THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

Industrial Training

At

(Tata Motors India Pvt. Ltd.)

Final Report

On

Reduction of DPH (by process)

Submitted to:

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Acknowledgement

As I Begin to reflect on the magnitude of my project report, I am reminded of all the support, help and encouragement provided to me by the members of the Engine shop, Pantnagar as without their support my project wouldn’t have been possible. I thank all my team members who inspired me to work and promote this unique way of learning around their surroundings. When I begin to put on paper the feelings I have towards the people the people who have changed my heart, soul. If I put it in real terms, I would call it a splendid team effort that has helped me to end my training on high notes. My experience here has been very enriching. I sincerely hope that their guidance would be of great help to me for the rest of the project. I show my gratitude and thankfulness-

First I would like to thank my university teacher as well as mentor **Dr. R.S. Joshi** (Assistant Professor, TIET) for giving me the opportunity to pursue my project semester at Tata Motors Pvt. Ltd.

To **Mr. Devesh Pandey** (Executive, Operations, TML Pantnagar) for his vision, integrity and sense of quality, which is quiet common. It is due to his penetrating sight that my inner talent was unveiled and has given me confidence to face the competitive world. During my highs and lows his words of wisdom have always been a source of inspiration for me. I am eternally grateful to you sir.

To **Mr. Mohan Gururani** (General Manager, Powertrain Shop, TML Pantnagar) for his strategic help. His sense of responsibility, logical way of treating the situation and vision is worth of being exemplified.

I might have missed some names, which were also a part of the journey, I am thankful to them. The end of a journey isn’t fixed but the beginning is always set, I am very thankful to my parents and the Almighty who embarked me on this journey and stood by me the whole time.

Manas Asija

Abstract

The objective of the project is "Reduction of leakage from the 275 IDI by top process issue", which gives reader and overview of the leakages from the engine and how to stop them. It provides knowledge of different problem solving techniques. The various QC tools such as 4W-1H analysis, Causation and Effectuation Diagram (Fishbone Diagram), Why-Why Analysis, Action Plan and defect monitoring. The different parts discussed in the report are head cover, water sensor adaptor, water by pass tube, upper cooling line.

The other objective in the report is the making of the PFMEA sheets of the 275IDI on the 275 assembly line of the Engine Shop, Powertrain, TML Pantnagar. It discusses the calculation of RPN number which is obtained by different input variables. It basically helps in finding errors in the process.

The last project is the making of Work Instruction Sheets of the 275 IDI on the 275 assembly line of the Engine Shop, Powertrain, TML Pantnagar. It helps in the operator training and contain the details about the parts used in the workstation.

Figures, Graphs, Flow Diagrams, Tables have been provided as and when necessary.

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Abbreviations Used

Sr. No.	Abbreviations	Full Form
1	BIW	Body in White
2	TCF	Trim Chassis Fitment
3	BSII	Bharat Stage II
4	MHCV	Medium and Heavy Commercial Vehichle
5	CVBU	Commercial Vehicle Business Unit
6	DCNR	Direct Current Nut Runner
7	PNR	Pneumatic Nut Runner
8	WIS	Work Instruction Sheet
9	PFMEA	Process Failure Mode and Effect analysis
10	CP	Control Plan
11	PFD	Process Flow Diagram
12	IDI	Integrated Direct Injection
13	DICOR	Direct Injection Common Rail
14	EGR	Exhaust Gas Recirculation
15	FIR	Fuel Injection Pump
16	RPN	Risk Priority Number
17	DPH	Defects Per Hundred

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CHAPTER-1

INTRODUCTION

1.1 Company Profile

The TATA Group is a business built on the foundation of Trust & Ethics.

J.R.D. Tata states ***"No success or achievement in material terms is worthwhile unless it serves the needs or interests of the country and its people and is achieved by fair and honest means."***

These values, which have been part of the Group's beliefs and convictions from its earliest days, continue to guide and drive the business decisions of Tata Companies.

1.2 About TATA Motors Ltd.

Tata Motors Limited is India's largest automobile company, with consolidated revenues of INR 2.697 trillion (USD 40 billion) in 2016-17. It is the leader in commercial vehicles in each segment, and among the top in passenger vehicles with winning products in the compact, midsize car and utility vehicle segments. It is also the world's fifth largest truck manufacturer and fourth largest bus manufacturer.

The Tata Motors Group's over 60,000 employees are guided by the mission "to be passionate in anticipating and providing the best vehicles and experiences that excite our customers globally."

Established in 1945, Tata Motors' presence cuts across the length and breadth of India. Over 8 million Tata vehicles ply on Indian roads, since the first rolled out in 1954. The company's manufacturing base in India is spread across Jamshedpur (Jharkhand), Pune (Maharashtra), Lucknow (Uttar Pradesh), Pantnagar (Uttarakhand), Sanand (Gujarat) and Dharwad (Karnataka). Following a strategic alliance with Fiat in 2005, it has set up an industrial joint venture with Fiat Group Automobiles at Ranjangaon (Maharashtra) to produce both Fiat and Tata cars and Fiat powertrains. The company's dealership, sales, services and spare parts network comprises over 6,600 touch points, across the world.

Tata Motors, also listed in the New York Stock Exchange (September 2004), has emerged as an international automobile company. Through subsidiaries and associate companies, Tata Motors has operations in the UK, South Korea, Thailand, South Africa and Indonesia. Among them is Jaguar Land Rover, acquired in 2008. In 2004, it acquired the Daewoo Commercial Vehicles Company, South Korea’s second largest truck maker. The rechristened Tata Daewoo Commercial Vehicles Company has launched several new products in the Korean market, while also exporting these products to several international markets.

FIGURE – 1, Tata Motors Logo

Tata Motors is also expanding its international footprint, established through exports since 1961. The company’s commercial and passenger vehicles are already being marketed in several countries in Europe, Africa, the Middle East, South East Asia, South Asia, South America, CIS and Russia. It has Franchisee/joint venture assembly operations in Bangladesh, Ukraine, and Senegal.

1.3 Joint Ventures

Indian auto major Tata Motors has entered into a joint venture with Brazil's Marcopolo, one of the worlds largest bus manufacturers, to set up a new plant in India to manufacture and assemble fully built buses and coaches with an investment of Rs 150 - 200 crore. Tata Motors will hold 51% stake in the company, while Marcopolo the rest 49%.

The joint venture company would have an initial capacity to manufacture 7,000 vehicles a year, which would be raised in a modular manner over the next few years. It will also explore emerging opportunities in bus rapid transit system.

In a statement here on Friday, Tata Motors chairman Ratan Tata said, "The joint venture with Marcopolo will enable Tata Motors to successfully address the growing demand in India, as well as relevant markets abroad."

Analysts feel the joint venture would enable Tata Motors to make their presence felt overseas and to strengthen its heavy segment in India. "The core strategy of Tata Motors would be to target the export markets, especially the Middle East, which was on their radar for quite some time," said HC Raveendra of KR Choksey.

The joint venture would combine Tata Motors technology and expertise in chassis and aggregates and Marcopolos expertise and know-how in processes and systems for bodybuilding and bus body design, the release said.

The joint venture will take help with technology and expertise in chassis and aggregates from Tata Motors, and expertise and know-how in processes and systems for bodybuilding and bus body design from Marcopolo. Both companies will actively participate in the management. The buses will conform to international standards in quality and safety, and will be marketed not only in India but also in all Tata Motors focussed markets globally.

FIGURE- 2 , Tata Marcopolo Joint Venture

1.4 About the Unit

The Tata Motors' plant at Pantnagar is the site where the best-selling Tata Ace - the mini one-ton truck, and its variants are manufactured. The plant is a world-class project that is spread across 1,000 acres in Uttarakhand's State Industrial Development Corporation.

The Pantnagar plant has been built with state-of-the-art facilities and is a key enabler of Tata Motors' leadership in the mini-truck segment. It also produces a few SUV models as well as medium and heavy vehicles.

The plant has been designed to enhance speed and efficiency in manufacturing. It is the company's first plant with an integrated vendor park, which occupies 337 acres of the plant's total area. This helps keep inventory low and ensures 'just-in-time' (JIT) supplies. The 73 vendors based here account for nearly 75 percent of the items supplied to the plant.

The general office at Pantnagar is a gold-rated green building, a testament to the unit's efforts to reduce energy consumption and boost energy efficiency. The plant has an Integrated Management System (IMS) certification, which includes ISO TS: 16949, OHSAS 18001, ISO 14001, and ISO 50001.

1.4.1 Some Facts About the Plant

- Fourth Tata Motors plant to come up, after Jamshedpur, Pune and Lucknow.
- Spread over 1,000 acres.
- Began commercial production in 2007.
- Facilities include weld shops, paint shops, engine and gear box shops, and assembly lines.
- Over 5,000 employees and 2,500+ contractual workforce (including vendors and service providers).
- First plant of TML to house an integrated vendor park.

1.4.2 Milestones

- Production started in record time after acquisition of land (in just 11 months).
- Received IMS certification within 18 months of commencement of operations.
- Achieved the 1 million ACE milestone in FY12 and aims to achieve the 2 million milestone in FY19.

1.5 Shops in the Plant

1. BIW Shop: (Body in White) BIW shop is where the frame and complete body is welded before the paint job thus the name body in white. It employs a closed circuit conveyor. Welding techniques used are spot welding and Co2 welding. There are many BIW shops in Pantnagar plant for different variants of vehicle.
2. Paint Shop: Paint shop is the biggest and most power hungry shop of the plant. There is only one paint shop. It has been designed while keeping future in mind and can accommodate all variant of TATA Ace and even MHCV body. It is the largest paint shop currently in asia.
3. Power Train: Power Train as the name suggests power train of the vehicle is built here, power train includes both engine and transmission. Almost all engine models and transmission models are made in house, thus saving cost on bulk transportation. Firstly the engine and the gear box is assembled in the separate room and finally they are fixed together. The engines and gear box is then transported to the TCF for the final assembly.
4. TCF Shop: (Trim Chassis Fitment) , this is where the final assembly of the vehicle takes place. . Trim stands for all the visual and appealing components such as side view mirror, floor mats, cleaning covers, door covers, dashboard, etc. There are 4 different TCF shops for the different models of the vehicles manufactured.

FIGURE-3, TCF shop Pantnagar

1.6 Models of Tata Ace Currently Produced

1. Tata Ace Gold
2. Tata Ace Mega XL
3. Tata Ace Super Ace
4. Tata Ace Mint
5. Tata Magic
6. Tata Venture
7. Tata Ace Intra (Latest Addition)

1.7 Layout of the Plant

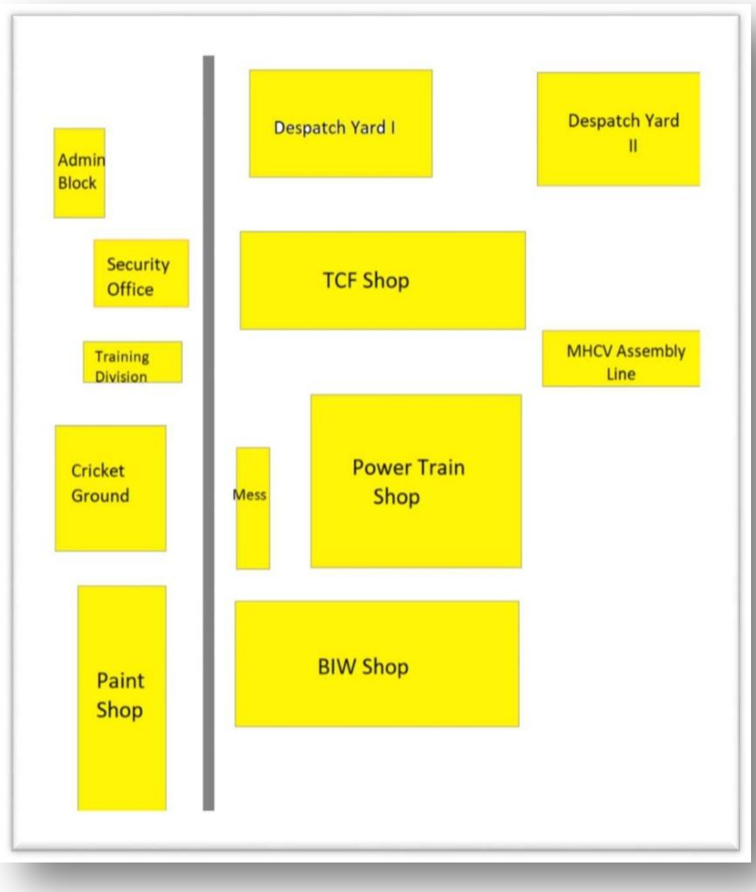


FIGURE-4, TML Pantnagar Layout

1.8 Layout of the Power train Shop

Since I was allotted the engine shop, I will explain more about the shop. Engine shop is sort of machining and assembly shop. Cylinder Block and head were sourced semi-finished from the vendors and the critical dimensions were machined in house, thus improving the quality. Engine models are separated into their basic families and equipment were kept accordingly.

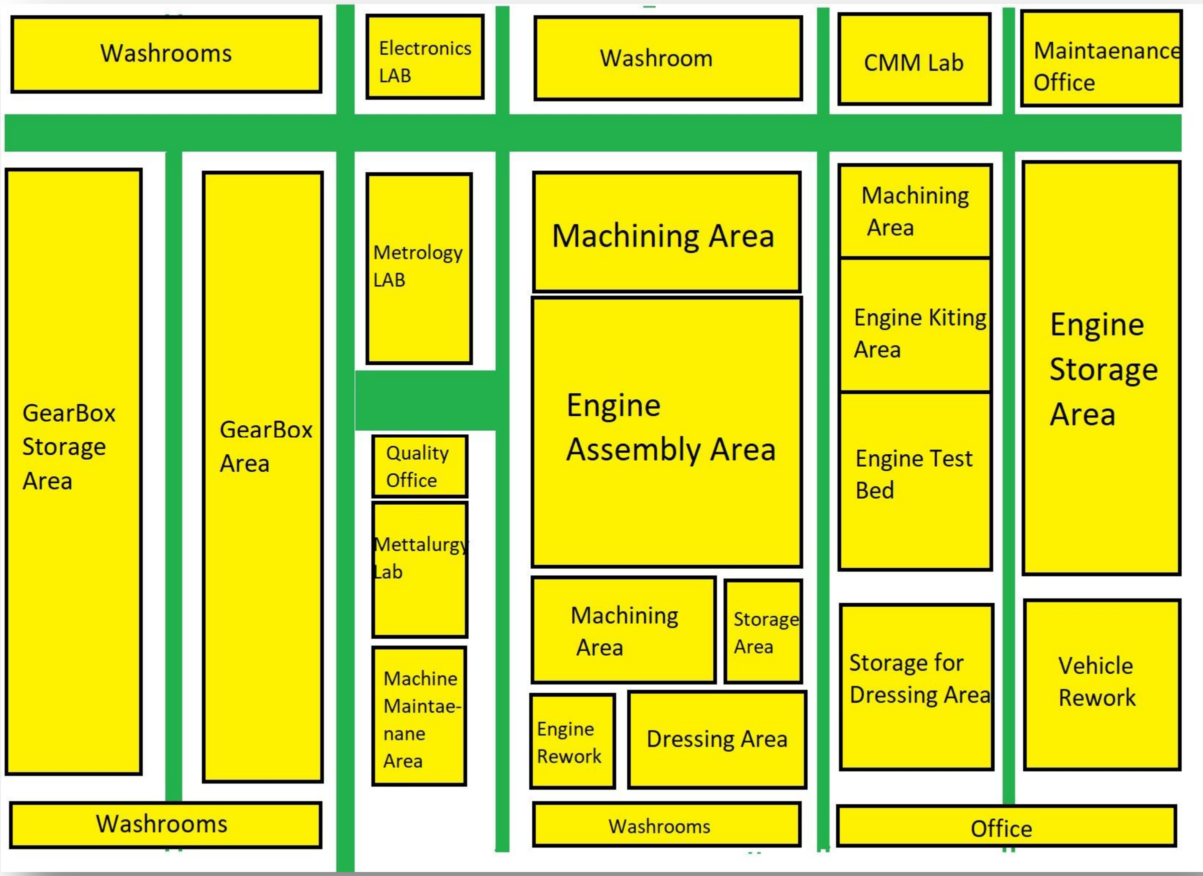


FIGURE- 5, Power train Layout

The engines are assembled in the Engine Assembly Area. There are 2 different assembly lines namely 275 assembly line and 475 assembly line. All the 2 cylinder engines are assembled on the 275 assembly line. The “2” in the 275 stands for the 2 cylinders, “75” stands for the bore diameter where pistons are inserted.

There are 2 different Gear Models made namely 4 speed gear and 5 speed gear. The Engine and the Gear box are assembled in the dressing line and then are transported to the TCF shop for the final fitment.

1.9 Different Parts of the Engine

1.9.1 Crank Shaft

A crankshaft is a mechanical part able to perform a conversion between reciprocating motion and rotational motion. In a reciprocating engine, it translates reciprocating motion of the piston into rotational motion, whereas in a reciprocating compressor, it converts the rotational motion into reciprocating motion.

FIGURE- 6, Crank Shafts

1.9.2 Flywheel

A flywheel is a mechanical device specifically designed to efficiently store rotational energy (kinetic energy). Flywheels resist changes in rotational speed by their moment of inertia. The amount of energy stored in a flywheel is proportional to the square of its rotational speed and its mass. The way to change a flywheel's stored energy without changing its mass is by increasing or decreasing its rotational speed.

FIGURE-7, Flywheel

1.9.3 Pistons

A piston is a component of reciprocating engines, reciprocating pumps, gas compressors and pneumatic cylinders, among other similar mechanisms. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod. In a pump, the function is reversed and force is transferred from the crankshaft to the piston for the purpose of compressing or ejecting the fluid in the cylinder. In some engines, the piston also acts as a valve by covering and uncovering ports in the cylinder.

FIGURE 8, Piston Head

1.9.4 Alternator

An alternator is an electrical generator that converts mechanical energy to electrical energy in the form of alternating current. For reasons of cost and simplicity, most alternators use a rotating magnetic field with a stationary armature. An alternator that uses a permanent magnet for its magnetic field is called a magneto.

FIGURE 9, Alternator

1.9.5 Oil Sump

The oil sump contains the engine oil required for lubrication. The oil is extracted from it by an oil pump and conveyed into the engine block's oil ducts via the oil filter. The oil then flows back into the oil sump from the lubrication points.

The oil sump is generally bolted on at the lowest point of the engine, below the crank mechanism on the crankcase. It features an oil drain plug, the opening of which in the oil sump allows the oil to drain out when changed. However, the oil sump is not merely a storage container. It performs one additional function in deforming and cooling the heated oil which flows back into the sump.

FIGURE 10, Oil Sump

1.9.6 Cylinder Head

A cylinder head performs many tasks such as holding and controlling the combustion process while allowing intake and exhaust gases to enter and exit the engine. Featured in the image above is a cross section of a cylinder head that incorporates intake and exhaust ports and valves. A cylinder head is fastened to the engine block using head bolts and sealed using a head gasket. A cylinder head also accommodates the intake and exhaust manifolds. These manifolds are sealed to the head using intake and exhaust manifold gaskets.

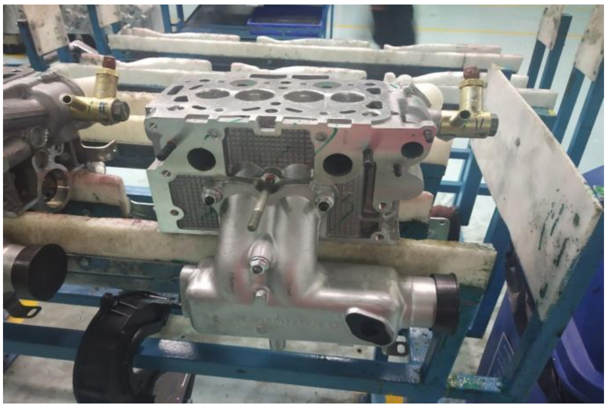


FIGURE 11, Cylinder Head

1.9.7 Clutch Plate

Clutches are useful in devices that have two rotating shafts. In these devices, one of the shafts is typically driven by a motor or pulley, and the other shaft drives another device. In a car, you need a clutch because the engine spins all the time, but the car's wheels do not. In order for a car to stop without killing the engine, the wheels need to be disconnected from the engine somehow. The clutch allows us to smoothly engage a spinning engine to a non-spinning transmission by controlling the slippage between them.

FIGURE 12, Clutch Plate

1.9.8 Timing Belt

The timing belt is a belt made of rubber that keeps your camshaft and your crankshaft synchronized so that your valve timing is always right. Some vehicles have a timing chain instead of a belt, but it serves the same purpose. If your valve timing is off, your engine won’t run properly. In fact, it may not run at all. The belt also regulates the power steering and the water pump.

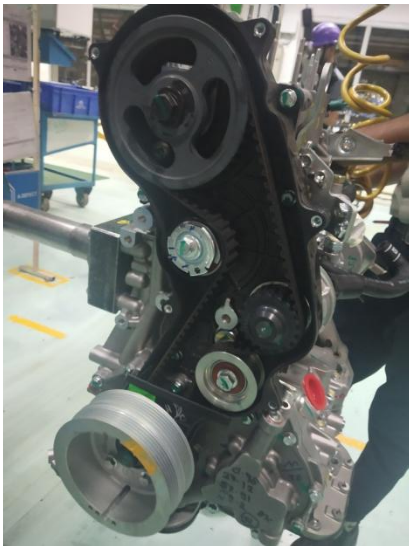


FIGURE 13, Timing belt

1.9.9 EGR (Exhaust Gas Recirculation)

In internal combustion engines, exhaust gas recirculation is a nitrogen oxide (NOx) emissions reduction technique used in petrol/gasoline and diesel engines. EGR works by recirculating a portion of an engine's exhaust gas back to the engine cylinders. This dilutes the O_2 in the incoming air stream and provides gases inert to combustion to act as absorbents of combustion heat to reduce peak in-cylinder temperatures. NOx is produced in high temperature mixtures of atmospheric nitrogen and oxygen that occur in the combustion cylinder, and this usually occurs at cylinder peak pressure.

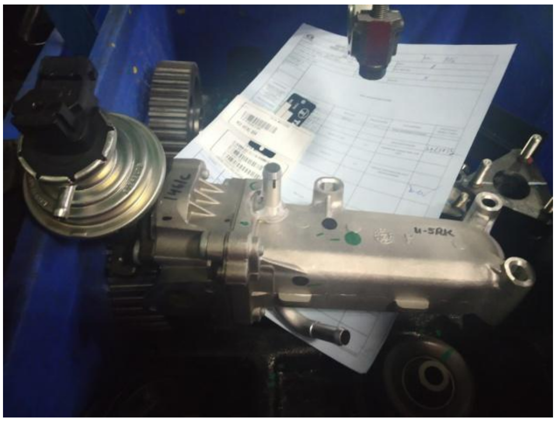


FIGURE 14, EGR

1.9.10 FIP (Fuel Injection Pump)

An Injection Pump is the device that pumps diesel (as the fuel) into the cylinders of a diesel engine. Traditionally, the injection pump is driven indirectly from the crankshaft by gears, chains or a toothed belt (often the timing belt) that also drives the camshaft. It rotates at half crankshaft speed in a conventional four-stroke diesel engine. Its timing is such that the fuel is injected only very slightly before top dead centre of that cylinder's compression stroke.

FIGURE 15, FIP

2.1 Introduction

Over the past several years, many automotive manufacturers have been motivated to increase the reliability of their products. Implementing machine vision for automated inspection helps these manufacturers achieve this reliability. Other driving forces include improving quality, streamlining production, decreasing scrap rates, and managing inventory and gathering process control data by reading part codes.

