INDUSTRIAL TRAINING REPORT I

TRAINING ORGANIZATION : SRI LANKA RAILWAYS

PERIOD OF TRAINING : FROM 30/10/2017 TO 07/01/2018

FIELD OF SPECIALIZATION : MECHANICAL ENGINEERING

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E/14/369

ACKNOWLEDGMENTS

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Also I am grateful to all foremen, Supervisors, Technicians and Labors of workshops 10, 32,14,16,28, of Chief Mechanical Engineering workshops, Rathmalana.

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LIST OF ABBREVIATIONS

BDC	Bottom Dead Center
CEE	Chief Electrical Engineer
CME	Chief Mechanical Engineer
DME	Deputy Mechanical Engineer
EEC	Electrical Engineer of Carriage
EEP	Electrical Engineer of power
EET	Electrical Engineer of Traction
MEC	Mechanical Engineer of Carriage
MED	Mechanical Engineer of Drawing
MEF	Mechanical Engineer of Foundry
MEL (E)	Mechanical Engineer of Locomotive
MEL (H)	Mechanical Engineer of Locomotive
MEL (P)	Mechanical Engineer of Locomotive -Power
MEP	Mechanical Engineer of Production
MES	Mechanical Engineer of special project
MEW	Mechanical Engineer of Wagon
TKC	Time keeper clerk
TDC	Top Dead Center

Chapter 1

INTRODUCTION

1.1 TRAINING SESSION

I was assigned as a trainee mechanical engineer at Chief Mechanical Engineering Workshops, Ratmalana, which is a government sub department of Sri Lanka Railways. The time period was 10 weeks, starting from 30.10.2017 to 07.01.2018.

Table 1.1 Training schedule

Section	Shop	Period	Start on
Diesel Electric Loco Repair (2 stroke)	14	02 weeks	30.10.2017
Diesel Electric Loco Repair (4 stroke)	16	02 weeks	09.11.2017
Diesel Hydraulic Loco Repair	28	02 weeks	24.11.2017
Automobile Repair	17	01 weeks	09.12.2017
Millwright Shop	32	01 weeks	16.12.2017
Diesel Engine Auxiliaries	10	02 weeks	24.12.2017

1.2 INTRODUCTION TO TRAINING ORGANIZATION

Sri Lanka Railways (SLR) is a government department functioning under the Ministry of Transport and Civil Aviation. It is a major transport service provider and is the only rail transport organization in the country. SLR transports both passenger and freight. At its inception, railway was carrying more freight than passenger. But today, it is passenger oriented. In Sri Lanka, the service provided by SLR in carrying the daily commuters to their workplaces, is inevitable. Sri Lanka Railway operates approximately 396 trains which include 67 Long-Distance and 16 intercity trains and carries about 3.72 million passengers daily. SLR owns and maintains 1561km of rail tracks, 72 locomotives, power sets 78565 carriages and the signalling network. At present, it has a workforce of 17634. As shown in the figure 1.1, Sri Lanka Railways has its own logo.

Figure 1.1 Sri Lanka Railways Logo

Sri Lanka Railways functions under the General Manager of Railways (GMR). The General Manager reports to the Secretary of the Ministry of Transport. SLR has been divided into ten Sub Departments and three Units. Sub departments are managed by the Heads of the Sub Departments who reports directly to the General Manager of Railways. Chief Mechanical Engineering Sub Department is organized as follows. See figure 1.2.

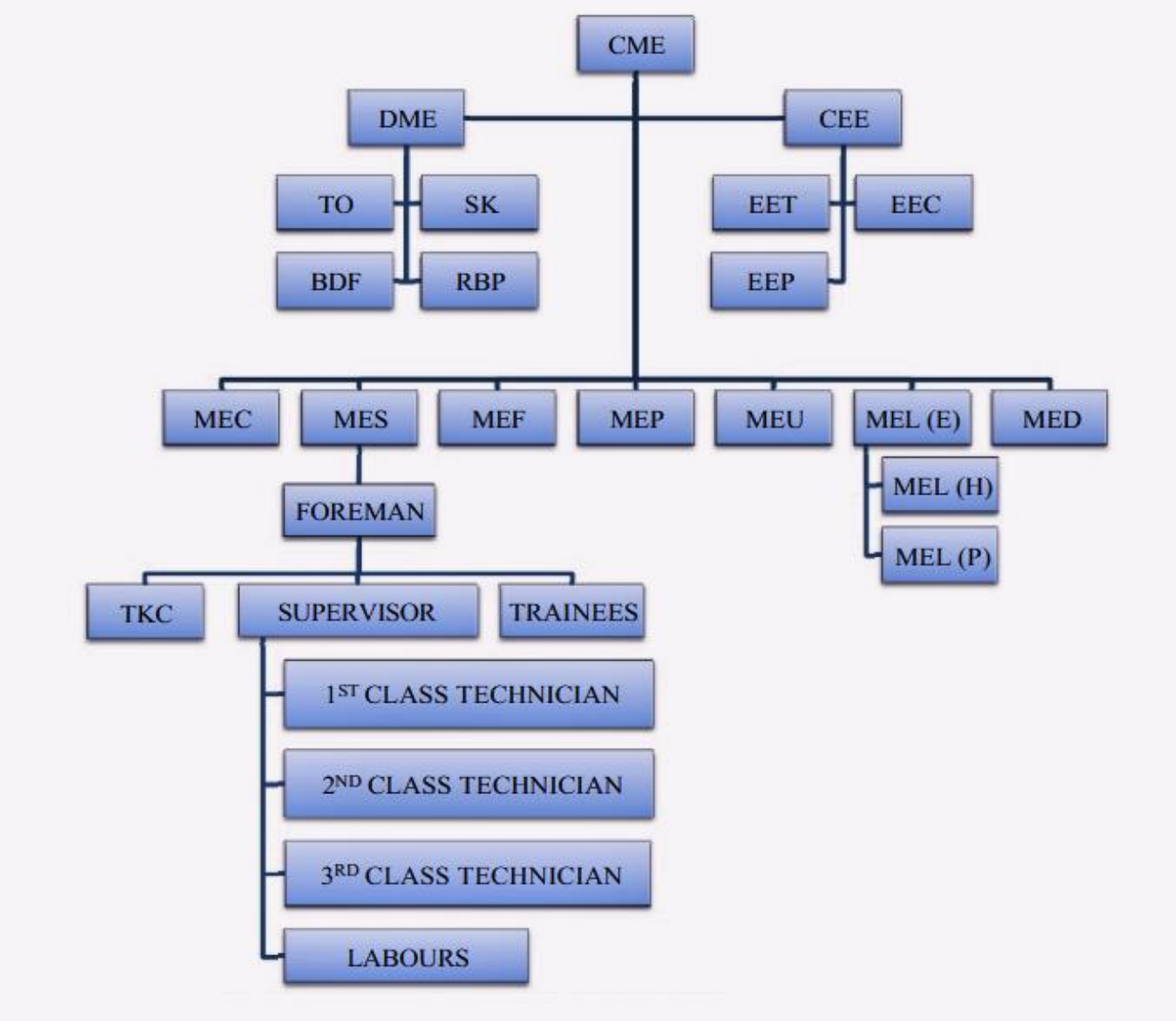

Figure 1.2 Organizational structure of CME's sub department

Vision: To be the most sought-after land transport provider in Sri Lanka, providing unsurpassed value to our stakeholders.

Mission: Provision of safe, reliable and punctual rail transport service for both passenger and freight traffic, economically and efficiently.

1.3 SUMMARY OF THE WORK ENGAGED IN TRAINING

The table 1.1 shows how the training period was divided in to several locations at the workshop. It was created to enhance the training exposure of the trainees considering their field of specialization. First four weeks were allocated to the diesel electric locomotive repair workshops and another two weeks were allocated for the diesel hydraulic locomotive repair workshop. Therefore, in six weeks of the training period, we were fully engaged with studying of locomotive working principles, repairing processes and the working principle of other engine auxiliaries.

Table 1.1 Training schedule

Section	Shop	Period	Start on
Diesel Electric Loco Repair (2 stroke)	14	02 weeks	30.10.2017
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Chapter 2

TRAINING EXPOSURE

2.1 INTRODUCTION

The training exposure can be categorized under six major topics. Each topic represents the experience gained in one particular training location at the Chief Mechanical Engineering sub department. Other than that, the last part of the chapter is allocated to discuss the safety and health care of the organization.

2.2 DIESEL ELECTRIC LOCO REPAIR (2 STROKE AND 4 STROKE-WORKSHOP 14 & 16)

2.2.1 Locomotive Maintenance

It was scheduled two weeks for each workshop in the time table. Workshop 14 mainly carries out repairs of two stroke diesel electric locomotives, while the workshop 16 undertake repairs of four stroke diesel electric engines. There are two main scheduled services for a locomotive engine. The first one is at 360 000 miles of run time and the other one is at 720 000 miles of run time.

In service done at 360 000 miles of run time, which is called the Light Repair, engine was kept in the engine casing and inspections and necessary repairs were carried out. In the General Repair, which is undertaken after a mileage of 720 000, engine is removed from the engine body and overhauled completely. The engine parts are sent to relevant workshops in order for the repairs to be done if they cannot be done in the workshop itself.

Mostly two stroke engines are used in hilly tracks because they are able to give more power. The size of bogie should be considered when there are steep bends in the track. A two-stroke engine basically occupies with two bogies with two traction motors in each. Some of them have two pairs of wheels with one motor per each and some have three pairs of wheels. In that case the middle pair does not have a traction motor.M1, M2, M3, M7 are the locomotive engine types, which belong to the two-stroke engine category. Following steps were taken out under the general repair.

1. Disassembling the whole engine
2. Repairing necessary engine parts
3. Reassembling
4. Checking the engine for any leakages
5. Re-torqueing the engine
6. Speed running
7. Load testing

What happens in the re-torqueing process is heating up the engine to a temperature of 150^0C by running it under stand still idle conditions and tightening the nuts of the engine, which has already

tightened before at the reassembling step. The temperature was measured using sophisticated infrared thermometers for accurate and precise readings.

In the process of speed running, the engine was run for 30 minutes at each notch and the functioning of the engine was checked by the following details, taken out while testing.

- Engine RPM
- Inlet and outlet circulating water temperatures
- Inlet and outlet circulating oil temperatures
- Engine oil pressure
- Piston pipe oil pressure
- Compressor oil pressure

Checking the engine for any leakages are done by using glass indicators, which are connected with fuel lines. They had to be filled with fuel without any air bubbles, if functioning perfectly. See figure 2.1.

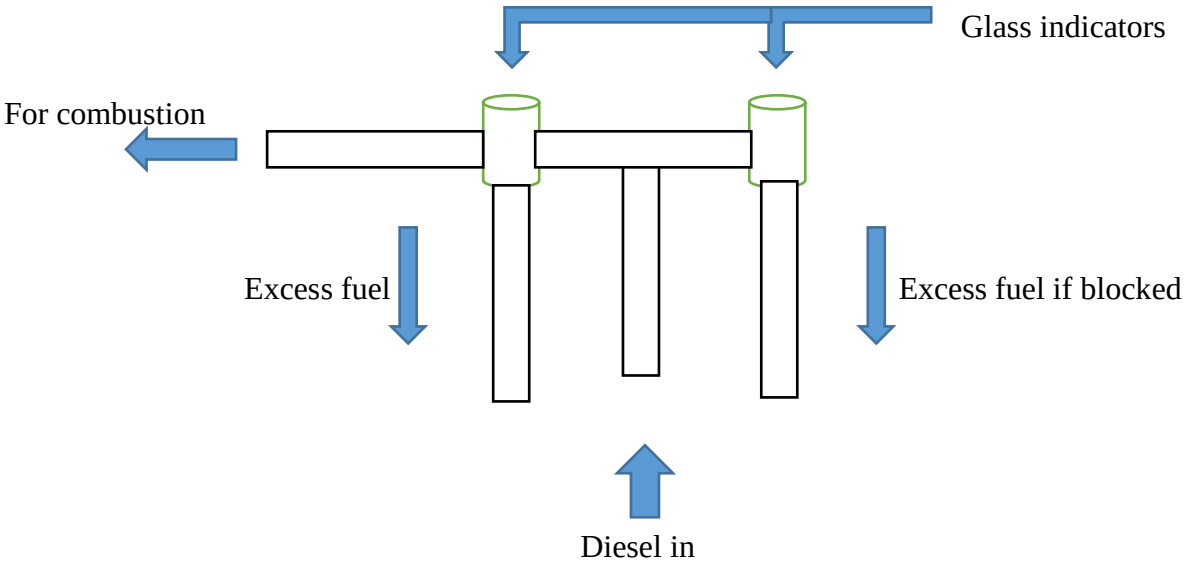

Figure 2.1 Diagram of Fuel Lines and Glass Indicators

2.2.2 Locomotive Governors

The governor room is an important part of the workshop 14. There, the governors of the locomotives, that has come for the general repair are disassembled, tested and repaired if needed.

Basically, what happens through the governor is controlling the fuel supply that is going for the combustion process.

The Accumulator Piston is an additional part in the governor, which regulates the fuel that goes to the engine for the combustion process. This is done by simply restricting the fuel from flowing further if the pressure is not 7 psi or more. In two stroke engines, which we observed in the workshop 14, fuel is pumped by separate pumps for each cylinder.

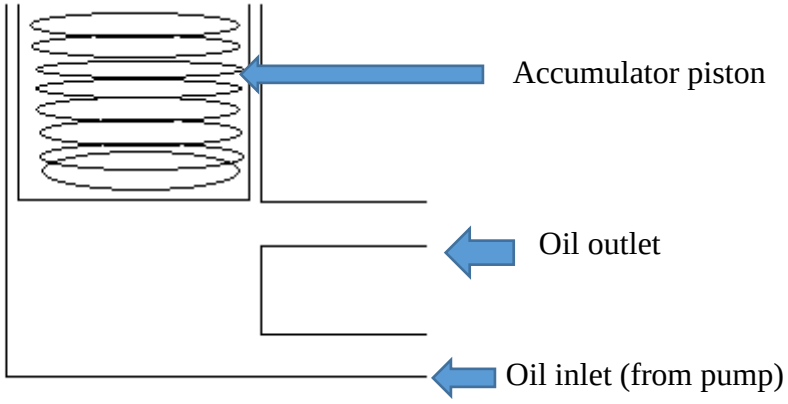

Figure 2.2 Accumulator Piston Setting

The governor of the two stroke and four stroke engines are connected to a setting piston, a power piston and a load controlling valve. Unlike the gear system of an automobile, trains have a notch system. The greater the number of the notch, greater the speed that a locomotive can achieve. When the notch of the train is increased by the train driver to go for a higher speed, the setting piston compresses the spring of the governor leading a slight closure of the oil supply to the power piston. The governor's rotating speed should be increased in order to regulate the fuel supply, which means the engine speed should also have to be increased. See figure 2.2, 2.3, 2.4.

