – stands foe wide converted diesel shunting

CHAPTER 2: SCOPE OF STUDY

The Scope of this research is to find out new approach and practices for the improvement in maintenance strategy, which can indeed minimize the in line break down time and lead time of maintenance, reduction in monetary loses.

1. Adaptation of better maintenance strategy
2. Introduction of new and zero maintenance technology
3. A systematic approach for maintenance of locomotives

Potential areas of diesel locomotive which is focused in this research which can enhance the performance of diesel locomotive

1. The changes made in power pack
2. The fueling system of diesel locomotive
3. The changes made in braking system
4. The changes made in cooling system
5. The changes made in maintenance schedule working
6. The miscellaneous changes made in different section

CHAPTER 3: OBJECTIVE OF STUDY

The Scope of this research work aims to analyses of present maintenance practice of WDM diesel locomotive and their failure rate. The objective of this research work to reduce the failure rate in the Indian railway WDM Locomotive and for this detailed analysis of the weekly and monthly failure report was studied and on the basis of failure report critical failure components identified in the various systems of engine of WDM locomotives. The root cause analysis has been done on cam gear and cam shaft and lube oil systems and other safety critical components. This analysis would be help full to improve the failure rate and increases the safety of passengers and reduces overall annual maintenance cost. This study would be helpful for the improving maintenance system and practices of diesel locomotive.

This research work has following objectives

1. Investigate causes of failure and their occurrence rate
2. Identify the causes which has high failure rate
3. To find out the different reasons of failure and their potential causes referring the failure report of a one financial year
4. Determine the scope of Implementation of new technology and its feasibility and compatibility with existing system
5. Various aspects of failure especially due to human intervention

CHAPTER 4: LITREATURE REVIEW

Sergejus Lebedevas et al have studied effect of on diesel engine locomotive with the transient operating modes of the energy usages

The paper analyzed the transient operating modes effect of the locomotive diesel engines on the basis of their energy usage on. The effect of the operating variables on the transient modes of locomotive diesel engines tested on load cycle in during operation condition and appropriate parameters like gross weight of train and other technical characteristics is to be modeled
It was observed that the that it will increase the fuel consumption less than 3% in transient mode of operation in comparison of steady state operation.by this research methodological based has been formulated and mathematical model of transient mode is prepared and optimize freight transportation and which in turn leads to significant reduction 3% fuel consumption

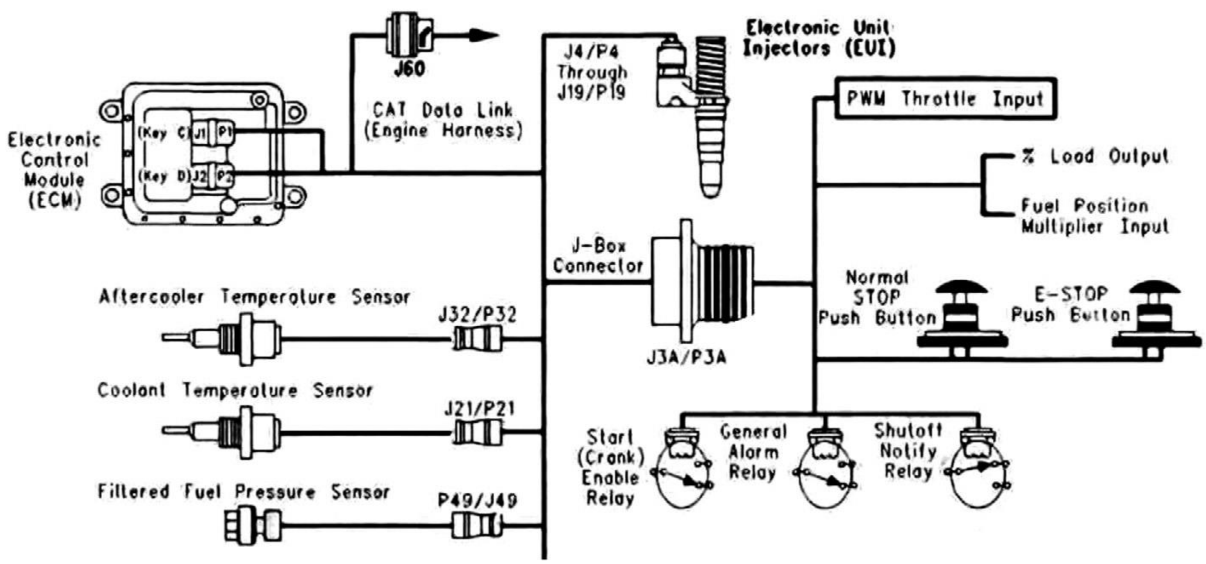


Figure 3.Schematic of the LCU diesel engine sensors. By segejius paper

Andrew S. Martinez et al. have studied and presented the comparative analysis of SOFC-GT freight locomotive fueled by natural and diesel engine with onboard reformation Andrew S Martinez [2]

This paper focused on the reducing the emission from diesel engines, which includes freight operations and passenger operation. This research is important because increasing percentage of railway transportation that leads higher emission of CO2 and NOX. This analysis is focused on CO2 and by careful thermal integration of the reformer unit from which we can attain NOX emission. Average fuel predicted for diesel fuel and natural gas to wheel efficiency is around 60% and 52% accordingly in operation could be provided additional SOFC gt (I) a reduction approach 98% in both fuel of NOX . (ii) A 54% saving in CO2 for natural gas operation. (iii) A 30% CO2 reduction using diesel fuel

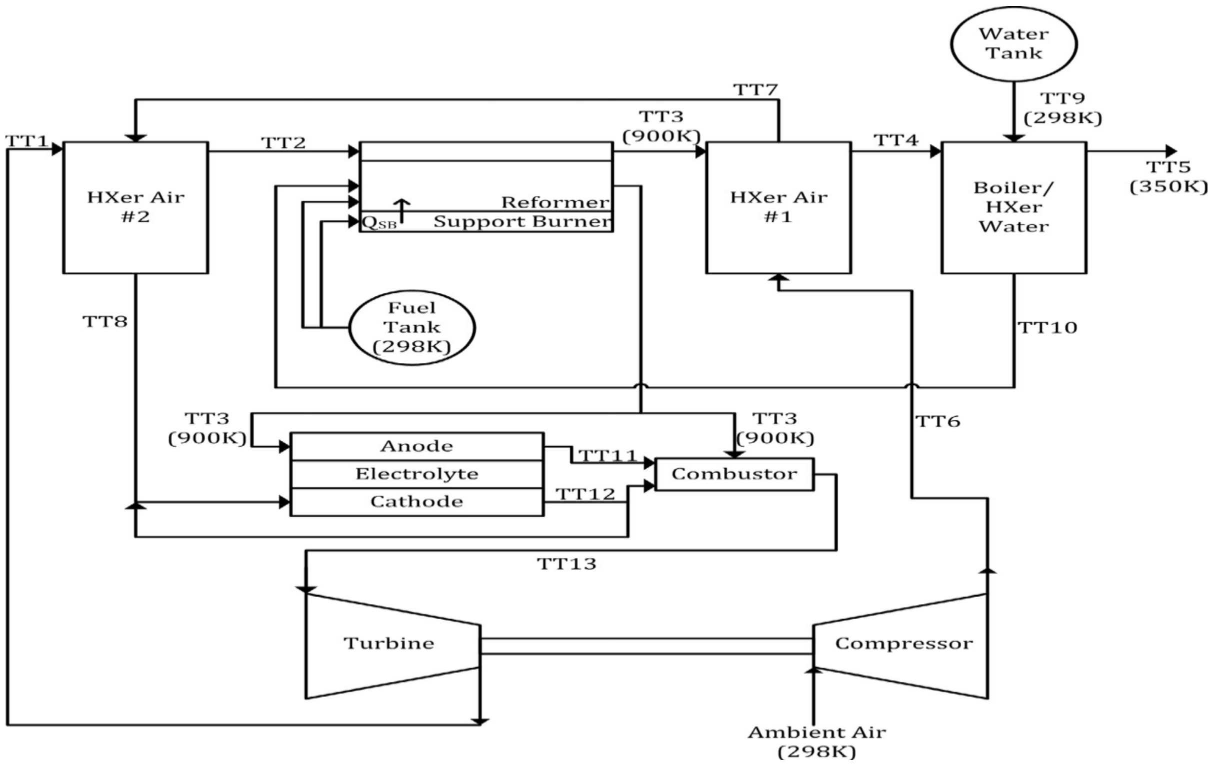


Figure 4. Thermally integrated SMR reformer Natural Gas system design with Andrew s, Martinez paper