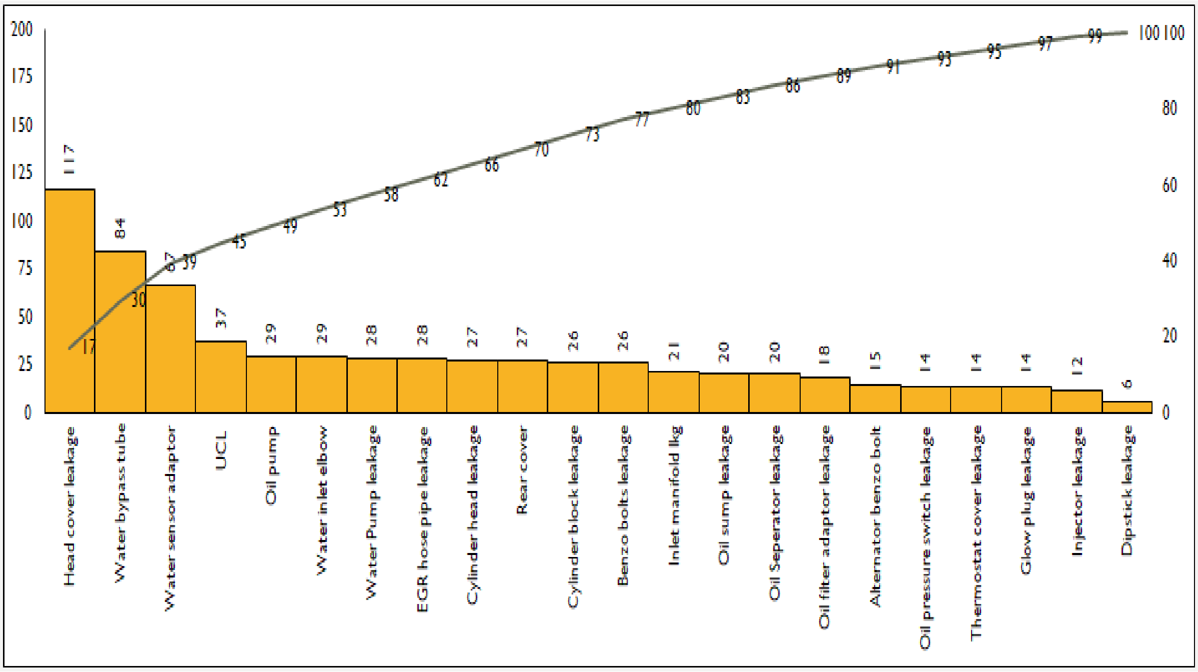
By far, one of the most important components in an automobile is the engine. It is the heart of an automobile. Therefore, it is imperative that this vital component operates correctly once it leaves the assembly line and is installed into a car.

In years past, machine vision was strictly reserved for end-of-the-line automotive engine assembly verification. However, vision systems can now be cost-effectively deployed at various key process points along the way. By distributing vision sensors at multiple points and using Ethernet communications to connect them, manufacturers can respond more quickly to manufacturing problems, achieve better process control and minimize production costs.

End-of-the-line inspection systems are fine for final part checking. However, conducting an inspection after an engine has undergone numerous value-adding assembly stages is not cost-effective. Defects need to be detected at the point of occurrence. If not, a line may be shut down for several hours. Operators then have to trace processes back upstream to determine the cause of the problem.

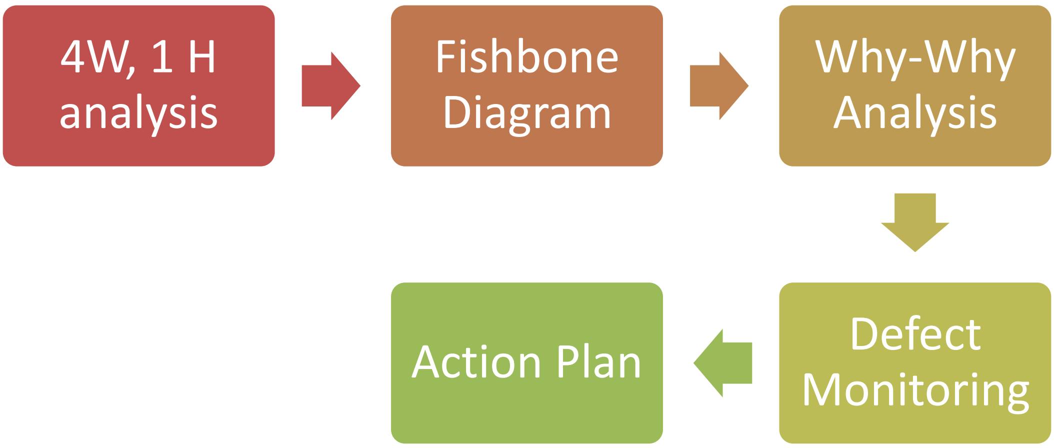
An incorrectly assembled engine necessitates rework, which can be expensive and time-consuming. Add in the costs associated with shipping a new engine to the customer and returning the defective engine, and the costs quickly increase. Some defective engines may even pass final test, be assembled into a vehicle, and reach the consumer. This results in an even more serious quality issue.

The following graph depicts the most commonly occurring defects in an industry-



Graph-1, DPH Trend November, December, January

The top contributors are leakages from Head cover, Water By pass tube, Water Sensor Adaptor, Water Inlet elbow. Since these are the top contributors, so we will later see the reason and remedy for each of the following defect in detail later on in the report. The trend will be



Flow Chart-1, Basic Process

DPH Reduction of Head Cover

A Cylinder Head Cover serve to seal off the cylinder head space from the outside of the engine. It closes in the top of the cylinder, forming the combustion chamber. This joint is sealed by a head gasket. In most engines, the head also provides space for the passages that feed air and fuel to the cylinder, and that allow the exhaust to escape. It serves as a housing for components such as the intake and exhaust valves, springs and lifters and the combustion chamber.

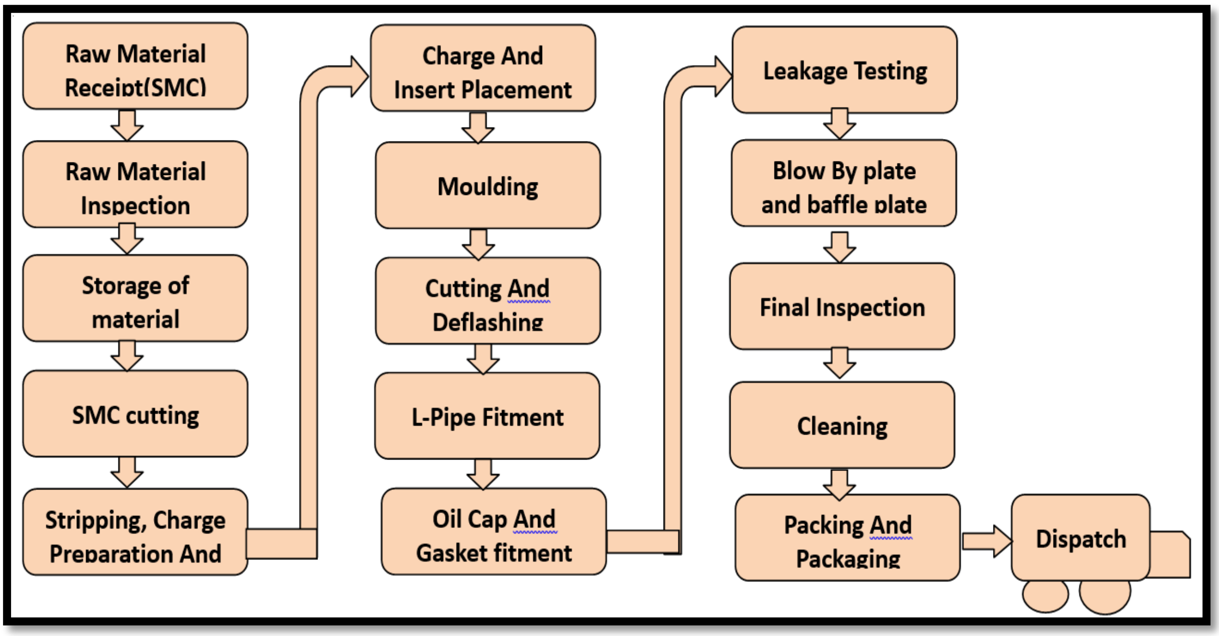
This particular Cylinder head cover for Engine type 275 IDI is manufactured by a company named Tata AutoComp System Ltd. (TACO) and the CHC is manufactured by a process known as Compression Molding and made up of SMC (Sheet mold composite). The CHC assembly is fitted with CHC gasket, Baffel Plate, Baffle gasket and Oil filler cap which is supplied by different sub-supplier and assembled at TACO end.

3.1 Manufacturing process of the Cylinder head cover

First of all Raw material SMC and child parts for CHC complete assembly is received at reception of raw material and processed through Inspection and stored in the storage room. Before moulding SMC is cut into strips and charge is made which is weighed before placement into insert and compession moulding is done.

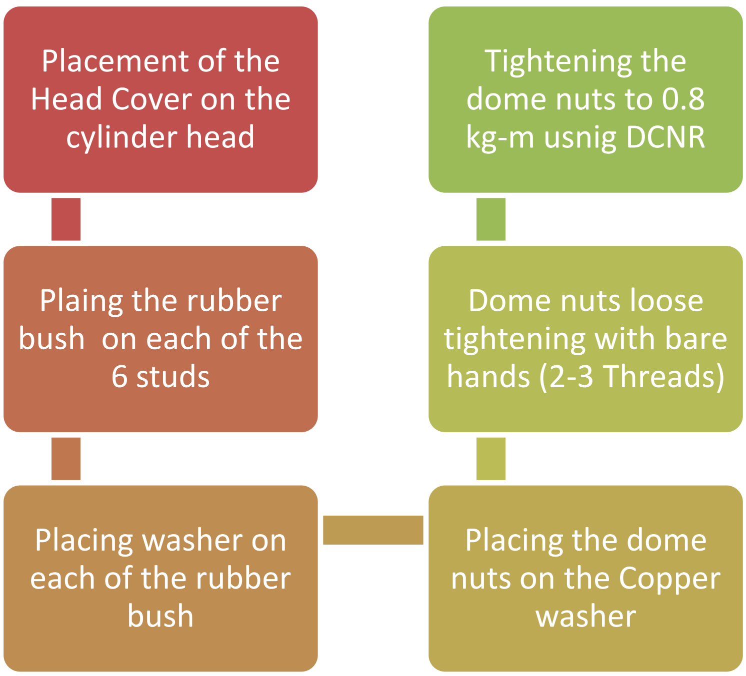
After moulding Cutting and deflashing of unwanted material generated during moulding is done and with the help of anabond L-pipe fitment is done. Then part is placed for post curing in Oven at 140deg C for 30 mintues. After Post-curing Oil Cap and gasket fitment done and leakage test conducted on every part at 1bar pressure with manual leakage teasting machine. Blow By plate and baffle palte is installed in cylinder head cover.After completed assembly Final inspection is done at PDI and package is dispacted to TML.

The process of compression moulding and post curing is taken into consideration for CHC crack issue and Oil cap and Gasket fitment is taken into consideration for loose fitment problem.



Flow Chart-2, Manufacturing of Head Cover

3.2 Head Cover Assembly on the 275 assembly line



Flow Chart-3, Head Cover assembly

3.3 Head Cover Crack

3.3.1 Defining the problem 4W, 1H analysis

What	**What is the problem?**	1. Head Cover Crack
	What has the problem? (part no, Lot no, etc.)	Cylinder Head Cover . Part no- 2788211501240
	What is the impact of the problem?	High value of DPH.
Where	**Where is problem located on Product/Part?**	It is located on the leftmost part where there is nose in the head cover
	Where does the problem occur in the process?	Problem is occurred during dome nut tightening using DCNR.
	Where was the problem observed in the process?	The problem is observed at the QG-1 (Quality Gate-1) in the 275 assembly line.
When	**When was the problem first noticed?**	The problem has been occurring since November (Start of my analysis)
	When has it been noticed since?	6 Months
Who	**Who is affected by the problem?**	Engine shop is affected by the problem as low targets achieved per day.
	Who First observed the problem?	Problem was first observed by the Engine Rework Area of the Powertrain.
	To whom was the problem reported?	Problem was reported to the VQA (Vendor Quality Assurance) team of the powertrain.
How	**How much is the problem?**	Most common reason for the oilways leakage in the engine.
	How is the problem being rectified?	Replacement of the head cover in the engine.

Table 1, Head Cover Crack 4W,1H analysis

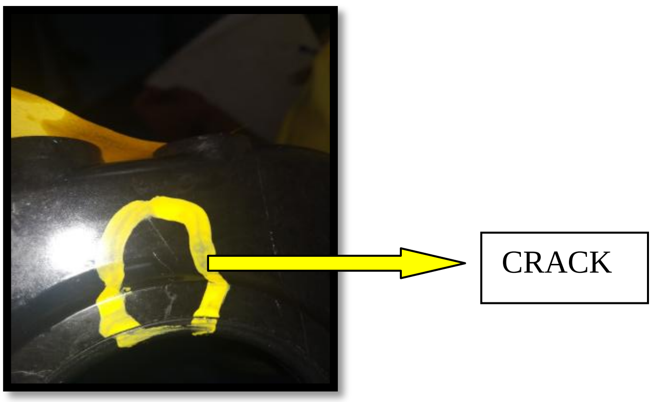


Figure 16, Head Cover Crack

3.3.2 Causation and Effectuation Diagram (Fishbone Diagram)

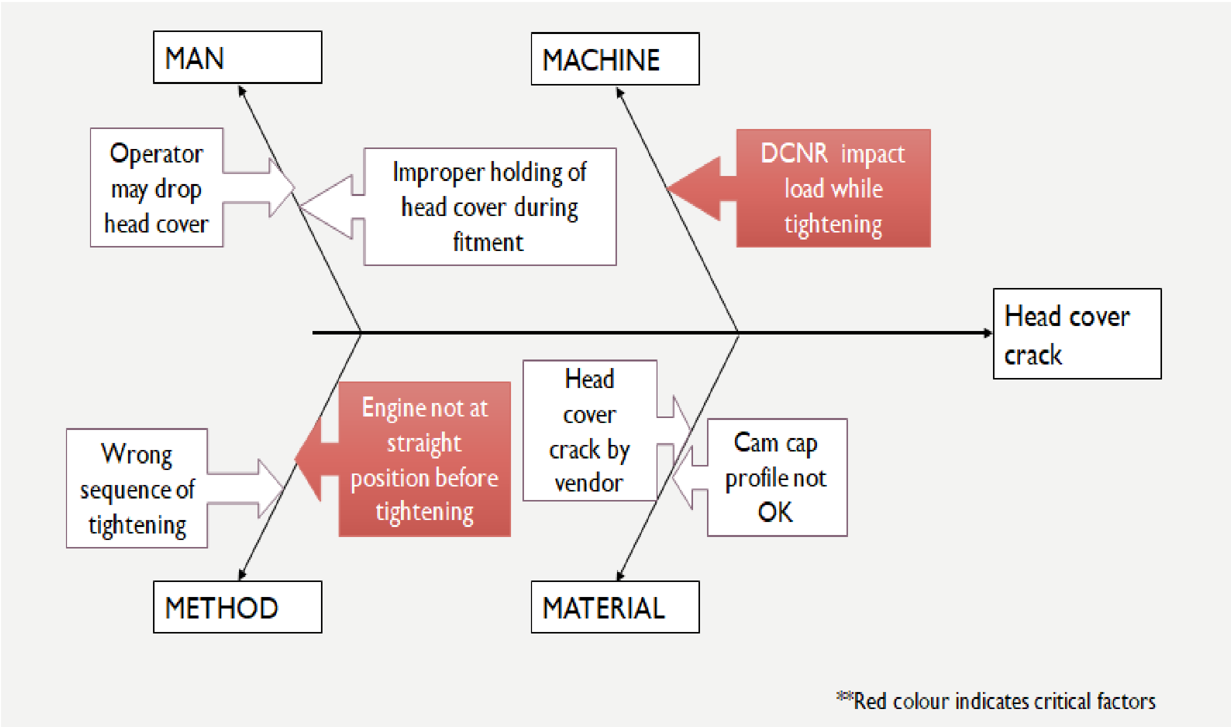
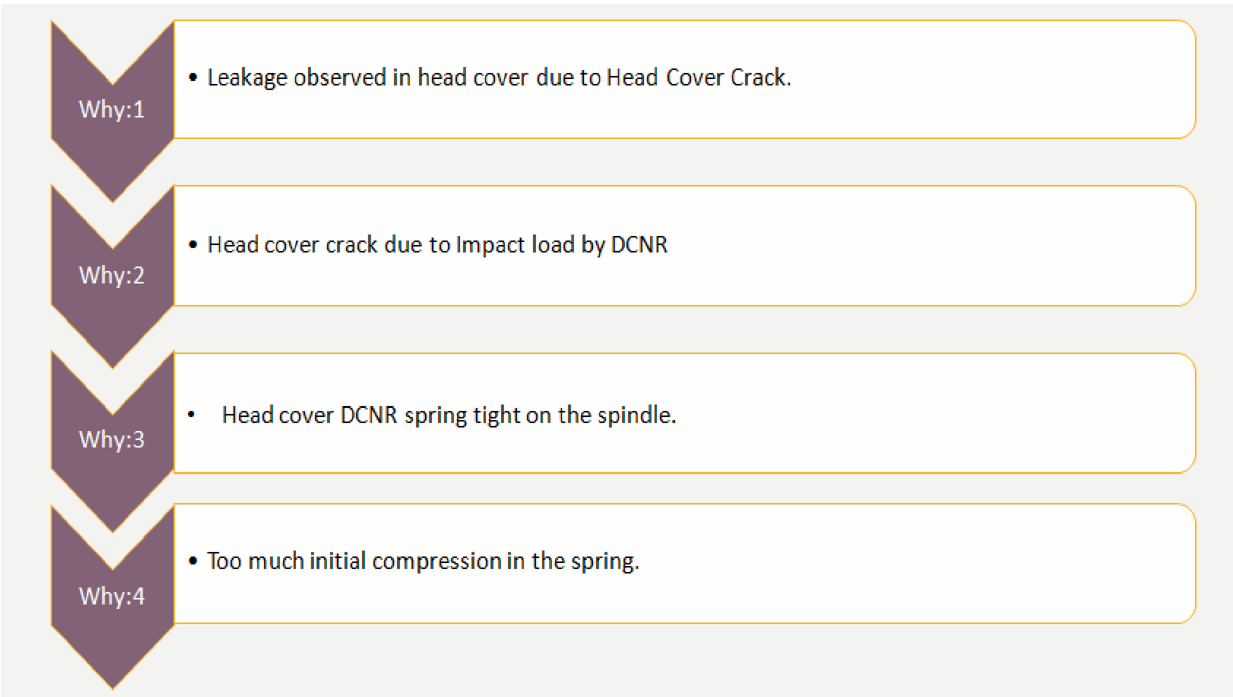


Figure 17, Fishbone Diagram, Head Cover Crack

3.3.3 Why-Why Analysis



Flowchart-4, why-why Head Cover Crack

3.3.4 Action Plan

In the assembly line engines are mounted on the J- Hook and it moves at each workstation. There is generally 0-5mm gap between the heights of these J hooks. The head cover tightening DCNR is installed at the fixed height and when it is to be used for tightening, it comes down to its fixed position. But there is the tolerance of 5 mm on the J- hooks. This distance is taken care by the spring on the each spindle of the DCNR so that its load is not transferred to the plastic head cover. If the load of DCNR is passed onto the head cover it cracks from its weakest end.

The springs used in the head cover tightening DCNR are already too compressed that they doesn't negate the 5 mm gap between the j-Hooks. Hench the complete DCNR load is transferred into the Head cover and it gets crack.

Therefore to correct the process, the initial compression of the spring needs to be 0. Therefore the DCNR spindles were taken out, the springs were detached, and then cut under the supervision so that the initial compression becomes 0. As a result the load of the DCNR is barred by the springs and the head cover doesn't gets crack.

OLD

NEW

FIGURE 18 springs cut out

The springs were cut shortened by 3 cm each and hence the extra force is reduced by

Spring Force $F=k.x$

3.4 Oil Cap Loose

3.4.1 Defining the problem, 4W, 1H analysis

What	What is the problem?	2. Oil cap loose or over tight
	What has the problem? (part no, Lot no, etc.)	Cylinder Head Cover . Part no-2788211501240
	What is the impact of the problem?	High value of DPH.
Where	Where is problem located on Product/Part?	It is located on the top of the head cover where oil filling is done.
	Where does the problem occur in the process?	Problem is occurred during tightening of oil cap after oil filling.
	Where was the problem observed in the process?	The problem is observed at the QG-1 (Quality Gate-1) .
When	When was the problem first noticed?	The problem has been occurring since November (Start of my analysis)
	When has it been noticed since?	6 Months
Who	Who is affected by the problem?	Engine shop is affected by the problem as low targets achieved per day.
	Who First observed the problem?	Problem was first observed by the Engine Rework Area of the Powertrain.
	To whom was the problem reported?	Problem was reported to the line in charge of the assembly line.
How	How much is the problem?	Problem is quite common and results in low targets achieved
	How is the problem being rectified?	Retightening of the oil cap on the head cover.

Table 2, Oil cap loose/ Over tight 4W,1H analysis

Oil cap is placed on the head cover and is tightened after the oil is filled on the assembly line for the testing purposes. The leakages occur due to either the seal is loose or it is over tight. The oil seal is to be tightened with torque of 0.5 kg-m after the oil filling. If we apply torque less than 0.5 kg-m the oil cap will be loose. If we over tight i.e. apply torque more than 0.5 kg-m then seal from the oil cap comes out hence resulting in the leakage.