Figure 2.3 Governor

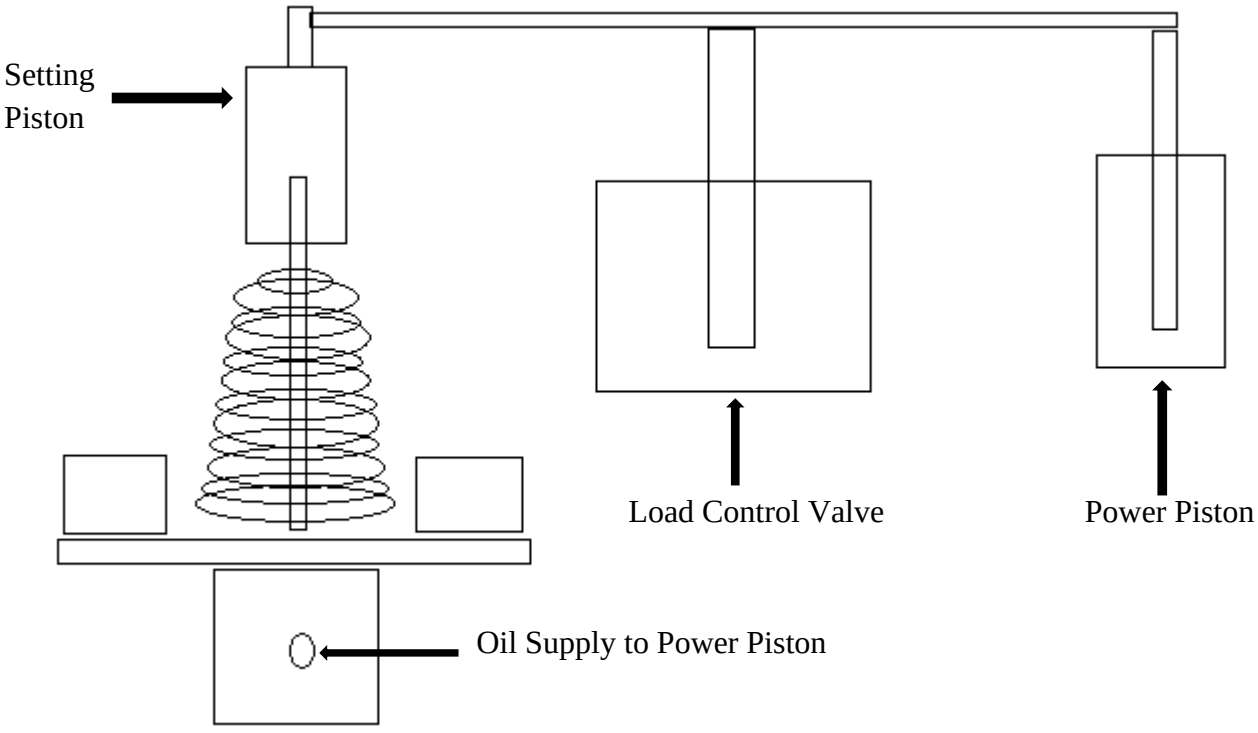

Figure 2.4 Diagram of the Governor Setting

When the speed of the engine reduces, speed of the rotation of the governor reduces causing the power piston to move upwards and to load control valve move and send a signal to the generator to increase the power, which is given to the traction motors.

The task of the power piston is adjusting the fuel amount that goes to the cylinders for the combustion. There are four solenoids in the governor called as A, B, C and D, which are used to change the position of the setting piston when driver changes the notch. In this workshop, the adjusting of the solenoids was observed in order to move the setting piston at the required amount. Figure 2.5 shows the combination for notches.

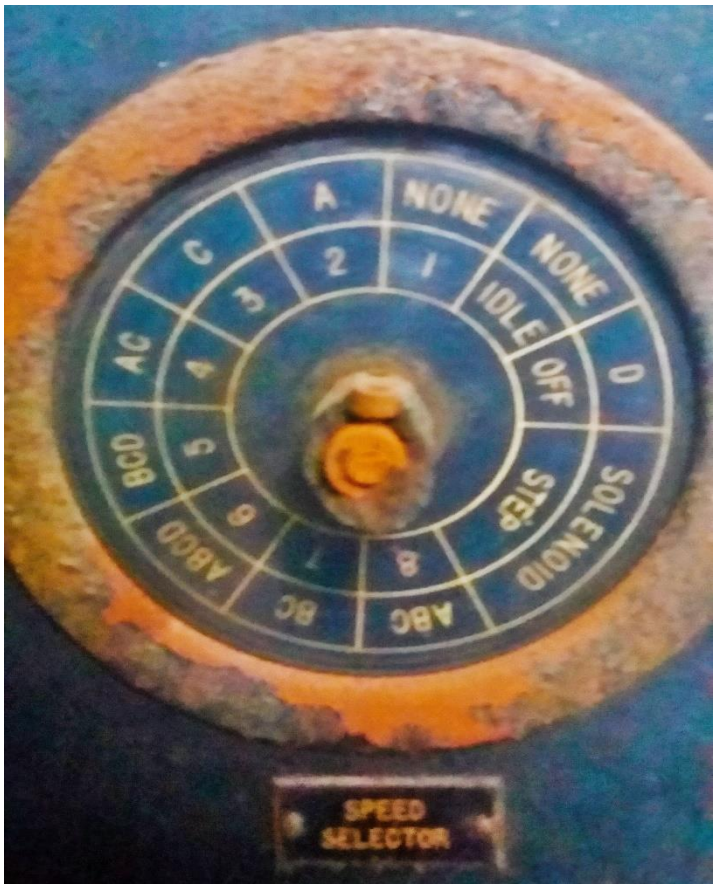

Figure 2.5 Solenoid Combination for Each Notch

There is a maximum load that can be carried in a certain notch. When the load increases, the current sent to the generator is decreased. Because of that the notch number should be lowered by the train driver before the load comes to a maximum point at the particular notch.

2.2.3 Locomotive Fuel Pump

The only difference of the workshop 16 when comparing to workshop 14 is the engines that are repaired in workshop 14 are two stroke and the all the engines in the workshop 16 are 4 stroke engines.

Figure 2.6 Fuel Pump Tester

There were two other rooms which are connected to the workshop 16 called Injectors Room and Cylinder Block Room. Injector Room is completely allocated for the testing and repairs of the fuel injectors and the Cylinder Block Room undertakes the repairs of engine cylinders, pistons and valves.

It was observed how the fuel pump of a locomotive engine works and how the calibration of fuel pumps is done at the Injector Room using the fuel pump tester, which occupies a separate indicating cylinder for each pump in a four-stroke engine. The necessary adjustments are done to change the fuel amount that is pumped. See figure 2.6.

The other testing type is phasing. In four stroke engines when the engine crack rotates an angle of 720^0, cam shaft rotates an angle of 360^0. When travelling through this 360^0, all pistons should have fired one time, which means fuel is injected only one time. The timing of these pumps is set with the help of the fuel pump tester. First the inlet pressure of a pump should set to 1 bar and the cam is rotated until the first drop of fuel is released under 15 seconds. The point at which that happens is set to 00 in the dial gauge and the other pumps are adjusted pump fuel at standard angles.

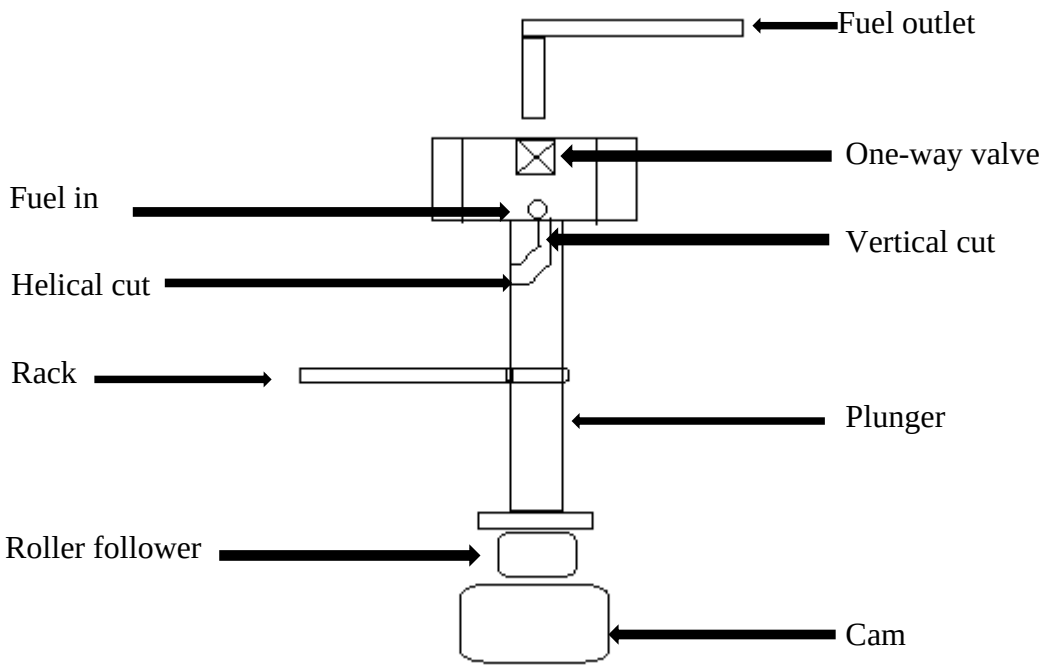

Figure 2.7 Fuel Pump of a Locomotive Engine

One plunger is occupied for each cylinder in the engine and they act as valves. The rack is used to rotate the plunger. When the vertical cut is in line with the fuel inlet hole, there is no pressure built up in fuel line. But when the plunger rotates there is a time that the fuel is pressurized and ready to be pumped under that pressure. The amount of fuel pumped is changed by rotating the plunger to change its position.

2.2.3 Locomotive Fuel Injector

There were two types of fuel injecting methods in the locomotive engines, which was observed in the workshop 16. One type occupies separate fuel pumps and an injectors for each cylinder, making the engine to have up to 16 unit type fuel injectors. The other method was having only one fuel pump and separate injectors for each cylinder.

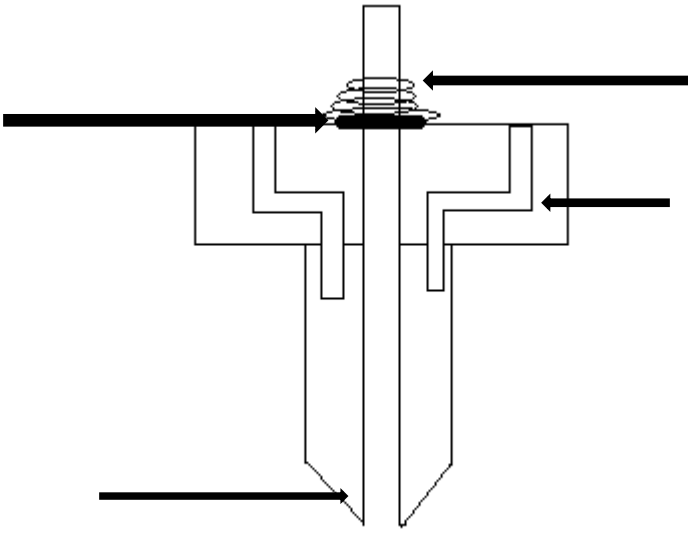

Figure 2.8 Unit Type Fuel Injector

Unit type injectors can be found in M8 and M9 engines. In M8 type engines the standard injecting pressure is 270 psi and in M9 engines it is 4300 psi. These standard pressures are fixed at the injector room for each injector individually, using methods, which are very old and time consuming. O-rings are used to change the tension in the spring in order to fix the standard pressure and the constant pressure valve keeps the pressure in the fuel line at a certain pressure. As an example the fuel line pressure in M9 engines are maintained as 3.5 bars. The injecting pressure values are changed by removing or adding O-rings of the spring.

2.2.3 Locomotive Suspension System

The locomotive suspension system, shown in figure 2.9 is also an important section as well as the engine section. It is somewhat different from other vehicles, because the load that the suspension system had to bear is large in amount. For the repairs to be done for the suspension system, engine compartment had to be separated from the bogie. Suspension system is mainly used to place the traction motors to the bogie (See figure 2.10).

A bolt is used to change the height of the suspension's alternating layers of rubber and steel.it was observed how the placing of suspensions after reducing the height and removing the bolts and again fixing it with nuts and bolts again.

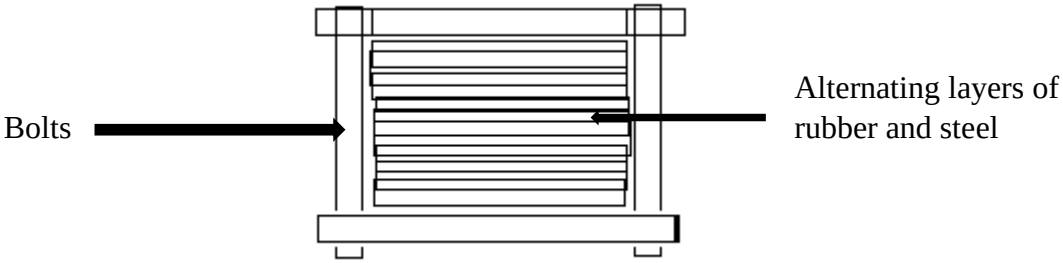

Figure 2.9 Locomotive Suspension System

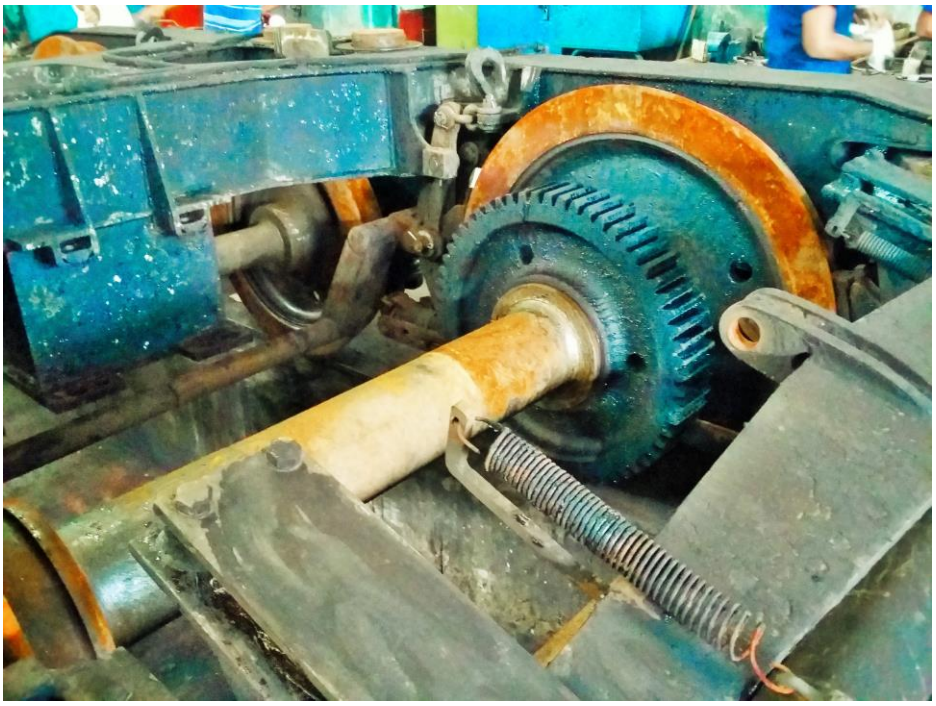

Figure 2.10 Locomotive Bogie

2.2.4 Oil Filters

Oil filters of the engine are contained in a cylindrical shape container. That container is filled with 7 oil filters, which are also cylindrical in shape. These oil filters were changed in every general and light repair, as shown in figure 2.11.

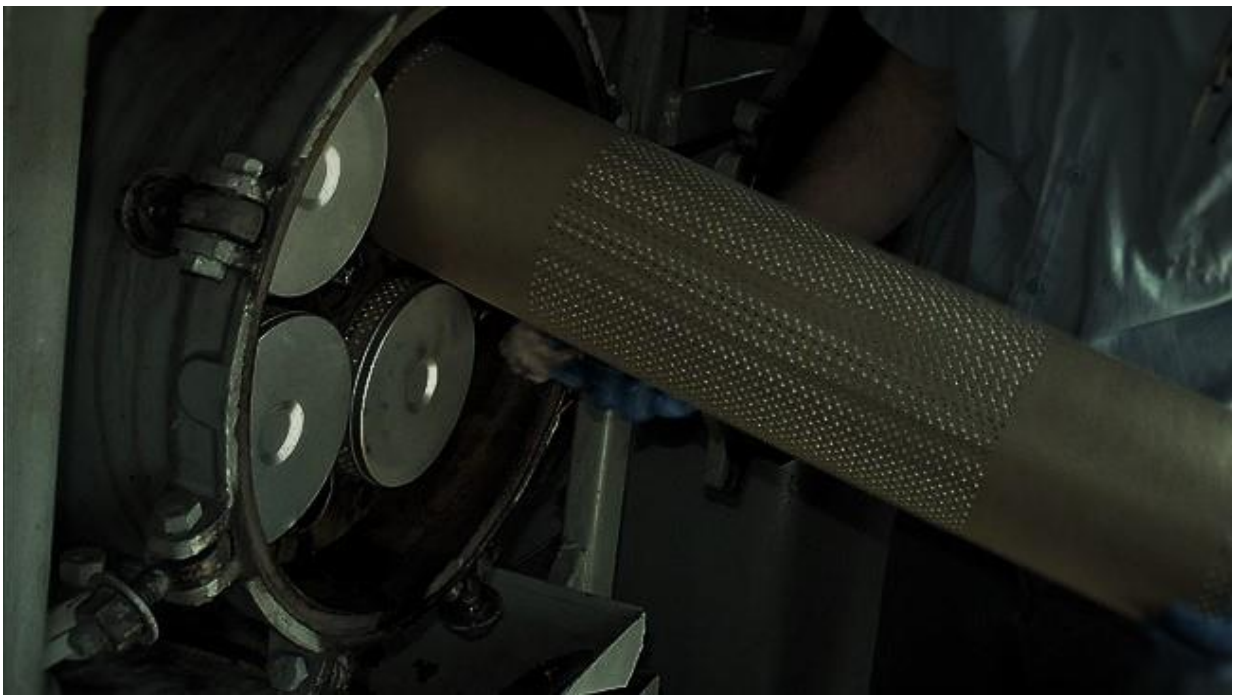

Figure 2.11 Oil Filter Replacement

2.2.5 Engine Cylinders

Damages caused to the engine cylinder cross heads, shown in figure 2.12 are inspected in a special room in workshop 16. Even if there are no damages in brand new engines they are delivered to this special room before let them in to the track. The whole piston cylinder arrangement is inspected for any defects and they are prepared for optimum functioning.