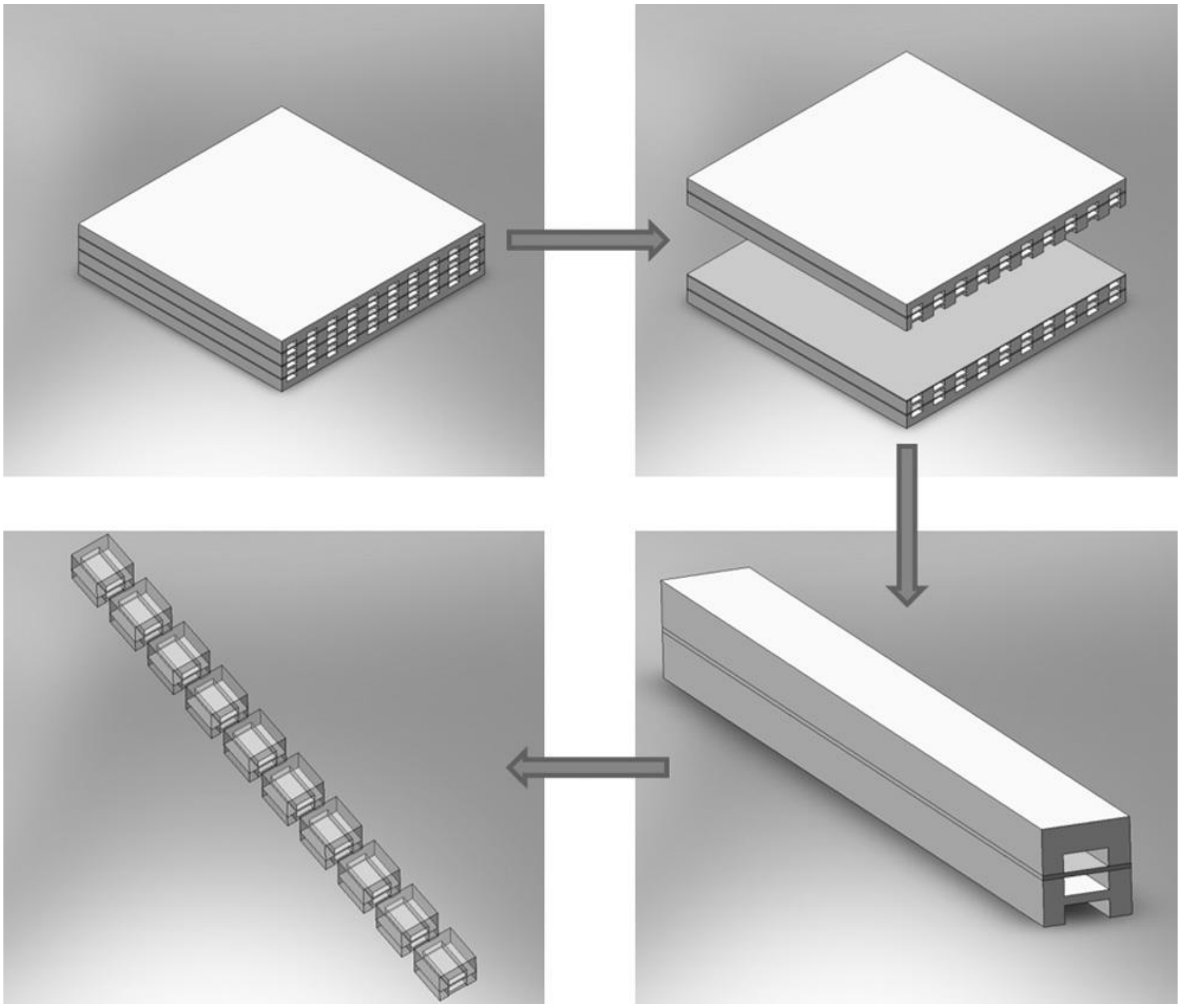


Figure 5 Modeled control volumes of SOFC simplification [2]

SOFC-GT diesel powered loco motive system efficiency of 52% and saving on emission of co2 97% and nox 70%

Nalgundwar A et al. have analyzed and compare the performance and emission characteristics CI engine fueled with dual biodiesel blend of the jatropha and palm

The Indian railway is looking forward to use bio fuels for blending of diesel and it is supported by Indian government which has allowed up to 15% of blending of bio fuels in diesel which can affect vast fleet of more than 5000 diesel locomotive in the Indian railway. The various bio fuels tested and analyzed in the study to find out suitable bio fuel which can be used in the we perform different biodiesel fuel mixed performance on locomotive. In this study a dual biodiesel blend mixture has been used like jatropha and diesel and analyzed their physical performance at various loads and made comparative analysis based on the performance.

This result lower blend of bio diesel (. 90%diesel, 10%biodiesel) the average increase in brake power is about 4.65%

Li X, Hou J et al analyzed the effect of bursting phenomenon in piecewise mechanical system with parameter perturbation in stiffness. with varying time scale has been studied and example of mechanical system a piecewise linear oscillation has been considered with parameters perturbation in stiffness and the external excitation has been examined .The order gap in time scale have been considered which has been related to the periodic excitation and different rates of variable.

Kappes W, Hentschel D et al have studied the potential improvements applied in service inspection of wheel set axels, these axels are safety critical components as they are made to perform under high static and dynamic loads. Therefore these components have been examined and periodically tested for Nondestructive tastings and examination to find out the potential defects before these can result into failure of the components

.

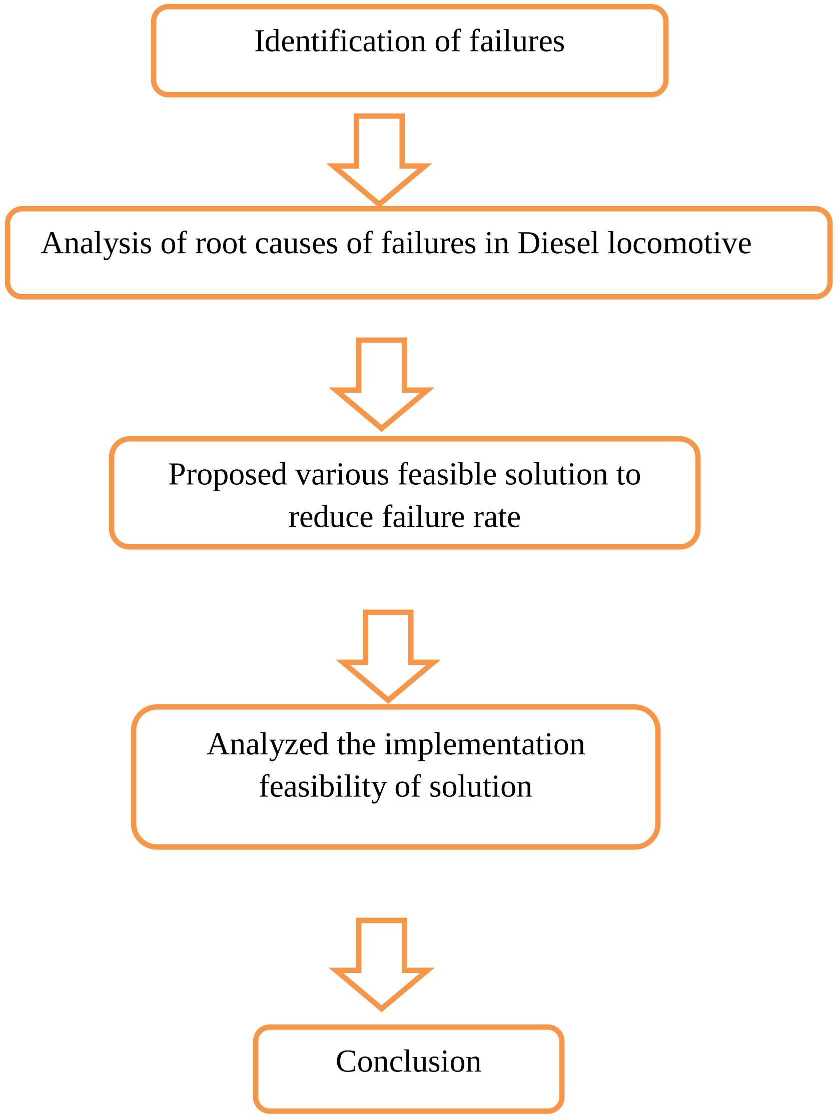
This minimizes the risk of major failure of approximately 3 million axels, potentially in service in Europe. Basic objective of this research study is to propose an Axel designing solution to euro axles and bench marking of the testing method like ultra-sonic inspection and others. .

Efforts have been made in this research study to develop an approach for spindle transient analysis with the consideration of thermal structure interaction the deformation of spindle system in both radial and axial during assembly process and deformation because of thermal extension and due to centrifugal effect all obtained. The transient analysis was based on steady classical model, the thermal deformation coupling and other time dependent parameter has been considered. Result of analysis shows clearly indicating large deviation while with the transient model is much more accurate at last the temperature rising curves, the balance timing of spindle system and temperature rise features for uninterrupted working conditions all are discussed in this study paper.

He W., Ding Y et al. has used algorithm based on sparsity in this paper for to find faults in rotating machines or any defect on that machine

Approach of the detection of periodic and transient vibration signals for detecting rotating faults in mechanism is very much given in this paper, To get their this purpose achieved they have used method they have used periodic-sparse noise signal This is based on the convex optimization formulation, they have invented the fast iterative method for the given solution. To verify and judge the performance of the wished for approach for episodic feature extraction by a simulated signal is formulated to verify The proportional methods and uncovering performances have been compare via RMSE values and receiver operating characteristic (ROC) curves. At end the planned approach applied to detect and single fault diagnosis of a locomotive bearing or compound fault judgment of motor bearing.

CHAPTER 5: RESEARCH METHODOLOGY



5.1 Identification of failure:

Failures of diesel locomotive are identified based on weekly and monthly maintenance failure rate. List is made based on the component failures and their periodic occurrence.

Sr.No	Component Failures	Failure rate
1	Fuel oil Systems	8
3	Heat Exchanger	2

1.3 5.2 Root causes of failure:

Component failures have identified and their possible causes have been figure out based on the data and observation.

Sr.No	Component Failures	Expected Root Cause of Failures
1	Fuel oil Systems	Catastrophic failure because of poor material selection and poor damping
2	Heat exchanger	Insufficient convective heat transfer

CHAPTER 6: RESULT OF EXPERIMENTAL WORK

6.1 Fuel oil system

Every diesel engine the fuel oil system is designed to introduce the fuel in to the cylinder through injector with correct pressure and quantity there is high pressurized fuel needed to lift the nozzle valve and for better atomization of fuel so that the every droplet of fuel mix with combustion chamber air

The high pressure of fuel is also required for better atomization so that every atomized fuel droplets come in the better contact with the compressed air in the combustion chamber.

Fuel oil arrangement comprises of dual systems.

