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REDUCTION OF M8 LEAKAGES IN FRONT FORK ASSEMBLY CELL

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A B S T R A C T

Front fork is one of the part of suspension system. Front fork serves as rigidity component just like a frame in two and three wheeler vehicle. As it is an important part of the suspension system but the manufacturers of front fork assembly is facing the leakage problem. The purpose of the study is to detect and reduce M8 leakages in front fork assembly and to reduce the rejection rate due to leakages.

In this study also the analysis of different materials when used for manufacturing of oil seal has been carried and also the theoretical as well analytical analysis has been done. For analytical analysis Ansys workbench ver.2022 has been used.

There are various parameters responsible for M8 leakages in front fork assembly, few parameters like pressure and torque contributes to more rejection rate. So, these parameters are considered for study. This study and analysis of the parameters, will not only help to increase the profit of the company but also help to improve the quality of front forks assembly

1. Main text

Gabriel India Limited is the flagship company of ANAND and a leading name in the Indian Auto Company Industry. Established in 24 February 1961, the company provides the widest range of ride control products in India, including Shock Absorbers, Struts, and Front Forks, across every automotive segment with over 300 product models offered. Gabriel India Limited has located in various location such as Nasik Maharashtra, Devas Madhya Pradesh, Gurgaon Haryana, Pune Maharashtra, Parwanoo Himachal Pradesh, Hosur Tamil Nadu, Noida Uttar Pradesh, Ahmedabad Gujarat, Mumbai Maharashtra.

Every new technology is being developed and hence the competition is increased a lot. In order to survive in this competitive world there should be fast growth in company Quality with higher accuracy. After finishing our sixth semester exam we were recruited for the industrial training in "GABRIEL" India Limited Nasik Maharashtra.

In that company there are two shops, the first one is 'Front Fork' & the second one is 'Shock Absorbers'. We were in Shock Absorber division. In shock absorber there are two lines i.e. Assembly line and Production Line. We worked on both lines. In shock absorber, there are 3 main parts such as Outer tube, Inner tube and Piston rod assembly. During our training period we noticed the Hard Movement issue in shock damper assembly is more in all defect. From all these problems, we selected Hard Movement problem for our project. Shock absorber is used in suspension system of all vehicles to reduce the vibration occurring due to the uneven roads and balancing of vehicle is properly done.

It has been studied that the most of the front fork assembly parts are rejected due to the M8 leakages. According to the company production data available and the discussion with concerned authority, the rejection rate due to M8 leakages is around 5% of total production. The main aim of the project is to find solutions to reduce the number of rejections due to M8 leakages. The analysis helps to increase the production of front fork of any company. It would help to reduce the rework cost and increase the customer satisfaction for the product. The scope of the project is to study the process of the assembly line and study the various parameters that might affect the leakages in front fork.

Nomenclature

I/T	Inner Tube	Kg/m^3	Kilogram per Meter Cube
O/T	Outer Tube	H_2S	Hydrogen Sulphide
Kg Cm	Kilogram Centimeter Torque Unit	CO_2	Carbon-di-oxide
Bar	PressureUnit	d_m	Diameter of Oil Seal
Φ	Diameter	t_m	Minimum Thickness
IGES	Initial Graphics Exchange	*P*	Pressure
N	Force in Newton	*W*	Weight

HO	Higher Order	σ_w	Longitudenal Stress
N/Sq.M	Newton per Square Meter	σ_x	Stress
ISO	International Organization of Standardization	σ_{eq}	Equivalent Stress
SAE	Society of Automotive Engineers	σ_c	Hooke's Stress
lb/ln3	Pound per Cubic Inch	σ_b	Bending Stress
°C	Degree Celsius	σ_R	Radial Stress
°F	Degree Ferranite	*Mpa*	Megapascal

1.1. Structure

Figure.1.1. Front Fork Assembly[Company Reference]

Gabriel manufactures world class front forks for different categories of vehicles namely scooters, commuter bikes and premium bikes. The patented design ensures reduced frictional force offering a noiseless experience. Our facilities for special alloy castings ensure higher safety and robustness standards for the premium segment. The figure 1.1 shows assembly of front fork