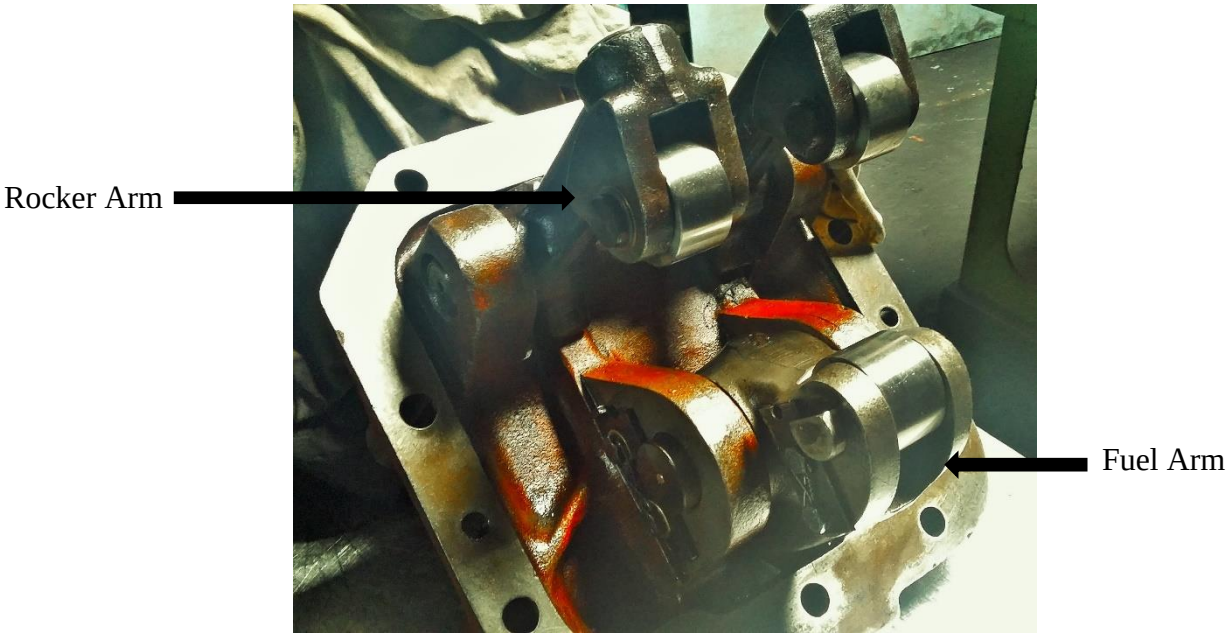

Figure 2.12 Cylinder Cross Head

The arms in the above figure are connected with cam shafts. Inlet and exhaust valves of the cylinder is controlled by the motion of the rocker arms and they can be moved separately when disassembled from the engine. Fuel arm controls the pumping of fuel for the combustion process. The defects of these arms may cause damages to the cam shafts, which can cost a considerable amount of money.

As the employees at the workshop complained, the valves of the cylinders of the locomotives that were imported recently from India are not in better conditions. So they had to be checked even before their first run. It was a significant problematic situation faced and in order to overcome it, the valves of the cylinders were cut to the standard angle by grinding.th inserts were also grinded to the standard form. Inserts are the parts that are used between the valves and their relevant ports for heat transfer purposes. There is a coolant water flow inside every insert. Usually repairs are done by replacing O-rings of the inserts. O-rings are used to seal the coolant water flow, as per figure 2.13.

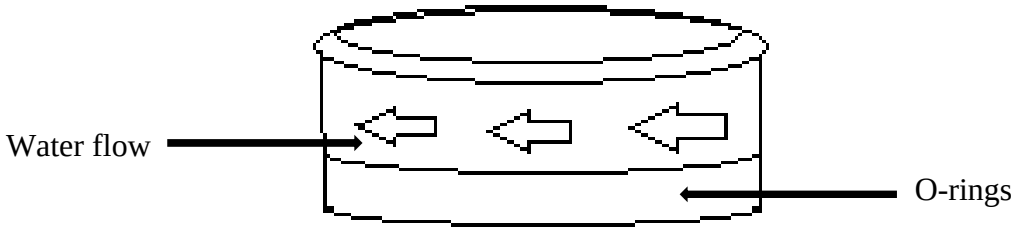

Figure 2.13 Insert

Tulip, flat head, sodium and mushroom are the most common type valve used in locomotive engines. Most of the valves, which were in the workshop were flat head and tulip type ones.

2.2.6 Firing Order

The power transmission and correct timing of each firing is fixed in the workshop itself without sending the transmission parts to another workshop, when trains come for the general repair or when engines face with problematic situations with the transmission system. (See figure 2.14)

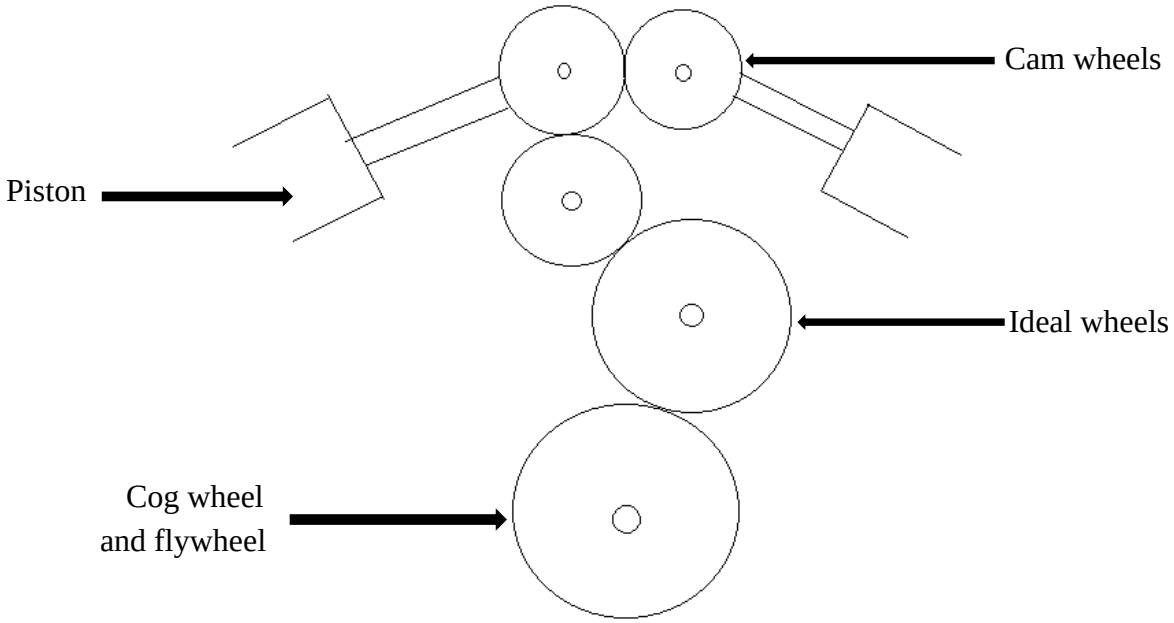

Figure 2.14 Cross Section of the Transmission System

In all above wheels there are marks to indicate the correct orientation for the perfect timing of the engine. Injector timing is adjusted as the fuel is injected for the combustion process, 4^0 before TDC (top death centre). Top death centre is marked in the fly wheel by fixing a dial gauge to the piston and moving the flywheel until the direction of the dial gauge is changed. The pointer is marked as the TDC, as per figure 2.15 and when TDC of the flywheel is identified the pointer is moved to the 0^0 position in the scale of the flywheel.

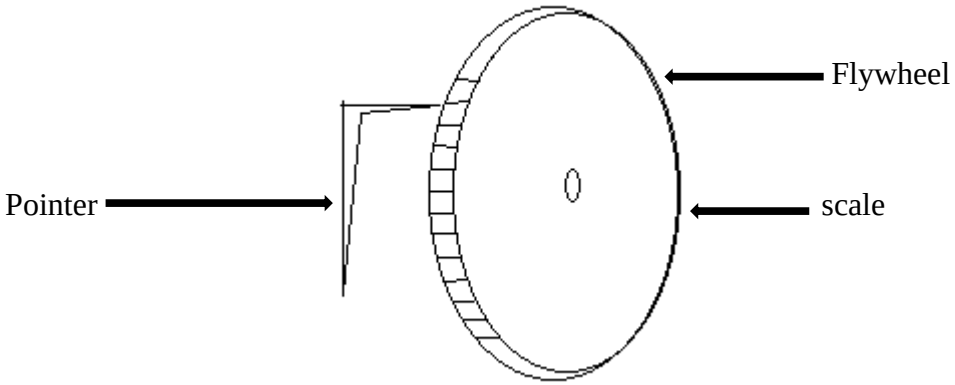

Figure 2.15 Flywheel and Pointer

At the same time the crankshaft (see figure 2.16) and the bearings should be aligned perfectly. If not the lifetime of them will be reduced drastically. For this task the bearings are separated from the engine body and fixed temporally at another engine body in the workshop. After that 'Engineering Blue' is applied on a shaft which has a diameter, similar to the crankshaft and it is turned inside the bearings. This process leads to show the points, at which the shaft is not in a good contact with bearings.

Figure 2.16 Crankshaft and Pistons

2.3 DIESEL HYDRAULIC LOCO REPAIR (WORKSHOP 28)

The difference between diesel electric engine and diesel hydraulic engine. (See figure 2.17 & 2.18)

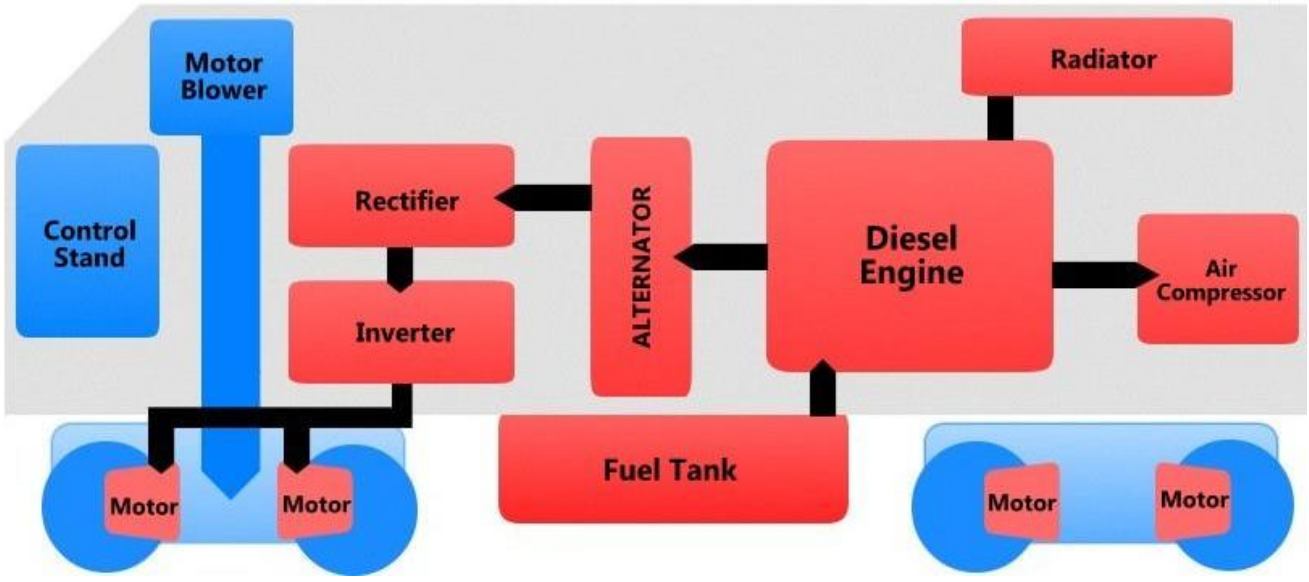

Figure 2.17 Schematic Diagram of Diesel Electric Locomotive

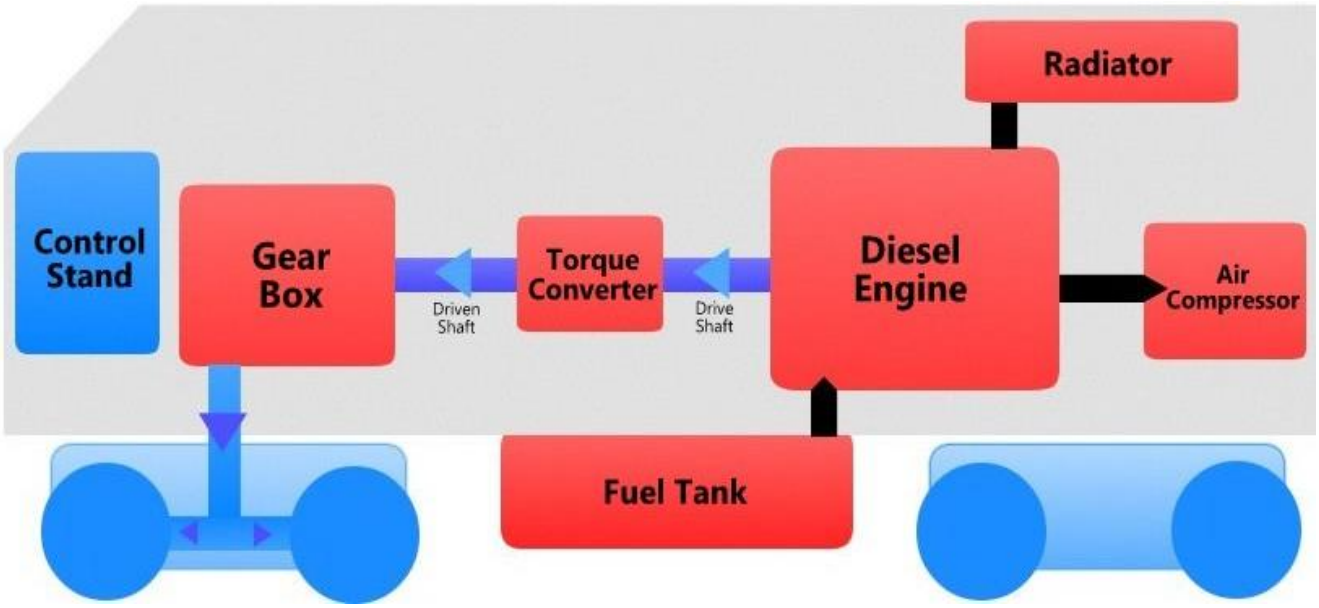

Figure 2.18 Schematic Diagram of Diesel hydraulic Locomotive

The workshop 28 or the Diesel hydraulic locomotive Repair workshop is solely allocated for the repairs of hydraulic locomotives. Unlike in other type of locomotives this type has a torque converter (see figure 2.19) and a gear box. To transmit the motion few shafts are used and the number of shafts depends on the type of the engine. Some diesel hydraulic locomotives are older than diesel electric locomotives but there are some S class engines running in Sri Lanka, which were imported recently. W class engines are the other type, which comes with a hydraulic transmission system and they are specially used in upcountry, since they could produce a large amount of power. Another significant feature of the diesel hydraulic locomotives is their high acceleration. Because of that they were widely used in commuter trains to accelerate and decelerate between small distances efficiently. Torque is a major factor for diesel hydraulic transmission and when the torque increases the speed get decreased. The solution for this is using an engine with a higher RPM value. The RPM of the Sri Lankan diesel hydraulic locomotives are around 1500.