1:- Fuel feed system

2:- Fuel injection system

6.1.1 Fuel Feed System.

4. Provides the back support to FIP pump.
5. Maintains steady supply of fuel at FIP inlet.
6. Ensures correct quality and quantity of fuel oil
7. Ensures minimum pressure required by Injection system.
8. Consists of
    1. Storing,
    2. Feeding and
    3. Filtering of fuel oil

6.2 Component associated with the fuel oil system:

1. Fuel oil tank
2. Fitted under super structure between two bogies.
3. 5000 for (WDM3a / WDM2).
4. 6000 for (WDG3A)
5. Fuel primary filter.
6. Fuel secondary filter.
7. Booster pump (fuel transfer pump).
8. Pump capacity- 14 lts/ minute (at 1725 rpm).
9. Fuel relief valve
10. Fuel regulating valve

6.3 Fuel injection system

Inject fuel oil into engine cylinders

1. Accurate time.
2. Accurate pressure.
3. Accurate quantity.
4. In precise atomized form.

All FIP pump starts deliver fuel oil at 4000psi through nozzle by h.p tubes in their respective firing order

6.4 Fuel Injecting

1. Pump Fuel injecting pump is constant plunger single acting type pump design to deliver fuel as per variable demand.
2. Stroke length and time depend on the angle and cam profile.
3. The plunger spring control the return stroke of the plunger
4. The plunger move in the Barrel having close tolerance to plunger at bottom dead center spills ports of barrel open up who have connected to the fuel feed system of fuel oil filled inside barrel empty space at right time in fuel cam pushes plunger in forward direction in diesel cycle and this moving plunger close the spill ports hence trapped oil in barrel is forced out through delivery valve and injector nozzle inject it in to combustion chamber.
5. To raise the fuel oil pressure which will efficiently atomize the fuel?
6. To supply the correct quantity of fuel as per the requirement of power and speed of engines.

To deliver fuel at correct time for efficient and economical operation of engine.

Figure 6.fip pump plunger and barrel

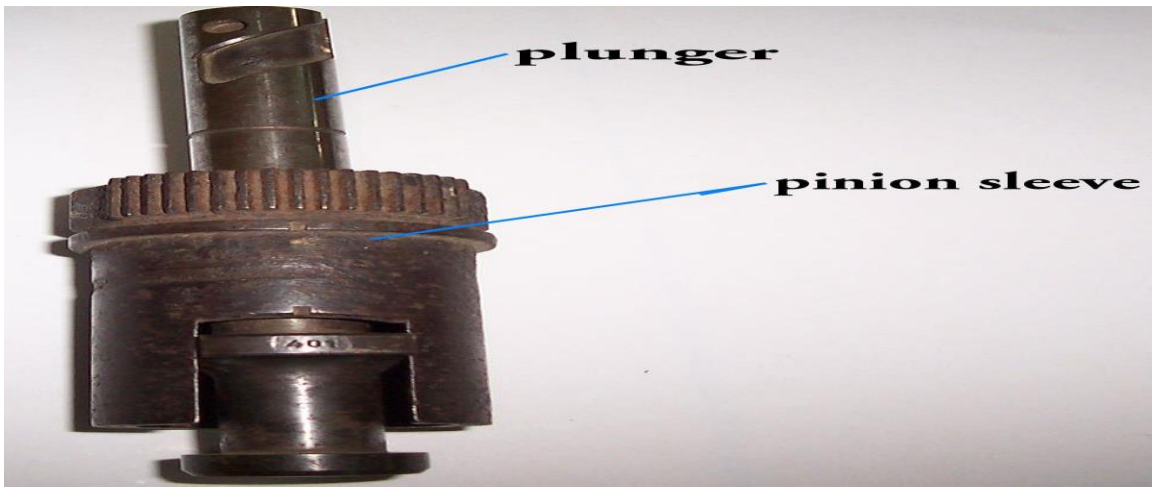


Figure 7.Fip Pump Plunger and Pinion Sleeve (rly dsl shed ldh)

6.5 Fuel injection nozzle

1:-To inject fuel at a sufficiently high pressure so that the fuel enters the cylinder with a high velocity.

2: -Fuel injection nozzle inject fuel oil in combustion chamber at desired pressure.

3:-Fitted in the cylinder head.

4:- Multi holed needle valve type operating against spring tension.

5:-The needle valve blocks the oil holes due to spring pressure.

Proper angle on the valve and the valve seat ensures proper closing of valve.

Important parts of fuel injection nozzle are as mentioned below-

1. Nozzle body
2. Nozzle Valve
3. Spacer
4. Pressure adjusting spring
5. Nozzle holder body.
6. Cap nut

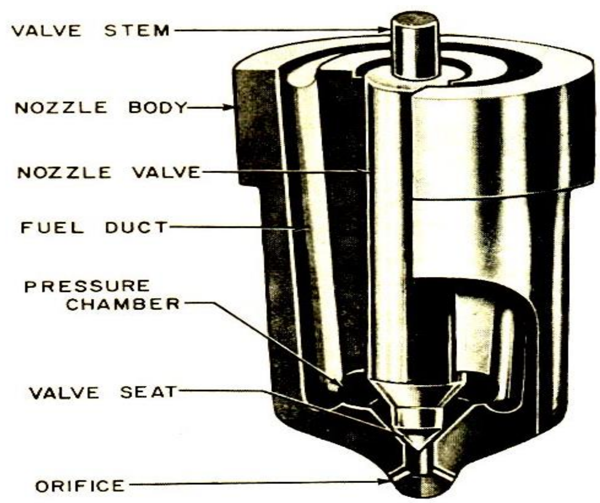


Figure 8. Nozzle valve (stc lko)

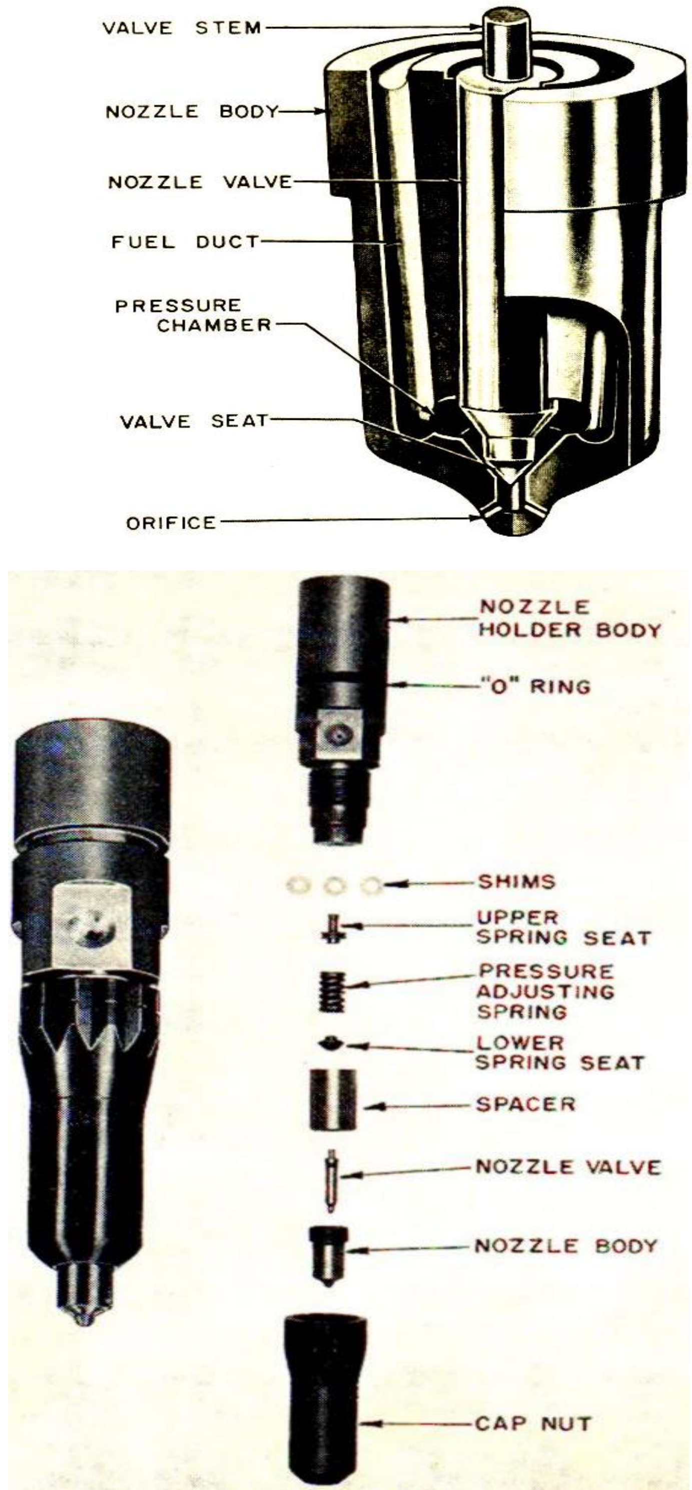


Figure 9. Exploded view fuel injection nozzle (stc lko)

6.5.1 Nozzle testing

1. Opening Pressure: 3900-4050 psi (New), 3700- 3800 psi (Old)
2. Spray Pattern/ Blotter test: Uniform pattern
3. Dribbling: Holding at 3500 PSI for 10 sec (No drop)
4. Leak off: 3500 to 1000 PSI drop down time 6-16 sec
5. Valve Lift: .026" (max), .005 to .007" (New

6.5.2 Benefits of testing

1. Good atomization.
2. Correct spray pattern.
3. Neither leakage nor dribbling.

6.6 Fuel pumps calibration phasing:

Setting of Pump per Injection Timing during fitment of FIP on the engine.

All fip adjusted individually Adjustment by screw provided in the cross head lifter mechanism.

The marking between guide cup and the sight window are to coincide with each other.