1.1.1. List of Parts of Front Fork:-

i. Piston Ring:- A piston ring is a split ring that fits into a groove on the outer diameter of a piston. The main function of piston ring is to maintain the proper quantity of the oil between the piston and the cylinder wall.

ii. Fork Tube Cap:- The fork tube cap is the part of a cycle's tubular frame within which the front fork steerer tube is mounted. On a motorcycle, the "fork tube cap" is normally called the steering head.

iii. Fork Spring:- The Role of Springs in Suspension Systems is to absorb minimal shocks. Any spring, whether it's a leaf, torsion or coil spring, must compensate for irregularities in the road surface, maintain the suspension system at a predetermined height and support added weight without excessive sagging.

iv. Piston:- A piston is a mechanical or hydraulic device designed to absorb and damp shock impulses. It does this by converting the kinetic energy of the shock into another form of energy (typically heat) which is then dissipated.

v. Rebound Spring:- Helical compressions springs of flat and round wire with linear and progressive characteristic are being used for controlled spring deflection in vehicle shock absorbers.

vi. Fork Tube Bushing:- It provides an interface between two parts, damping the energy transmitted through the bushing. A common application is in vehicle suspension systems, where a bushing made of rubber (or, more often, synthetic rubber or polyurethane) separates the faces of two metal objects while allowing a certain amount of movement.

vii. Socket Bolt:- Bolts use a wide variety of head designs, as do screws. These are designed to engage with the tool used to tighten them. Some bolt heads instead lock the bolt in place, so that it does not move and a tool is only needed for the nut end.

viii. Slider:- Slider is the outer rod of front fork assembly. Piston is inserted in Inner rod and both inner rod and piston is guided by slider.

ix. Backup Ring:- A back-up ring is a rigid ring that holds an elastomeric seal or plastic (such as Polyethylene) connection to its designed shape and in its correct place. Back up rings are commonly used with O-rings, lip seals, and as reciprocating shaft seals.

x. Oil Seal:- Oil seal is a device (as a gland with packing) for preventing the escape or entrance of oil. The function of the oil seal is to stop whatever fluid is inside from leaking out the clearance between the shaft and housing. The seal may also be used to prevent outside materials, such as dirt, from moving in through the clearance.

xi. Stop Ring:- The function of Stop ring is to restrict the over damping of the piston from the inner rod. The stop ring for fork tube is a component suitable for the production of single acting piston rod.

xii. Dust Seal:- Bearing seals can prevent lubricants from escaping and stop dust, water and other harmful substances such as metal particles from getting into the bearing. By doing so, they help to ensure that bearings last as long as possible.

xiii. Fork Tube:- A fork typically consists of two blades which are joined at the top by a fork crown. It is a inner tube of the front fork assembly, in which piston is inserted and inner tube & outer tube assembled together.

xiv. Fork Tube Spacer:- The stack height of a frame and fork is the difference between the steerer tube length and the head tube length. If the headset has a lower stack height than the frame and fork, spacers are added to make up the difference.