2.3.1 Hydraulic Locomotive Power Transmission

Diesel from the fuel tank travels to the combustion chambers of the diesel engine & the drive shaft starts its rotation. There's a connection between this shaft & the driven shaft through a special component called Torque Convertor. It's a modified fluid coupling. When the driver changes the notch, gearbox acts accordingly & rotates the wheels of the locomotive by a shaft. The dynamic brakes of these locomotives are known as Hydro Dynamic Brakes. Here a special chamber gets filled with oil which creates a resistive force for the rotation of the wheels.

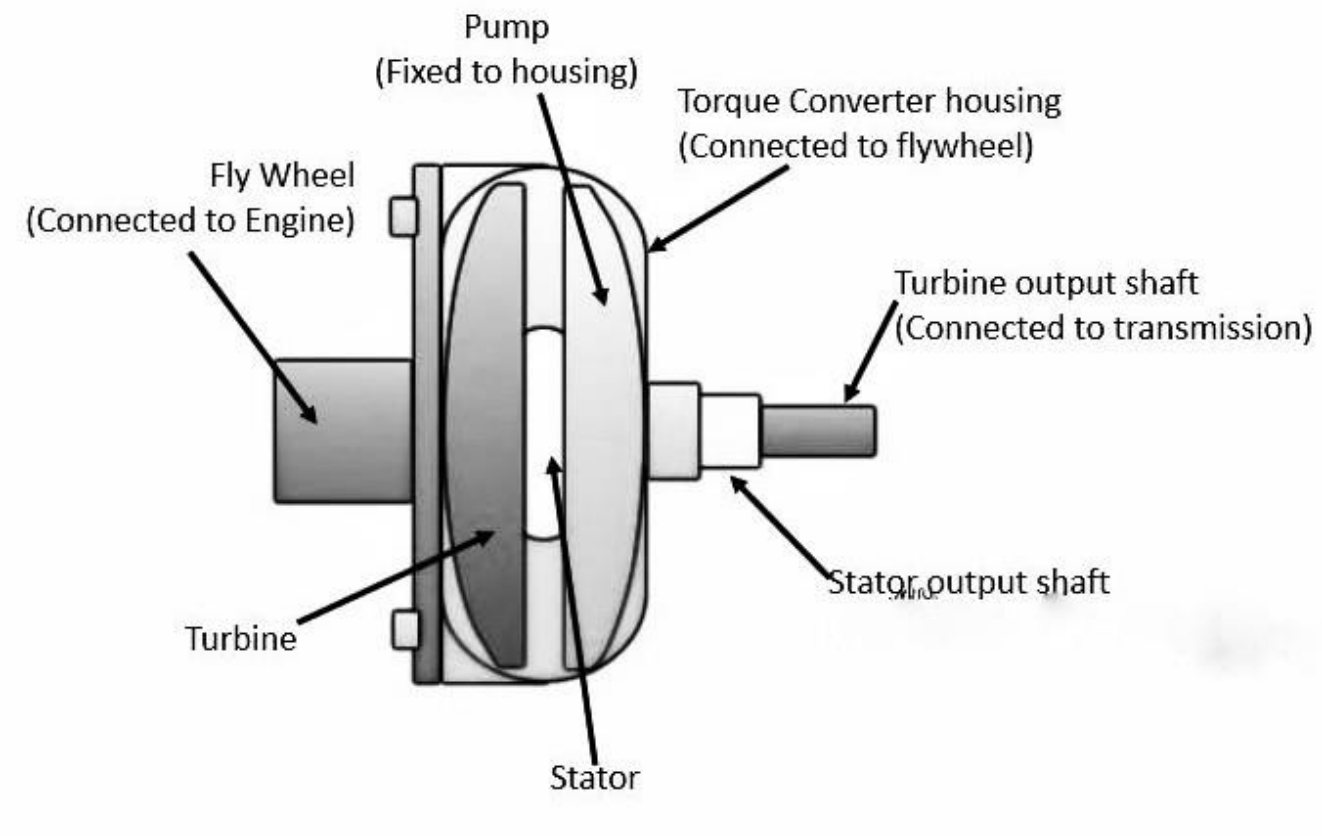

Figure 2.19 Torque Converter

As stated above torque converter is a modified fluid coupling. Therefore, we should identify the features of fluid coupling. A fluid coupler consists of 2 main parts.

1. An Impeller or a Pump connected to the engine which rotates with the engine
2. A turbine connected to the gear box

These two parts consist of 2 rotors fixed very close to each other & the space between these fans are filled with a high dense oil. Therefore, when the engine rotates impeller also get rotated. But there is a limit for power transmission by this method. Torque doesn't increase above a certain value and you cannot transmit more power than that level. Therefore, power output gets decreased and the highest torque is equal to the input power. The fluid used in the converter is cooled down by a heat exchanger. Unlike in S8 engines, in Y class engines, it is possible to couple the engine to the transmission system directly, when they reach the same speed. It is done by using four clutch plates and three gear wheels, as per figure 2.20.

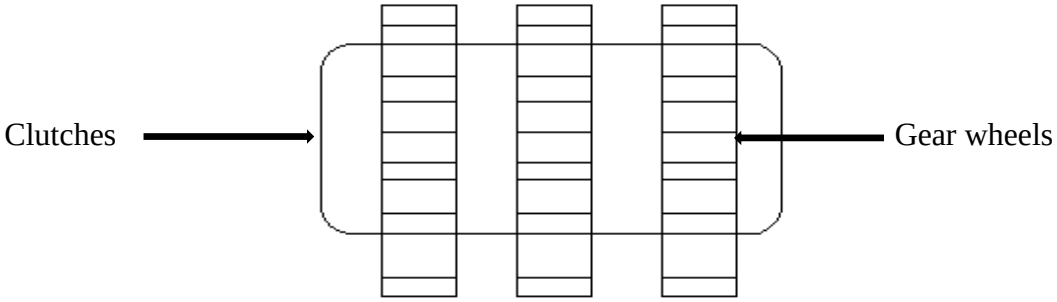

Figure 2.20 Gear System

Connecting shafts (see figure 2.22, 2.23, 2.24) on the other hand play an important role in the hydraulic transmission system. The power delivered from the torque converter is delivered to the gear system and then to the connecting shafts, which are connected with the locomotive wheels. As the vibrations, other internal and external stresses are occurred while the train is moving and because of the fact that the connecting shafts are not co-linear, there are universal joints between shafts. The length of the shafts is also slightly adjustable when in running mode. The cross link (see figure 2.21) allows the shaft to be bend and rotate at the same time.

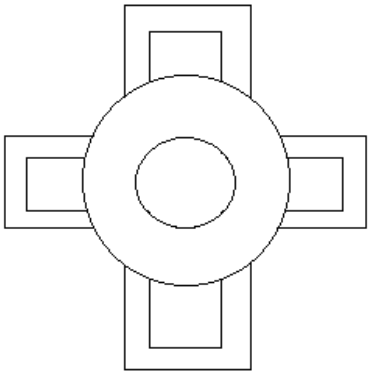

Figure 2.21 Front View of the Cross link

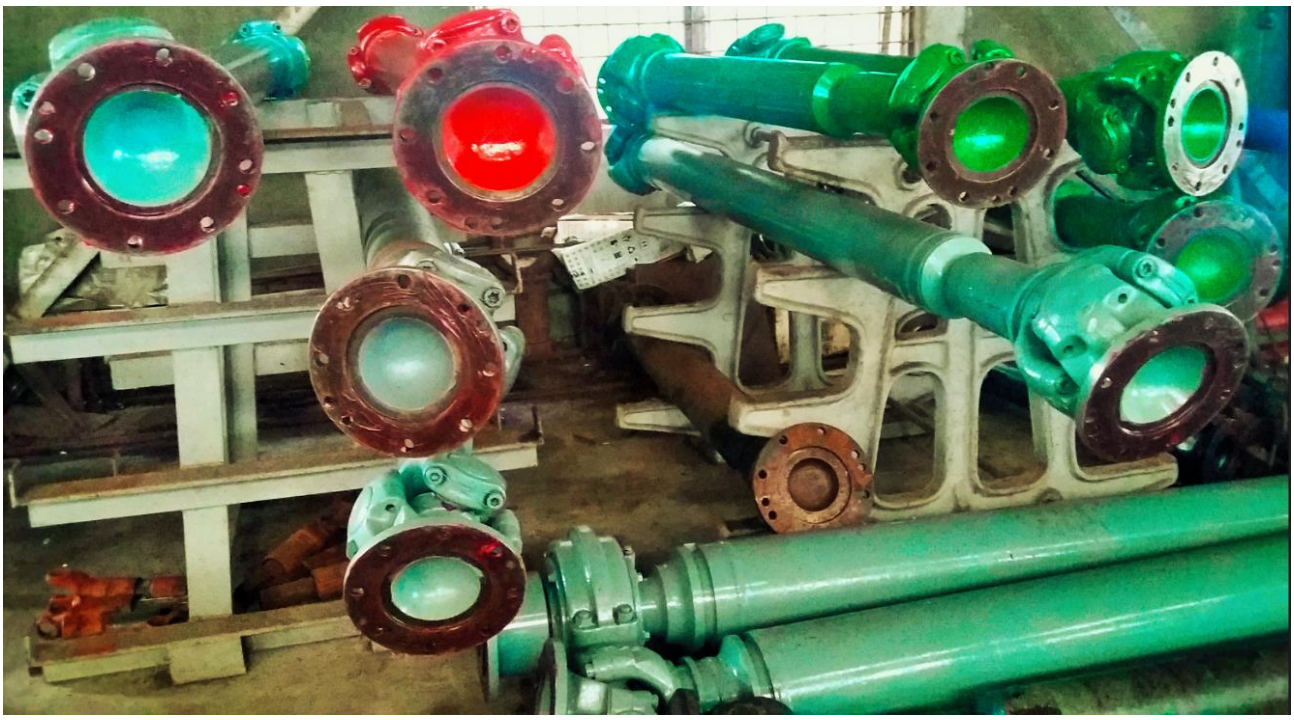

Figure 2.22 Connecting Shafts

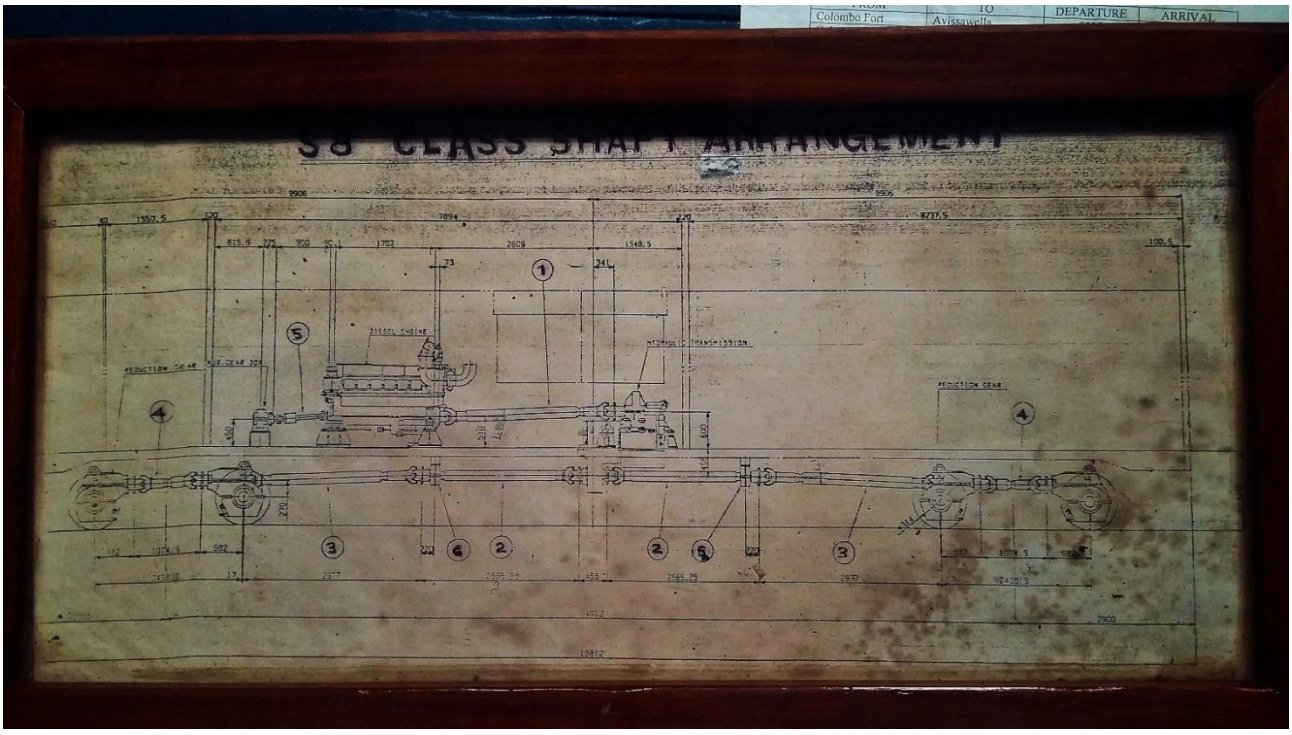

Figure 2.23 Shaft Arrangement of a S8 Engine

In the workshop 28, new shafts or repaired shafts are cleaned and lubricated before connecting to a train for smooth operation and for the durability of the components. Since there are two universal joints, the non-uniformity of the rotation through the shaft is corrected at the other end of the shaft, where

the output is taken. The spline joint is usually biased to an edge of the shaft to lower the impact of centre of mass to the rotation and to eliminate vibration.

Figure 2.24 Universal Joint and Spline Joint

There are several lathe machines (see figure 2.25) in the workshop 28 and they are used only to make parts, which are needed in the workshop 28. There is also a shaping machine used to carve through metal easily. The tip of that is made out of high-speed steel (20% tungsten).