CALIBRATION: Calibrating delivery of the pump per rack Position Checked by hart ridge 1100 calibrated machine at 300 rpm and 300 stroke 9mm = 45 ml

Figure 10 Fip testing machine (rly dsl shed ldh)

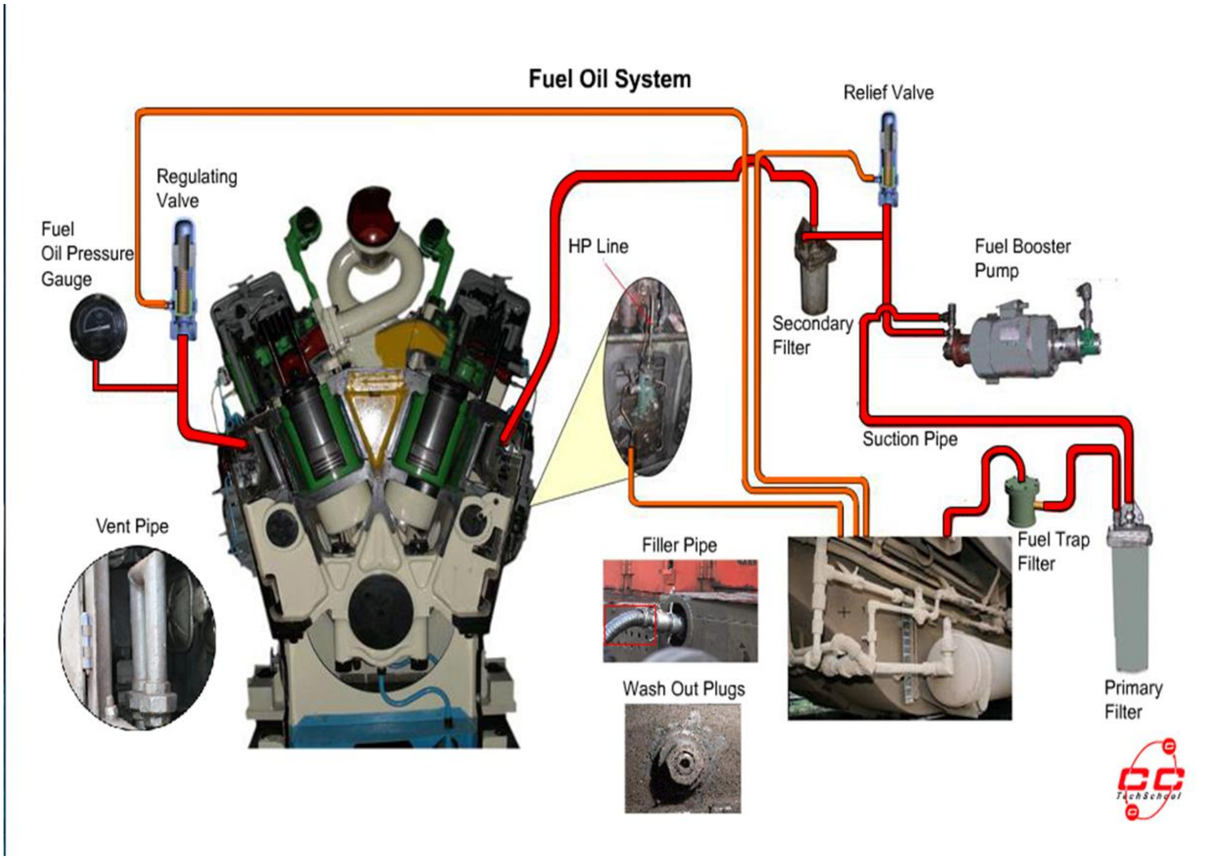


Figure 11.Fuel-oil system (stc lko)

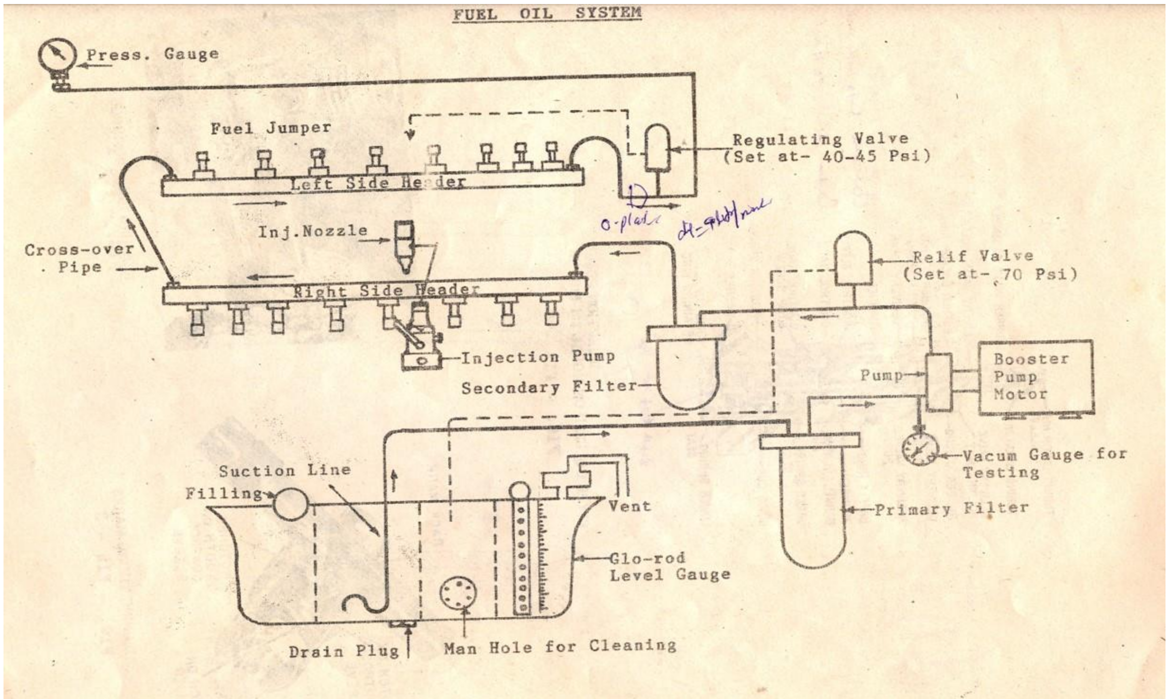


Figure 12. Layout of Fuel oil system(rly dsl shed ldh)

The above we discuss about fuel oil system in this so now we can know the failures to be causes in the system

4. Fuel injection pump vibration causes failure of pump
5. Benzo pipe failure due to vibration and material defect causes failure and makes fuel oil leakage
6. High pressure tube failure
7. Fuel rack jamming problem causes failure of locos
8. Fip pump collar breakage

The above failure come in diesel locomotives in general the failure rate about 10 to 20 % on an average

The different FIP system parts figure listed below

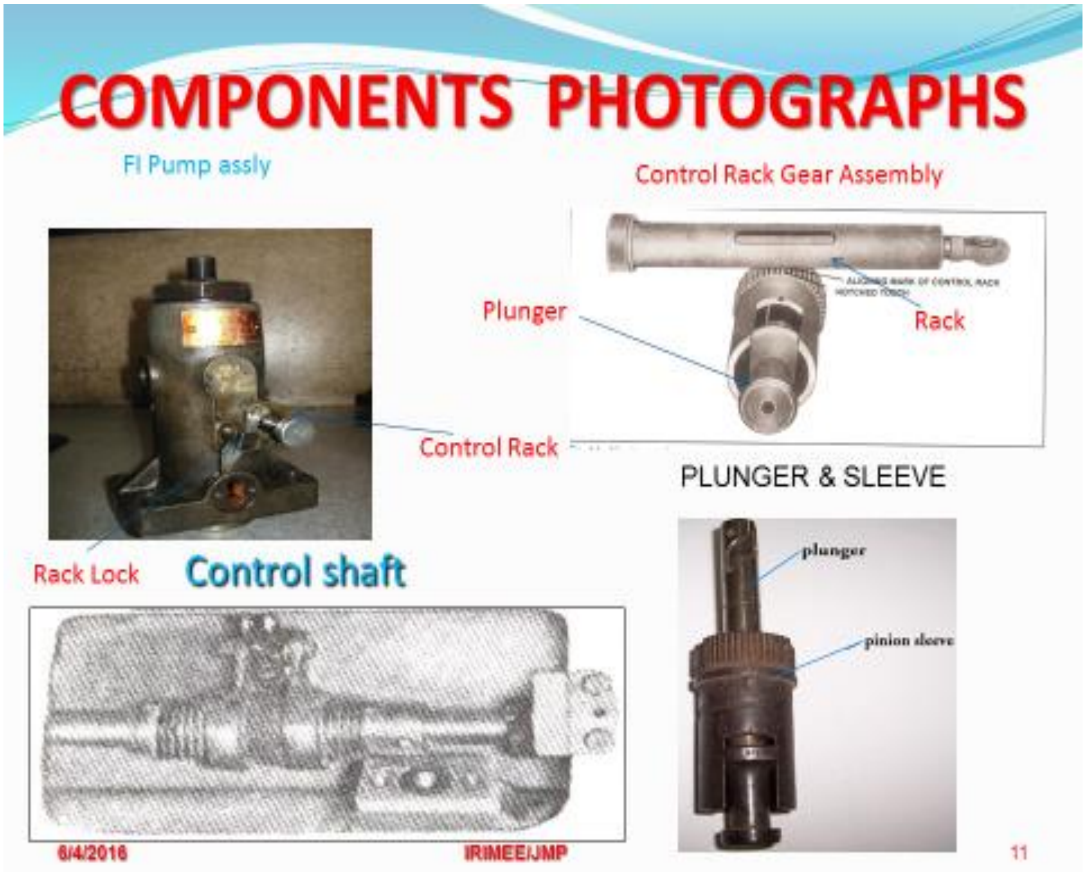


Figure 13H.p tube of FIP pump (rly dsl shed ldh)

Figure 14.Fuel injection pump mount (rly dsl shed ldh)