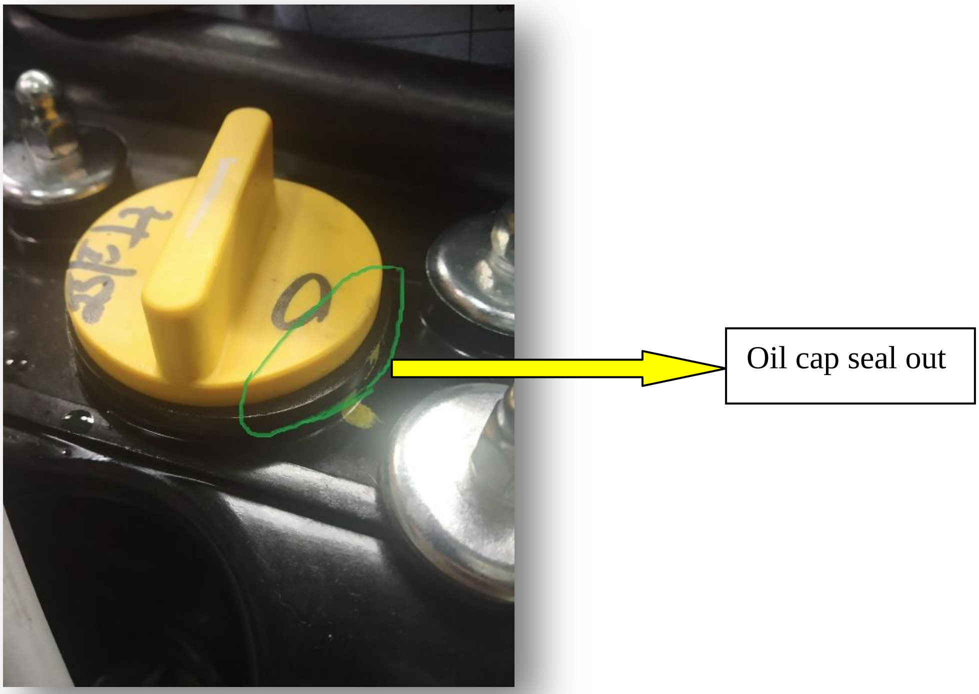


Figure 19, Oil cap seal out

3.4.2 Causation and Effectuation Diagram (Fishbone Diagram)

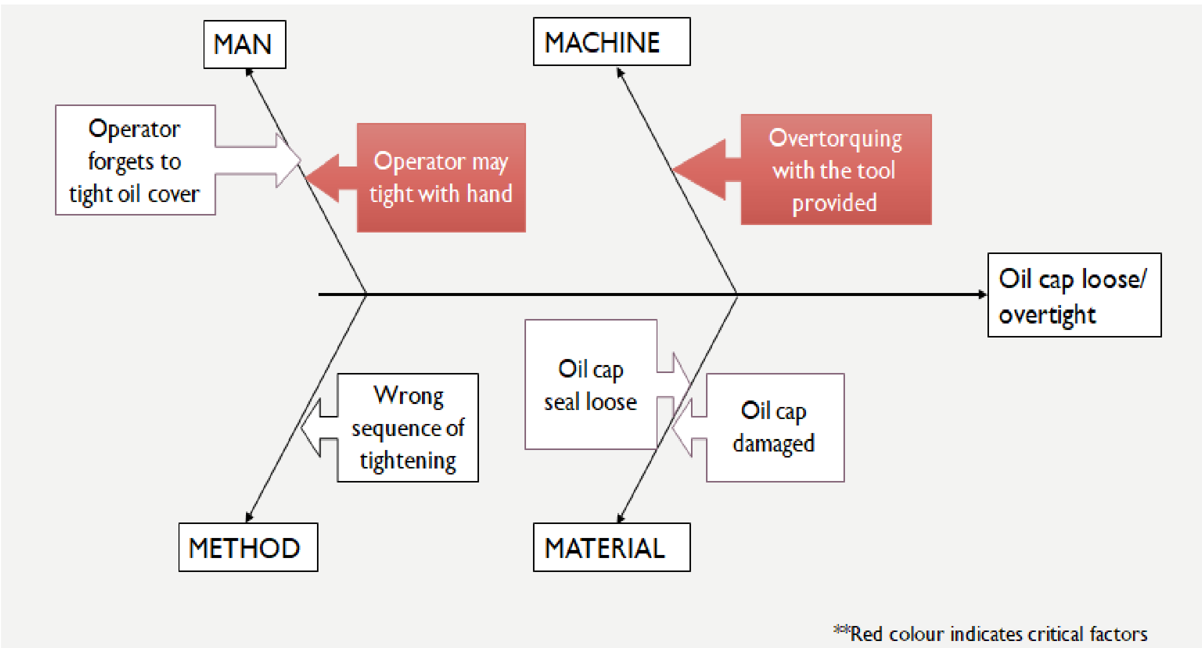
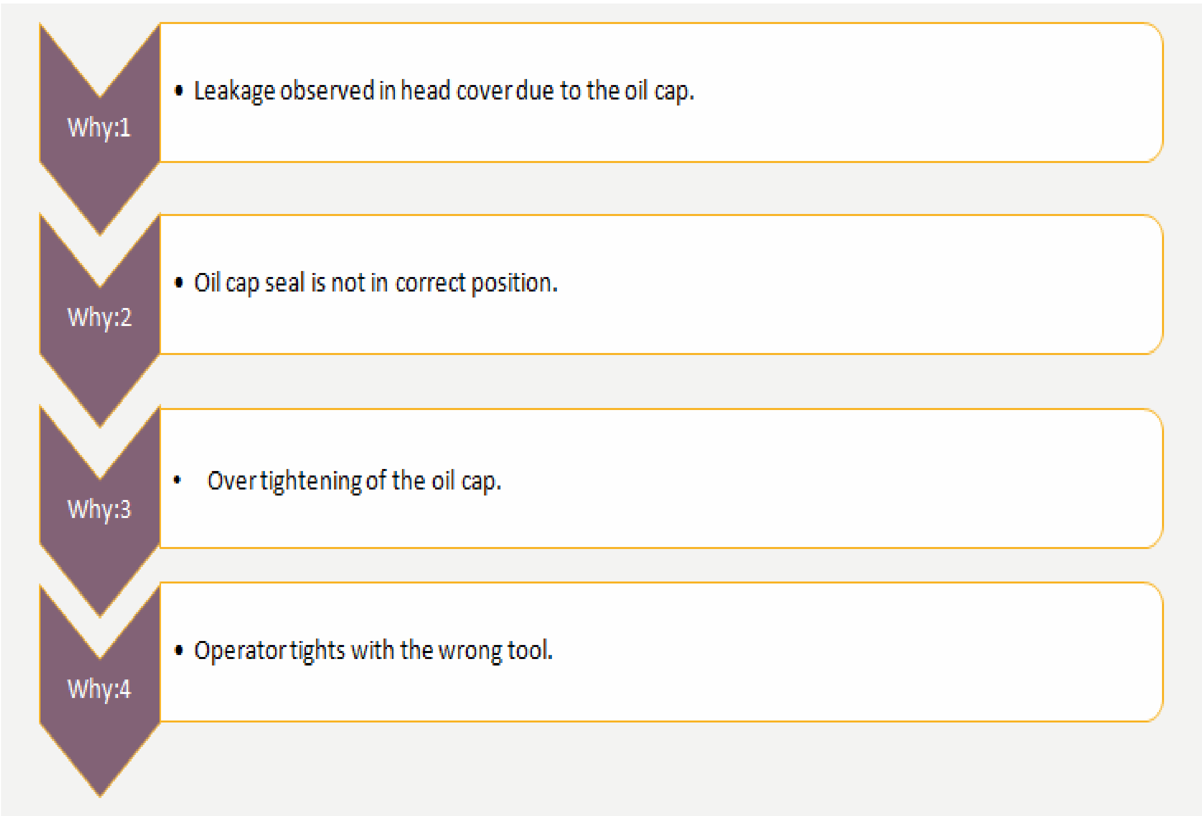


Figure 20, Fishbone Diagram, Oil Cap Loose/ Over tight

3.4.3 Why-Why Analysis

Flow Chart 5, Why-Why analysis, oil cap loose



Flow Chart 6, Why-Why Analysis, Oil cap over tight

Above are the two why-why analysis for the leakage occurring because either the oil cap is loose or it is over tight.

3.4.4 Action Plan

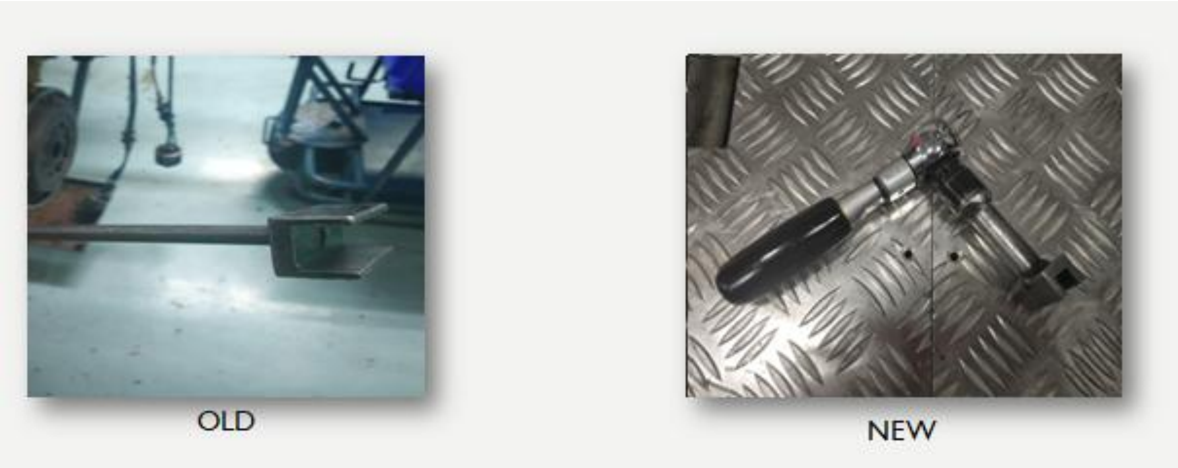


Figure 21, New tool designed

The oil cap is tightened to the head cover from the vendor side. Here on the 275 assembly line, the operator first opens the oil cap from the head cover with the tool currently provided. There is no issue in opening of the tool. After filling of the oil, the cap needs to be closed. Here is when the problem arises. The oil cap needs to be tightened with the 0.5 kg-m torque wrench. But with the current tool there is no method for the operator to verify the 0.5 kgm torque wrench. So either the operator tights the cap with bare hands or if it is tightened using the current tool it may get over tight and seal might come out. So a click type torque wrench was ordered to get the work done.

A torque wrench is a tool used to apply a specific torque to a fastener such as a nut or bolt. It is usually in the form of a socket wrench with special internal mechanisms.

A torque wrench is used where the tightness of screws and bolts is crucial. It allows the operator to set the torque applied to the fastener so it can be matched to the specifications for a particular application. This permits proper tension and loading of all parts. A torque wrench uses torque as a proxy for bolt tension. The technique suffers from inaccuracy due to inconsistent or uncalibrated friction between the fastener and its mating hole. Measuring bolt tension (indirectly via bolt stretch) is actually what is desired, but often torque is the only practical measurement which can be made.

3.5 Gasket fold/ shift

3.5.1 Defining the problem, 4W-1H analysis

What	What is the problem?	3. Gasket shift during head cover fitment
	What has the problem? (part no, Lot no, etc.)	Cylinder Head Cover . Part no-2788211501240
	What is the impact of the problem?	High value of DPH.
Where	Where is problem located on Product/Part?	Gasket is placed in the bottom of the head cover and is placed is fitted in the grooves.
	Where does the problem occur in the process?	Problem is occurred during fitment of head cover in the engine.
	Where was the problem observed in the process?	The problem is observed at the QG-1 (Quality Gate-1) .
When	When was the problem first noticed?	The problem has been occurring since November (Start of my analysis)
	When has it been noticed since?	6 Months
Who	Who is affected by the problem?	Engine shop is affected by the problem as low targets achieved per day.
	Who First observed the problem?	Problem was first observed by the Engine Rework Area of the Powertrain.
	To whom was the problem reported?	Problem was reported to the line in charge of the assembly line.
How	How much is the problem?	Problem is quite common and results in low targets achieved
	How is the problem being rectified?	Problem is rectified by Refitment of gasket in the head cover.

Table 3, Gasket Shift , 4W-1H

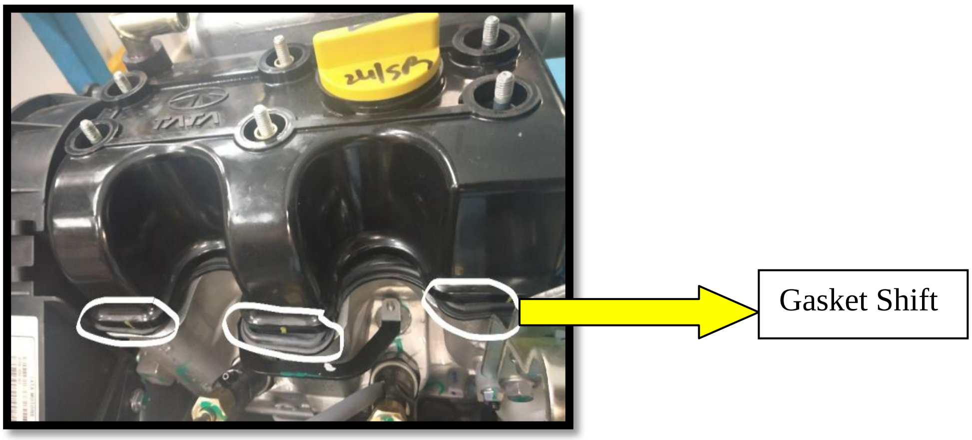


FIGURE 22, Gasket Shift

3.5.2 Causation and Effectuation Diagram (Fishbone Diagram)

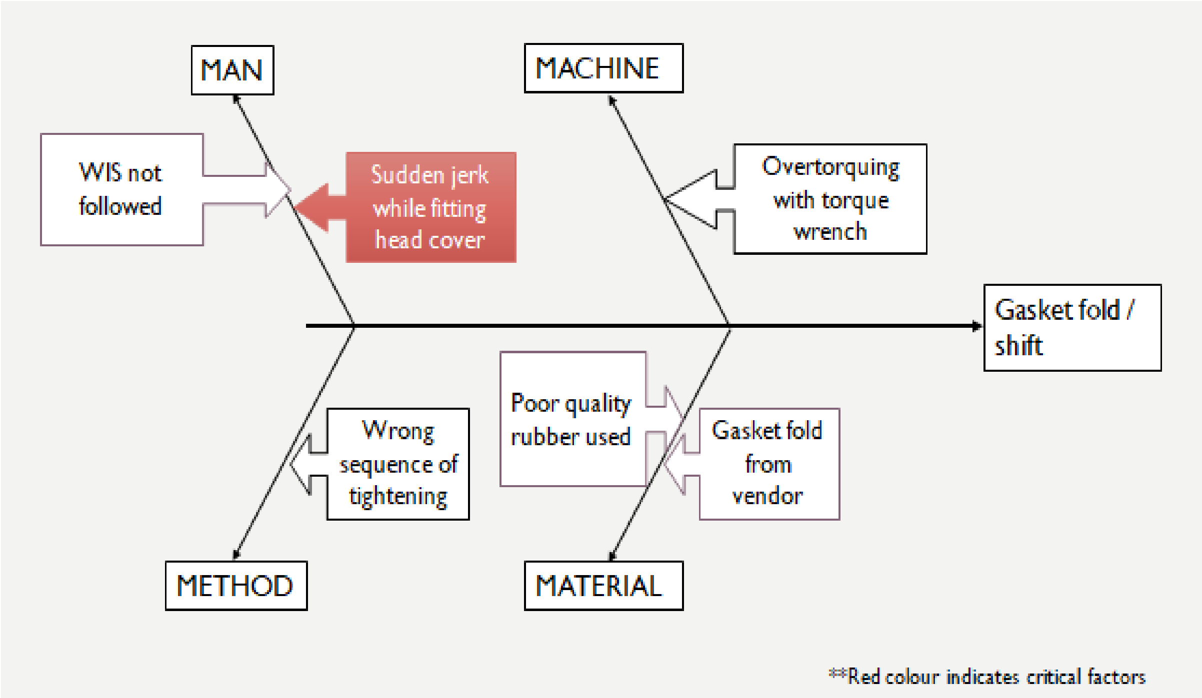
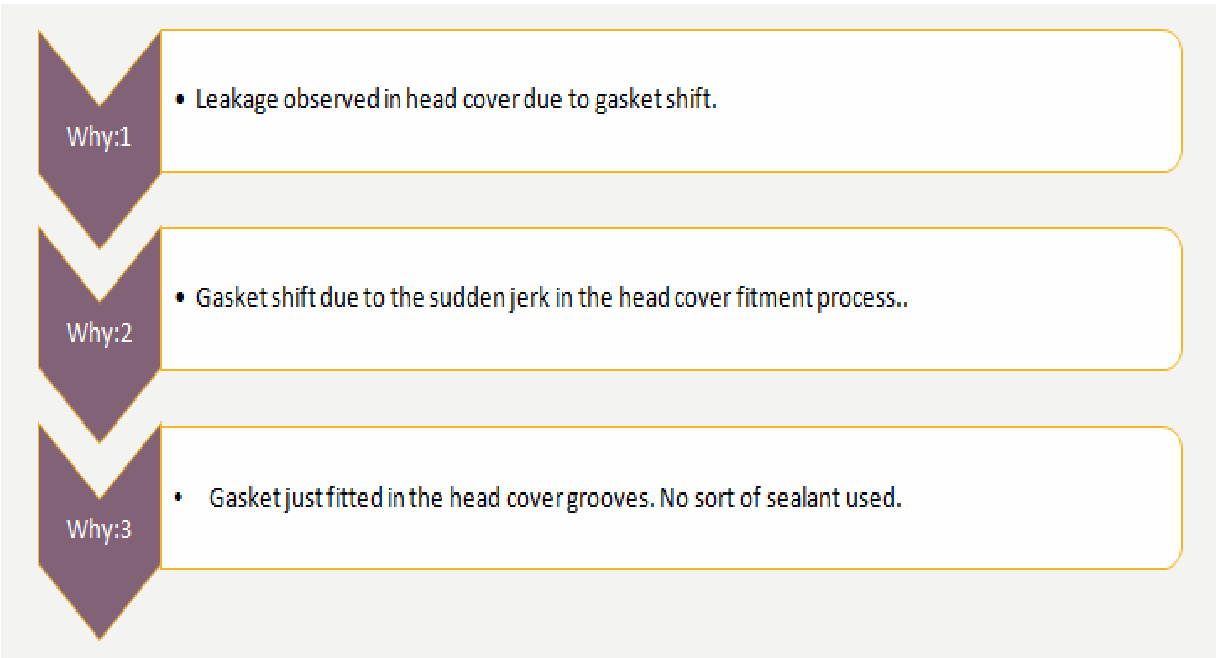


Figure 23, Fishbone Diagram Gasket Fold

3.5.3 Why-Why Analysis



Flow Chart 7, Why-Why analysis Gasket Fold

3.5.4 Action Plan

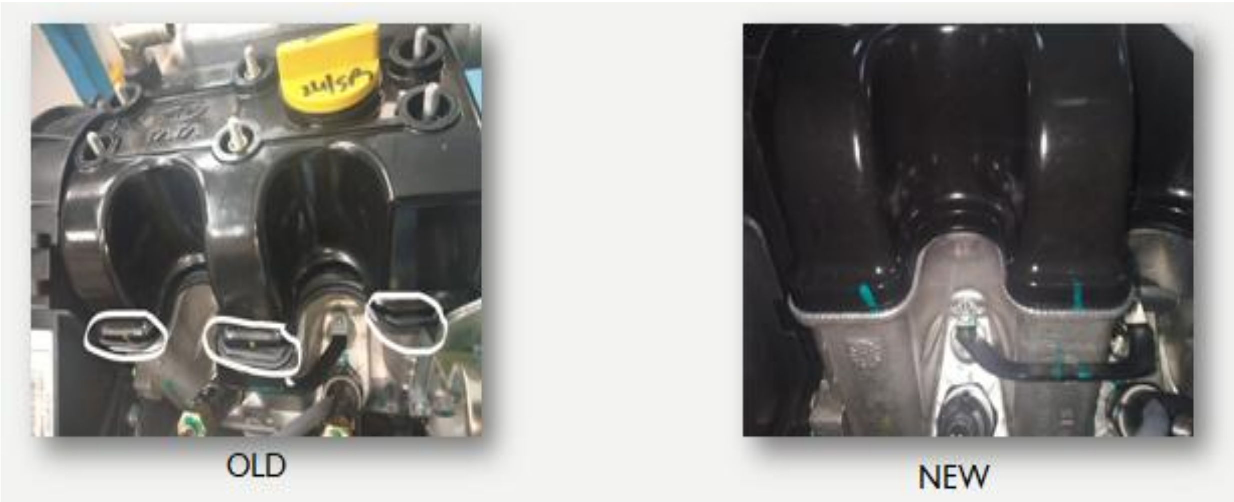


Figure 24, Action Plan Gasket Shift

During the fitment of head cover gasket by the vendor, it is inserted in the grooves at the bottom of the head cover. There is no type of sealant used to bind the head cover and the gasket together. So there are possibly 2 methods to reduce the cases of the gasket failure-

Use of Ana bond 676 (most common sealant in an industry) between the head cover grooves and the gasket before binding them together.

Anabond is a company headquartered in Thiruvanmiyur, Chennai, India. It manufactures engineering adhesives and sealants which are used in automobile and engineering product manufacturing, electrical and electronic products manufacturing and maintenance of these equipments. Anabond was the first company in India to manufacture anaerobic adhesives and sealants.

The R&D centre carries out research in different areas such as anaerobic adhesives (anaerobic sealants), epoxies, silicone sealants, and rubber-based adhesives. They also joined their hands with Indian Space Research Organisation and Defence Research and Development Organisation in developing products for them to be used in their space and missile programmes.

The only drawback of applying the anabond is the cost increase in manufacturing.

So the method which was adopted by the industry is the confirmatory marking done after the fitment of head cover on the cylinder head. The marking is done on the gasket by the operator confirming that the head cover gasket is tact.

3.6 Dome Nuts Loose

3.6.1 Defining the problem, 4W-1H analysis

An acorn nut, also referred to as crown hex nut, blind nut, cap nut, domed cap nut, or dome nut (UK), is a nut that has a domed end on one side. When used together with a threaded fastener with an external male thread, the domed end encloses the external thread.

What	What is the problem?	4. Dome Nuts Loose
	What has the problem? (part no, Lot no, etc.)	Cylinder Head Cover . Part no-2788211501240
	What is the impact of the problem?	High value of DPH.
Where	Where is problem located on Product/Part?	Dome Nuts are Used for tightening of the Head cover.
	Where does the problem occur in the process?	Problem is occured during tightening of the head cover.
	Where was the problem observed in the process?	The problem is observed at the QG-1 (Quality Gate-1) .
When	When was the problem first noticed?	The problem has been occurring since November (Start of my analysis)
	When has it been noticed since?	6 Months
Who	Who is affected by the problem?	Engine shop is affected by the problem as low targets achieved per day.
	Who First observed the problem?	Problem was first observed by the Engine Rework Area of the Powertrain.
	To whom was the problem reported?	Problem was reported to the line in charge of the assembly line.
How	How much is the problem?	Problem is quite common and results in low targets achieved
	How is the problem being rectified?	Problem is rectified by tightening of the dome nuts with the click type torque wrench