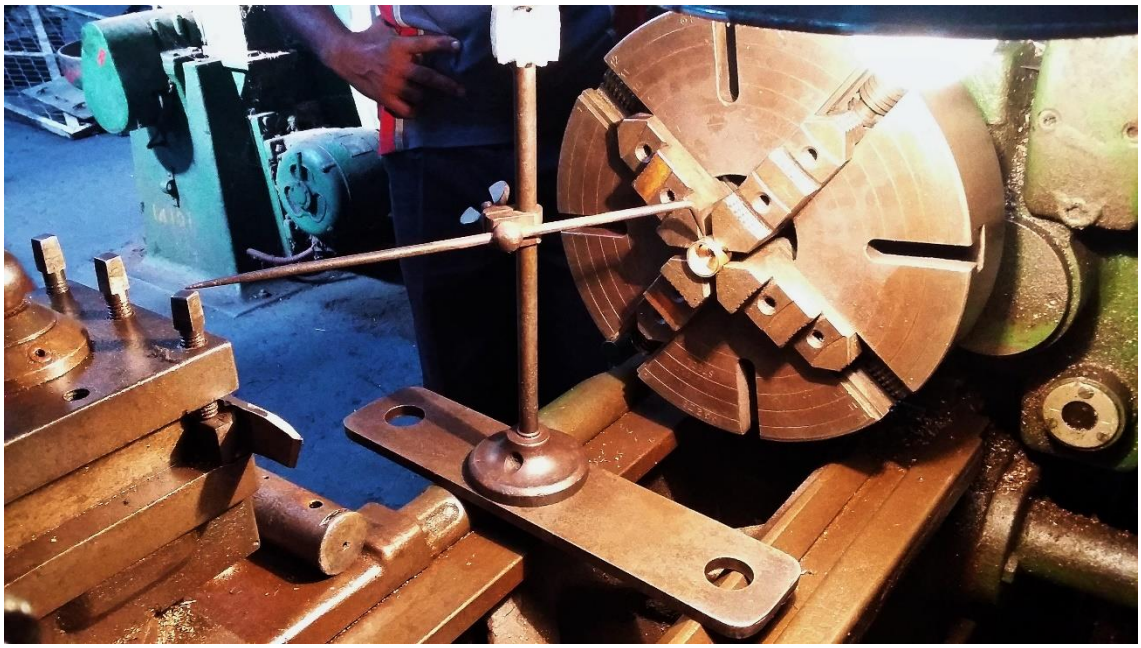

Figure 2.25 Lathe Machine

In the workshop 28, there is a special section allocated for repairs done for cylinder heads. Cylinder heads are usually exposed to high amount of wear due to the continuous combustion process. This happens due to the cyclic contact with the piston. These non-uniform surfaces are grinded or filled with metals, as the repair is undertaken. (see figure 2.26)

2.3.2 Cylinder Head Repair

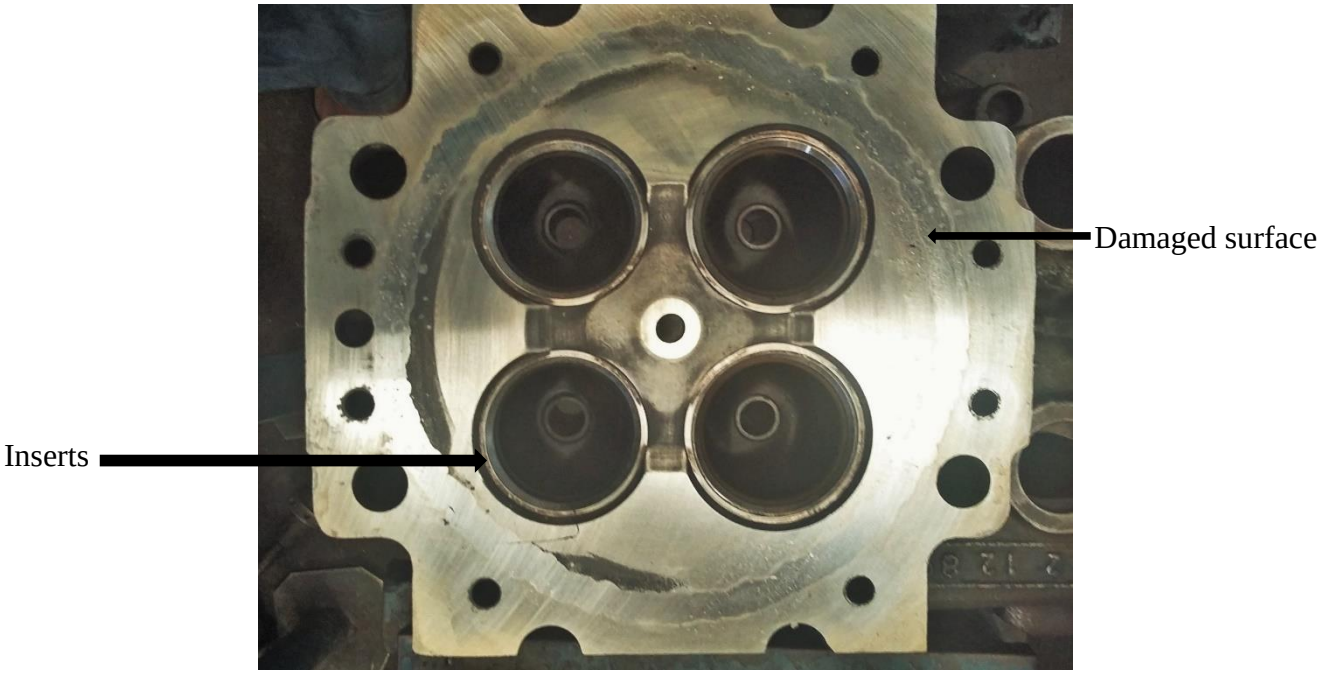

Figure 2.26 Surface of the Cylinder Head

Inserts are the ring like components, which are used fixed between the valves and the valve ports in the cylinder head. It was observed and studied how the inserts (see figure 2.27) are inserted to the cylinder heads.

Procedure of inserting inserts is as follows.

1. Submerging inserts in liquid Nitrogen.
2. Submerging cylinder heads in the water, at a temperature of 160^0 F.
3. Connecting those two without any delays.

Submerging inserts in liquid Nitrogen will shrink them while submerging cylinder heads in hot water will expand their valve ports. After connected, these two attempts to go back into their original size, due to heat transfer process. But it will only create a strong bond between them.

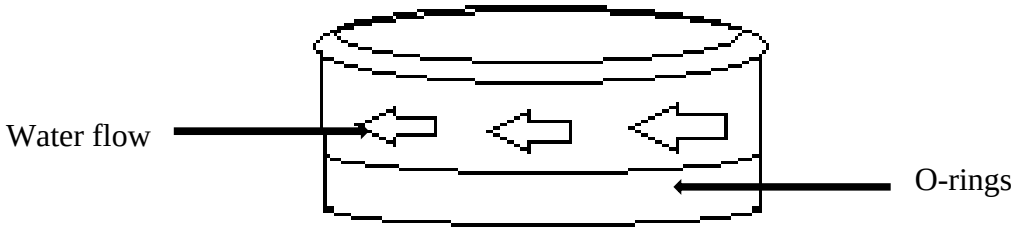

Figure 2.27 Insert

2.3.3 Engine Cooling Problem

There was a locomotive engine with a problematic situation of its cooling system in the workshop 28. It was found that there is some sort of a leakage in cooling water lines. To figure out the exact location or locations of leakages, pressurized water was used. Water was pressurized inside the cooling line and it led to visible locations where there are leakages.

2.3.4 Tamping Machine

Apart from passenger carrying locomotives, there were tamping machines shown in figure 2.28 that are used to repair railway tracks, to get repaired. Those machines can lift, straighten and level railroads.

Figure 2.28 Tamping Machine

2.4 AUTOMOBILE WORKSHOP (WORKSHOP 17)

2.4.1 Introduction to Automobile Workshop

Figure 2.29 Automobile Workshop

Only one week was allocated for the automobile workshop to observe and study the work done there. The main task of workshop 17 (see figure 2.29) is carrying out all types of repairs in automobiles, which belongs to Sri Lanka Railways Chief Mechanical Engineering Department.

Having an automobile workshop inside the engineering workshops is very helpful because the vehicles like forklifts, tractors, fire department vehicles do not have to leave the workshop premises for the repairs. On the other hand, it's a huge save of money since every vehicle which belongs to Sri Lanka Railways can be repaired in this workshop without any charging and do not have to worry about scams. This workshop undertook every kind of vehicle repairs of many kind of automobile.

1. Light vehicles

- Cars
- Vans
- Three wheelers
- Cabs
- Jeeps

2. Heavy vehicles

- Buses
- Trucks
- Firefighting trucks

- Dozers
- Excavators

3. Industrial vehicles

- Fork lifts
- Tractors

Repairs undertaken

- Battery works
- Tyre works
- Paint jobs
- Body works
- Mechanical repairs

2.4.2 Automobile Clutch Issue

A car, which belongs to Sri Lanka Railways had found with some trouble of a noise that is coming out from the engine part. The suspicion of the mechanics at the workshop was, a problematic situation with the clutches. When disassembled the parts they found that their suspicion was correct. The clutch plate's (see figure 2.31) fibres had worn to the point they make a weird noise.

Clutch plates have to be replaced if they were found with exposed reverts, worn fibres, or untighten damping cushions. The different of those can be identified by going on a test run. The clutch plate is pressured by a pressure plate, shown in figure 2.32.

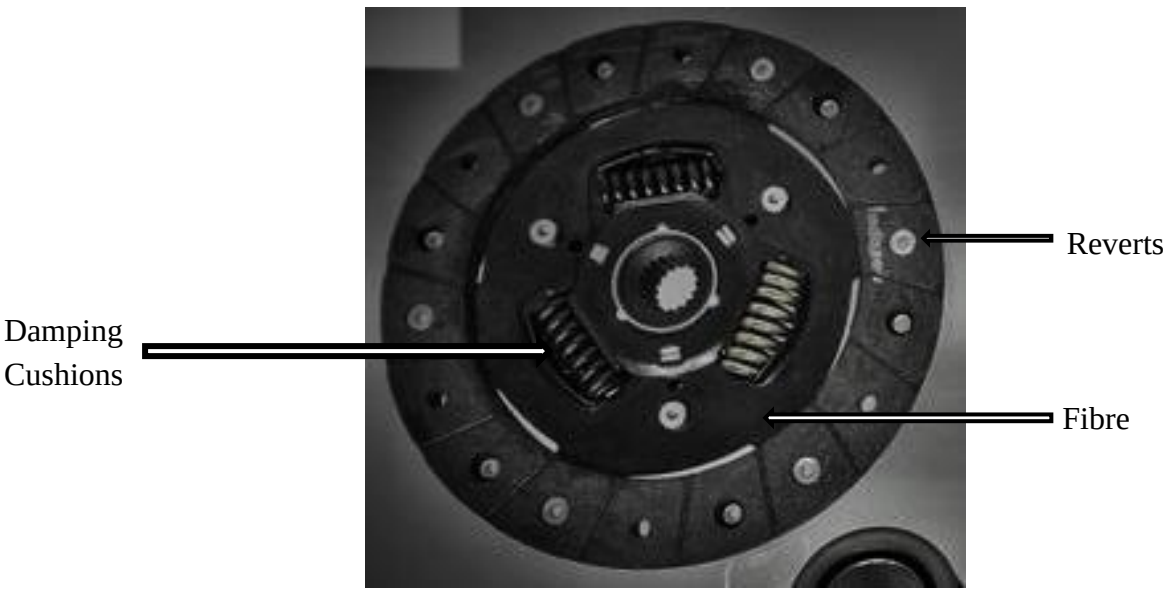

Figure 2.30 Clutch Plate

Figure 2.31 Pressure Plate

2.5 MILLWRIGHT WORKSHOP (WORKSHOP 32)

2.5.1 Introduction to Millwright Workshop

The main task of workshop 32 is to undertake the repairs of the machines, which are used to repair locomotive components. It did not have any specific type of components, but has a huge variety. From foot bicycles to internal components of milling machines are repaired, since the workshop has several sections in it.

2.5.2 Tools Used in the Workshop

Figure 2.32 Workshop Crane

A turning machine is used to cut a metal piece, which was moulded in the foundry to make a crane wheel. Cranes are the ones those are used in almost every workshop to carry heavy components within the workshop area (see figure 2.32). They have the ability of lifting a whole engine at a time.

A socket is used to fix the cutting tool to the machine. It is a taper cut, shown in figure 2.33, which is used to change the drill bits of a drill. It helps to fix the tool rigidly and conveniently and at same time makes it easy to remove it. A hammer is used to separate the tool from the socket.

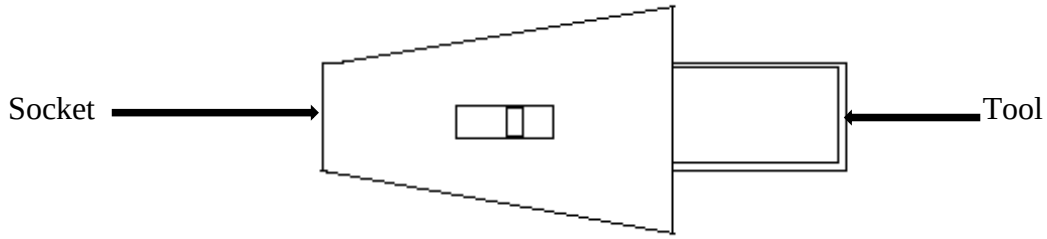

Figure 2.33 Taper Cut

A helical gear wheel set from a boring machine (see figure 2.34), which is at workshop 41 was found trouble in functioning due to some damages happened. Some parts of the teeth of the gear wheel was gone missing and had had to be filled with metal pieces and some parts were appropriately cut out. If the only option is replacing them, they can be manufactured within the workshops alone

Figure 2.34 Damaged Gear Wheel Set

The ticket machine, which is used in every railway station in Sri Lanka is still same as the one, which was used fifty years ago. The machine is manufactured by casting its parts in the railway workshops. But there is still some work left with cutting threads. That operation was done by taps in the workshop 32. As shown in figure 2.35 taps have different types.

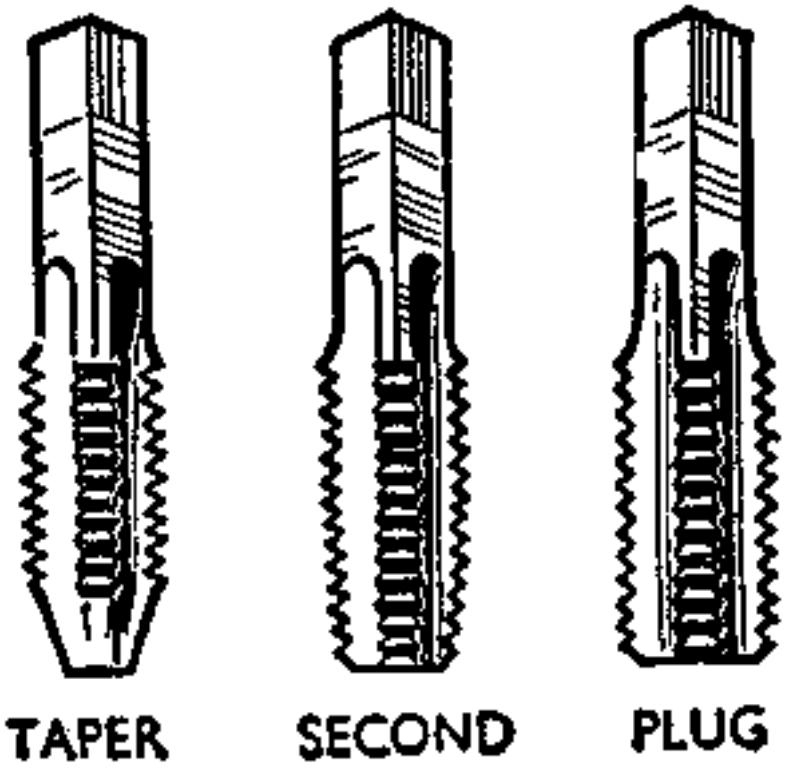

Figure 2.35 Different Types of Taps

Bevel protractor (see figure 2.36) was used in workshop 32 to measure the taper angle of the crane wheels, which are made by the lathe machine. The bevel protractor used in workshop 32 was more than fifty years old and it was not a very precise way of measuring angles.

Figure 2.36 Bevel Protractor

2.6 DIESEL ENGINE AUXILIARIES (WORKSHOP 10)

In the workshop 10, the repairs of all types of diesel engine auxiliaries are undertaken. Some of the main auxiliaries we got to familiarized are air compressors, radiators, water pumps, engine pipes, exhausters and expressers.

Radiator is a main components of engine cooling system. Radiators are used for cooling the water that circulating through the engine and other components. Radiators surface area had to be maximized to transfer the heat to the atmosphere. Locomotives have 6-8 radiators for cooling huge amount of water. As shown in figure 2.37, water, which comes from a tank is pressurized and sent into the tank on the other side of the radiator.

Figure 2.37 Radiator

Cleaning of radiator pipes (see figure 2.38) is done by merging them in a special tank, where there is an air supply at the bottom of the tank. The tank is filled with NaOH. In order to clean the blocked lines, compressors have to be turned on.

Figure 2.38 Cleaning Radiator Pipes

In air compressors (see figure 2.39 & 2.40) of locomotives, there are two stage compressors and single stage compressors. The two stages in two stage compressors are the law pressure compressor and the high-pressure compressor. There are few advantages of two stage compressor over single stage compressor.

- Gas can be compressed to sufficient high pressure
- Pressure ratio of each stage lower. So, air leakage is lower
- Low pressure ratio in cylinder improve the volumetric efficiency

The valves of the air compressors are designed such that they only allow the air to flow in one direction. If air tries to flow in the other direction, air path gets closed with the help of a mechanism, driven by two disks, which are placed adjacent to each other.to make sure the perfect seal the plates are polished by silicon carbide dust.