(i) Piston Ring

(ii) Fork Tube Cap

(iii) Fork Spring

(iv) Piston

(v) Rebound Spring

(vi) Fork Tube Bushing

(vii) Socket Bolt

(viii) Slider

(ix) Backup Ring

(x) Oil Seal

(xi) Stop Ring

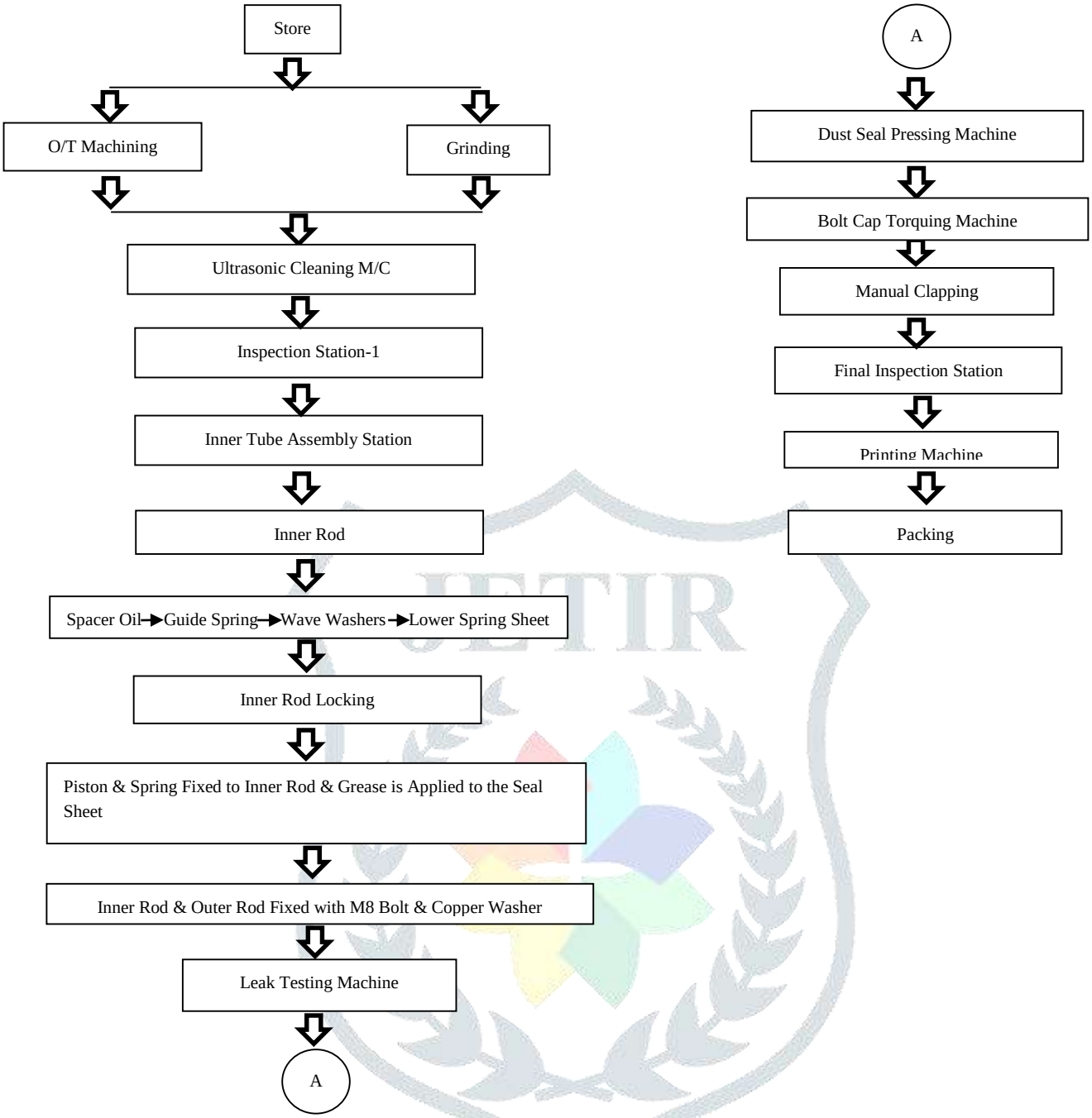
(xii) Dust Seal

(xiii) Fork Tube

(xiv) Fork Tube Spacer

Figure.1.2.Detailed List of Parts of Front Fork[Company Reference]

1.1.2. Front Fork Assembly Flowchart:-



2. Methodology

Considering the problem statement of this project, the production data has been collected from the production catalogue and analyzed by various statistical and analytical tools. The various leakage problems can be identified by study, observation and past history of production line. The important factors affecting the leakage can be identified by reliability analysis. After identifying the most important reason of leakage, the appropriate solution will be implemented reduce the rejection rate and ultimately to increase productivity.

2.1 Problem Selection:-

In company, there were two shops the first one is 'Front Fork' and the second one is 'Shocks'. We were in the Front Fork division. In Shock Assembly there were also lines i.e. Assembly Line & Production. We had worked in both Production as well as Assembly line for 'M8 Oil Leakages. During our training period, we had identified various problem in some machine and collect the data for rejection work. From these all the problems, we have selected one problem for our project i.e. M8 Oil Leakagae in Front Fork Assembly.