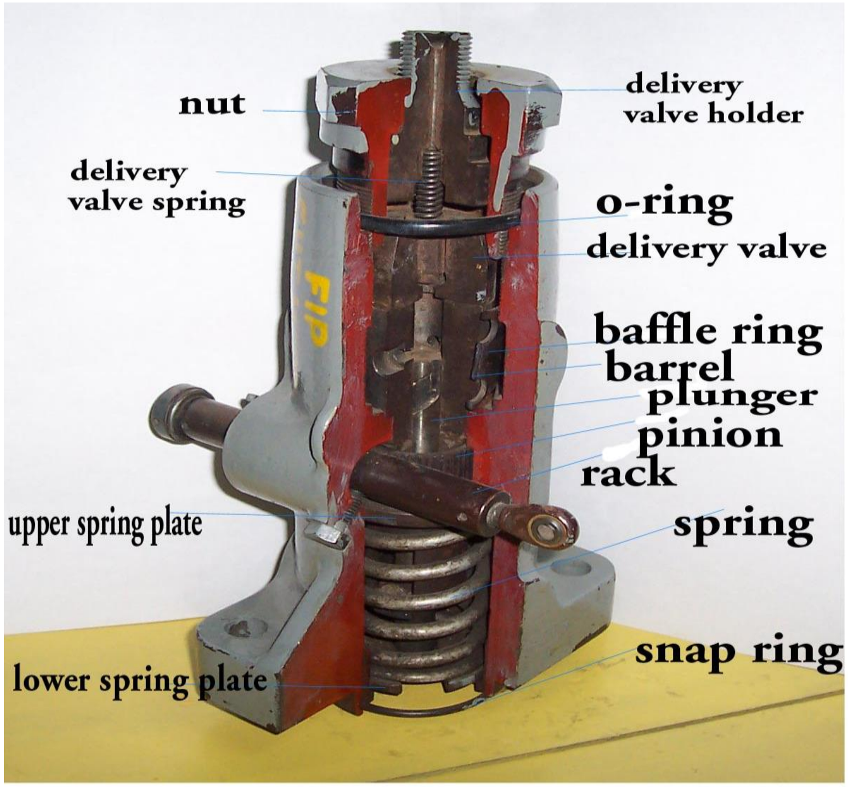


Figure 15.Cross section view of fip pump (rly dsl shed ldh)

6.7 Fuel pump failure

The basic function of fuel pump is to inject the fuel from fuel header pipe to high pressure tube with the help of non-return snubbed valve to injector so it is key element of locomotive if it can be failed causes failure of locomotive

The basic failure causes of pump failure due to vibration the vibration causes which effect the pump working and prone to failure is due to mechanical and fluid excitation vibration or radiated noise

1:- Engine generator block bolt not fully torque

2:- Due to pump wear and tear due regular working and not properly calibrated

3:- The vibration due moving parts of engine like power assemblies and other moving part

The various solution is are of following

1:- To be assure full torqueing of block bolt both engine and generator regular basis

2:-Regular pump calibration to be done periodic basis and defective pump to be change

3:- To control vibration checking to be done of vibration on regular basis

The vibration checking of fip pump is to be done on idle and 8^{th} notch

1:- FIP CHEST VIBRATION CHECKING

2:- H.P. TUBE VIBRATION CHECKING

All to be done on idle and 8^{th} notch

The vibration limit are to be 30 to 130 wdm 3a and 30 to 150 wdm 2

This vibration is calculated and making sure to control vibration

Figure 16 :Vibration Meter (rly dsl shed ldh)

Fig 17: Benzo Pipe (rly dsl shed ldh)

Figure 17:Benzo Pipe and Benzo Bolt (rly dsl shed ldh)

6.8 Benzo Pipe Failure

The benzo pipe is the pipe with benzo bolt of non-return valve to supply fuel from fuel header pipe to fuel injection pump is the key area of failure of fuel oil system

The various causes of failure of benzo pipe are

1: - material flaw or structural changing material

2:-vibration due mechanical excitation or fluid excitation

3:-Benzo bolt type non return valve thread work out

4:- washers gasket misalignment or displacement (copper or flexi tolic)

There are some causes material are to be

1:- The material used are in benzo pipe is cast iron which have failed due fracture called brittle fracture

I: - Brittle fracture is used when a part is overloads and brakes without any visible distortion because of brittle material

Ii: - whenever load applied extremely rapidly to any part causes severe shock load causes failure

Iii: - changes in material due to fatigue failure under resonant vibration condition

To overcome all these problem, we either change material of benzo or make vibration damping design of benzo

a:- To be change material from cast iron to nodular cast iron or steel alloy but there is a financial constraint and design constraint come on to change this

2: -To make any medium of vibration damping such as design of single piece cast iron to split in two parts with leather or rubber material of high strength which absorb vibration and overload shock

3: -Benzo bolt thread to inspect timely and change it accordingly its condition and make sure in torqueing do not forcibly to be done or cross screwing done

4: -make sure washer and gasket properly fitted and copper washer annealing to do before fitment to remove residual stresses

Benzo pipe failure caused by due to the vibrations occurred during operations of the locomotives

The other measure cause is the material of benzo pipe is cast iron

The failure rate of benzo pipes is of maximum of near block of loco means R 1, 2 7, 8 and L 1,2,7,8

To solve this, we have required to damping of vibration effecting on benzo pipe

The different methods of vibration damping are

Force reduction – This is to be occurred due to unbalance or misalignment which decreases response of vibration system

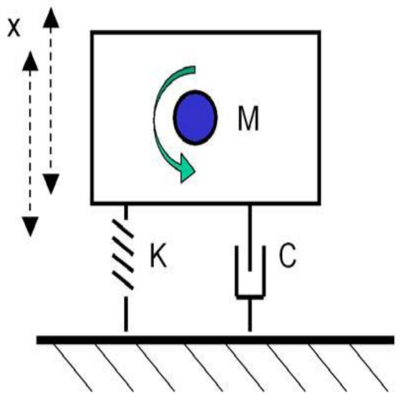
Mass addition – This is decrease’s the impact of constant excitation

Tuning- varying natural frequency of component reduce and exclude resonance amplitude or elimination of vibration excitation

Isolation- Be repositioning the excitation force we get to eliminate or decrease vibration

Damping- to convert vibrational energy (mechanical form energy) in to heat energy

A vibration system with one degree of freedom shown in fig 1.8, below forces input is comprised of three distinct component damping inertia stiffness a. The relationship component forces shown as vector in fig 18



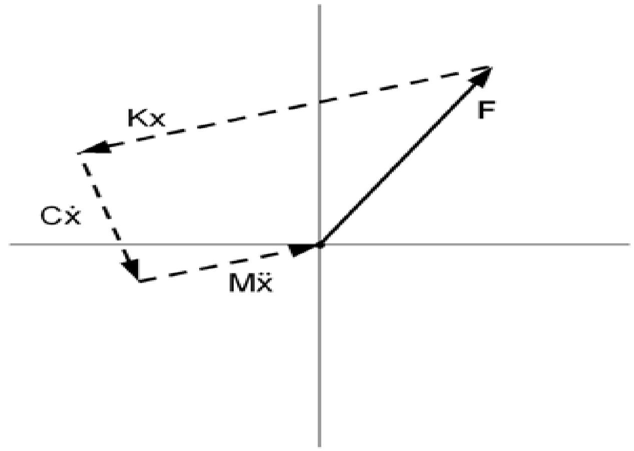


Figure 18.1 simple vibration system **Figure 18** force component

We use isolators to be in cooperate in our benzo design for this we can take rubber and metal rubber

As we know that metal rubber and changes non linearly accordingly to the hysteretic damping theory and conservation a prototype of stiffness developed the ring type of isolator made up of metal rubber and rubber are studied the isolator tested on the electro hydraulic loading testing secured by clamping devices in quasi static loading states.

Rubber- A Large loss factor and viscoelastic material having good to isolates vibration efficiently, but does not supply corrosion and high temperature metal rubber also called wire mess dampers which consists of wire helix which consumes vibration energy by relative slip friction the mathematical study of this is very complicated so we make model and test here we do quasi static loading test

Quasi static loading test

The dynamic stiffness is non linearly changes and related to many other parameters of the stiffness ,rock tri axel test plant of TAW 2000 used to conduct the axial quasi static loading experiment

Figure 19: Rubber Isolator, Metal Rubber Isolator

The metal rubber made of 18 mm wire consists of 1 cr 18 ni 9 ti

Relative denisity is 0.6 ,outer dia- 70mm , inner dia—34 mm

Height- 23 mm , denisity- 0.127 kg/m3(made by drilling)