Figure 2.39 Air Compressor

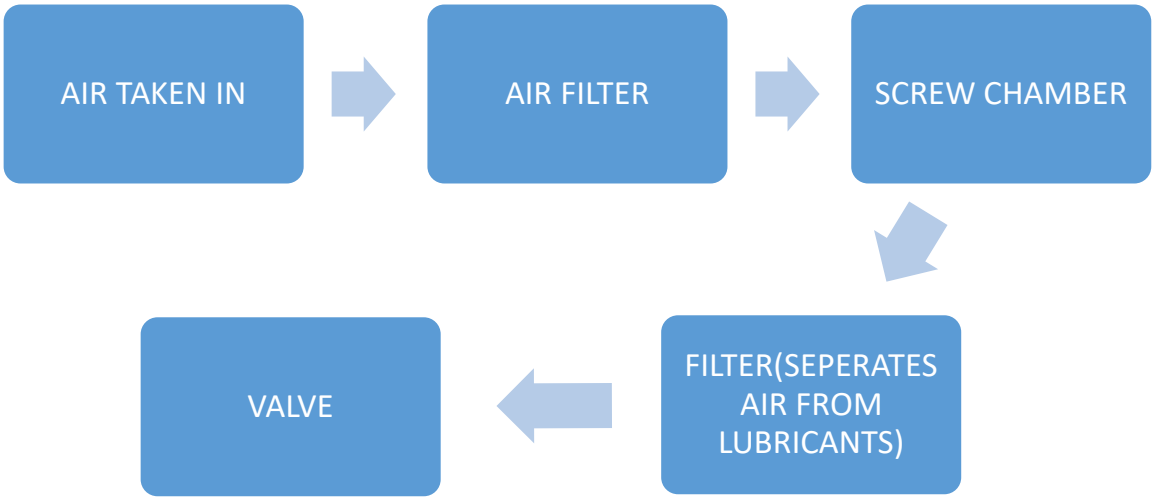

Figure 2.40 Schematic Diagram of a Screw Type Compressor

Expresser, shown in figure 2.41 is a device that combination of air compressor and exhauster. This used for air brakes of engine and vacuum brake of rail carriage. Exhauster is the inverse process of the air compressor. It is making a vacuum. It is used for vacuum brakes.

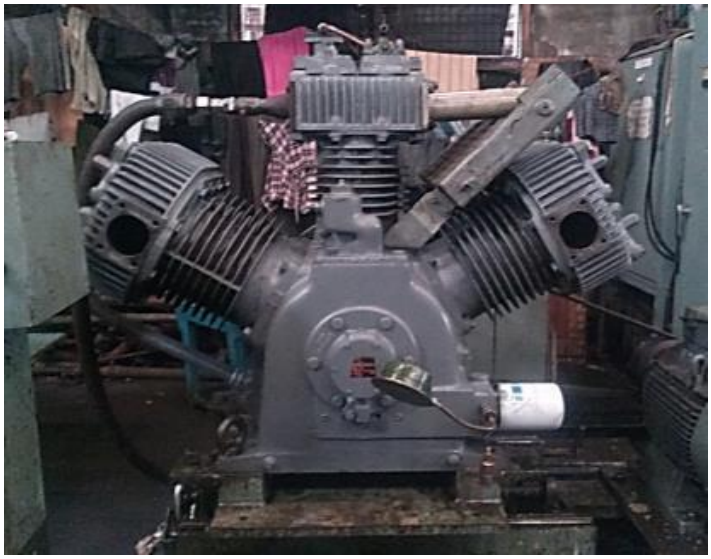

Figure 2.41 Expresser

Turbocharger, shown in figure 2.42 is used for four stroke engines to breathe more air into the combustion chamber using exhaust power. Turbochargers contain two main parts. Impeller (see figure

2.43) and turbine. With the use of the exhaust gas, the turbine is rotated initially and as it has coupled to the impeller, the impeller will rotate and pressurize the air, which flows into the engine.

Figure 2.42 Turbocharger

Figure 2.43 Impeller of the Turbocharger

The pressurized air, which comes out of the turbocharger has some amount of heat carrying and the engine after coolers (see figure 2.44 & 2.45) are used to take out the heat from that gas and cool them down. Those will ensure the minimum vapour quantity in the gas. Air coolers are made by attaching metal pieces to the pipes, in order to enlarge the heat transfer area and enhance the heat transfer rate for a better cooling process. These air coolers are fully designed and manufactured in the workshop 10, itself.

Figure 2.44 Air Coolers -Original

Figure 2.45 Air Coolers-Made in the Workshop 10

In the workshop 10, mainly gas welding could be observed as a process of joining.it is used when arc welding could cause metal surfaces to crack or when the material of the welding electrode is unavailable.

In the gas welding process, the components that needed to be weld are heated and the rod used to weld is dipped in sif-flux to remove the surface impurities and improve weld performance.

Figure 2.46 Bearing Fitting Process

At the workshop we had the chance to see the process of fixing a roller type tapered bearing to a shaft of a compressor, as shown in figure 2.46. Bearings are fitted to the shaft without using any means of holding them together other than fitting them tightly. In order to succeed this, the bearing is first placed in a hot oil bath, so that its' hole expands and can be easily fitted to the shaft and once it cooled down it will tightly fit to the shaft. Hydraulic pressure is used to remove the bearing, if needed.

2.7 HEALTH AND SAFETY IN INDUSTRIAL ENVIRONMENT

- Precautions like wearing helmets and gloves were barely taken by the technicians and the labours, even though they were instructed in advance.
- There are notices indicating high voltage danger signs.
- There were dengue prevention programmes conducted, since some of the workers reported, infected.
- There is a medical centre, which is open for all the employees.

CONCLUSION

As a second year undergraduate, who did not have any experience in the industry before, it was a great opportunity for me to work as a trainee Mechanical Engineer at Sri Lanka Railways Chief Mechanical Engineering Workshops. The knowledge gained was unique since it was about locomotive technology, but sometimes universally applicable, which made the training experience a useful one.

We were appointed to six workshops and three of them were engine workshops, which mainly focus on locomotive engine repairing and maintaining. The difference in three workshops depend on the engine types that is undertaken into the repairing process.

The Millwright workshop is the place, where the machines used to repair locomotive components are being repaired. At that workshop a bore machine's gear repairing and replacement procedure was observed mainly. A cutting procedure using a turning machine, working principle of workshop cranes were observed and studied about types of taps used in metal drilling operations.

But when it comes to interacting with the employees, it was bit difficult for us to reach and learn from them since some of them were not friendly and were not willing to teach us. But majority of the workshop foremen, technicians, labours were friendly and kind enough to share whatever they know and their experience the industry. Even though we started our training at 7.30 am daily, we had to wait for several hours to study or observe something, since the technicians and labours do not start their work at the time they are supposed to. My suggestion is to change the time period a trainee engineer should start their work, because throughout the training period we were not assign to any responsibility, but had to learn each and everything from the technicians and supervisors. But it is also not convenient to give a trainee engineer a responsibility or a duty in a workshop either. Assigning a project would be a better idea from my point of view.

The things that were taught in the second-year mechanical programme were so much useful in understanding the principles and technologies used in the workshops. At the engine workshops we could get hands on experience on governors, which was taught under ME 211, Mechanics of Machines.

The knowledge on power transmission systems and gears, gained under the course ME 205 Tribology and Power Transmission Elements were widely used in many applications in many workshops as well. In Applied Thermodynamics I, the internal combustion engines were a special part that we learnt and it was much easier for us to understand the practical situations when comes to locomotive engines.

The fundamentals of cooling systems in a locomotive engine system could be observed and studied when we were at the workshops and they were taught furthermore in detail in the fifth semester under Applied Thermodynamics II. It was at the sixth semester that we were supposed to study about whirling of shafts under the course ME 301 Vibrations. But we were able to learn about whirling and the reducing solutions in advance at the workshop 28.

INDUSTRIAL TRAINING REPORT I I

TRAINING ORGANIZATION : NORITAKE LANKA PORCELAIN

PERIOD OF TRAINING : FROM 25/02/2019 TO 05/05/2019

FIELD OF SPECIALIZATION: MECHANICAL ENGINEERING

P.H.T.D. WEERARATHNE

E/14/369

ACKNOWLEDGMENTS

It is with great honor that I express my sincere gratitude to Mr.W.R.M.U Wickramasinghe, Director of the Industrial Training and Career Guidance Unit, Faculty of Engineering, University of Peradeniya, his staff, and the staff of National Apprentice & Industrial Training Authority, for extending me the precious opportunity to work for the Noritake Lanka (Pvt) Ltd, which was indeed a great industrial exposure.

Furthermore, I am very much obliged to Eng. Nihal Hewage, Factory Engineer, for letting me work as a trainee in the maintenance department and for guiding me with widespread knowledge and skills.

I also thank Eng. Duminda Herath, Production Engineer, Eng. Pasan Dorakumbura, Assistant Factory Engineer, Eng. Sanka Samaraweera, Production Engineer for helping me to blend my knowledge with the industrial working atmosphere. I sincerely thank all the other Engineers, Engineering Assistants, technicians, and other staff members of engineering office for their generous support given to us without any hesitation.

At last but not least, I thank my dearest colleagues Mr. Rajeev Karunanayake, Mr. Mahesh Alahakone, Miss Dinelka Premarathne, Miss Nayanamali Ekanayake, Miss Inosha Jayakody for their immense support and guidance given from time to time as team members to make this ten-week training process a success.

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LIST OF ABBREVIATIONS

KY Kiken Yoshi

Chapter 1

INTRODUCTION

1.1 TRAINING SESSION

This training session was covered as per the requirement of the completion of the 10-week internship program at the end of the third year as a part of the B.Sc. Mechanical Engineering degree programme. Training was conducted at Noritake Lanka Porcelain (Pvt) Ltd, Matale. The 10-week training programme was from 25/02/2019 to 05/05/2019.

1.2 INTRODUCTION TO THE TRAINING ORGANIZATION

Figure 1.1 Noritake Logo

In 1904 a factory was founded by baron Ichizamon Morimura was established in Nagoya, Japan under the name of NIPPON TOKI KAISHA Ltd. This company established in Japan grew to be named as Noritake which went into a joint venture with Ceylon Ceramic Corporation in 1972, which was then the leading porcelain manufacturer in Sri Lanka. The joint venture enjoyed a lot of success, which led to creating of a well spread culture of porcelain manufacturing in Sri Lanka. This success and the deeply rooted culture lead to the complete acquisition of the venture by the Japanese parent company and was named as Noritake Lanka Porcelain (Pvt) Ltd in 1990 which remains unchanged to this date.

The main factory is situated in Warakamura, Matale which is responsible for most of the production while another factory is located in Pannala, Kurunegala which handles decorations. Noritake also has showrooms located in Wattala, at the factory outlet in Matale and another in Colombo 07.

Noritake Lanka Porcelain (Pvt) Ltd mainly produces tableware while other branches of Noritake scattered around the world are responsible for the production of electronics and other ceramic wares. An estimated amount of 900,000 pieces are produced each month. While 80% of these are exported worldwide the rest is distributed inland in which most of the products are distributed supplementing the tourism industry. Noritake Lanka boasts a permanent staff of 1240, while supplementing the production process with a temporary staff of 250. Noritake Lanka follows an integrated management system since 2015.

1.2.1 Organizational structure

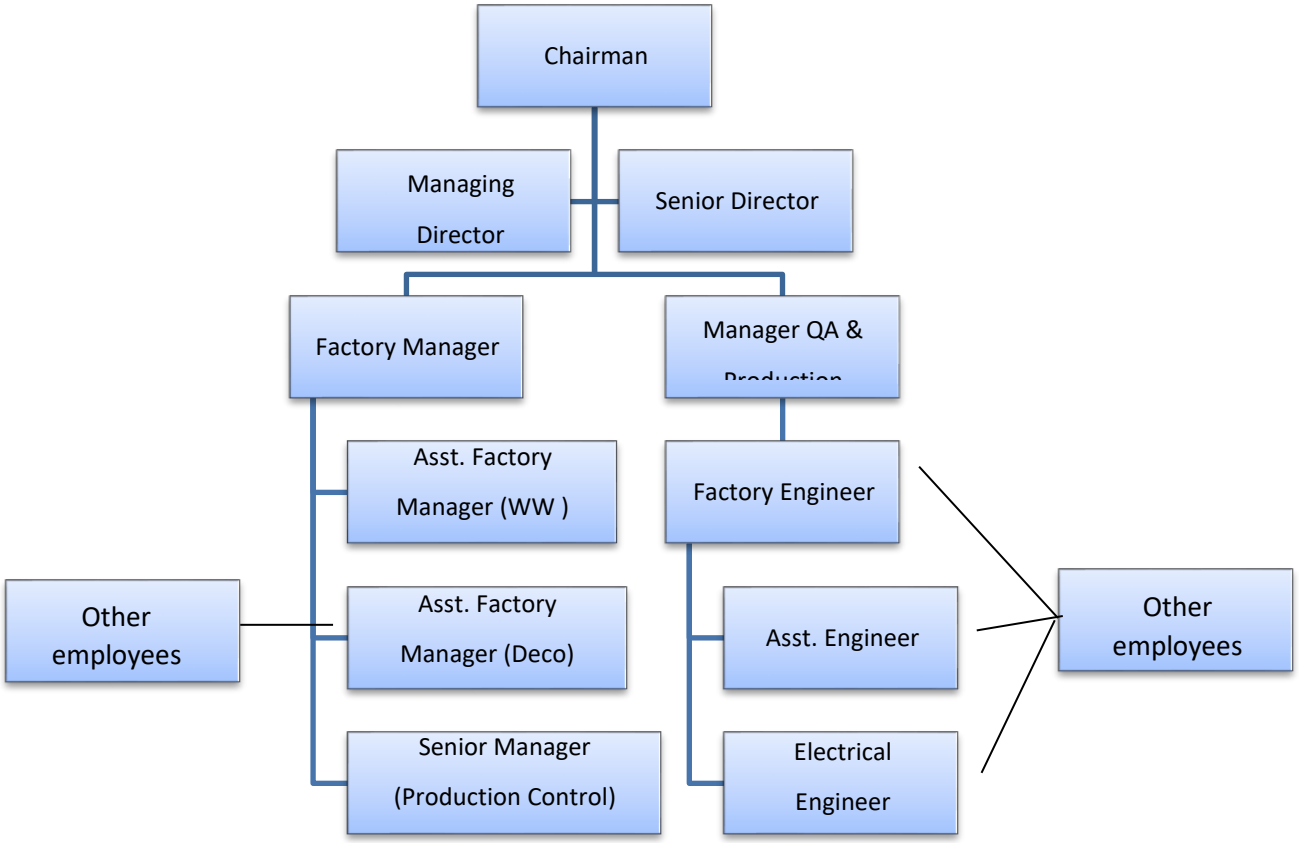

Figure 1.2 Organization Chart

1.2.2 Mission

Noritake Lanka Porcelain Private Limited is the pioneer porcelain tableware manufacturing conglomerate in Sri Lanka. The Company was established in 1972 as a joint venture company between Ceylon Ceramic Corporation and Noritake Co., Limited of Japan. Noritake Co., Limited of Japan is a hundred years old company which markets tableware under the brand "Noritake" all over the world.

The Company's production facility is located in Matale where country's rich minerals such as quartz, feldspar and dolomite deposits are spread. Factory operates with the production systems developed by the parent company in Japan. There are several Japanese technical advisors' station in the factory to monitor production process to ensure products are manufactured in par with the international quality standards. The factory started its operations in 1972 just with 150 workforce and as at today workforce stands with 1200 skilled workers. Some of the workers, supervisors and managers of the factory are trained in Japan in their relevant fields.

Since the inception, company went with several expansion programs by investing nearly 1 billion rupees to increase the production facility from 3,000 sets to 12,000 sets per month. In year 2008 the Company invested Rs.160 million to introduce a plant, which produces Bone China Tableware. Bone China Tableware is regarded as the most expensive tableware in the world and this company is now the pioneer in this segment in Sri Lanka.

1.2.3 General function of the factory

The main factory of Noritake Lanka Porcelain Private Limited has several departments as follows, in order to complete the production process.

- Preparation Department.
- Forming Department.
- Glazing Department.
- Decoration Department.
- Inspection Department.

Other than those departments, the maintenance department, which we, the engineering trainees were attached to, oversees the maintenance procedure of the entire factory weather it is production related or not. The Human Resource Department looks into the employees and their needs while keeping records of salaries. The Finance Department looks into the finances and accounts of the organization. The IT Department looks into IT related breakdowns and other activities.