Before some months, the M8 Oil Leakages rejection were more coming in the company. The Hard Movement will come due to many reasons which has been listed above. This was a big problem for the company. This would may also affect the company's reputation in the market. There was 1.11 percent rejection work which was the main disadvantage forming for all the defect in shock absorber cell. Due to M8 Oil Leakage, there was 0.45 percent rejection work.

After selection of the problem we started to find the cause because of problem occurs. Then after finding the cause because of which the problem occurs; we started to find out the root cause of M8 Oil Leakage and jerky due to incomplete seal pressing in seal pressing machine. The machine is special

purpose machine so only one operation was conducted on that machine. We also observed each and every process which was carried out on different machine carefully in the assembly cell and find the cause to incomplete seal pressing and alignment in seal pressing is not good.

2.2. List of Problems Identified:-

1) The case cap was not ok or missing in the shock damper assembly:
   Cause: Human error or machine error.
2) Hard movement / Jerk in shock damper assembly:
   Cause: Child part was not as per drawing.
3) Inner tube or piston not ok:
   Cause: Spindle T.I.R. not ok.
4) Inner diameter not ok:
   Cause: Ball burnishing (from supplier side was not done/ok).
   It was detected after the assembly of the shock absorber.
5) Piston rod run out:
   Cause: Burr & chips accumulation in collet.
6) Oil quantity not ok:
   Cause: Filling excess or less quantity of oil in the outer tube due to manual setting in machine.

2.3. Problem Definition:-

Earlier in the company on shock damper assembly cell, there was machining operation done. Due to this operation, some Hard Movement will come. The Hard Movement was also come due to raw material. For raw material, the certain parameter was wrong. Due to this, Hard Movement was coming. For overall rejection (4508), the quality of Hard Movement is 2540 in shock damper assembly. If 1piece price is 200 then Rs. 5,08,000 are utilized for rework per month which was main disadvantage for company.

2.4. Objective:-

1) To collect and analyze data related to front fork assembly.
2) To identify various leakaging causes.
3) To focus on the major problems and finding its solution.
4) To reduce the leakages in the Front Fork assembly and rejection rate of the product.
5) To increase the productivity of the company.
6) To analyze the oil seal parameters with different materials and to carry ou the numerical as well simulation analysis of oil seal.

2.5. Steps involved in Problem Study:-

i. Define the problem, improvement activity, opportunity for improvement, the project goals, and customer (internal and external) requirements.
ii. Measure process performance.
iii. Analyze the process to determine root causes of variation, poor performance
iv. Improve process performance by addressing and eliminating the root causes.
v. Control the improved process and future process performance

2.6. Measure

Table.2.1. Rod Guide Diameter

Before Solution		After Solution	
Sr.No.	Guide Rod Diameter(mm)	Sr.No.	Guide Rod Diameter(mm)
1	18.4	1	23.1
2	18.3	2	23.08
3	18.1	3	23.1
4	18.1	4	23.09
5	18.8	5	23.09
6	18.8	6	2308
7	18.2	7	23.1
8	18.3	8	23.1

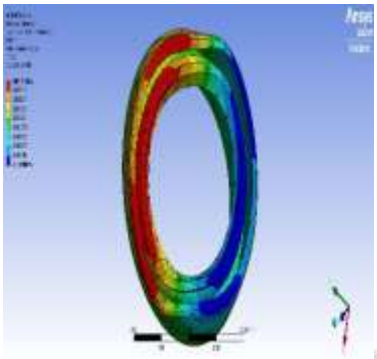
Table.2.2. Locantor Height

Before Solution		After Solution	
Sr.No.	Locator Height(mm)	Sr.No.	Locator Height(mm)
1	6.4	1	8.5
2	7	2	8.4
3	7.1	3	8.55
4	7.2	4	8.4
5	6.9	5	8.5
6	7	6	8.5
7	6.7	7	8.4
8	6.7	8	8.5

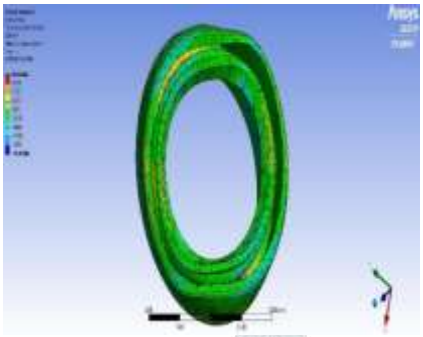
2.7. Front Fork Analysis After Applying Solution