Table-4, Dome Nut Loose, 4W-1H

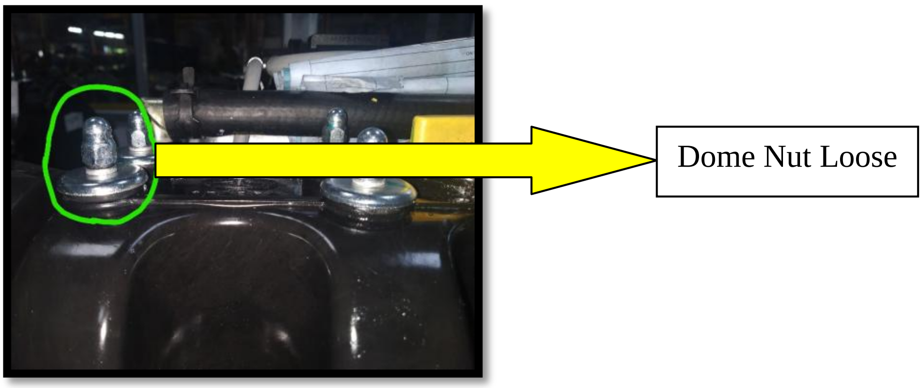


Figure 25, Dome Nut Loose

3.6.2 Causation and Effectuation Diagram (Fishbone Diagram)

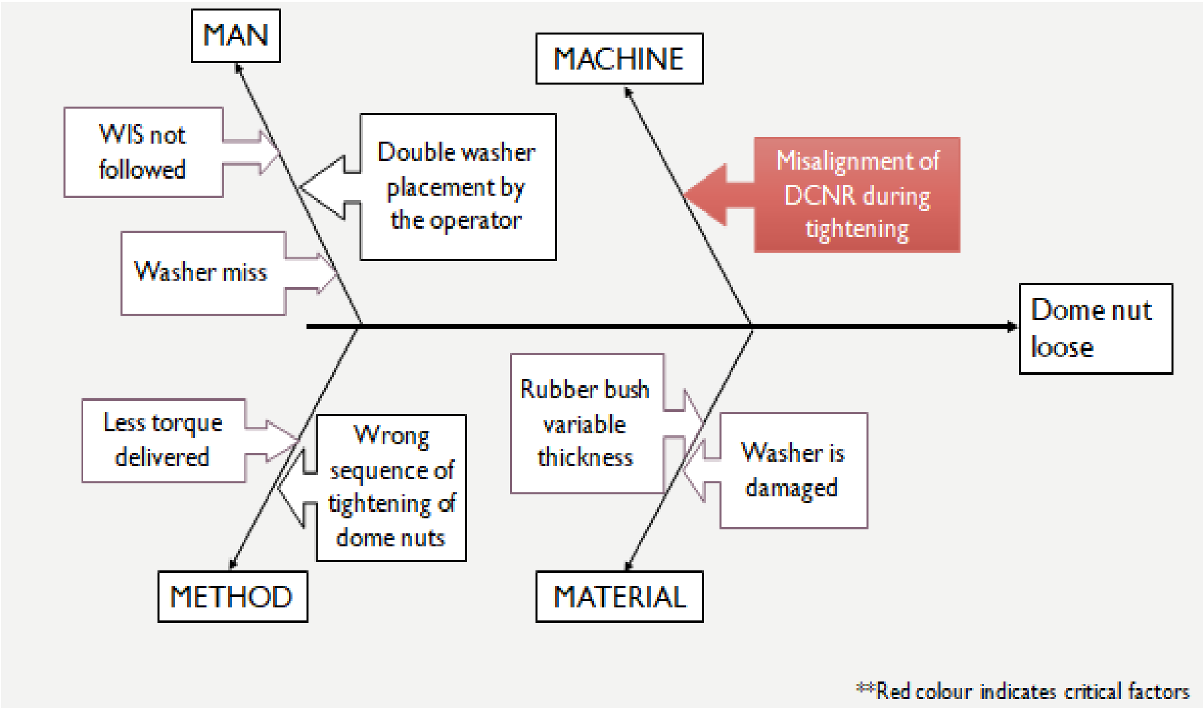
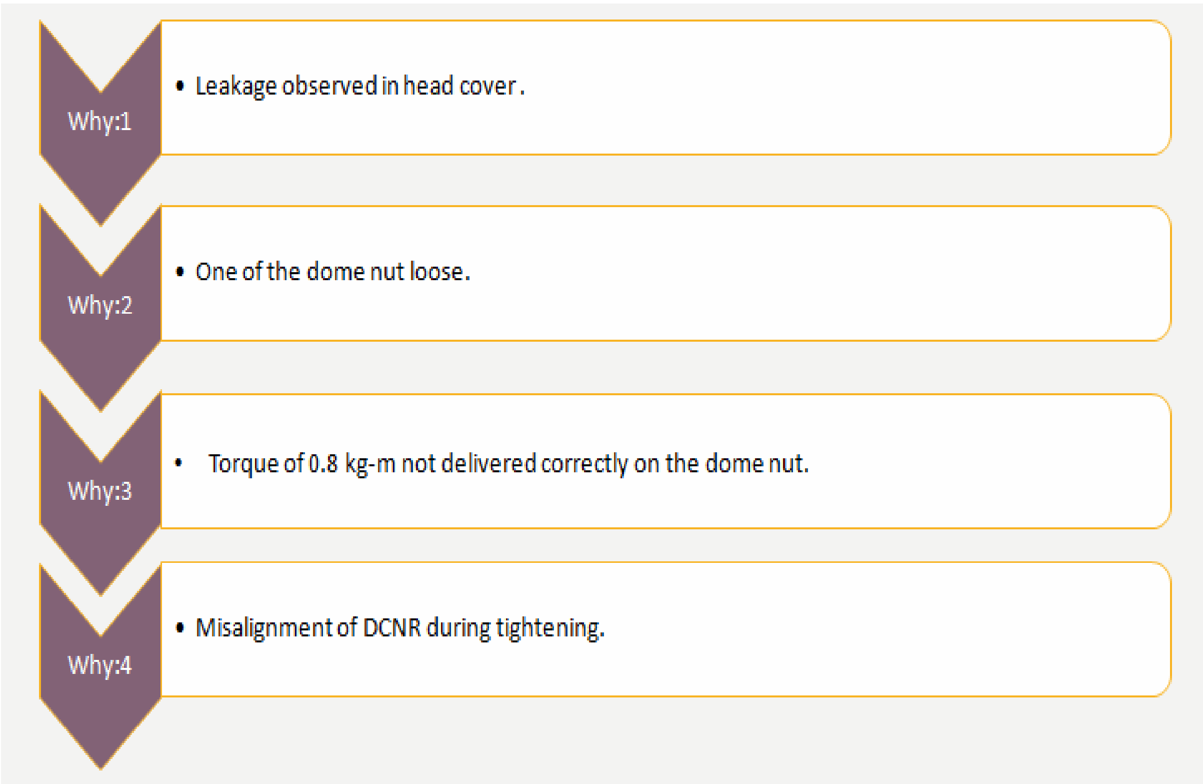


Figure 26, Fishbone Diagram, Dome Nut loose

3.6.3 Why-Why Analysis



Flow Chart-8, Why-Why, Dome nut loose

3.6.4 Action Plan

Nut runners and nut drivers are tools used for tightening nuts. By definition, nut drivers are purely mechanical hand tools, while nut runners are pneumatic, electric, or hydraulic power tools.

Pneumatic nut runners are powered by compressed air and vary in terms of air fittings and air consumption. Electric nut runners use a DC controller as a power supply. Hand held cylindrical devices are lightweight and portable. Pistol-style devices with trigger actuators are also available. Large nut runner systems are designed to be mounted in a fixed position, usually on an assembly line.

The dome nuts are tightened on the head cover by the multi spindle DCNR i.e. Direct Current Nut runner. As the J-Hook is moving there can be misalignment in the DCNR at the time of tightening. Though there is display system on the DCNR if all the nuts are tightened properly but sometimes the operator ignores that. As a result some of the dome nuts may remain loose and hence cause leakage.

To tackle the situation describe above a new process has been imposed on the line that after the DCNR tights the dome nuts, the operator has to manually check each of the 6 dome nuts using the click type torque wrench and do the confirmatory marking thereafter.

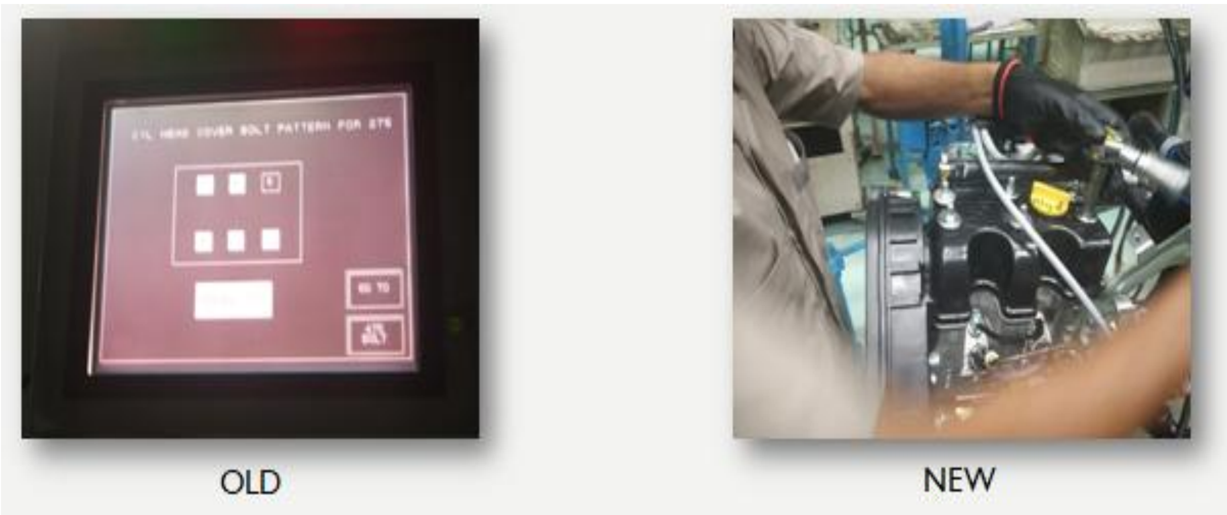


Figure 27, Action Plan Dome Nut tightening

As shown in the above picture the 3rd nut (top right dome nut) remained loose as the used spindle was misaligned during dome nut tightening using the DCNR.

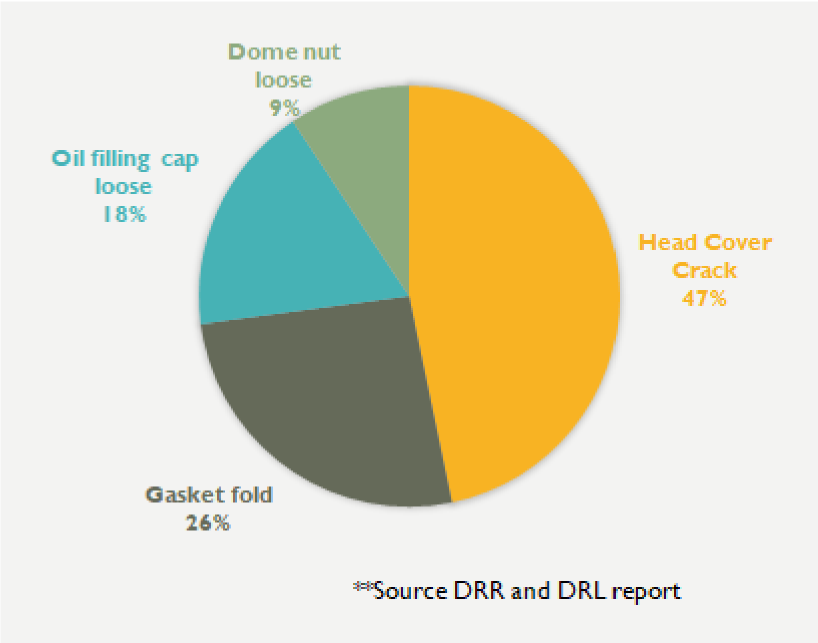
3.7 Impact on the Leakages

There were reportedly 117 leakages because of the head cover in the 3 months as depicted in the graph-1. The graph was made using DRR and DRL reports. The production of the 275 IDI model in these 3 months were 39,679 units.

$$DPH(Defects\ per\ Hundred) = \left(\frac{Reported\ Leakages}{Total\ Units\ Produced}\right) * 100$$

DPH= (117/39679)*100 = 0.295

Out of the 117 defects below graph depicts the leakages due to each of the individual error.



Graph-2, Head Cover Defects Bifurcation

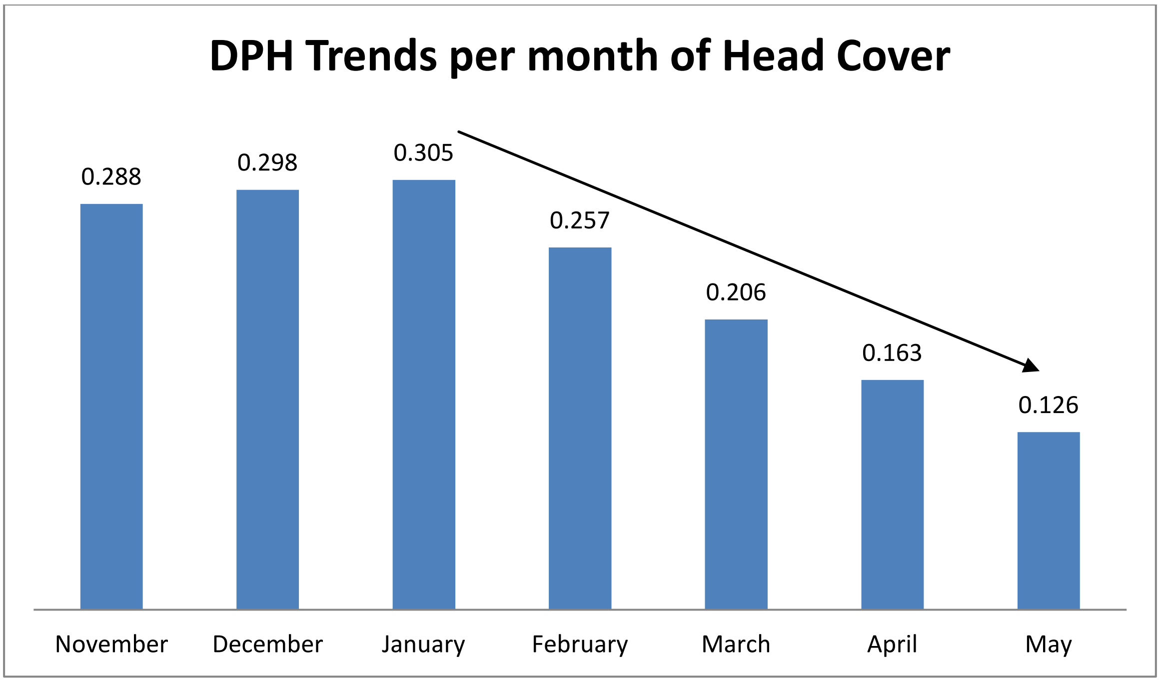
As shown in the graph about 50 percent of the leakages were because of the Head cover Crack, 26 percent because of the gasket fold, 18 percent because of oil filling cap loose and 9 percent because of the Dome nut loose.

After implementing all the changes as described above, in the month of May there were reportedly 18 defects due to the head cover. The 275 IDI models made in the month of May were 14,290 engines. Therefore the DPH for the month of May for the head cover is-

DPH = (18/14290)*100 i.e. 0.126.

$$Percentage\ Reduction = \frac{Original\ DPH - Final\ DPH}{Original\ DPH} * 100$$

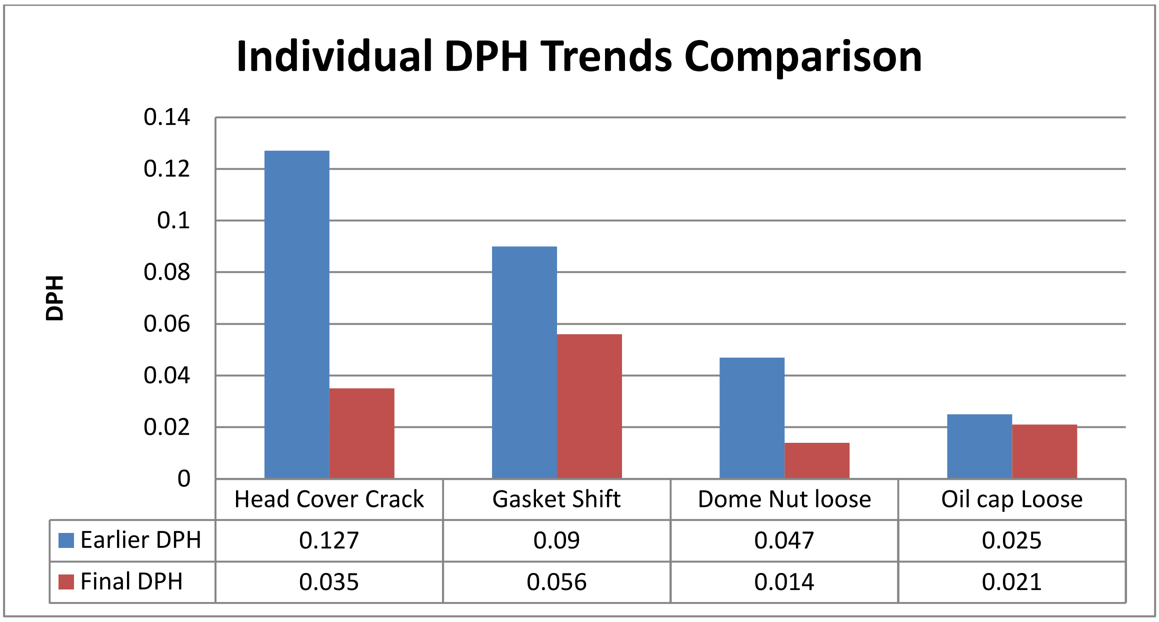
Percentage Reduction of DPH= [(0.295-0.126)/0.295]*100 i.e. 57.28%.



Graph 3, DPH trends Head Cover

There is the gradual reduce in the DPH because of the above changes in the process. Reduction of DPH means improving in the Quality of the process.Out of the 18 defects in the month of May, 8 defects were because of the gasket fold, 5 defects were because of the head cover crack, 3 defects were because of the Dome nuts loose, and 2 defects were because of the oil cap loose.

Next graph will show the DPH comparison for each of the defect.



Graph 4, Individual Comparison

DPH Reduction of Water by Pass Tube

This is a passage that allows the coolant to bypass the radiator and return directly back to the engine. Some engines use a rubber hose, or a fixed steel tube. In other engines, there is a cast in passage built into the water pump or front housing. In any case, when the thermostat is closed, coolant is directed to this bypass and channelled back to the water pump, which sends the coolant back into the engine without being cooled by the radiator.

The cooling system allows a small part of the coolant to circulate within the engine during warm up while the thermostat is closed. The by-pass is a small passage connecting the engine side of the thermostat to the inlet side of the vacuum pump The by-pass may be the cast or drilled into the engine and the pump parts, called external by-pass, that connects the engine coolant outlet to the coolant pump. Coolant flows through the bypass , short circulating the radiator when there is a pressure difference on the ends of the by-pass, even also the thermostat is open. The by-pass helps in uniform warm up, eliminates the hot spots, and prevents excessive coolant pressure in the engine when the thermostat is closed.

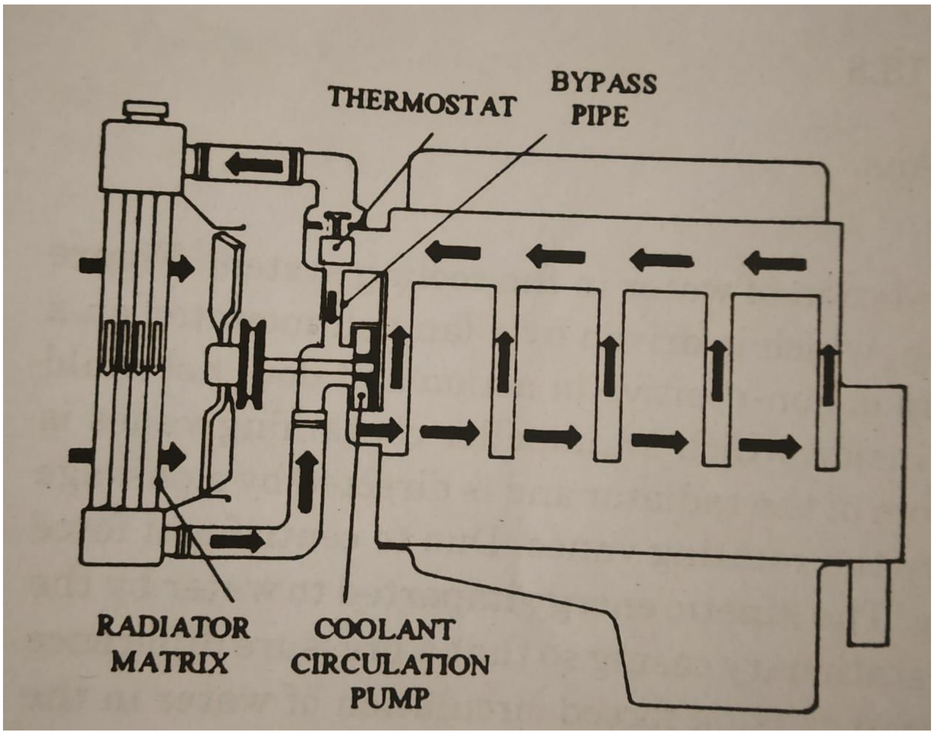


Figure 28, Bypass Diagram

4.1 Roughness on the Surface

4.1.1 Defining the problem, 4W-1H analysis

What	What is the problem?	1. Roughness on the Surface
	What has the problem? (part no, Lot no, etc.)	Water by pass tube
	What is the impact of the problem?	High value of DPH.
Where	Where is problem located on Product/Part?	Surface of the water by pass tube
	Where does the problem occur in the process?	Problem is occured during assembly
	Where was the problem observed in the process?	The problem is observed at the QG-1 (Quality Gate-1) .
When	When was the problem first noticed?	The problem has been occurring since November (Start of my analysis)
	When has it been noticed since?	6 Months
Who	Who is affected by the problem?	Engine shop is affected by the problem as low targets achieved per day.
	Who First observed the problem?	Problem was first observed by the Engine Rework Area of the Powertrain.
	To whom was the problem reported?	The problem was reported to the VQA dept.
How	How much is the problem?	Problem is quite common and results in low targets achieved
	How is the problem being rectified?	The problem is rectified by changing of the water by pass tube.

Table 5, Surface Roughness, 4W-1H

Figure 29, By pass tube

4.1.2 Causation and Effectuation Diagram (Fishbone Diagram)

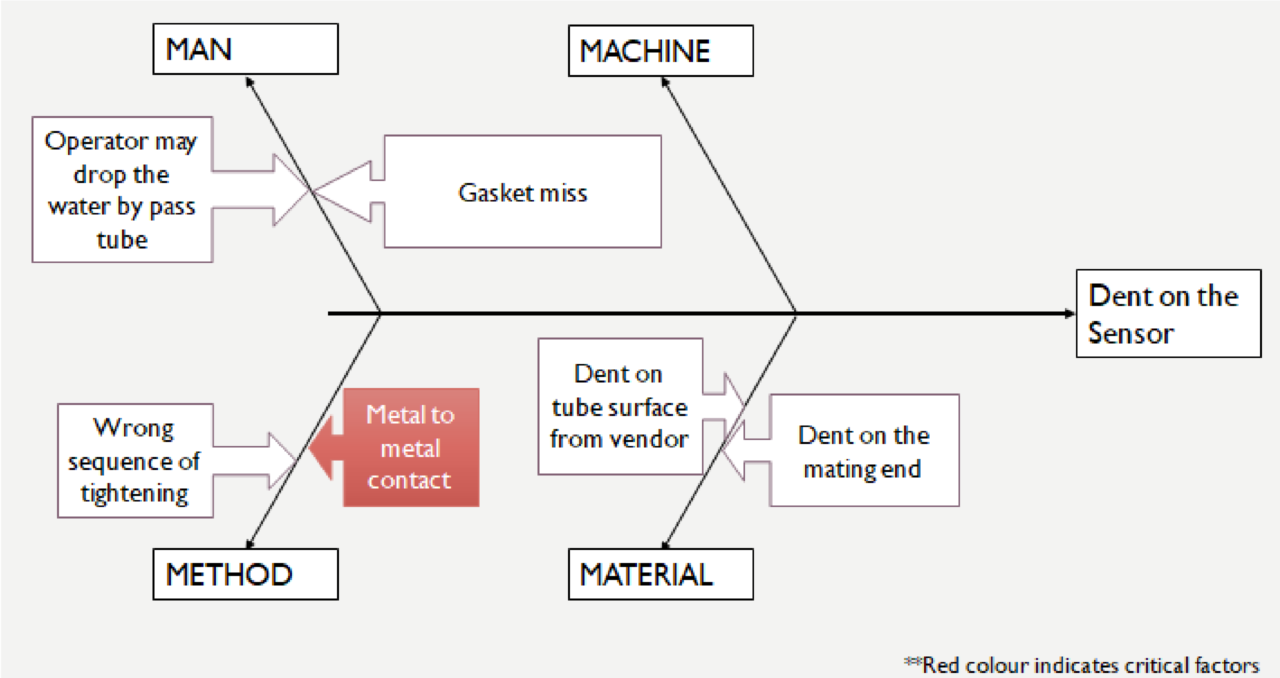
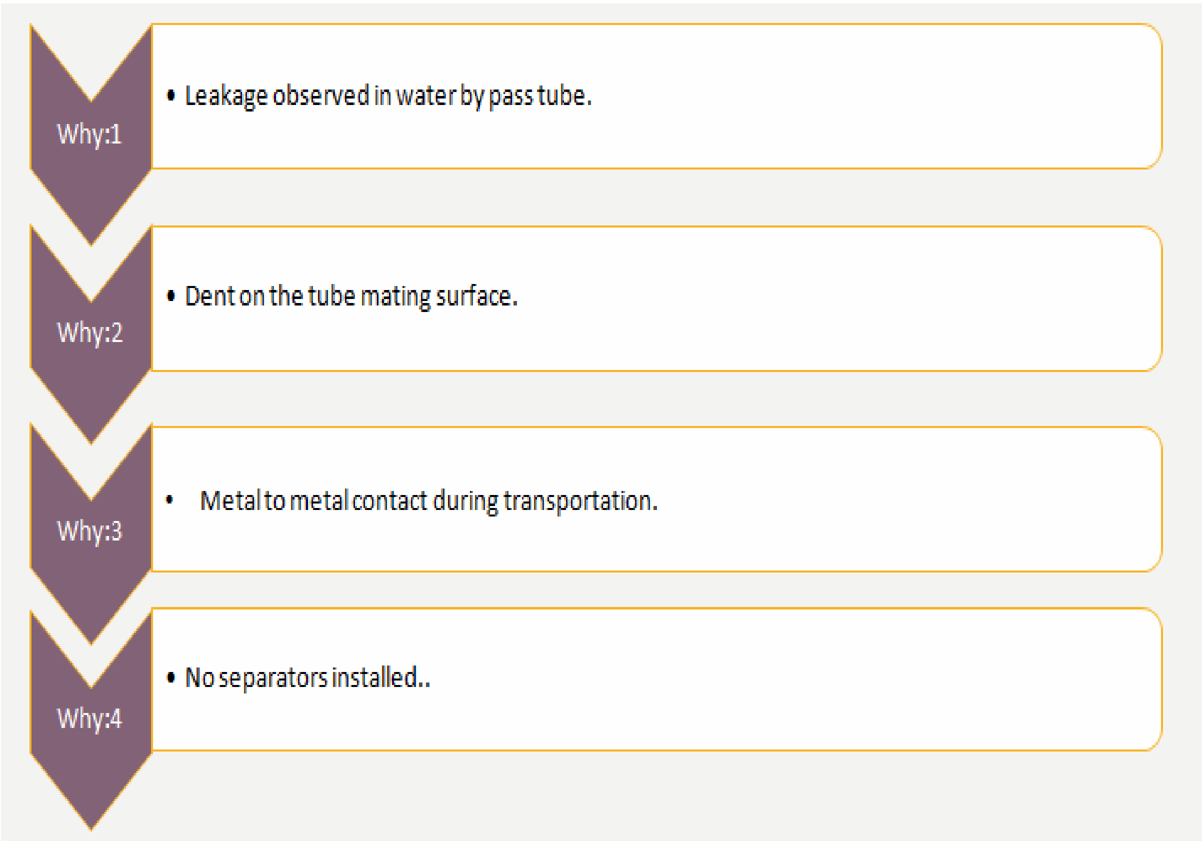


Figure 30, Fishbone diagram, Sensor Dent

4.1.3 Why-Why analysis



Flow chart 9, Why-why, Dent on tube

4.1.4 Action Plan

Metal to metal contact can cause the dent on the water by pass tube. The dent may be caused during the transportation or the 275 IDI parts store in the power train shop. In case of the defect due to the dent on the surface, the problem is reported to the VQA team for the further assessment. If the problem is repeated from the vendor side then the vendor is informed and hence the problem is rectified.