Benzo dia on fip end-d1-37,d2inner-23

Total length 120mm

Middle section -60 mm

Benzo dia on fuel rack shaft end D-28.7.d 12.30

Width-23mm

Total length-67mm

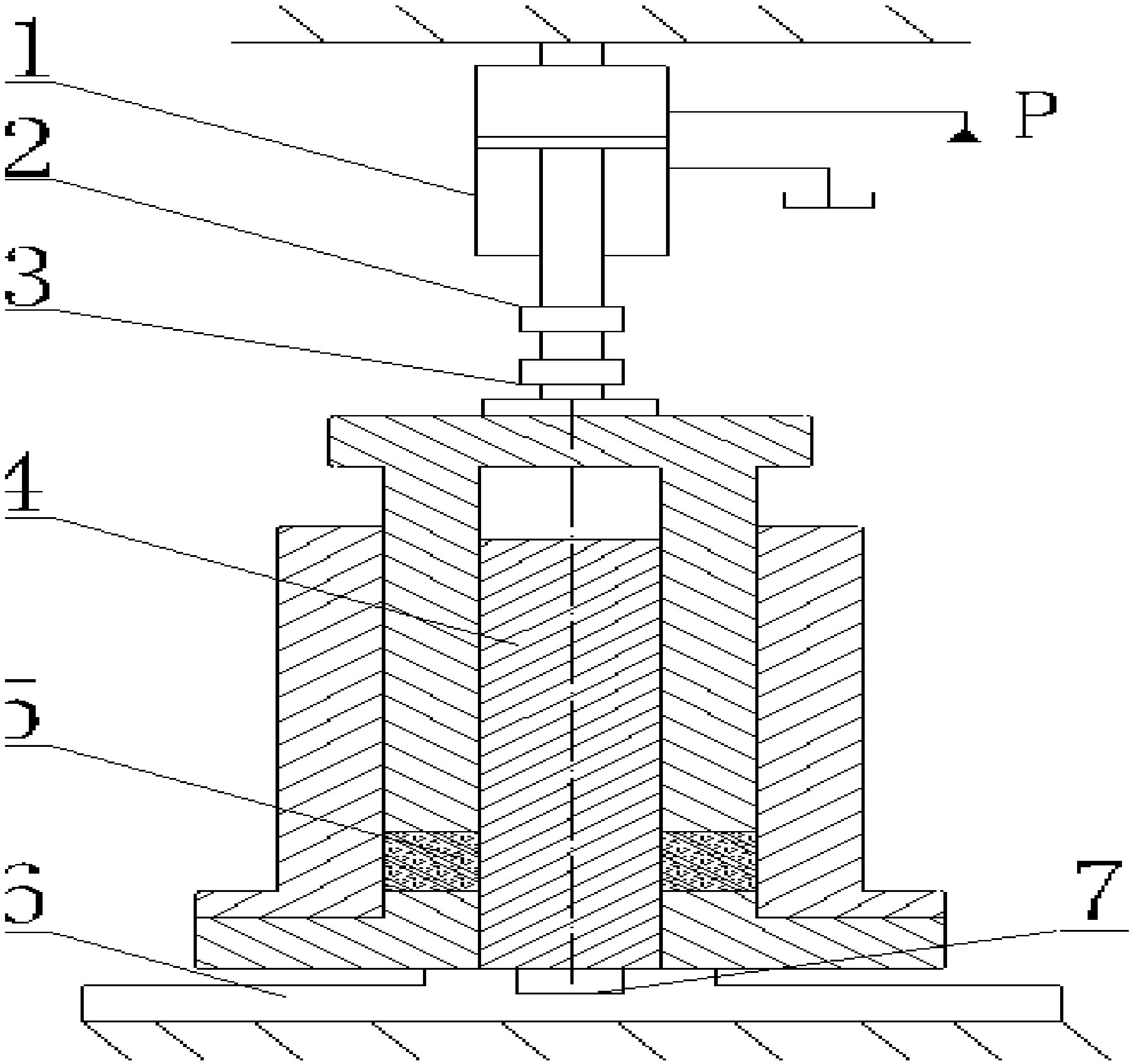


Fig 22: A device containing clamping fixed on the annulus isolated design.

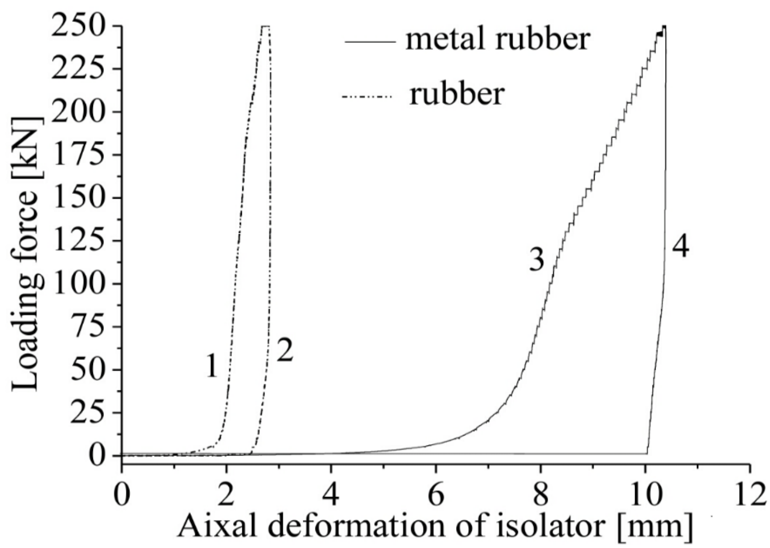
- Schematic experiment principle

- Loading cylinder
- Displacement sensor
- Force sensor
- Clamping device
- Annulus isolate

The isolator composed of piston, core rod and cylinder with high stiffness is fixed inside clamping device the axial forces excited by the three axel test machine put impact on piston or the isolator, by force sensors. Measure the loading and isolating force the displacement calculate the loading and isolating force the sensor record changes in shape by means of hydraulic pressure loading forces to be set and to avoid sudden high pressure incensement we have a relief valve to study stiffness under different loading force and loading rates two loading stages includes, loading and unloading.

Point Loading Test- To avoid hysteretic impact the point load test is performed in the isolator. The maximum loading force is 250KN.

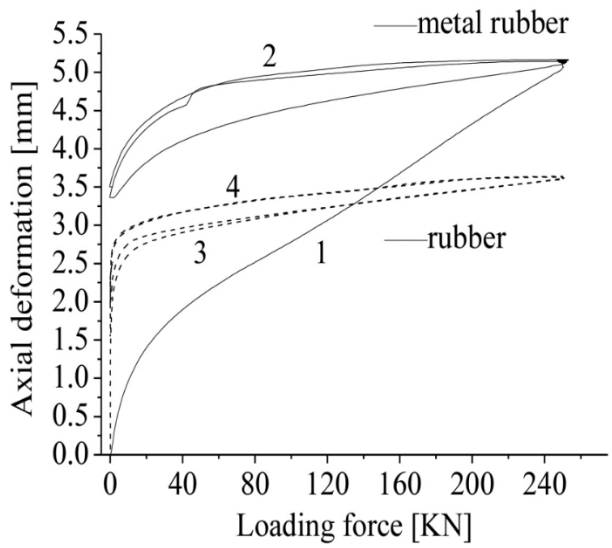
Fig graph plot of isolator deformation under the point loading (1 and 3) and unloading (2and4) under the equal loading deformation of metal rubber is 4.2mm and compared with zero of rubber.



Deformation of isolator under point loading test

Continuous loading Test.

Loading test in continuity can reflect the hysteretic effect on isolating material the stiffness under different loading rates is tested is rested at different loading times the below deformation under the different continuous loading rates. The curve 1 and 2 in fig are the axial deformation of the metal rubber with loading rate of 12.5KN min and 25KN min



. Deformation of metal rubber and rubber under continuous loading

The result shown that deformation of metal rubber is more than rubber in terms of loading rate, it is inverse proportion to the each other.

Conclusion-

The result shown after quasi static loading are that metal rubber has more plastic deformation under loading while the rubber does not have, this is resulted from bad uniformity the dampening of rubber and metal rubber decreases at the same time because of slip and friction, the total deformation of metal rubber isolator is smaller than rubber isolator, hence Metal rubber isolator has good damping than rubber or metal individual.

6.9 High pressure tube failure

A high-pressure tube is a tube to transfer highly pressured fluid to feed in injector inlet about 3000to 4000 psi so it is very important of function of locomotive engine and its failure causes the fire hazard

The causes of H.P tube failure are

1: -Lack of proper fitment

2:-over or less torqueing h.p tube nut

3: -misalignment about injector or tube in tension or stress

Remedies of this problem are:-

1: -Make sure h.p tube properly fitted along with snubber valve and injector inlet

2: -To ensure proper torturing done with either torque wrench or automatic torque wrench not to be done with manual wrench

3: - To ensure proper alignment h.p tube outlet with injector inlet and h,p tube timely tempering to be done in automated controlled furnace rather than open furnace

Some other precaution is

6. Zyglo testing of H.P. pipe before fitment.
7. These tubes are to be tested up to 5000psi.
8. The rubber ferule to dampen the vibrations must be provided in these HP tubes.
9. Radius of HP pipes should be checked up on a fixture.

Fig 23 h.p tube (rly dsl shed ldh)

6.10 Fuel rack jamming

The one of the problem of failure of fuel oil system is rack jamming due which fuel pump not working and power pack not working of that pump and causes hauling power poor loco hunting and causes heating of jammed pump makes pump breaking

The basic problem of jamming is poor lubrication as lubrication done manually and there is no means of lubrication while loco working over the track

So solve this we punched or drill few small holes pocket in control shaft on which lubricating oil filled and lubricate rack some while locomotive working in the line due to evaporation or splashing due to movement of locomotive

6.11 HEATEXCHANGER

6.11.1 Introduction:

Tube and Shell heat exchanger are most adoptable type of heat exchanger and able to provide high efficiency. They are mainly used in the process engineering, as well as nuclear and conventional power station as condensers, steam generators in pressurized water reactor power plants, feed water heater and they are proposed for many alternative energy application including geothermal and ocean and some air conditioners refrigerators

Shell and tube type heat exchanger provide comparatively large ratio of heat transfer area to weight and volume ratio they offer green flexibility to.

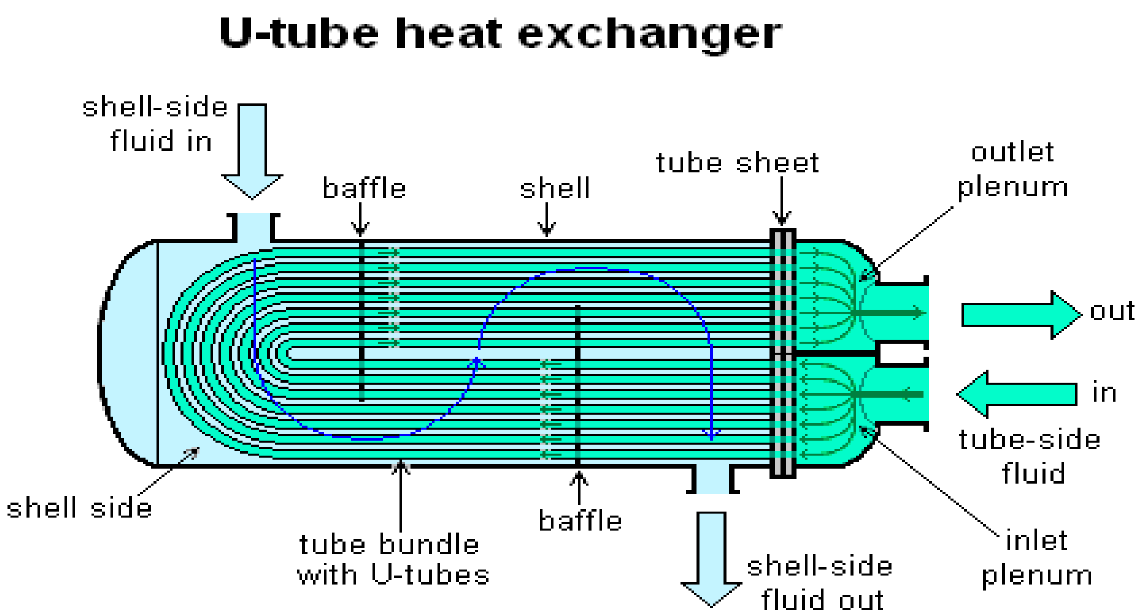


Figure 20: U tube type heat exchanger (sadik kakac hmt book)

6.11.2 Shell type:

Different front and rear heads type and shell type have been standardized by tubular exchange manufacturing association. They are identified by an alphabetic character as shown. Shows the most regular type as condensers. The E shell is the most common due to its cheapness and simplicity. In such shells the shell fluid enters at one end of the shell and leaves at other end i.e. there is one pass on the shell side. The tube may have single or multiple passes and are supported by transvers baffles.