1.2.4 Manufacturing Process

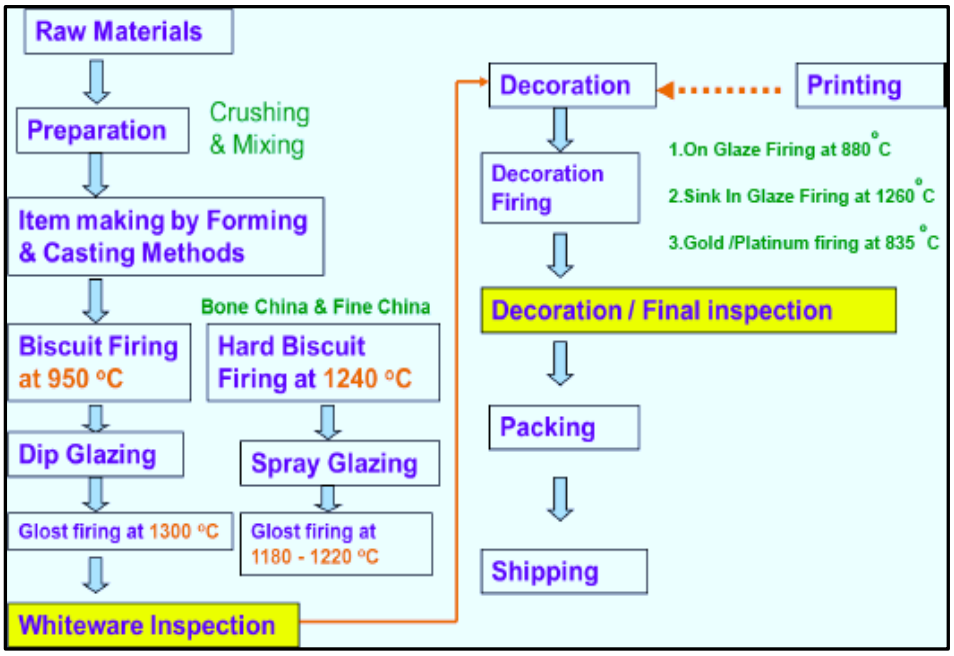

Figure 1.3 Flowchart of Manufacturing Process

1.3 SUMMARY OF THE WORK ENGAGED

The first few weeks of the training period were spent to get familiarized with the factory premises, the porcelain product manufacturing processes, the processes in different departments and how they contribute towards the overall production process, how machines work and the components inside of the machines etc. Furthermore, we were given the opportunity to engage in ongoing projects, and to undertake ongoing maintenance procedures with the supervision of the factory engineer. Most importantly we were able to learn about efficient Engineering managing and production methods through some lectures given by the Monozukuri team in the factory.

Chapter 2

MAINTENANCE DEPARTMENT

2.1 INTRODUCTION

The Maintenance Department is the place where, the Mechanical, Electrical and Production Engineering trainees are being appointed for their training and they are being trained under the head of the department, Factory Engineer, Mr. Nihal Hewage. The two main divisions of maintenance department are workshop and electrical division. This department is responsible for the maintenance and repair of mechanical and electrical equipment of the factory. Civil Engineering work is also being undertaken by the maintenance department, but they are somewhat rare compared to mechanical and electrical maintenance work done in each day. The crew at the department is adequate to get the day to day work done but if the demand is high or the skill set of the available workers are not up to the required work, outsourcing of work is done with the approval of the factory manager.

2.2 WORKSHOP

The workshop is headed by the foreman, Mr.Athula and the technical superintend, Mr.Pieris. Conducting meetings at 7.30 a.m. to assign the jobs to the technicians is a usual task done under the factory engineer. Maintenance requests are sent to the workshop through a responsible person of each deparment and work is allocated after the approval of the factory engineer. The foreman allocates the work under the supervision of the factory engineer. Workshop has various machines such as lathe machines and other useful items stored at the store room.

2.3 ELECTRICAL DIVISION

The electrical unit is headed by the electrical engineer. This unit is responsible for continuous electrical maintenance of the factory through repairing of electrical faults, maintenance of power distribution systems and electrical machines like motors. The department has four generators stand by to face any power cuts during any time of the day.

2.4 PREVENTIVE MAINTENANCE

As the name indicates, this type of maintenance is being done before break downs. This is what is done at Noritake Lanka Porcelain Limited as a usual thing, because it is believed to reduce cost greatly. To prevent faults from occurring, replacements of certain mechanical parts, cleaning of components, and tests are performed time to time within certain time periods. The main maintenance work is carried out during the mid-April vacation, which is call as ‘Vacation Maintenance’. Because workers get a vacation of two weeks for the New Year. ‘Vacation Maintenance’ plan for 2019 were prepared by us, the engineering trainees, under the supervision of the factory engineer and with the help of other department heads, the workshop foremen and the superintend. The plan is attached under the chapter, ‘Annex’. The following steps were done to update the Vacation Maintenance plan.

- Collecting data from the last year list, on jobs that has to be done.
- Contacting heads of the departments to collect data on this year.
- Contacting the relevant technician for each job.
- Combining the data with Electrical Engineering division.
- Planning suitable dates.

Every preventive maintenance is done after shutting down the relevant machinery for the sake of safety. As an example, the kilns were shut down 3 days prior for the maintenance, since they need time to cool down before checking replacing components inside of them. Safety tags were used as shown in figure 2.1 to indicate that the particular machine is shut down.

Figure 2.1 Kiln Closed Tag

2.5 BREAKDOWN MAINTENANCE

The workers working at certain machines at the factory has some amount of knowledge on repairing their devices in small break down situations. But, most of the times they need help from the maintenance department. Therefore, they are supposed to inform the head of the relevant department in order to send a 'Job Card' to the maintenance department. Once the maintenance department receives the Job Card, the factory engineer or the foreman decides on what actions has to be taken to fulfill the requirements.

2.6 EFFLUENT PLANT MALFUNCTION

The main function of the effluent plant in the factory is to clean the waste water, which has contaminated with clay particles and other chemicals used in the porcelain production process. The tank, which is used to mix the water after the chemicals are being added has an agitator to stir the mixture for efficient cleaning. A Job Card was sent to the maintenance department of informing that the agitator was not up to the standard speed.

The agitator is run by a motor and the energy is transferred through a pully arrangement. To increase the speed of the agitator, the pulley at the motor end has to be enlarged. First, the plant was temporarily shut down and pulley at the motor end was disassembled as shown in figure 2.2.

Figure 2.2 Disassembled Pulley

The pulley, which was chosen to replace the existed one was not compatible with the shaft of the motor. Because, the bore of the pulley was too large to fit perfectly with the motor shaft. Therefore, the bore was enlarged furthermore using lathe operation and welded with a bush at the bore as shown in figure 2.2. The bush was designed to fit perfectly with the motor shaft.

Furthermore, the new pulley had a three-groove configuration, whereas the old one was two grooved. If the three-groove one was replaced regardless of number of grooves, it might result in extra energy loss and vibration. Therefore, the extra part was separated using a lathe machine.

Figure 2.3 Pulley with the Attached Bush

2.7 LATHE MACHINES AT THE WORKSHOP

The lathe machines at the workshop had following special features in order to enhance safety and to create an ergonomically friendly environment.

- There were four lathe machines and they were placed parallelly to each other but angled with the walls of the building. Because of that, the hot metal chips coming out while operating will not contact with the technician, who is working in the front lathe machine.
- Lathe work is usually done while standing for several hours continuously. Therefore, there is a chance for the technician to faint while in the operation leading to catastrophic situations. This is being avoided by using wood pallets, which are designed to ensure a good blood circulation to the legs.

Metal moulds, which are used to get the shape of the porcelain products, are manufactured using lathe machines at the workshop. The mould templates that helps to create the metal moulds are received from Japan. Those templates can be used to use as a guide to the tool placement of the lathe machine.

For each lathe operation, the chuck is need to be checked for the balance. There are two main types of chucks.

- Three-jaw chuck – Adjusting nuts move simultaneously
- Four-jaw chuck – the screw threads are adjusted separately to tighten the drill bits.

The dial gauge shown in the figure 2.3 is used to check whether the work pieces are centered perfectly. It has a magnetic base so that it would contact with the lathe machine tightly ensuring zero unwanted movements while calibrating.

Figure 2.4 Lathe Machine Dial Gauge

Chapter 3

PREPARATION DEPARTMENT

3.1 INTRODUCTION

The production process begins at the preparation department. Raw materials such as Feldspar, Dolomite and Quartz are broken down and processed so that it could be further processed into desired products. The raw materials are transported usually by trucks from Galaha and several locations in Matale district and the preparation department is placed such that the raw materials can be conveyed easily from the trucks to the department. There are three unloading locations allocated separately for Feldspar lumps, Quartz, Dolomite and pebbles. Quartz is the main raw material, which is used

Figure 3.1 Crusher

Figure 3.2 Jaws of the Crusher

The first machine the raw materials meet, after unloading from the trucks is the crusher. See figure 3.1. There are three stages of crushing raw materials. First two stages use jaw crushers, which has metal plates designed as jaws, as per shown in figure 3.2 to crush the raw materials into smaller particles.

The final stage involves with a roller crusher and the outcome of the crushing process is particles which has the diameter in the range of 5 mm – 10 mm. Those particles are fed into the crusher separately according to the type of the raw material and before every time when a new raw material, which is different from the previous one is fed into the crusher, the crusher is cleaned to avoid contamination. The dust particles are collected at the bottom of the crusher as shown in the figure 3.3 and disposed.

Figure 3.3 Dust Particle Collector

The crushed raw materials are stored in a nearby location to transfer them to the ball mills for the grinding process.

When the regular checkup of the crusher is done it was found out that the jaws have worn out. Therefore, it had to be filled by welding. See figure 3.4.

Figure 3.4 Welded Jaw Crusher

3.2 BALL MILL

Figure 3.5 Ball Mill

There are 15 Ball Mills at the preparation department and 12 of them were at the working condition. A ball mill as shown in figure 3.5 consists of a hollow cylindrical shell rotating about its horizontal axis. It is partially filled with balls, which are made of steel (chrome steel), stainless steel, ceramic, or rubber. The function of the balls is to grind the raw materials. The inner surface of the cylindrical shell is usually lined with an abrasion- resistant material such as manganese steel or rubber. Less wear takes place in rubber lined mills. The length of the mill is approximately equal to its diameter. Huge particles of Quartz, Feldspar and Dolomite are broken down in this process.

As the shell of the ball mill rotates, the balls are lifted up on the rising side of the shell and then they are dropped down on to the feed from near the top of the shell. In doing so, the solid particles in between the balls and ground are reduced in size by impact. The normal size range of the raw materials is 5 mm to 10 mm of average diameter. They are reduced to an average diameter of 8 µm at the ball mill. There are three types of balls as S1, S2 and S3 and they are combined in ball mills such that it suits the objective of the grinding. Alumina balls are being lately considered as a substitution for pebbles to reduce the cost. In case of maintenance, an annual maintenance procedure is followed to replace the worn-out parts. The main part which wears out is the bearing and bearings for Ball Mills are in constant demand.

The materials are mixed with water in the ball mills and transferred to the tanks to store according to the type of the mixture and they are continuously stirred to keep mixed.

3.3 FILTER PRESS

Figure 3.6 Filter Press

Filter press is a device, which is used to take out water from the clay mixture. The mixtures, which are stored in the tanks after the milling process, are pumped and pressurized through the filter presses in order to get clay plates with a reduced water percentage.

We were assigned to address a problem with an engineering solution, as the newly installed filter press, which includes plastic plates instead of metal plates as in older models, produced larger clay plates. The specific problem was, the weight of the clay plates that has to be carried out by a worker has increased exposing them to an unsafe working environment.

Figure 3.7 Filter Press Plates

The solution, the engineering team came up with was facing off the plastic plates in order to decrease the thickness of the clay plates.As shown in Figure 3.7, the plastic plates were taken out from the filter press to take the current measurements of the thickness values and face them using a facing machine.

3.3.1 Annual Filter Press Pump Service

The annual membrane pump service was undertaken by the maintenance department of the factory and we were assigned to create the working standard report for the future use, to improve and secure the safety and the efficiency of the process. The working standard report is attached at the end of the report. The main tasks of the annual service of the filter press pump are as follows.

- Getting ready for the task by taking safety measures
- Checking the diaphragm pump for damages and repairing
- Changing of oil
- Cleaning of pipelines
- Cleaning of the ferro magnet

3.4 PUG MILL

As shown in figure 3.8, clay plates are transported from the filter presses and stored at the pug mill unit. They are fed into the pug mill and it can achieve a thoroughly mixed, homogeneous mixture as the output in a few seconds. It is come out in a cylindrical shaped rod. Therefore, it is convenient for the forming processes that are still to be done.

Figure 3.8 Pug Mill with Clay Plates

3.5 FERRO FILTERS

Ferro filters are mainly used at the inlets of the filter presses. See figure 3.9. Other than that, they are used to test clay mixtures for iron particles. It is simply a magnet, which is attached between the membrane pump and the filter press. This is an important part of the porcelain production, since the iron particles create cracks when the products are exposed to higher temperatures at kilns.

Figure 3.9 Ferro Filter

Chapter 4

FORMING DEPARTMENT

4.1 INTRODUCTION

The main function of the forming department is to shape the raw material mixture rods by the preparation department. In total there are 12 forming machines at the factory. Forming machines consist of mainly two steps.

1. Jiggering
2. Drying

4.2 JIGGERING

Jiggering is the process of mixing of raw material mixture and turning it on a wheel beneath a mould to a specified size and shape. Jiggering is an application of use of centrifugal forces in the industry. The roller head velocities and other parameters vary from product to product and are provided to machine operators. There are mainly two types of jiggering.

4.2.1 Outside jiggering

As the name implies, the outside surface of the mould is used to obtain the shape. A profile describing the outside shape of the ware is used to force the soft clay against a rotating plaster mould describing the inside shape. This is mainly used for flatware.

4.2.2 Inside jiggering

The inner surface of the mould is used to obtain the shape. A profile describing the outside shape of the ware is used to force the soft clay against a rotating plaster mould describing the inside shape as shown in figure 4.1. This is mainly used for hollow ware.

Figure 4.1 Inside Jiggering Machine

4.3 DRYER

After the jiggering process, the products are sent to long tunnel like structures as shown in figure 4.2 called dryers. A dryer consists of 120 trays with 4-5 items per tray. These trays slowly travel along the tunnel and items are dried in the process. These products are called green ware. After drying against the plaster, the clay shrinks and can be removed from the mould and the process is repeated.

Figure 4.2 Dryer

4.4 BONE CHINA DRYER PROBLEM

It was found that some of the products coming out from the bone china dryer are cracked. After investigations done by the Engineers, the problem was suspected to be the high humidity inside the dryer. Because, if the moisture inside the clay products could not be removed properly, it might lead to cracks in products. This happens due to saturation of water vapor inside the dryer. There are 6 dampers on the top of the dryer to acts as outlets for the water vapor.

In order to address the problem with a solution, the temperature and humidity data had to be taken from the inside of the dryer as shown in figure 4.3. But it was not a success due to following reasons.

- Lack of responsiveness of the RH meter shown in figure 4.4. Therefore, the time was not enough to get readings.
- Difficulty of getting readings due to unfavorable dryer layout. (Some of the dampers were not reachable)

Figure 4.3 Measuring Thermodynamic Properties Inside the Dryer

Figure 4.4 Taking Readings from the RH Meter

Chapter 5

DECORATION DEPARTMENT

5.1 INTRODUCTION

Decoration is the final process of a porcelain product prior to shipping. Decorating products is done in two steps. Initially they are stickered by the relevant decoration or hand drawn by skilled workers and then it is processed through a dryer to make the decoration permanent. This adds value to the product and if the decoration is handmade, the value is increases drastically. The decoration part is called the decal and it is designed and printed by the printing department. It is pasted onto the item and squeezed to get rid of air bubbles before the drying process.

5.2 DECORATION RENOVATION

5.2.1 Dust Problem

Decoration department is a place where there should not be any dust particles. Because, dust particles might stick between the printed stickers and the porcelain products. It will lower the quality of the products. Even though the decoration department is air conditioned, there are still ways of dust particles coming into the department. We were assigned to find out a solution for the dust particle problem and it was obvious that the main carriers of the dust particles are the carts that are entering the decoration department, with porcelain products, which are to be decorated.