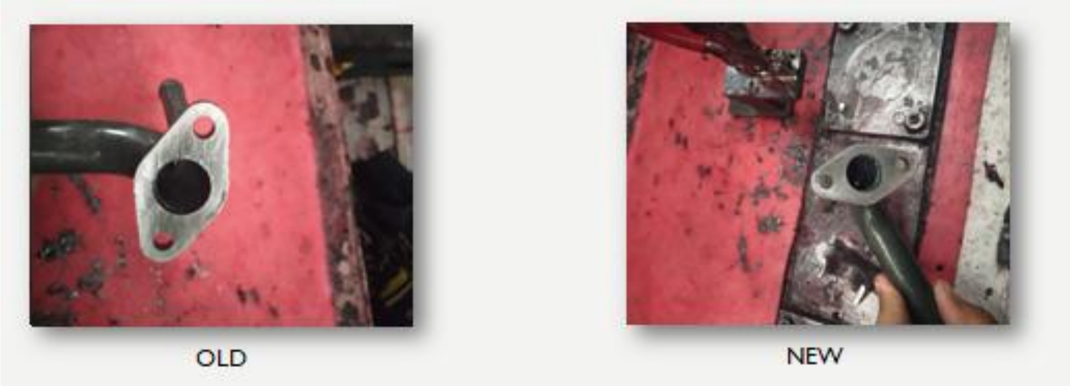


Figure 31, Bypass tube dent

Even the small roughness on the pipe can cause the leakage from the engine.

4.2 Ovality in the pipe

The dimensions of the pipe are as follows-

Outer Diameter = 20±0.2mm

Here 20 mm is the basic size of the pipe and 0.2 mm are the tolerances.

Bead Diameter = 22.40+0.25mm

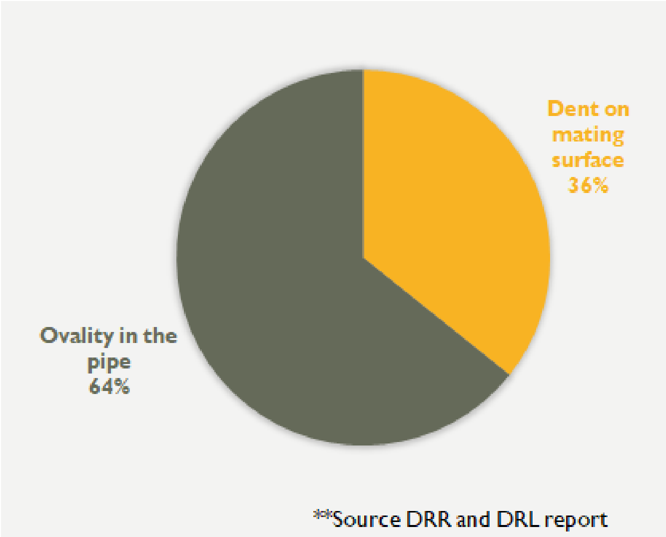
Here 22.40 mm is the basic size and 0.25 is the positive tolerance. Note that there is no negative tolerance for the bead diameter. The diameter is checked using dial gauge.

This is the problem from the vendor, thus the VQA team was informed and hence it was rectified. There was no problem in the process. This problem had the major impact on the leakage and is thus mentioned in the report.

Figure 32, Ovality

4.3 Result

There were reportedly 84 leakages due to the sensor adaptor. Of them 30 were because of the dent on the mating surface of the pipe and rest 54 were due to Ovality in the pipe. The number of engines made during the study was 39679 engines.



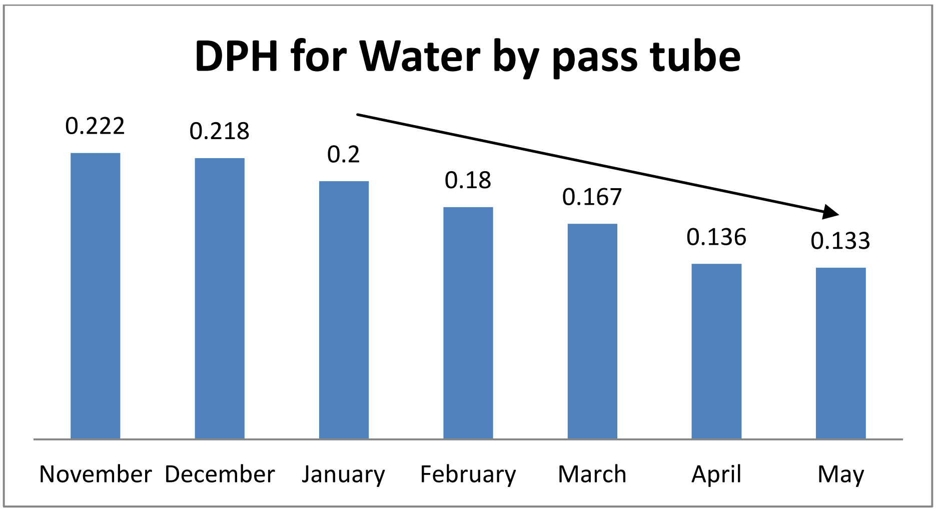
Graph 5, Bypass defect Bifurcation

Therefore the DPH will be 0.211

After implementing all the changes as described above, in the month of May there were reportedly 19 defects due to the head cover. The 275 IDI models made in the month of May were 14,290 engines. Therefore the DPH for the month of May for the head cover is-

DPH= 0.133

Percentage Reduction = [(0.211-0.133)/0.211]*100 i.e. 37%



Graph 6, DPH trends Bypass tube

There are 2 sensors installed on the water sensor adaptor, they are temperature senor and the water sensor.

5.1 Temperature Sensor

The Engine Temperature Sensor accurately measures the engine coolant temperature. Thereby, it gives an indication of the temperature of the engine. Engine Coolant Temperature sensor is primarily located in the coolant passage of the liquid cooled engine; typically near the thermostat valve. The engine temperature sensor connects either to the temperature gauge or to the temperature indicator in the dashboard. In modern cars, you will notice that there is no separate engine temperature gauge. Instead, there is a tiny ‘light’ symbolizing the engine temperature; which is integrated with rpm-meter.

5.1.1 Working of the Temperature Sensor

The engine temperature sensor is a type of sensor that changes its resistance with temperature. Many critical engine functions such as selection of air-fuel ratio, fuel injection timing, ignition timing etc. depend on the engine’s temperature. This is because a cold engine requires a rich air-fuel mixture; whereas the engine running at optimum operating temperature requires a lean mixture.

The engine temperature sensor informs the engine’s ECU about the current & ongoing variations in the engine temperature. ECU, in turn, adjusts and regulates the fuel quantity & ignition timing. The data from the engine temperature sensor provides readings for engine temperature gauge on the dashboard. Based on this data, the ECU also controls the additional functions such as switching on / off the engine cooling fan.

The temperature sensor mainly fails in a car due to corrosion. It is because it is in contact with the coolant.

5.2 Water Sensor

It is the level sensing device used to measure the level of the flow. They use ultrasonic sensors to measure the flow. Ultrasonic sensors operate by transmitting sound waves that reflect from the liquid surface and are obtained by the sensor. The sensor measures the time interval between the transmitted and received signals, which is then converted into distance measurement with the help of electronic circuits within the sensor thereby measuring the level of the liquid.

5.3 Parts Used

- Water Sensor
- Temperature sensor
- Adaptor
- 4 washers
- Benzo Bolt

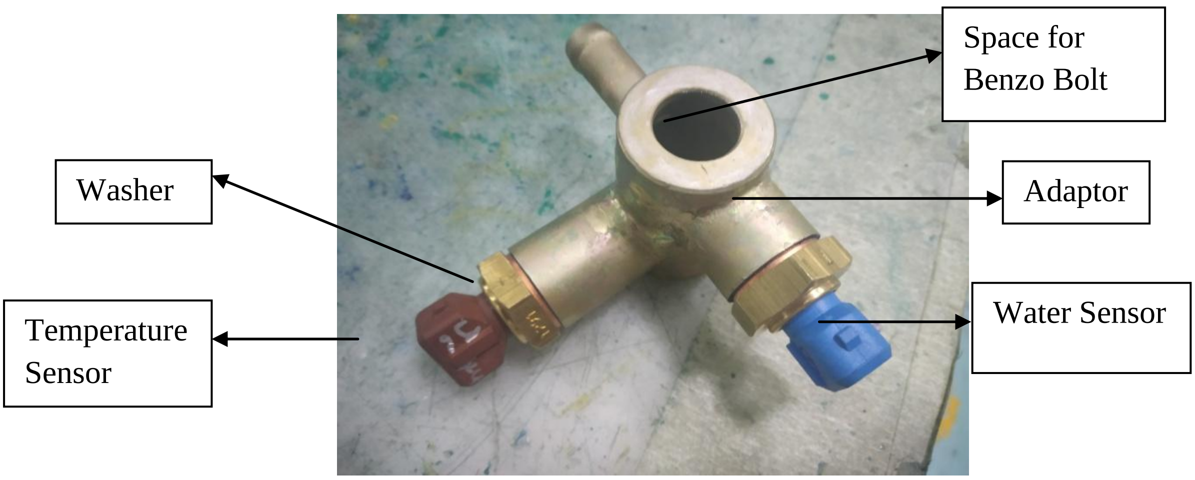


Figure 33, Sensor adaptor

5.4 Dent on Adaptor Surface

5.4.1 Defining the problem, 4W-1H analysis

What	**What is the problem?**	1. Dent on the Surface
	What has the problem? (part no, Lot no, etc.)	Temperature Sensor
	What is the impact of the problem?	High value of DPH.
Where	**Where is problem located on Product/Part?**	On the mating surface between Temperature Sensor and Adaptor.
	Where does the problem occur in the process?	Problem is occured during transportation.
	Where was the problem observed in the process?	The problem is observed at the QG-1 (Quality Gate-1) .
When	**When was the problem first noticed?**	The problem has been occurring since November (Start of my analysis)
	When has it been noticed since?	6 Months
Who	**Who is affected by the problem?**	Engine shop is affected by the problem as low targets achieved per day.
	Who First observed the problem?	Problem was first observed by the Engine Rework Area of the Powertrain.
	To whom was the problem reported?	Problem was reported to the line in charge of the assembly line.
How	**How much is the problem?**	Problem is quite common and results in low targets achieved
	How is the problem being rectified?	Problem is rectified by changing of the Temperature Sensor on the Engine.

Table 6, Dent on adaptor, 4W-1H

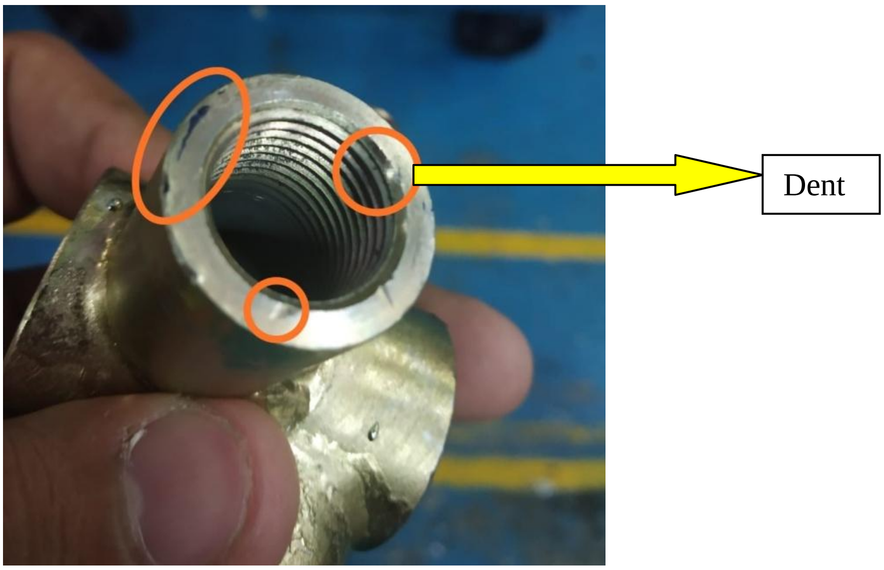


Figure 34, Adaptor dent

5.4.2 Causation and Effectuation Diagram, Fishbone Diagram

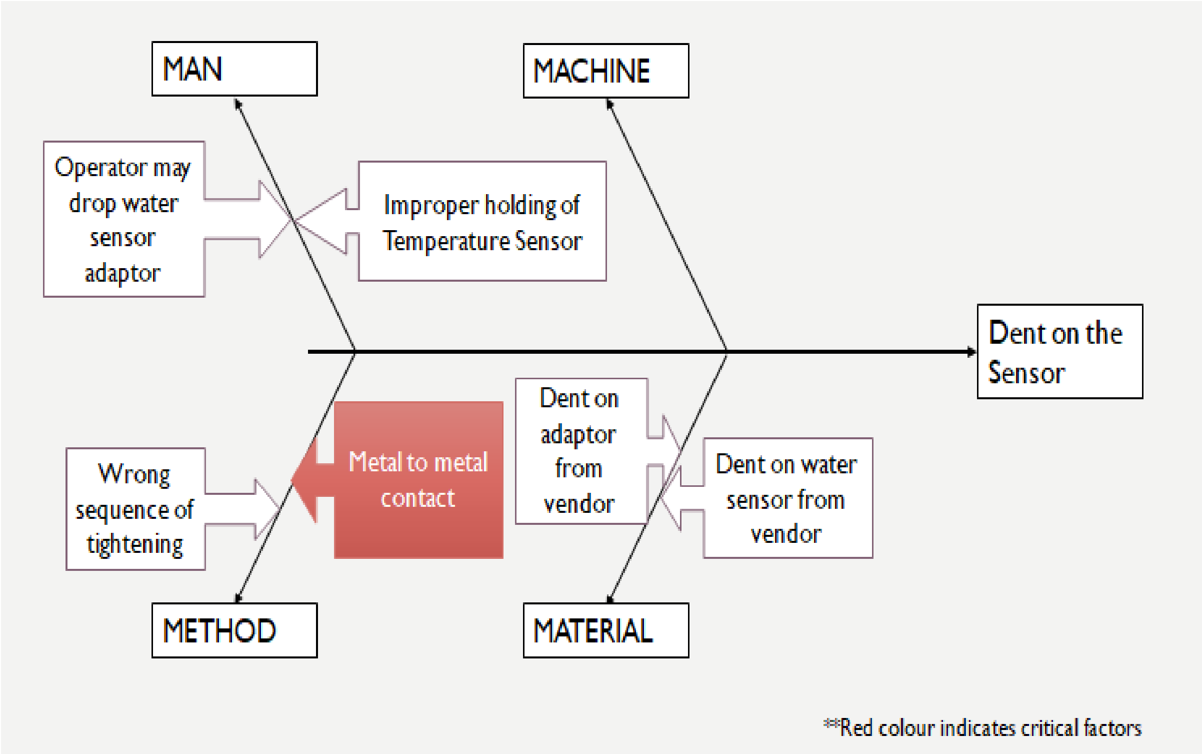
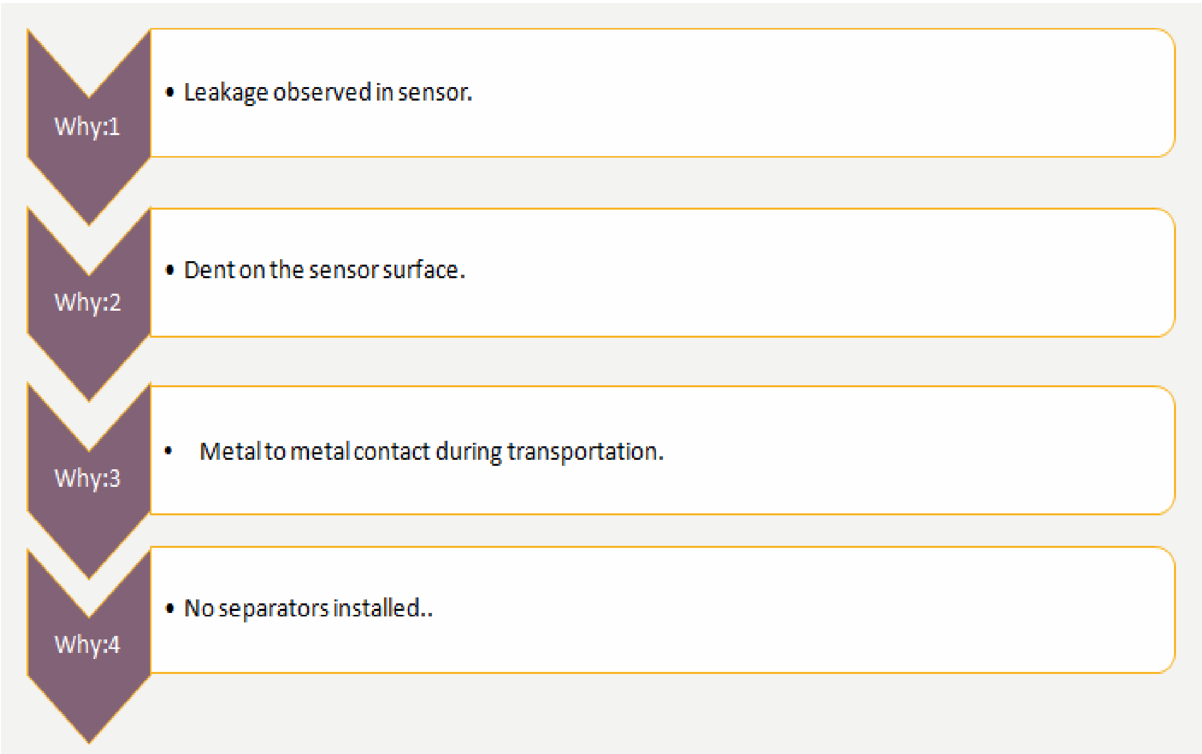


Figure 35, Fishbone diagram Sensor Dent

5.4.3 Why-Why Analysis



Flow chart 10, Why-Why, Dent on the Adaptor

5.4.4 Action Plan

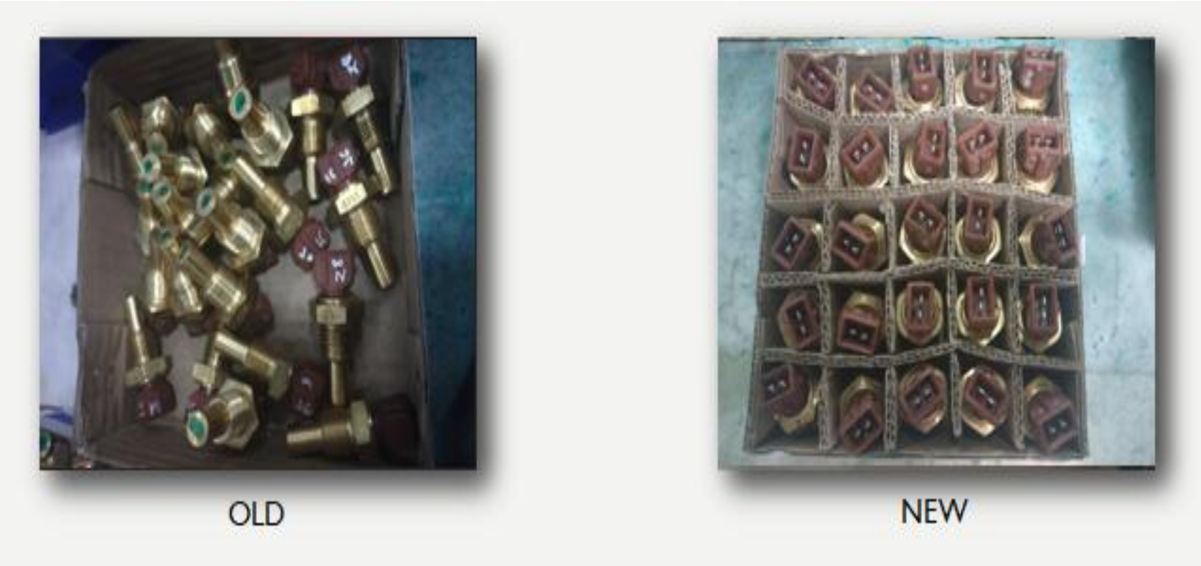


Figure 36, Separators Installed

We know that the metal to metal contact can cause dent. There were no seperators installed in the temperature sensor and water sensor from the vendor side. This causes dents in the sensor and hence leakage in the engine. So the vendor was asked to install seperators in the engine to tackle the situation. This increased some cost of manufacturing but overall this reduced the cost as there was a significant reduction in the dents.

5.5 Washer miss

A washer is a thin plate (typically disk-shaped, but sometimes square) with a hole (typically in the middle) that is normally used to distribute the load of a threaded fastener, such as a bolt or nut. Washers are usually metal or plastic. High-quality bolted joints require hardened steel washers to prevent the loss of pre-load due to Brine lining after the torque is applied.

Rubber or fiber gaskets used in taps (or faucets, or valves) to seal against water leaks are sometimes referred to colloquially as washers; but, while they may look similar, washers and gaskets are usually designed for different functions and made differently.

Washers are also important for preventing galvanic corrosion, particularly by insulating steel screws from aluminium surfaces.