This shell is the most popular for single-phase shell fluid application with a single tube pass, a nominal counter flow can be obtained. To increase the considerable temperature differences and hence exchanger effectiveness, a pure counter flow arrangement is desirable for tube pass exchanger. This is achieved using an F –shell with longitudinal baffles and resulting in two shell passes; it is used when unit in series is required with each shell pass representing one unit. The pressure drop is much more than the pressure drop in comparable shell.

6.11.3 Finned tube exchanger

Heat exchanger, the two fluids namely cold and hot is separated by the metal wall. Under this condition the rate of heat transfer will depend on over all heat transfer, in tube fin heat exchanger rectangular, elliptical, round tubes are used and fins are employed either on outside or inside or both inside and outside of the tubes, depending on application. In gas to liquid heat exchanger, the gas side heat transfer coefficient is very low compared to the liquid side therefore no fins have been provided to the liquid side area.

Figure 21: Tube Fin Type Heat Exchanger Courtesy (Indian Railway Diesel Shed Ludhiana)

In some application fins are also used inside the tubes. The liquid flow in the tube side which can accommodate high pressure tube fin heat exchanger examples of heat exchanger are given fig 22

Fins on outside tubes may be categorized

A. Flat external fins on array of tubes.

B. Normal fins on individual tubes.

C. Longitudinal fins on individual tubes.

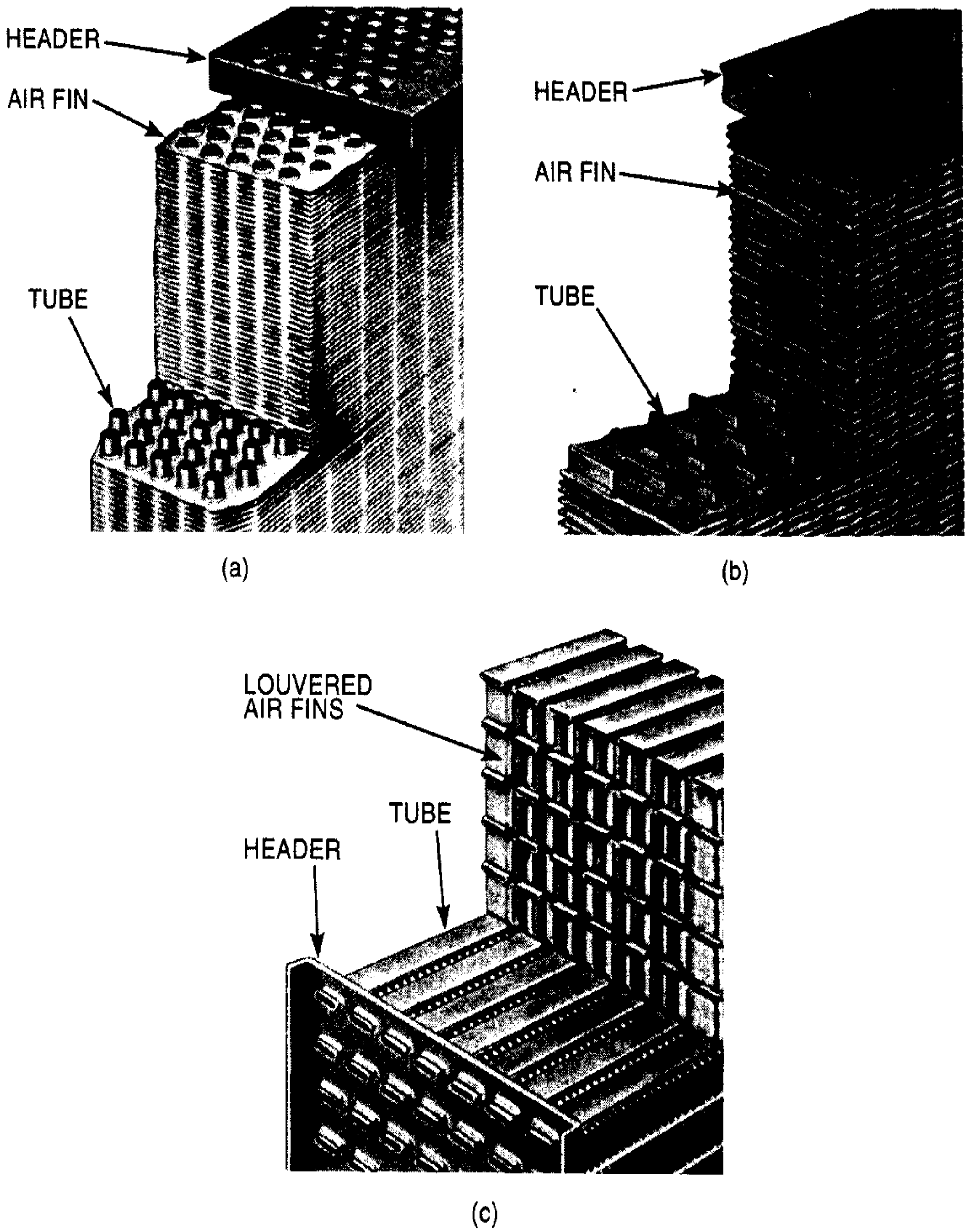


Figure 22: (a) Flat external fins on an array of Tubes (b) Normal fins on individual tubes (c) Longitudinal fins on individual tubes (sadik kakac hmt book)

$$\frac{1}{UiAi} = \frac{1}{hiAi} + \frac{x}{KAlm} + \frac{1}{hoAo} \qquad - \quad - (1)$$

Where

Ui = Over all heat transfer coefficient based on inner area.

Uo = Over all heat transfer coefficient based on outer area.

hi,ho= inside and outside film heat transfer coefficients

Ai,Ao= Inside and outside surface area.

When thick fluids are heated in double pipe heat exchanger or any standard tubular heat exchanger by condensing steam or hot liquid of low viscosity the film heat transfer coefficient of viscous (Thick) fluid will be much smaller than that on the hot fluid side and will therefore become controlling resistance of heat transfer coefficient.

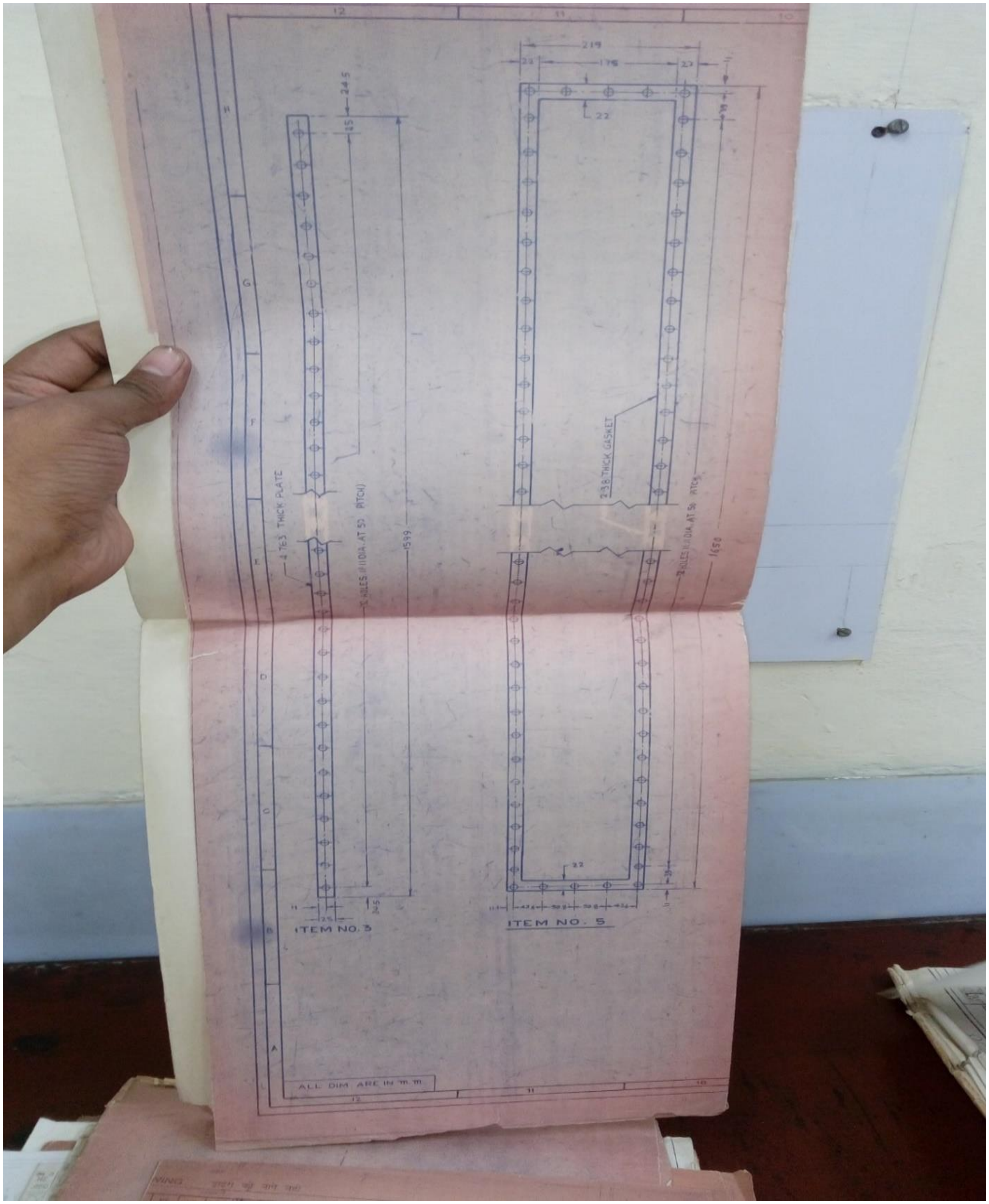


Figure 23: Layout of fin tube Heat Exchanger (Courtesy Indian Railway Diesel Shed Ludhiana)