5.2.2 Modification of the cart entrance

Cart entrance had to be modified such that the contact with the outside is minimum in the process of good transportation. Therefore, a new method was introduced to use separate carts to transport goods inside the decoration department. The new entrance is designed such that the goods, which are coming from the outside in outside carts will be transferred safely to the inside carts, minimizing the dust particle arrival to the decoration department. As shown in figure 5.1, the old cart pathway was not straight therefore, the workers had to give an extra effort to pull the carts towards the entrance. Figure 5.2 shows how the layout was changed, addressing the major issues. A conveyer was introduced to transfer goods from outside to the decoration department and it was designed such that all types of carts can be used to transport the products.

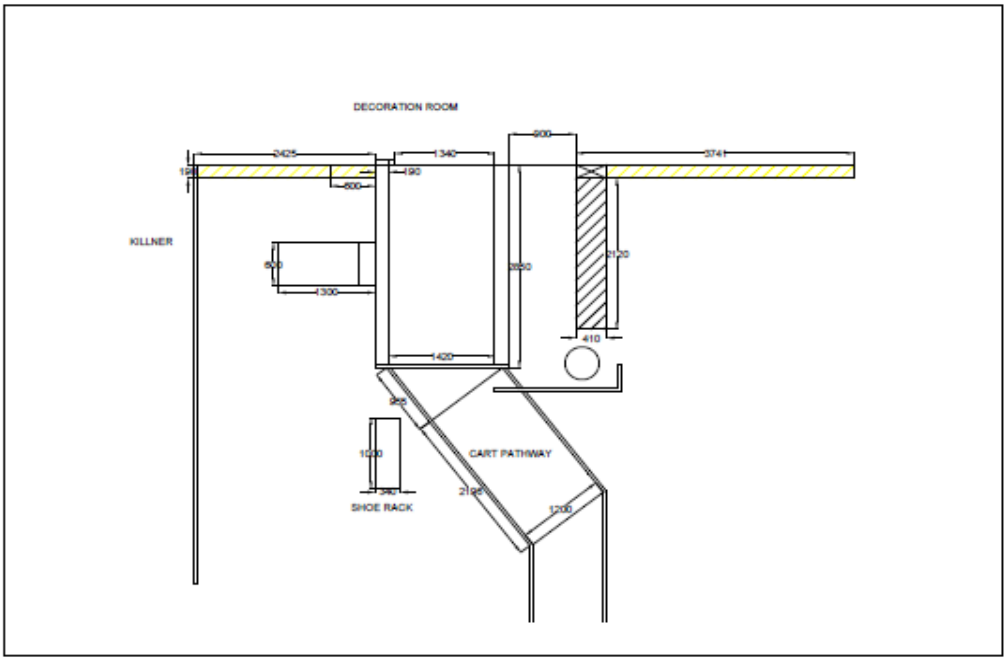

Figure 5.1 Old Entrance Layout

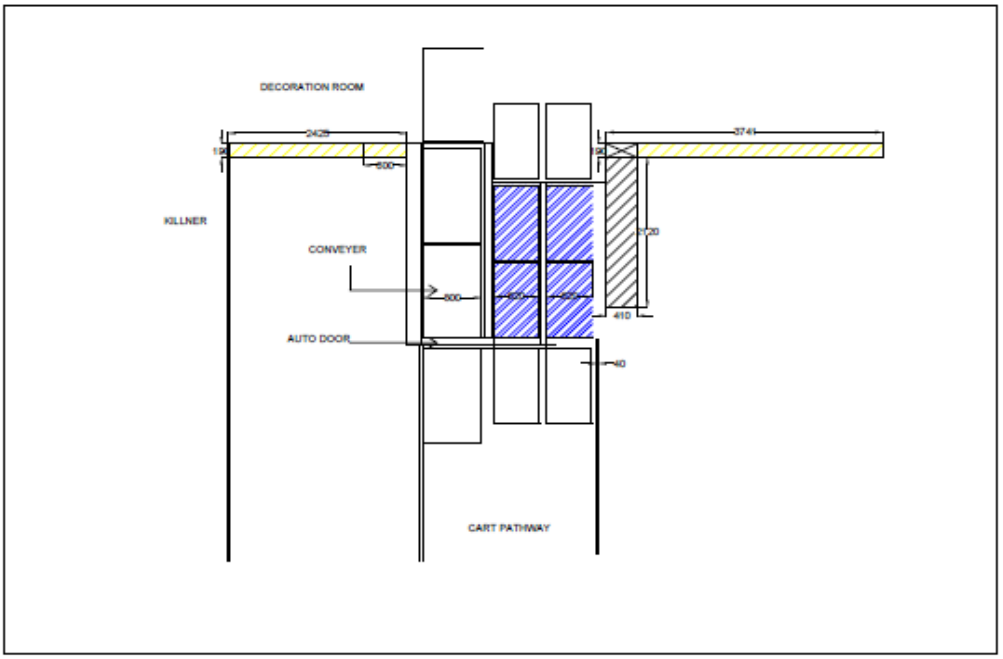

Figure 5.2 Designed Layout

5.2.3 Modification of the people in/out

The workers in the decoration department used the people in/out, which is separated from the cart entrance. But with renovation of the cart entrance this too had to be changed in the following way and two possible design concepts were pitched as shown in figure 5.3 and figure 5.4.

- Removing the existing air shower booth.
- Relocating the shoe rack.
- Removing the sink and relocating.
- Relocating lockers.
- Fabricating a new compartment for ‘Clean Room’.
- Ceiling fabrication.

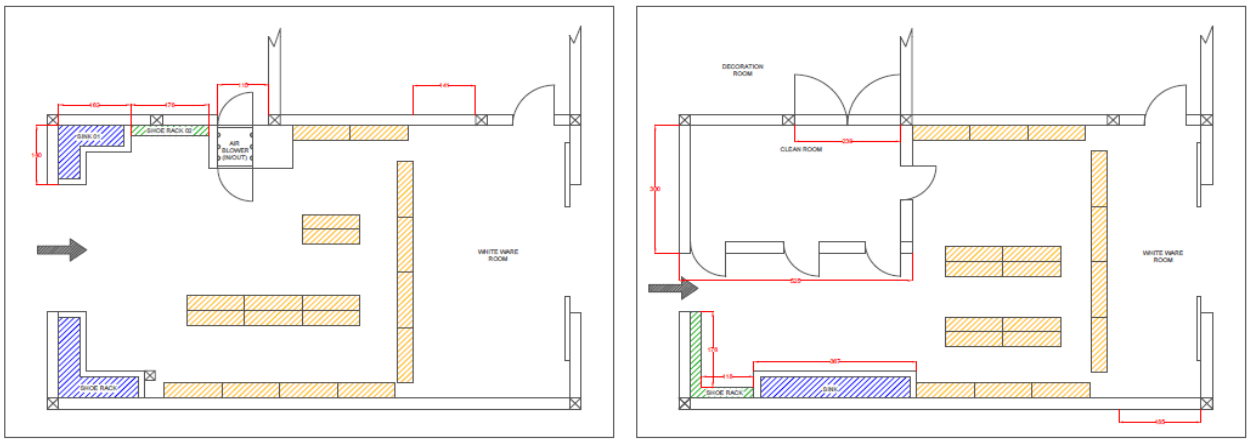

Figure 5.3 Comparison of the Present Layout with Proposal 01

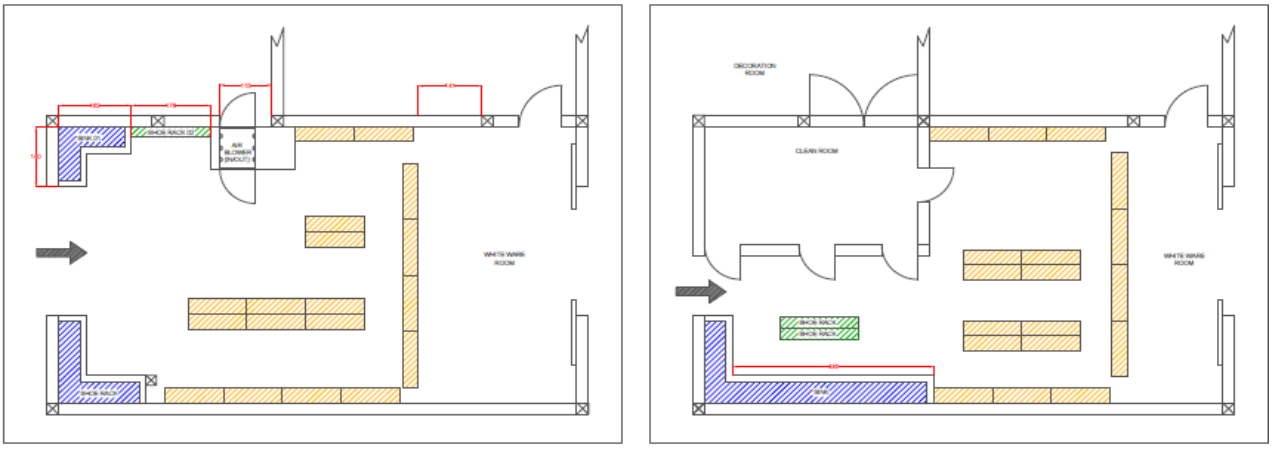

Figure 5.4 Comparison of the Present Layout with Proposal 02

5.2.4 Modification of the carts

The existing carts could be categorized in to two types as type A (See figure 5.5) and type B (See figure 5.6) according to their dimensions. They all were checked to identify their type and separated for modifications. For the transferring of goods to the decoration department, goods should first go through the conveyer at the entrance. Therefore, the goods need to be transferred using a plate from the cart to the conveyer. The plate is rolled on 'Corocone rollers', which are newly fixed to both type of carts. See figure 5.8.

Figure 5.5 Cart type A

Figure 5.6 Cart type B

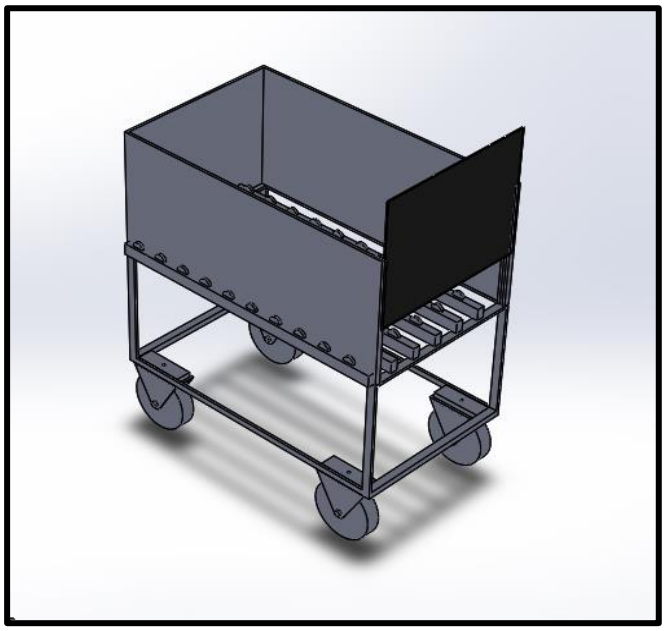

Figure 5.7 New Cart Design

The following steps are supposed to take in order to make the carts as shown in figure 5.7.

- Modifying Type A and Type B carts by fixing corocone rollers.
- Opening the front side of the carts and setting up a sliding door.
- Standardizing Type B carts by changing the height.

Figure 5.8 Corocone Rollers

Chapter 6

KILNS

6.1 INTRODUCTION

The Kiln is a one of the most important parts of the factory, since almost all porcelain products goes through a kiln one or more times in the process. The Kiln is only switched off during the month of April in each year for maintenance work, giving all the workers the April vacation except the workers at the Maintenance Department. Workers at the Maintenance department should be involved in vacation maintenance at the time. Kilns need to be fired 72 hours – 80 hours before operation and the same amount of time needs to be given for the Kiln to cool down as well.

There are three kinds of firing as hard biscuit, soft biscuit and gloss firing and they are categorized according to the temperature at which they are fired and the process step. Hard biscuit firing is done at 1250 ^{0}C and soft biscuit firing is done at 950 ^{0}C. gloss firing is done after glazing the products. There are two types of kilns in the factory according to the firing process.

- Oxidation firing – Fired under excess Oxygen. This is the most efficient firing process since it combusts the fuel with the help of Oxygen. Therefore, it produces a blue flame.
- Reduction firing – Fired under low Oxygen. The incomplete combustion will produce CO along with CO_2. Therefore, it will produce a yellow flame instead of a blue flame. CO has to be burnt afterwards with oxygen to reduce the pollution.

6.2 KILN OPERATION

Gross kilns at Noritake Lanka Porcelain Limited has a special mechanism to transfer carts in to the kilns and to take them out. The time period a cart should be inside the kiln is standard and it should be constant for all the carts. Carts are pushed to the kiln by a hydraulic piston as shown in figure 6.1.

Figure 6.1 Hydraulic Piston Moving Carts

The piston’s working range is equal to the cart length. At a time, the kiln has 46 carts inside of it this means the kiln’s length is equal to the 46 times of one cart’s length. A new cart is pushed to the kiln by the hydraulic piston in every 45 minutes. A kiln has three major zones as following.

- Pre-heating zone
- Firing zone
- Cooling zone

Chapter 7

SAFETY AND QUALITY

7.1 INTRODUCTION

This chapter contains a description of the quality control safety measures taken by Noritake. Since Noritake Lanka Porcelain Limited is a Japanese company, the safety measure taken are up to the international standards.

7.2 QUALITY ASSURANCES & STANDARDS

- ISO 9001:2008 certified since 2000, International standards that specifies requirements for a Quality Management System (QMS)
- ISO 14001:2004 , International standards that specifies requirements for an Environmental Management System (EMS)
- OHSAS 18001:2007, Occupational Health and Safety Assessment Series, is a British Standard for occupational health and safety management system.

7.3 KAIZEN

'Kaizen' the Japanese word when translated to English is Good change. The employees at Noritake are encouraged to improve processes by contributing ideas and suggestions and they are even awarded with money for the best contributions. Contributions from any of the employees are welcomed regardless of the department they represent.

7.4 SAFETY MEASURES

They define a situation called 'Abnormal Situation', which is not the same situation as usual but an emergency situation, which needs to be addressed by the authority. All the workers are advised to follow the simple three step method called, 'Stop Call Wait', where in an abnormal situation, you are supposed to stop the work immediately, call the authority and wait for the authority to get some action.

At the first day of the work, every worker is given a lecture on safety by the department of Human Resources, and then tested by giving an examination paper on safety. This ensures the knowledge on safety of each and every worker in the factory.

Whenever a maintenance work has to be done, the workers of the maintenance department uses safety gloves as shown in figure 7.1 and safety shoes as shown in figure 7.2.

Figure 7.1 Using of Safety Gloves

KY is a risk assessment method used in industrial working environments. Listing up the hazards and risks existing among job processes and environments, crucial risk information such as accident reports, near miss event reports and safety improvement are done in a KY assessment. It is important to overcome above obstacles for further application of this technique with enough validity. This method is widely used in the factory in maintenance activities and time to time KY assessments are done with the help of experts as an exercise to enhance the experience of the workers. Figure 7.3 shows how the KY sheet is stuck near the location, where the maintenance work is ongoing.

Figure 7.2 Using of Safety Shoes

The work area is covered with caution tapes and tags are used to indicate signs as shown in figure 7.3 and figure 7.4.

Figure 7.3 Using of Caution Strip

Figure 7.4 Tagging Warning Sign and KY Sheet

CONCLUSION

The first two weeks of our training period was spent on familiarizing the organization, and familiarizing the production process and as well as with the people. The Factory Engineer Mr. Nihal Hewage was very helpful in us getting used to the surroundings and introduced us to several projects, which are ongoing at the time. Most of the projects aimed for a solution for a critical problem at the factory that needs to be addressed by professionals.

The lessons learnt under the academic curriculum were pretty useful in some of the problems we encountered such as designing of the cart project and other micro designs using SolidWorks and AutoCAD. Even though the time frame was not adequate to finish all the projects that we were assigned, we were able to cover almost every main process at each department while completing one project with a proposal for a new cart entrance design for the decoration department.

The training period at Noritake was an enjoyable experience and many lessons were learnt on Engineering related matter and otherwise. Beside the academic curriculum a lot was on understanding human interactions at a factory workplace.