5.5.1 Defining the problem, 4W-1H analysis

What	What is the problem?	2. Washer Miss
	What has the problem? (part no, Lot no, etc.)	Adaptor Surface
	What is the impact of the problem?	High value of DPH.
Where	Where is problem located on Product/Part?	On the surface between water sensors and the adaptor
	Where does the problem occur in the process?	Problem is occured during assembly
	Where was the problem observed in the process?	The problem is observed at the QG-1 (Quality Gate-1) .
When	When was the problem first noticed?	The problem has been occurring since November (Start of my analysis)
	When has it been noticed since?	6 Months
Who	Who is affected by the problem?	Engine shop is affected by the problem as low targets achieved per day.
	Who First observed the problem?	Problem was first observed by the Engine Rework Area of the Powertrain.
	To whom was the problem reported?	Problem was reported to the line in charge of the assembly line.
How	How much is the problem?	Problem is quite common and results in low targets achieved
	How is the problem being rectified?	Problem is rectified by reassembly of the sensor adaptor.

Table 7, Washer Miss, 4W-1H

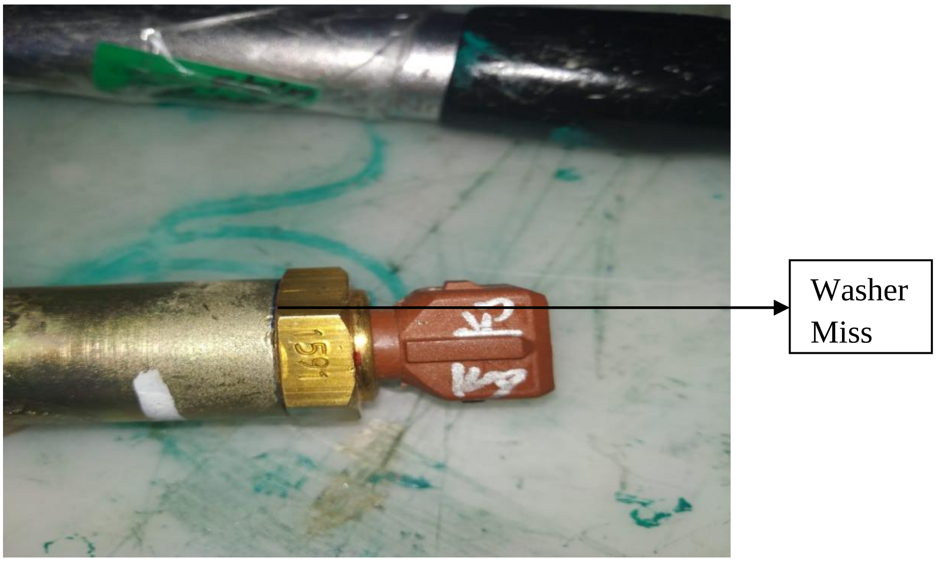


Figure 37, Washer miss

5.5.2 Causation and Effectuation diagram (Fishbone Diagram)

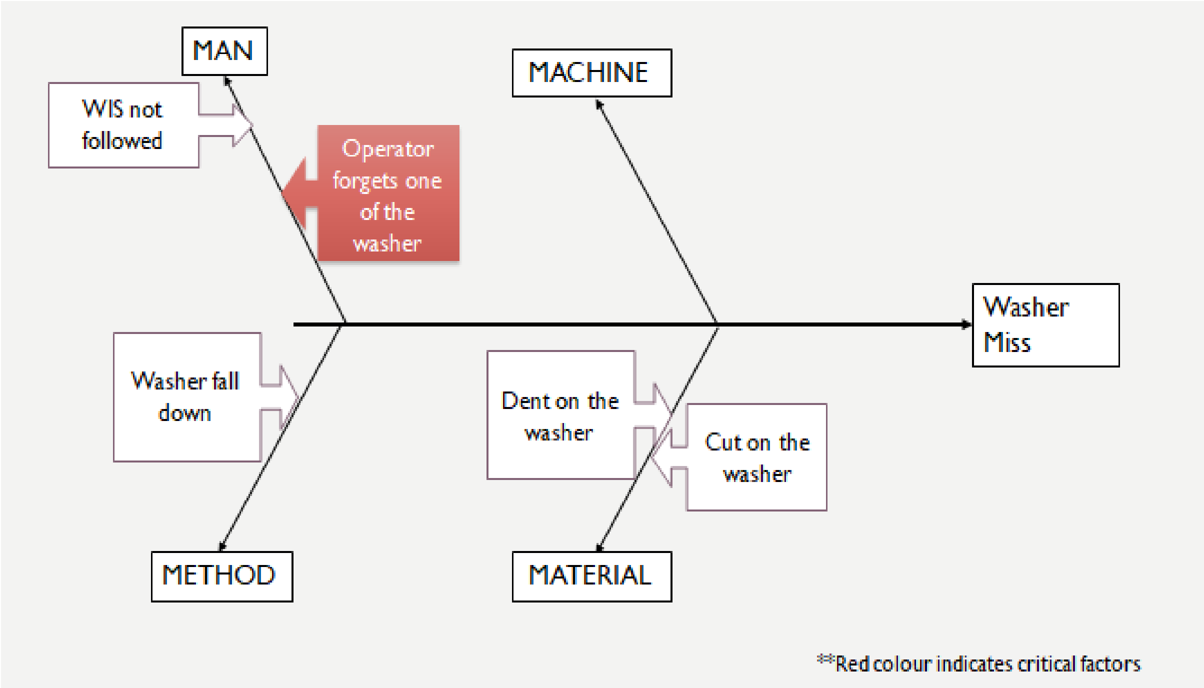
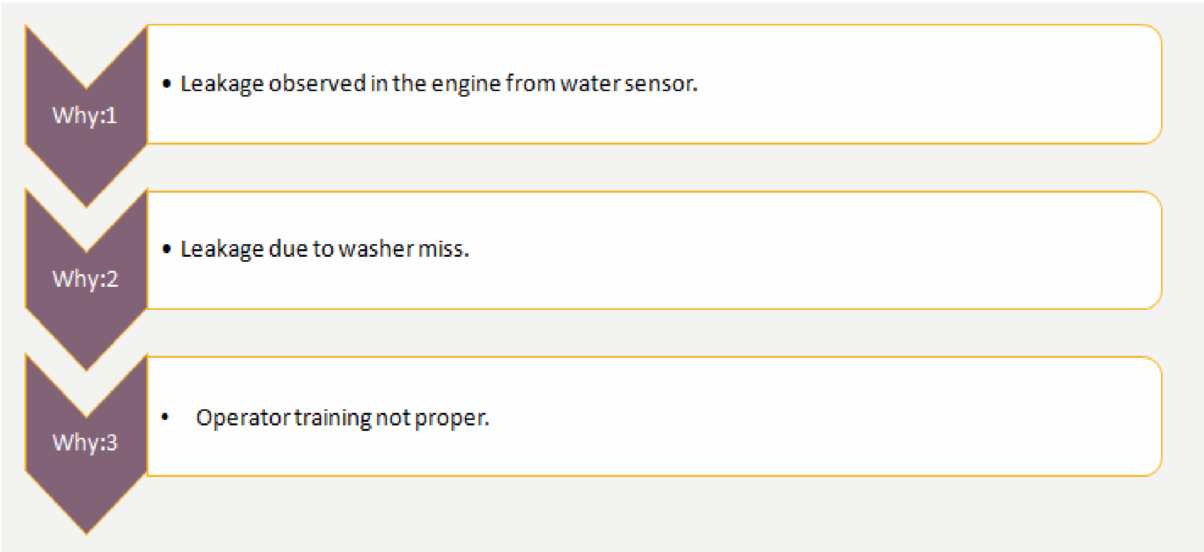


Figure 38, Fishbone Diagram, Washer Miss

5.5.3` Why-why analysis



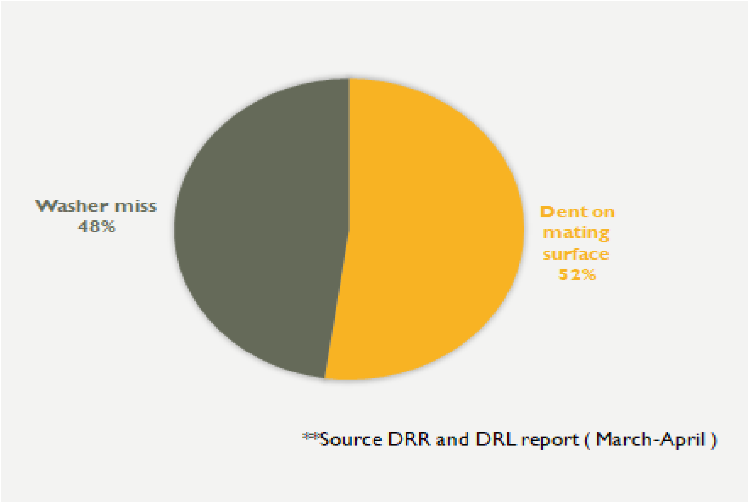
Flow chart 11, Why-why, Washer Miss

5.5.4 Action Plan

There are 4 washers installed in the assembly of the sensor adaptor. There can be leakage even of one of the washer is missed or damaged. Therefore the operator was trained for a day and was then monitored for the week to ensure that the cases of washer miss decrease significantly.

5.6 Result

There were reportedly 67 leakages due to the sensor adaptor. Of them 35 were because of the dent on the adaptor surface and rest 32 were due to the washer miss. The number of engines made during the study was 39679 engines.



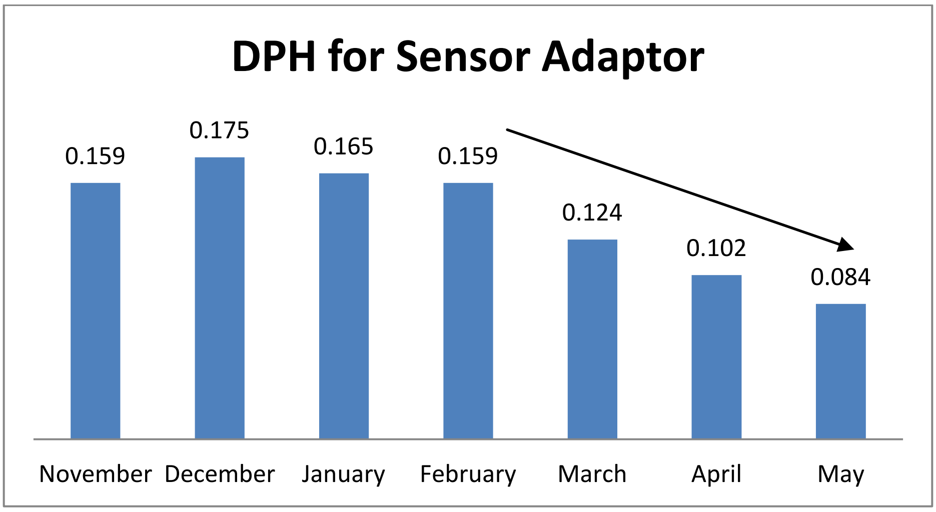
Graph 7, Adaptor Defects Bifurcation

Therefore the DPH will be 0.169.

After implementing all the changes as described above, in the month of May there were reportedly 12 defects due to the head cover. The 275 IDI models made in the month of May were 14,290 engines. Therefore the DPH for the month of May for the head cover is-

DPH= 0.084

Percentage Reduction = [(0.169-0.084)/0.169]*100 i.e. 50.3%



Graph 8, DPH trends Sensor adaptors

6.1 Introduction

A car engine produces a lot of heat when it is running, and must be cooled continuously to avoid engine damage.

Generally this is done by circulating coolant liquid usually water mixed with an antifreeze solution through special cooling passages. Some engines are cooled by air flowing over finned cylinder casings.

6.2 A water-cooled cooling system

A water-cooled engine block and cylinder head have interconnected coolant channels running through them. At the top of the cylinder head all the channels converge to a single outlet.

A pump, driven by a pulley and belt from the crankshaft, drives hot coolant out of the engine to the radiator, which is a form of heat exchanger.

Unwanted heat is passed from the radiator into the air stream, and the cooled liquid then returns to an inlet at the bottom of the block and flows back into the channels again.

Usually the pump sends coolant up through the engine and down through the radiator, taking advantage of the fact that hot water expands, becomes lighter and rises above cool water when heated. Its natural tendency is to flow upwards, and the pump assists circulation.

The radiator is linked to the engine by rubber hoses, and has a top and bottom tank connected by a core a bank of many fine tubes.

The tubes pass through holes in a stack of thin sheet-metal fins, so that the core has a very large surface area and can lose heat rapidly to the cooler air passing through it.

On older cars the tubes run vertically, but modern, low-fronted cars have crossflow radiators with tubes that run from side to side.

In an engine at its ordinary working temperature, the coolant is only just below normal boiling point.

The risk of boiling is avoided by increasing the pressure in the system, which raises the boiling point.

The extra pressure is limited by the radiator cap, which has a pressure valve in it. Excessive pressure opens the valve, and coolant flows out through an overflow pipe.

In a cooling system of this type there is a continual slight loss of coolant if the engine runs very hot. The system needs topping up from time to time.

Later cars have a sealed system in which any overflow goes into an expansion tank, from which it is sucked back into the engine when the remaining liquid cools.

6.3 UCL Clamp Issue

6.3.1 Defining the Problem, 4W-1H analysis

What	What is the problem?	1. Clamp not at correct position.
	What has the problem? (part no, Lot no, etc.)	Upper cooling line
	What is the impact of the problem?	High value of DPH.
Where	Where is problem located on Product/Part?	End of the upper cooling line hose
	Where does the problem occur in the process?	Problem is occured during UCL assembly
	Where was the problem observed in the process?	The problem is observed at the QG-1 (Quality Gate-1) .
When	When was the problem first noticed?	The problem has been occurring since November (Start of my analysis)
	When has it been noticed since?	6 Months
Who	Who is affected by the problem?	Engine shop is affected by the problem as low targets achieved per day.
	Who First observed the problem?	Problem was first observed by the Engine Rework Area of the Powertrain.
	To whom was the problem reported?	The problem was reported to the line incharge
How	How much is the problem?	Problem is quite common and results in low targets achieved
	How is the problem being rectified?	The problem is rectified by refitment of the clamps on the UCL

Table 8, UCL clamp problem, 4W-1H

6.3.2 Causation and Effectuation Diagram (Fishbone Diagram)

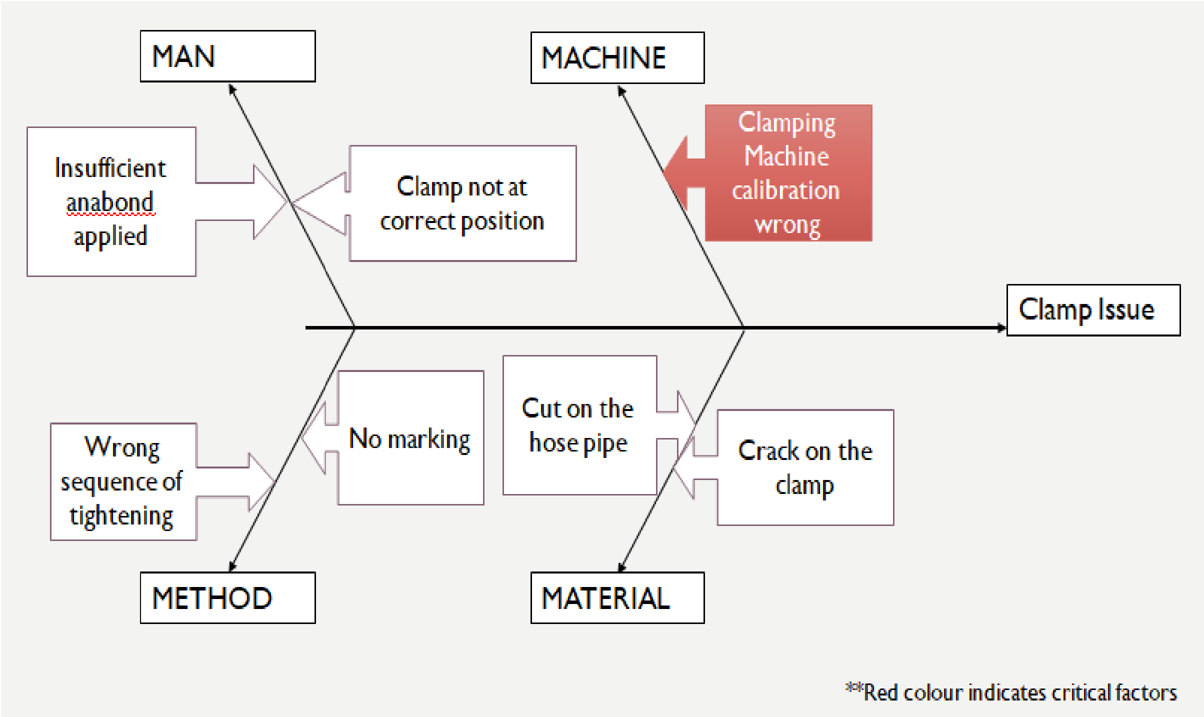
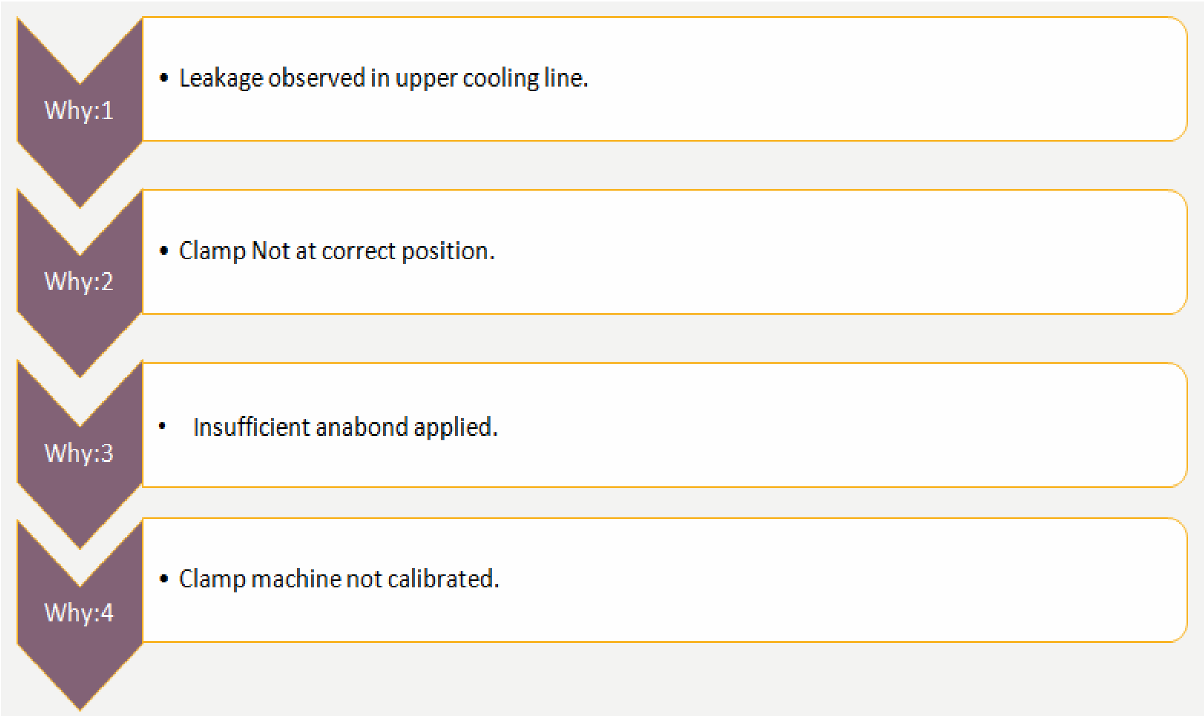


Figure 39, Fishbone Diagram, Clamp issue

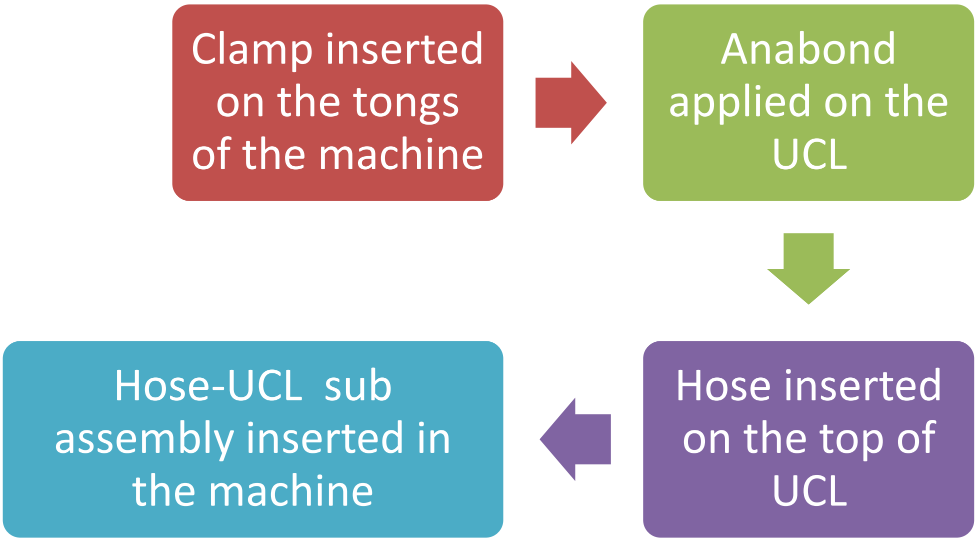
6.3.3 Why-Why Analysis



Flow chart 12, why-why, Clamp problem

Now we will see the actions taken to tackle the situation.

6.3.4 Steps Involved



Flow chart 13, UCL sub assembly process

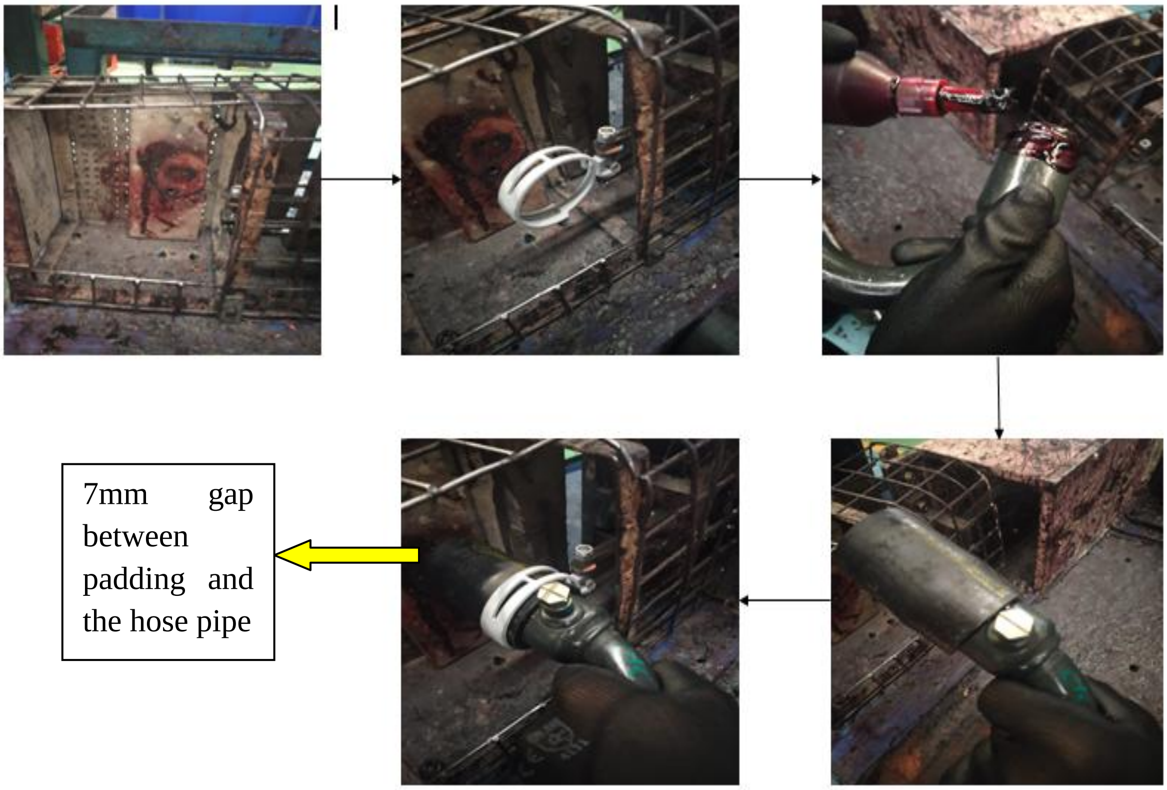


Figure 40, UCL subassembly process

These pictures represent the different stages of the subassembly of the hose pipe and the UCL. The gap is represented above.