6.11.5: Plate fin type exchanger:

In this type, each channel distinct by two parallel plates detached by fins or spacers. Fin or spacers are sandwiched between parallel plates formed tubes. Examples of compact plate heat exchanger are shown in figure 6.6 fins are attached to the plates by brazing, sold in, adhesive bonding, welding mechanical fit, and extrusion. Alternate fluid passage is connected in parallel by the ends head to form two sides of a heat exchanger. Fins in co-operated both side gas to gas heat exchanger

In gas to liquid heat exchanger application fins are usually employed only on the gas side where the heat transfer coefficient is lower. If fins are employed on the liquid side, the fins provided a structural strength. The fins used in the plate heat exchanger may be plain but wavy fins, or interrupted fins like perforated strip

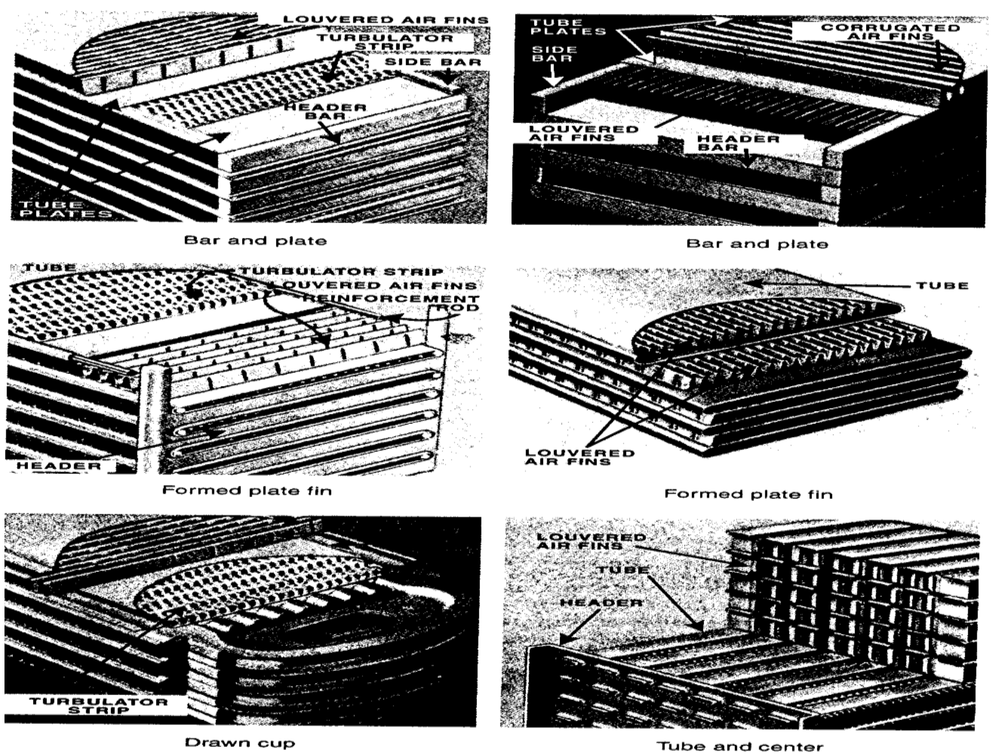


Figure 24: Plate fin type exchanger (sadik kakac hmt book)

6.11.6 Mathematical calculation

For prediction of the heat exchanger performance we have following data available from which we find pressure drop, heat transfer coefficient (h) to better heat exchanger between plate fin type and tube fin type

Specification of heat exchanger (Courtesy Indian railway tube fin type)

195 *f water in and 131 *f water out

Water flow 300v u's gallon /min

Number of tubes 896

Length of tubes 5.725 ft.

Pitch 1.96 in

No passes 2

Dia 11.11 mm OD

Holes 32 11.11 dia. over 50 mm pitch

Total tubes in section 7*32*4= 896

Gap between 2 tubes 43.8

All other parameters to be taken standard number Reynolds number, Prandtl number etc.

The air densities at the inlet and outlet are

Þi = 0.9721 kg/m3

Þo = 1.534kg/m3

The properties at the bulk temperature of (90+54)/2=72.5^{0}C

Þ=1.038kg/m3

Pr = 0.719

μ=2.04x10^{-5} Kg/m. s

Cp= 1.007KJ/kg. k

The pressure drop is calculated from eq (9.8)

Ai/Am = βAfrL/Afrσ

β=Al/V=748m^2/m^3

$\frac{Al}{Amin} = \frac{\beta}{\sigma}$L = 748/0.78*1.75 = 1678 kg/m. s

Amin = σxAk = 0.780x7.8=6.084 m2

G= 18.9/6.084 = 3.10 kg/m. s

Dh = 4x$\frac{L}{At/Amin}$ = 4x 1.75/1678 = 4.17 mm

Re = GDh/μ = 3.10x0.00417/ (2.04x10$^{-3)}$ = 633

H=0.0058X3.1030/(0.718)$^{2/3}$ =800 W/m2.K

Re = 633 f = 0.06

Pressure drop = (3.10)^{2}x 1/ (2x1.77) [0.06x1678x1.177/1.038+ (1+0.78^2) (1.177/0.954 -1)

=1256 N/m^2

Pressure Drop of tube fin type heat exchanger = 1256 N/m^2

Calculation Plate Type Heat Exchanger

Pressure drop = 0.023x1678x $(3.10)^2/(2x1.41)$

= 131.52 N/m^2

Pressure drop of fin Plate Type Heat exchanger =131.52N/m^2

$$\frac{h}{GCp} Pr^{\frac{2}{3}} = 0.015$$

$H=0.015x3.10x1.007x10^{-3}x\ (0.982)^{2/3}$

Heat transfer coefficient: 46.2 w/m^2. K

6.12 Result:

The result shows that the tube type heat exchanger having more pressure drop compare to plate type hence it requires more pump work to minimise that pressure drop so the plate type is more efficient in compare to the tube type.

The main causes of failure of heat exchanger is improper working of it during summers which leads to failure of locomotives due to increase in working temperature of engine. Hence efficient plate fin type heat exchangers should be used in place of fin tube heat exchanger.

6.13 Plate fin type exchanger:

In this type of heat exchanger arrangements of plate are side by side fixed along with gaskets, two adjacent fitted plate will make fluid flow b, gasket which is fitted between two adjacent plates will make the fluid between two ports of block remaining ports, to imagine a rectangular port having four holes near its edges and these are fixed in such a way that gasket between plate makes an enough room for fluid to flow and change the direction of fluid as required. This operates fluid in counter current wise for attaining maximum heat exchange. It has benefit which supersedes other heat exchangers are:

1. Negative heat loss.
2. Over all weight of set is less

3. Fits in less space.
4. Less maintenance cost.
5. Over all heat transfer coefficient.

Cons

Not Suitable for higher pressure

Application: Used in automobile and refrigerator systems.

Fin Type Heat exchanger:

Fin type heat exchanger are called as extended surface exchanger which is used in the conditions when process fluid is having low heat transfer coefficient when compared to other fluids because overall heat transfer coefficient decreases which affects the capacity of heat transfer by the available surface area so that area of contact to be increased. A metal piece is welded to the surface of tube to increase the surface area which is called as fin and mostly found on outside of the tube. Fin type heat exchanger is classified into longitudinal fin type and transverse fins type.

Pros

1. Use to handle low heat transfer coefficient.
2. Used for cooling waste gases and heating.

Cons

1. Slurry fluids cannot be handled
2. Difficult to clean
3. Sludge deposition on tubes
4. Chocking of tubes
5. Fins easily get dirt deposition
6. Maintenance is difficult and not easy

Application: Used in the automobile radiators and economizers

CHAPTER 7: CONCLUSIONS

The above analysis is conducted in report to find out causes of failure, their remedies and feasible solution of problem in Indian railways diesel locomotive. The final conclusions of the report are as follows:

10. The analysis of fuel injection pump revealed that pump failure occurred due to humane negligence , improper calibration of pump and tool usage , loosening of engine block bolt which causes vibrations and cam or cross head structural deformability. As a remedial measure, use of calibrated Fuel injection Pump, regular checking of engine block bolt, use of standard calibrated tool and frequent checking of vibrations of pumps should be implemented which can increase the working efficiency of Fuel Injection Pumps.

11. Benzo Pipe analysis is done by design improvement in the benzo pipe which had to suffer higher deformation rate due to pressure loads and vibrations. So benzo pipe with and without rubber mesh wire were tested in Quasi static Load Testing machine and it was concluded that benzo pipe with rubber mesh wire fitted over them were having less deformation under point and continuous loads as compared to simple benzo pipes. Hence as a new maintenance practice, use of new benzo pipes fitted with rubber wire mesh is proposed.

12. Various causes of failure of high pressure tube used in fuel injection pump were found out to be error in fitting these tubes with Fuel Injection Pump and cylinder head, higher vibrational effects, material defects and errors in calibration. Hence suggesting effective maintenance practices it is proposed that regular inspection of tube joint should be done to ensure that there are no traces of stresses developed in it. Use of vibration meter is suggested to check the vibrations developed during working of the Fuel Injection Pump

.

13. Another frequent failure in the locomotive is malfunctioning of Heat exchanger. Hence an analysis is conducted on the two types of heat exchanger-Plate fin Type and tube fin type heat exchangers (which is currently being used in Indian Railways). So based on the study it is concluded that the plate type heat exchanger is more efficient than tube type heat exchanger for this application in the Indian railway.

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