6.3.5 Action Plan

The clamp fixing machine is used to connect the hose pipe and the UCL in the sub assembly. There are 2 hose pipes installed on the each side of the UCL. The hose pipe and the UCL are attached in the sub assembly. The other part of the UCL is attached on the engine through the 2nd hose pipe. Clamps are used to fix the hose pipe and the UCL. There are usually markings on the hose pipes to assist the operators to fix the clamp in between the markings. But there are no markings on the hose pipes connected through the hose pipe. Hence, the hose pipe and the UCL are connected with the clamps with a 5 mm gap. There is no method to maintain the 5 mm gap on the assembly lines so there might be the leakage. But on the sub assembly there is a machine which helps maintaining the 5mm gaps. Firstly the clamp is fixed on the 2 tongs of the machine. Then the hose pipe dipped in anabond and attached with the UCL is passed through the clamp till it touches the padding. The thickness of padding is in such a way that when the pipe touches the padding, there is a 5mm gap between the clamp and the hose pipe. But there is a problem in the padding. The padding is a bit thin and the hose pipe cannot touch it. Hence the operator is maintaining the 5 mm gap just by guess. Hence the padding was to be increased to maintain the gap. On measuring the padding was found to be 7 mm thinner than the design. Hence the padding was removed and hence the accurate gap of 5 mm was maintained between the clamp and the hose pipe.

Figure 41, Clamp machine calibration

6.4 Result

There were reportedly 37 leakages UCL. Half of them were during the sub assembly and rest half of them were at the assembly line. Total engines made during the time period was 39,679 engines.

$$DPH(Defects\ per\ Hundred) = \left(\frac{Reported\ Leakages}{Total\ Units\ Produced}\right) * 100$$

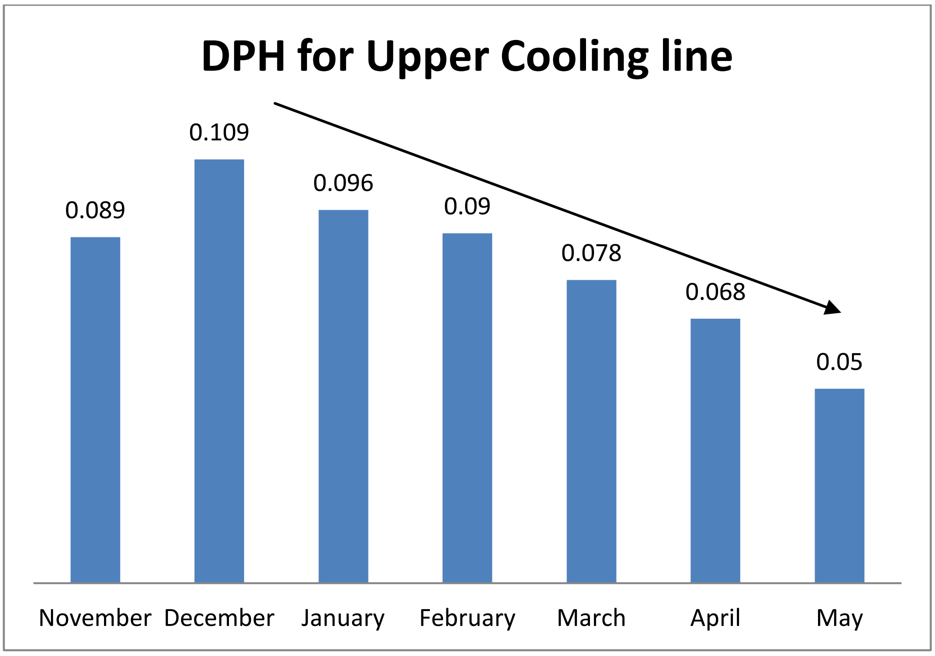
Therefore the DPH will be 0.93.

After implementing all the changes as described above, in the month of May there were reportedly 7 defects due to the head cover. The 275 IDI models made in the month of May were 14,290 engines. Therefore the DPH for the month of May for the head cover is-

DPH= 0.05

$$Percentage\ Reduction = \frac{Original\ DPH - Final\ DPH}{Original\ DPH} * 100$$

Percentage Reduction = [(0.093-0.05)/0.093]*100 i.e. 46.2%



Graph 9, DPH trends upper cooling line

7.1 Aim

The aim of the project is to design the PFMEA sheets for each workstation of the 275 IDI model (2 cylinder engine) made on the 475 assembly line.

7.2 Introduction

In Tata Motors Limited there are 2 assembly lines, 275 assembly line for all the 2 cylinder models and 475 assembly line for all the 4 cylinder models. But due to the increase in demand of the 2 cylinders models, the 4 cylinders assembly lines were modified so that the 2 cylinder models can also be made on them. So it was necessary to make the PFMEA sheet for each workstation on the 475 assembly line for the 275 IDI model.

A Process Failure Mode Effects Analysis (PFMEA) is a structured analytical tool used by an organization, business unit, or cross-functional team to identify and evaluate the potential failures of a process. PFMEA helps to establish the impact of the failure, and identify and prioritize the action items with the goal of alleviating risk. It is a living document that should be initiated prior to process of production and maintained through the life cycle of the product.

PFMEA evaluates each process step and assigns a score on a scale of 1 to 10 for the following variables:

1. Severity — Assesses the impact of the failure mode (the error in the process), with 1 representing the least safety concern and 10 representing the most dangerous safety concern. In most cases, processes with severity scores exceeding 8 may require a fault tree analysis, which estimates the probability of the failure mode by breaking it down into further sub-elements.
2. Occurrence — Assesses the chance of a failure happening, with 1 representing the lowest occurrence and 10 representing the highest occurrence. For example, a score of 1 may be assigned to a failure that happens once in every 5 years, while a score of 10 may be assigned to a failure that occurs once per hour, once per minute, etc.

3. Detection — Assesses the chance of a failure being detected, with 1 representing the highest chance of detection and 10 representing the lowest chance of detection.
4. RPN — Risk priority number = severity X occurrence X detection. According to the new rule the RPN value needs to be decreased no matter what. Earlier it had to be less than 80(depends on industry to industry) but now we need to decrease the number. The corrective action ideally leads to a lower RPN number

$$RPN = Severity \times Occurance\ \times Detection$$

Manufacturing and Process Engineers envision a process is free of errors. Unfortunately, errors and especially errors propagated when people are present can be quite catastrophic. Process Failure Mode and Effects Analysis (PFMEA) looks at each process step to identify risks and possible errors from many different sources. The sources most often considered are:

- Man
- Methods
- Material
- Machinery
- Measurement
- Mother Earth (Environment)

7.3 Importance of the PFMEA sheets

Risk is the substitute for failure on new processes. It is a good practice to identify risks for each process step as early as possible. The main goal is to identify risk prior to tooling acquisition. Mitigation of the identified risk prior to first article or Production Part Approval Process (PPAP) will validate the expectation of superior process performance.

Risks are identified on new technology and processes, which if left unattended, could result in failure. The PFMEA is applied when:

- There is a new technology or new process introduced
- There is a current process with modifications, which may include changes due to updated processes, continuous Improvement, Kaizenor Cost of Quality (COQ).
- There is a current process exposed to a new environment or change in location (no physical change made to process).

The effects of a failure are focused on impacts to the processes, subsequent operations and possibly customer impact. Many effects could be possible for any one failure mode. All effects should appear in the same cell next to the corresponding failure mode. It is also important to note that there may be more than one customer; both internal and external customers may be affected.

The Recommended Actions column is the location within the Process FMEA that all potential improvements are placed. Completed actions are the purpose of the PFMEA. Actions must be detailed enough that it makes sense if it stood alone in a risk register or actions list. Actions are directed against one of the rankings previously assigned.

There were 20 workstations in the 475 assembly line, so a total of 20 PFMEA sheets were to be made. They are confidential so the 1 PFMEA will be thoroughly explained in the report.

The different sections of a PFMEA sheet are as follow-

7.3.1 List of Operations and Videos

List of Operations / Stations in Scope					
#	Operation / Station Description	Station No.	Video (Y/N)	Link of Video (if available)	Remarks (if any)
11	Piston Sub Assembly	PCS-205	N		None

Table 9, List of Operations

In this section we attach the link to any video if available.

7.3.2 Elemental level decomposition

Element Level Decomposition Of Operation			
#	Operation / Station Description	Element Level Decompostion Of The Operation	
		#	Elemental activity/ step
		1	Checking the serial number of bed plate and block
		2	Locating of bed plate in fixture of Robotic Sealant Machine
	Bed Plate sealent application, fitment and axial play check	3	Sealant application by the machine(Anabond 5188)
		4	Placement of bed plate on the cylinder block
		5	Place 8 bolts of M8*105 on bed plate(lower bolts)
		6	Place 6 bolts of M10*120 on bed plate(upper bolts)
		7	Tight the bolts with DCNR
		8	Rotation of crank shaft and balancer after tightening bolts with DCNR
		9	Check crank shaft, balancer axial play with dial gauge
		10	Note down the readings in the History Card

Table 10, Elemental level decomposition

In this section the work done in the workstation into different work elements. A work element is the smallest work which cannot be broken further.

7.3.3 Error Modes

Error Modes	Corresponding Human Errors	Number of Errors
(1) Omission	-Forgetting to take out or set parts/materials -Forgetting to operate buttons, valves, or switches	292 (28.1%)
(2) Excessive/ Insufficient	-Re-executing the finished work -Excessively/insufficiently repeating work	2 (0.2%)
(3) Wrong Order	-Executing two sequential work operations in an inverted order	7 (0.7%)
(4) Early/Late Execution	-Beginning work earlier/later than specified -Ending work earlier/later than specified	2 (0.2%)
(5) Execution of Restricted Work	-Executing restricted work which is likely to cause poor quality, injuries, or accidents	11 (1.1%)
(6) Incorrect Selection	-Selecting the wrong parts/materials -Using the wrong tools	176 (17.5%)
(7) Incorrect Counting	-Supplying more material than specified -Transporting less parts than ordered	9 (0.9%)
(8) Misrecognition	-Misreading work-order sheets, meters, or records -Failing to determine defective products	165 (16.4%)
(9) Failing to Sense Danger	-Failing to sense items not to be touched -Failing to sense areas not to be approached	17 (1.7%)
(10) Incorrect Holding	-Holding a damageable part of materials/parts -Holding tools the incorrect way	3 (0.3%)
(11) Incorrect Positioning	-Setting parts in the wrong position -Transporting materials to the wrong place	50 (5.0%)
(12) Incorrect Orientation	-Setting materials/parts the wrong way around -Bending materials to the wrong side	102 (10.1%)
(13) Incorrect Motion	-Bending material too much -Opening valve too fast	1 (0.1%)
(14) Improper Holding	-Failing to ensure material/parts do not to move -Dropping parts, products, or tools	20 (2.0%)
(15) Inaccurate Motion	-Setting materials/parts in accurate positions #NAME?	88 (8.8%)
(16) Insufficient Avoidance	-Knocking parts/tools into each other - Falling/stumbling -Touching machine switches without intention	60 (6.0%)

Table 11, Error Modes

Error modes means all the possible error in an industry is divided into the 16 different type of error modes. Most common errors include the omission. Most of the times in a process, the operator forgets to apply one of the washer, dome nut and these type of small but important parts.

Next we will see the error identification.

7.3.4 Error Identification

#	16 Error Modes	Checking the serial number of bed plate and block	Location of bed plate in fixture of Robotic Sealant Machine	Sealant application by the machine(Anabond 5188)	Placement of bed plate on the cylinder block	Place 8 bolts of M8*105 on bed plate(lower bolts)	Place 6 bolts of M10*120 on bed plate(upper bolts)	Tight the bolts with DCNR	Check the rotation of crank shaft and balancer after tightening bolts with DCNR	Check crank shaft, balancer axial play with dial gauge	Note down the readings in the History Card
1	Omission	NA	NA	NA	Placement of different serial number bed plate on different block	Operator may forget to place one of the bolts	Operator may forget to place one of the bolts	NA	NA	operator may forget to check axial play	NA
2	Excessive / Insufficient	NA	NA	Insufficient application of sealant Excess application of sealent	NA	NA	NA	NA	NA	NA	NA
4	Early / late execution	NA	NA	Bed plate kept for long after applying sealant.	NA	NA	NA	NA	NA	NA	NA
5	Execution of restricted work	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	Incorrect selection	NA	NA	NA	NA	NA	NA	NA	NA	Dial gauge not calibrated	NA
7	Incorrect counting	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Misrecognition	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9	Failing to sense	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10	Incorrect holding	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	Incorrect positioning	NA	Bed plate can be located in incorrect position	NA	NA	NA	NA	NA	NA	NA	NA
12	Incorrect orientation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
13	Incorrect motion	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
14	Improper holding	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
15	Inaccurate motion	NA	NA	NA	NA	NA	NA	Under Torquing of bolts Over Torquing of upper bolts	NA	NA	NA

Table 12, Error Identification

Now is the process of error identification.

7.3.5 Determination of Product Characteristics Method-1

Determination Of Product Characteristics (Method 1)					
#	Operation / Station Description	What IS expected on the product (as this step)	What is NOT expected on the product (as this step)	Product Characteristics	Failure Mode
	Bed Plate sealent application, fitment and axial play check	Application of sealent(Anabond 5188) on bed plate		Sufficient application of sealent	Insufficient/Excess application of sealant
			Different serial number bed plate assembled on block	Fitment of same serial number bed plate as that of block	Bed plate and block have different serial numbers
		Crank shaft axial play between 0.06-0.245mm		Crank shaft Axial play within desired limits	Crank shaft Axial play high/low
		Balancer axial play between 0.1-0.192 mm		Balancer Axial play within desired limits	Balancer Axial play high/low

Table 13, Product Char, Method-1

Here the things which are expected and not expected in the product are written. Then product characteristic and corresponding failure modes are noted.

7.3.6 Determination of Product Characteristics Method-2

Determination Of Product Characteristics (Method 2)				
#	Operation & Elemental Activity	#	Final list of error's identified (Without any repeatation of an error in an element level step within the operation)	Effect of the error on the product if it may occur at current operation / at this stage (i.e. it is something not expected on product i.e. Defect / Failure Mode)
1	Checking the serial number of bed plate and block		NA	NA
2	Location of bed plate in fixture of Robotic Sealant Machine		Bed plate can be located in incorrect position	Sealant profile not ok
3	Sealant application by the machine(Anabond 5188)		Breakage of continuity of sealent	Insufficient sealent application
			Excessive sealant application	Over application of sealant
			Bed plate kept for long after applying sealant	dry sealant
4	Placement of bed plate on the cylinder block		Bed plate and block no. mismatch	Bed plate not fitted correctly
5	Place 8 bolts of M8*105 on bed plate(lower bolts)		Operator may forget to place one of the bolts	Bed plate not fitted correctly
6	Place 6 bolts of M10*120 on bed plate(upper bolts)		Operator may forget to place one of the bolts	Bed plate not fitted correctly
7	Tight the bolts with DCNR		Torque set too low	Under torquing of bolts
			Torque set too high	Over torquing of bolts
8	Check the rotation of crank shaft and balancer after tightening bolts with DCNR		NA	NA
9	Check crank shaft, balancer axial play with dial gauge		Operator may forget to check axial play	No entry in history card
			Dial gauge not calibrated	Wrong readings of axial play
11	Note down the readings in the History Card		NA	NA

Table 14, Product Char, Method-2

Now the union of failure modes is taken from Method-1, Method-2 and further the 6M analysis is done for each of the following failure mode.

7.3.7 Fishbone Diagram

Before the fishbone diagram, the 6M analysis is done for each of the failure mode where 6M include, Man, Method, Machine, Material, Mother Nature, and Measurement.

6M Analysis									
#	Operation / Station Description	Description of Failure Mode	#	Men	Machine	Method	Mother Nature (Environment)	Measurement System	Material
	Bed Plate sealent application , fitment and axial play check	Insufficient/ Excess Sealent			Incorrect holding of sealant Breakage of continuity of sealant				Bed plate has bad surface finish
		Dry Sealant		Bed plate kept for long after applying sealant			Atmosphere is too hot		
		Bed plate and block not fitted correctly		Bed plate and block no. mismatch Operator may forget to place one of the bolts					Bed plate has a dent
		Under torquing of bolts		Torque set too low				DCNR not calibrated	Bolts are not strong

Table 15, 6M analysis

7.3.8 PFD (Process Flow Diagram)

Opn. No.	Opn desciprtion	Incoming source of variation	Process flow	Product characteristics	Process characterstics	Cause
	Bed Plate sealent application, fitment and axial play check	Bed plate has bad surface finish			Sealant must be properly applied	Continuity breakage during application of sealant
					Bed plate should not be kept too long after applying sealant	Operator starts sealant application too early
		Bed plate has a dent			Bed plate and engine block should have same serial number	Bed plate of different serial number than that of block fitted
		Bolts have damaged threads			Bolts should be tightly torqued	DCNR may not be calibrated
						Torque set too high/low
		Burr in crank bore/ shaft			Crank shaft axial play to be within specified limits	Oiling missed
						Thrust washer missing
		Dent in shaft			Balancer axial play to be within specified limits	Oiling missed
						Dent in shaft

Table 16, PFD

7.3.9 PFMEA (Process FMEA)

Model	Process Responsibility :		Rev Date: -
Core Team :	Key Date :		Prepared by :
	FMEA Date :		Approved by :

Operation No	Operation Description	Requirements	Potential Failure Mode	Potential Effects of failure mode		SEV	Class	Potential Causes / Mechanisms of Failure	Current Process Controls Prevention	OCC	Current Process Controls Detection	DET	S &O	RPN
		Sealant application on bed plate		NO	No Effect									
				SO (Testing)	Detection in oilways test			Bed plate can be located in incorrect position in robotic sealant dispenser	Operator training		Confirmation by operator			
				OS	NIL			Break in continuity during application	Sealent flow feedback		Confirmation by operator			
				EU	NIL			Excess application of sealent	Sealent flow feedback		Confirmation by operator			
				M/c.	NIL			Bed plate kept for long after applying sealant.	a . WIS b. Operator training		Confirmation by operator			
								Careless handling of Bed plate causing a dent	Operator training		Confirmation by operator			
		Fitment of bed plate of same serial number block		NO	No Effect									
				SO	Leakage in engine testing			Placement of different serial number bed plate on different block	a . WIS b. Operator training		Visual confirmation by operator			
				EU	No Effect									
				OS	No Effect									
				MC	No Effect									

Table 17, Sample PFMEA

7.4 Severity Ranking

The Severity of each effect is selected based on both Process Effects as well as Design Effects. The severity ranking is typically between 1 through 10.

Typical Severity for Process Effects (when no Special Characteristics / design inputs are given) is as follows:

- 2-4: Minor Disruption with rework / adjustment in stations; slows down production (does not describe a lean operation)
- 5-6: Minor disruption with rework out of station; additional operations required (does not describe a lean operation)
- 7-8: Major disruption, rework and/or scrap is produced; may shutdown lines at customer or internally within the organization
- 9-10: Regulatory and safety of the station is a concern; machine / tool damage or unsafe work conditions

The highest severity is chosen from the many potential effects and placed in the Severity Column. Actions may be identified to can change the design direction on any failure mode with an effect of failure ranked 9 or 10. If a recommended action is identified, it is placed in the Recommended Actions column of the PFMEA.

7.5 Occurrence Number

The Occurrence ranking is an estimate based on known data or lack of it. The Occurrence in Process FMEAs can be related to known / similar technology or new process technology. A modification to the ranking table is suggested based on volumes and specific use. Typical Occurrence rankings for known / similar technology are as follows:

- 1: Prevented through product / process design; error proofed
- 2: 1 in 1,000, 000
- 3: 1in 100,000
- 4: 1 in 10,000
- 5: 1 in 2,000
- 6: 1 in 500
- 7: 1 in 100
- 8: 1 in 50
- 9: 1 in 20

- 10: 1 in 10

Actions may be directed against causes of failure which have a high occurrence. Special attention must be placed on items with Severity 9 or 10. These severity rankings must be examined to assure that due diligence has been satisfied.

7.6 Detection Ranking

Detection Rankings are assigned to each method or inspection based on the type of technique used. Each detection control is given a detection ranking using a predetermined scale. There is often more than one test / evaluation technique per Cause-Failure Mode combination. Listing all in one cell and applying a detection ranking for each is the best practice. The lowest of the detection rankings is then placed in the detection column. Typical Process Controls Detection Rankings are as follows:

- 1: Error (Cause) has been fully prevented and cannot occur
- 2: Error Detection in-station, will not allow a nonconforming product to be made
- 3: Failure Detection in-station, will not allow nonconforming product to pass
- 4: Failure Detection out of station, will not leave plant / pass through to customer
- 5-6: Variables gage, attribute gages, control charts, etc., requires operator to complete the activity
- 7-8: Visual, tactile or audible inspection
- 9: Lot sample by inspection personnel
- 10: No Controls

Actions may be necessary to improve inspection or evaluation capability. The improvement will address the weakness in the inspection and evaluation strategy.

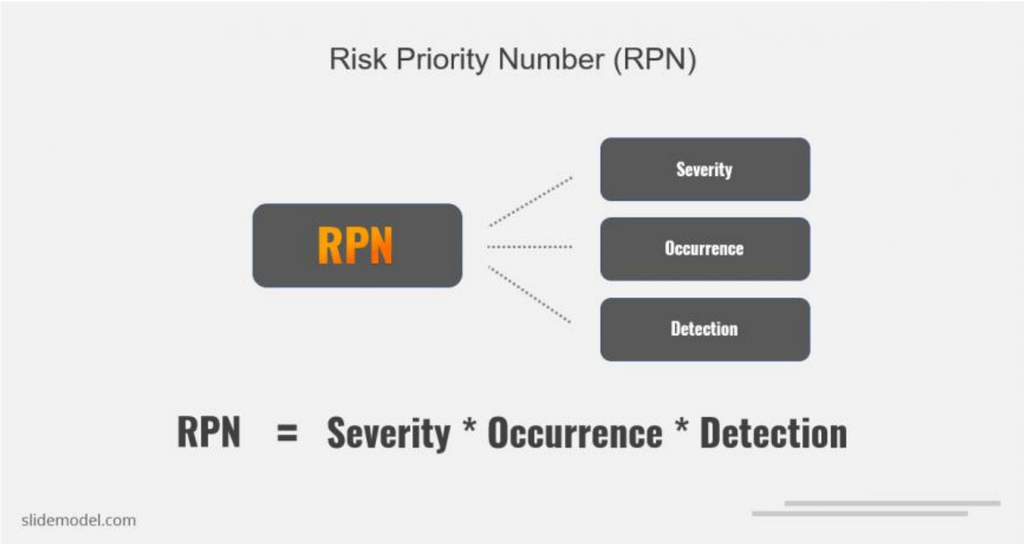


Figure 42, RPN

7.7 Result

As discussed above there are 20 workstations on the 475 assembly line. So these many PFMEA sheets were made and printed on the A3 sheets. The following steps were involved-

1. Gemba observation for the workstation.
2. Elemental level decomposition of the operation.
3. Error identification in each elemental level.
4. Construction of Product, Process Characteristics matrices.
5. 6M analysis and fishbone diagram.
6. Filling of the PFMEA sheet on the layout.
7. Calculation of the RPN number of each failure mode.

7.8 Major Challenges Faced

- Determining all the possible errors in the process.
- There was a difficulty in segregation of the errors into different error modes.
- Examining the effects of the possible failure mode in an operation was difficult.
- Finding the correct severity number from the table provided.

7.9 Learning Outcomes

- Learnt different observation techniques such as Gemba Study.
- Leant the importance of the PFMEA sheets in the industry.
- Studied about 16 different errors modes i.e. how all the possible errors can be segregated into 16 different error modes.

8.1 Aim

The aim of the project is to design the Work Instruction Sheets (WIS) of the 275 IDI model (2cylinder engine) on the 475 assembly line.

8.2 Importance of the Project

It is important to establish (plan) the instructions that your people must execute. The references must then be effectively implemented (do) so they are accessible to personnel. Documentation must be verified (check) so the instructions assist your problem-solving methodology. Finally, it is important to use (act) what has been defined in order to continuously improve.

Reason #1. Training (Plan). Training is the essential first step to ensuring that people are competent in their duties. It is important to define, within the quality planning activities, the type of training that each function is to receive. It is equally necessary to ensure that the trainers are executing the plan, including improvements made to the instructions.

New employees should start their training with the process expert so they can observe how the process should be performed. It is here that detailed training discussions and hands-on activities take place between the expert and the trainee. The trainer uses the work instructions so new employees understand the basis for the tasks they are performing. The process is an opportunity for additional review of the work instruction content. The veteran can reaffirm the defined steps, and the new employee can confirm the validity of the process.

Reason #2. Reference (Do). This quality activity should focus on both access and format of the instructions. The documentation must be implemented so workers are not wary of having to locate the information relative to their areas of responsibility.

Write out how the instruction is to be performed specific to each core task.

Once employees have been trained and have demonstrated that they can be effective performers, you must ensure that the work instructions are available in case of questions.

The instructions must be presented in an easy-to-understand format so that access and review will not take up valuable time.

Write out how the instruction is to be performed specific to each core task. Avoid defining why the activity is performed. There should be no need for an expert organization to reaffirm why core tasks are needed. If the "why" information must be defined, keep that separate from the work instructions and make the additional information available as reference-only training documents.

Reason #4. Continuous Improvement (Act). Work instructions should not be stagnant documents accessed only when auditors ask for them. Reviewing work instructions when improvement opportunities are identified demonstrates that they are "living documents."

8.3 Parts of the WIS

8.3.1 Operation Sequence

In this section all the steps performed on that workstation are written in the Hindi for the easy understanding of the operators. This is the most important part of the WIS as this contains the detailed process of the workstation

Operation Sequence (What is to be done & How it is to be done)
सबसे पहले ऑयल गैलरी में एक कॉपर वाशर लगाकर ब्लॉक में फिट करते है या सबअसेम्बल्ड ऑयल गैलरी प्लग को ट्रे से उठाते हैं और ब्लॉक में फिट करते है।
उसके बाद MB cap को निकालते है और किमटेक क्लोथ की सहायता से MB cap और कैंक बोर को क्लीन करते है ।
उसके बाद MB cell को बिन में से उठाते है और MB cap में फिट करते है।
उसके बाद MB cell को ब्लॉक के कैंक बोर में फिट करते है
उसके बाद दो Lower thrust washer को बिन में से उठाकर ब्लॉक में फिट करते है उसे प्रेस करते है तथा समय पर जेएच करते है और जेएच शीट भरते है।

Table 18, Operational Sequence

8.3.2 Quality Key points

In this section of the WIS there are certain Quality key points before performing any step. Operators are specially trained with the key points so that the error can be identified before and not at the end of the product.

Quality Key Point
ऑयल गैलरी में कॉपर वाशर अवश्य लगाएं।
MB cap व क्रैंक बोर को अच्छे से क्लीन करें।
बियरिंग शैल लग में सही से बैठी होनी चाहिए।
बियरिंग शैल लग में सही से बैठी होनी चाहिए।
a) थ्रस्ट वाशर में ग्रीस अवश्य लगाएं। b) थ्रस्ट वाशर का ग्रूव वाला सिरा बाहर की तरफ हो।

Table 19, Quality Key Points

8.3.3 Reaction Plan

There are several different processes performed on the workstation. Each process can have any abnormality. Hence the operators are also trained to react as per the faced abnormality.

It can be anything like stopping the production line or immediately calling the supervisor.

For Abnormality Reaction Plan
कोई भी प्रॉब्लम आने पर अपने लाइन इंचार्ज को संपर्क करें।
कोई भी प्रॉब्लम आने पर अपने लाइन इंचार्ज को संपर्क करें।
कोई भी प्रॉब्लम आने पर अपने लाइन इंचार्ज को संपर्क करें।

Table 20, Reaction Plan

8.3.4` Process steps photograph

These play a vital role during the audit. They help the person to identify if the process is being done correctly by the operator. Also sometimes operators can also use it for their reference.

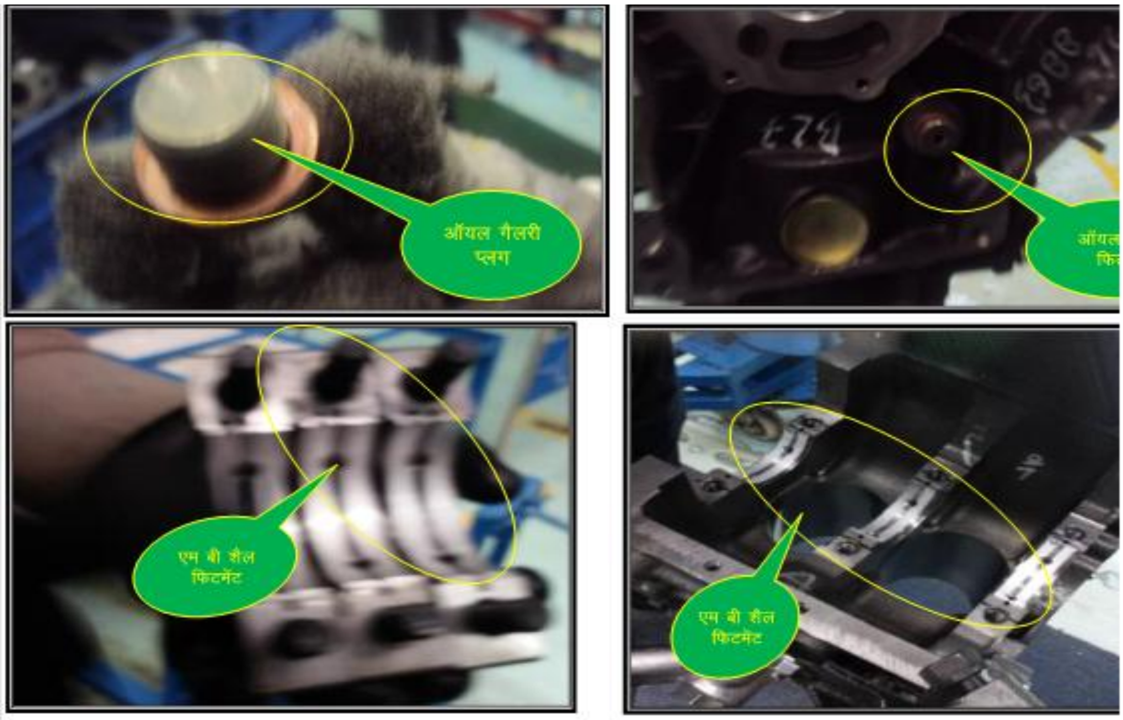


Figure 43, Process steps

8.3.5 Part Description

This section contains all the major steps involved in the process. It includes part number of the parts, their name, quantity and the model.

PART DETAIL				
Part Code	Part No.	Part Description	Model	Validity
1	NA	OIL GALLERY	275IDI	1
2	NA	CU WASHER	275IDI	1
3	279003123112	MB CELL	275IDI	6
4	279003123117118	THRUST WASHER	275IDI	2

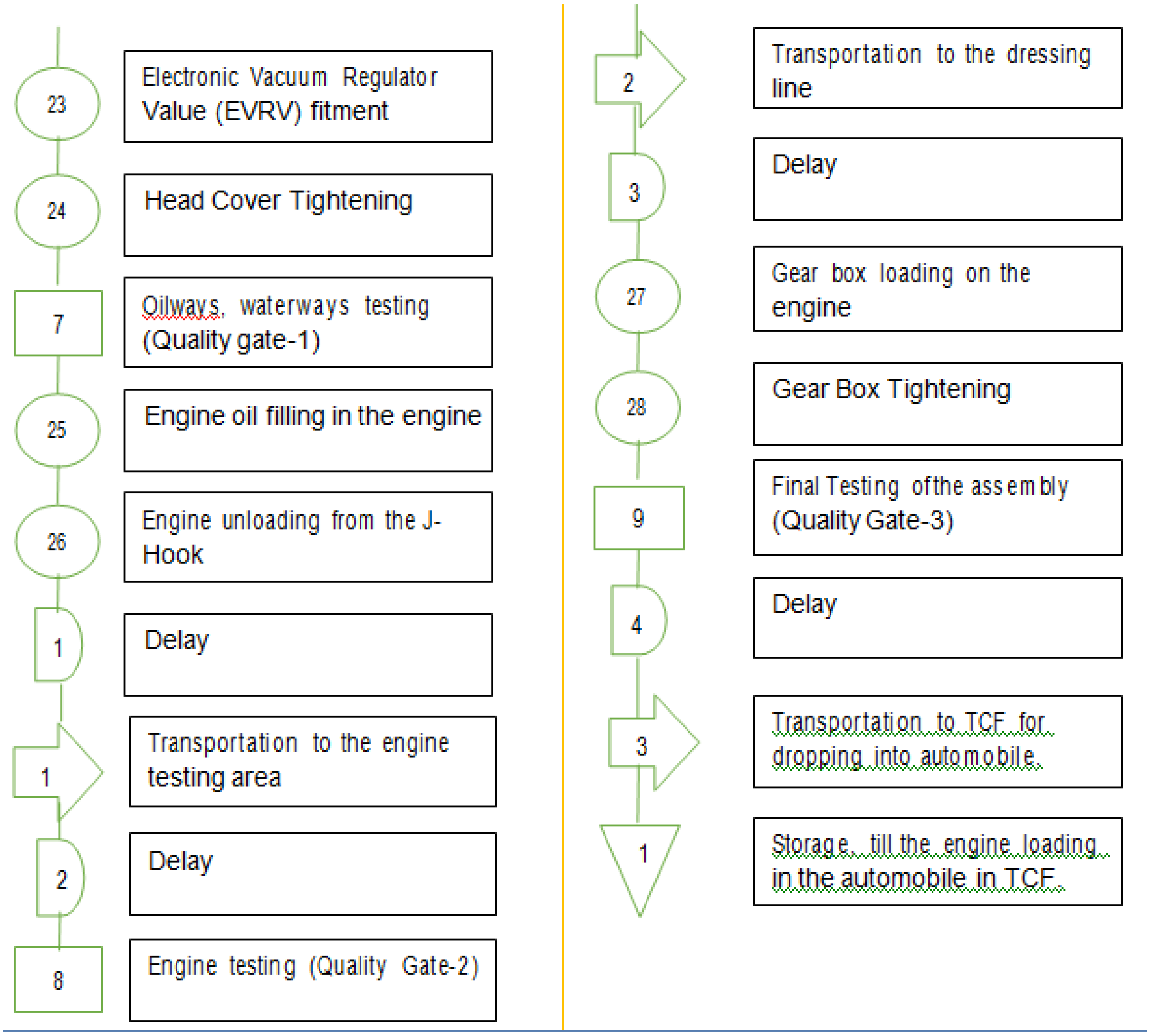
Table 21, Part Description

8.4 Process Flow Diagram

TYPE	DESCREPTION
○ 1	Engineblock loading on J hook
○ 2	Crank shaft dropping
○ 3	Main Bearing cap tightening
○ 4	Oilpump, waterpump, rear cover fitment
□ 1	Oil Pump seal inspection
○ 5	Piston Dropping
□ 2	Piston grade, con rod and con rod cap number match
○ 6	Connecting rod cap tightening
□ 3	Axial play check
○ 7	Oil sump fitment
□ 4	Main Bearing Shell detection
○ 8	Alternator fitment
○ 9	Fly wheel, clutch plate, pressure plate fitment
○ 10	Water inlet elbow, water by pass tube fitment

TYPE	DESCREPTION
□ 5	Piston topping check
○ 11	Cylinder head dropping
○ 12	Damper pulley, cam gear, idler, tensioner fitment
○ 13	Fuel Injection Pump (FIP), FIP gear fitment
○ 14	Timing belt fitment and tension
○ 15	Exhaust manifold fitment
○ 16	Fuel Injection Pump setting.
□ 6	Fuel Injection Pump setting check
○ 17	Inlet manifold fitment
○ 18	High pressure line, head cover loose fitment
○ 19	Exhaust gas Recirculation (EGR) fitment
○ 20	Upper Cooling line (UCL) fitment
○ 21	Oil separator fitment
○ 22	Oil filter torqueing with torque wrench

Continued..



Flow Chart 14, PFD 275IDI

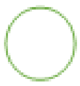
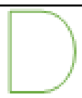
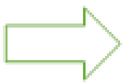
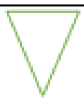
SR No.	**SYMBOL**	**MEANING**
1		Operation
2		Inspection
3		Delay
4		Transportation
5		Storage

Table 22, PFD symbols

8.5 Sample WIS

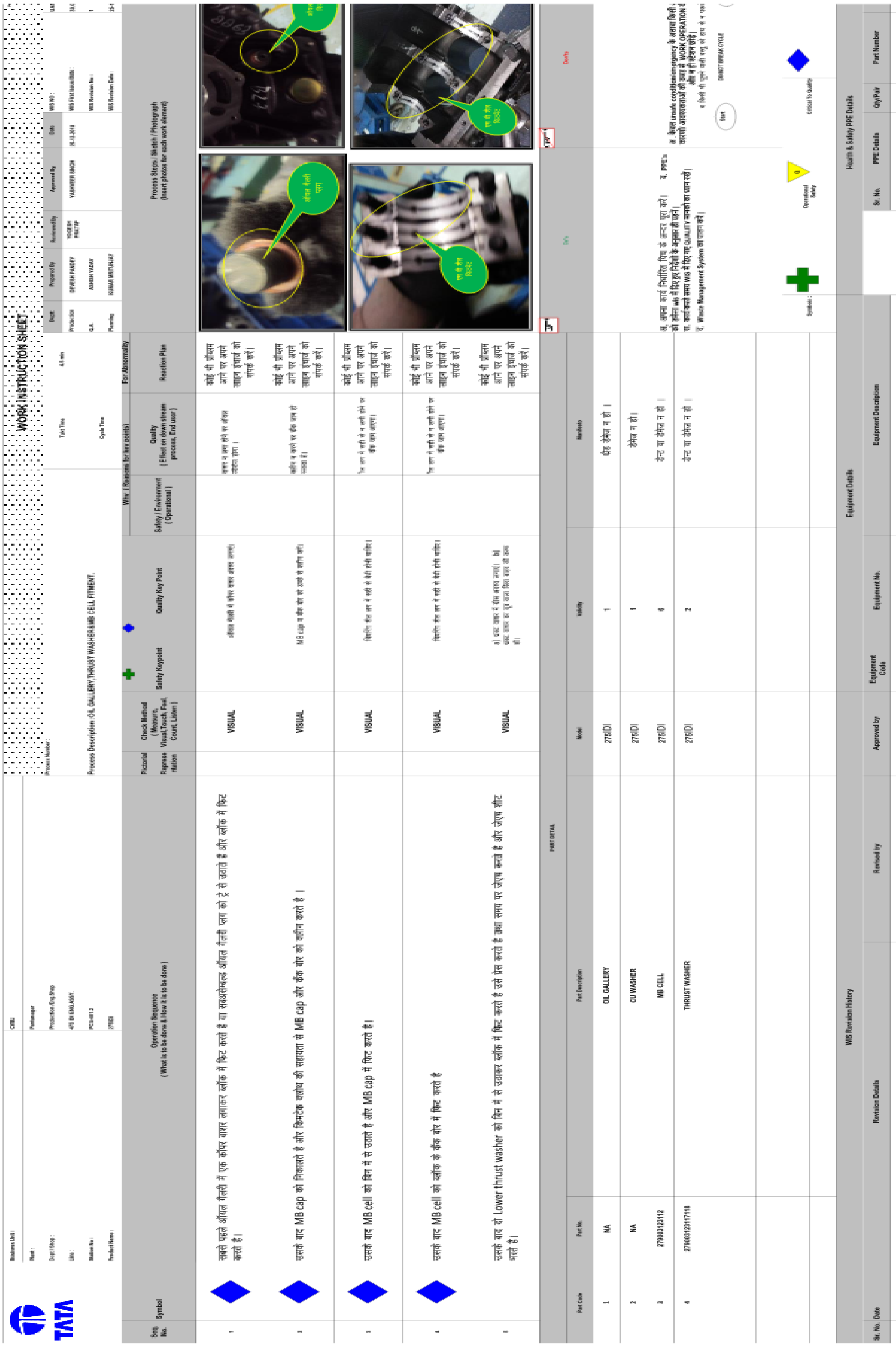


Table 23, Sample WIS

8.6 Steps Involved

- Gemba observation to be done on each workstation.
- With help of the WIS of 275 IDI model from the 2 cylinder assembly line, modify the sheets for the 275 IDI for 4 cylinder line.
- Correct the process and note it down physically and hand over to the assigned person for Hindi typing.
- For further understanding of the production system a process flow diagram is to be made as the part of this project.
- Process Flow Diagram of the engine starting from the attachment of block on the J-Hook to the dispatch to the trim chassis fitment (TCF) where the engine is attached in the automobile.

8.7 Result

There were 20 workstations in the 475 assembly line. Hence 20 work instruction sheets (WIS) were made, printed on the A3 paper and set up on the assembly line. Following are the learning outcomes of the project.

- Learnt about the importance of the WIS for the operators in the industry.
- Basically learning the engine assembly was outcome of this project.
- Importance of small steps in an industry e.g. keeping the torque wrench in the bin. This helps in the operator safety and less wear out of the equipment.

8.8 Learning Outcomes

- Learnt about the importance of the WIS for the operators in the industry.
- Basically learning the whole engine assembly was the outcome of this project.
- Importance of small steps in an industry e.g. keeping the torque wrench in the bin. This helps in the operator safety and less wear out of the equipment.

9.1 Conclusion

It was a great opportunity to work in TATA MOTORS, Pantnagar. The work carried out at the industry was of varied nature, where it gave me chance to work on different areas like mechanical, electrical and computer. During the tenure of the internship, I learnt how a commercial vehicle differs from each other, not only in their shape and size but technically also.

Since my department was Engine shop, I learnt how important production and quality go hand in hand in the company. Production and quality department are two Supporting pillar. Even if one of the pillars fall, the whole building crumbles.

9.2 Learning Outcomes

Working in a Manufacturing MNC was a great experience, one learns a lot about how a company competes with its international competitors and what technology and tools are used for implementing the same. I learned that company is very strict about its policies such as quality and safety. Company sends a lot of money on implementing the same.

Major learning outcomes were-

- How the production takes place in the big industry.
- Cycle time of the assembly line.
- Implementation of extensive industrial training.
- Industry standards for the working environment.
- Use of the safety shoes and helmet.
- Industry hierarchy of jobs.
- Importance of working in the team.
- How to find the root cause of a problem’
- Importance of PFMEA and WIS sheets in an industry.
- How to present yourself in front of executives.

9.3 References

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19. Images- Engine Shop, Powertrain, Tata Motors Limited, Pantnagar

APPENDICES

Appendix-1

Section A:

PROJECT SEMESTER		
Student Name: Manas Asija	**Regd No: 101788031**	
Branch: Mechanical (MEE)	**Faculty Supervisor: Dr. RS Joshi**	
Host Organization & Address: **TATA MOTORS LTD, Plot No.1, Sector 11, Integrated Industrial Estate, SIDCUL, Pantnagar-263145**		
Industry Mentor with email and contact number: **DEVESH PANDEY, devesh.pandey@tatamotors.com , 08791062843**		
A. As a result of completing this component, please take some time to reflect and highlight below three areas (mention at least three) of new learning or insight for you, including references for further reading cited? *Note to student: A1+A2+A3 together should be a minimum of 500 words. Enter word count here_566_*		
Student Input	**Faculty Supervisor Comments**	
A1. **Since I have been deputed in the engine shop, I have been tasked with reducing leakage fall out in 275 IDI engine by top process issue. Top process issue comprises of topmost defects contributors. Firstly to understand why the defect is coming we need to know the process, so I had seen all the assembly of 275 IDI to begin with right from the main bearing shells placements, crank shaft dropping, alternator fitment, oil sump fitment, flywheel and clutch plate fitment to the belt timing, head dropping oilways and waterways testing. For the project I have collected data for the 3 months i.e. October, November, December for the reference and plan onto a complete a pareto analysis, causation and effectuation diagrams(fishbone), why-why analysis of the defects. Using this information, I will develop a corrective action plan and implement necessary process improvement changes to reduce the leakage fallout hence improving the productivity of the engines. The preliminary data shows that the largest contributors include head cover leakage, water by pass tube leakage and the water sensor adaptor leakage. After dealing with these 3 I will look forward onto further defects. Till date I have examined the process of head cover issue and the water adaptor sensor and have done pareto analysis, fishbone for the same and had also made the action plan for the cylinder head cover leakage. In head cover major leakages fall outs were because of the gasket damage issue, dome nut, washer issue, variable thickness of rubber bush, and crack on the head cover. As for water adaptor sensor the contributors were metal to metal contact at the time of assembly, washer damage. Further I will study deeper for the same and hopefully will be able to complete my project reducing the leakage.**		

A2. **The other project discussed with me is on updatation of WIS (work instruction sheet) of the 275 IDI on 475 assembly line. A WIS lists all the steps of the job, detailing small to small activity that may be required to complete the job correctly and safely with utmost quality and efficiency. To balance the workload, now 2 cylinder engines are being assembled on 475 line (4 cylinder line). The tact time in high on the 4 cylinder line as per the demand and hence the process has been designed that way. That is the reason the operations are somewhat different. For e.g. the process done earlier in 275 line might be done later in 475 line for the same model of engine. Currently I am using the older WIS and updating ones till the latest date. There are currently 20 workstation on 475 line.**	
A3. **The third project I have planned is on designing the PFMEA sheet (Potential Failure Mode and Effect Analysis sheet) of the 275 IDI on 475 line. It helps to identify possible risks and errors which may come from the various sources 6Ms (Man, Method, Machine, Measurement, Mother Nature, Material).Initially we have to write the elemental steps of the workstation. This includes the smallest of the smallest step. Then we identify all possible errors and segregate them into various 16 error modes. Then product characteristics matrix is made followed by the fishbone diagram. Finally the PFMEA is made and the RPN is calculated. It is the multiple of 3 factors- Occurrence, Severity, Detection. The value has to be lower than the one given by the quality team.**	

Appendix -2

Section :B

Student Input	Faculty Supervisor Comments
B1. **The shop management has informed all the concerned staff in the shop about the defect analysis study and has given me the necessary data for the previous months to study, analyse and hence improve. I have also been helped by the operators to understand the basic operations of the 275 IDI assembly. I have also been provided with various documents such as PFD, WIS, PFMEA, CP, station deployment work station sheets for the proper understanding.**	
B2. **My mentor has provided me with the literature why-why analysis, 7 QC tools. I will use this literature for formulating my strategy for completing the study along with discussion with my mentor. The company has also provided with earlier reports of similar kind which I can use for reference.**	
B3. **I will be using standard books such as Kaizen Express, Wikipedia from the internet for the better study of PFMEA. Older formats also makes the study easy and complete. WIS of the other line i.e. 275 line helps in writing the elemental steps as per the latest format adopted by the company.**	