- Fork seals leak from normal wear and tear, age, and debris getting into the seals. .However, the majority of the time your fork seals are leaking it's simply because debris is caught in the seal holding it open and allowing fork oil to sneak by. When you first notice the leak is the best time to take immediate action.
- Oil change without removing Forks:- You will need to remove the caps to refill the fork tubes with oil. Determine if the fork legs have oil drain plugs near the bottom of the legs. If they do, you are in luck and will be able to change the oil without removing the fork legs.
- Fork seals should be replaced as soon as leaking oil is noticed. If the seal is left unchanged, the oil could leak onto the brake pads and ruin your motorcycle or you could run out of oil completely and ruin your motorcycle.

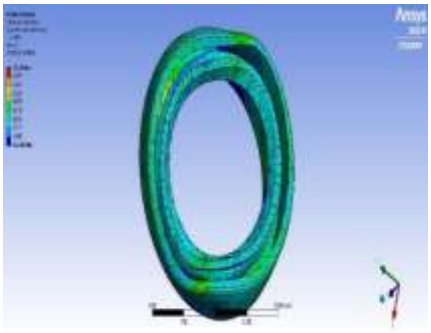
3. SOLUTION



Oil Seal Longitudenal Stress(i)



Oil Seal Bending Stress (ii)



Oil Seal Shear Stress(iii)

Table3.1.Oil Seal Analysis

Results(Mpa)	**Analytical**	**Simualtion**
Longitudenal Stress	0.001154	0.0011604
Bending Stress	20.186	20.614
Shear Stress	30.33	30.334

Table.3.2. Oil Seal Material Wise Comparison

Results(Mpa)/ Materials	Rubber		Neoprene-Rubber		Polyethylene		Silicon(Pure)		PCB Laminate	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Longitudenal Stress	0.0011604	-0.001171	11.215	-9.9777	0.001388	-0.00139	1.083	-1.0279	0.00286	-0.00828
Bending Stress	20.61	-19.397	-	-	17.69	-17.796	187.46	-297.81	14.845	-14.866
Shear Stress	30.334	0.12416	-	-	25.533	0.31466	278.44	10.231	25.702	0.362

Table.3.3. Cost Analysis of Oil Seal

Material	**Cost(Per Oil Seal Raw Material)**	**Rejections out of 100**	**Rework Cost**
Rubber	152	10	1520
Neoprene Rubber	300	12	3600
Polyethylene	110	15	1650
Silicon	585	2	1170
PCB Laminate	950	4	3800

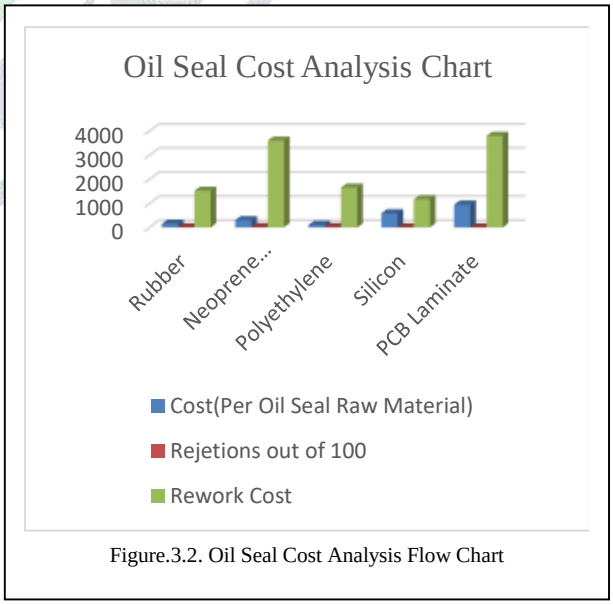


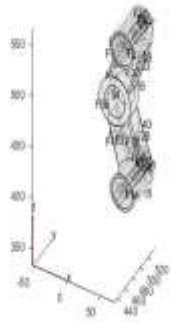
Figure.3.2. Oil Seal Cost Analysis Flow Chart

3.1. MATLAB Code for Analysis

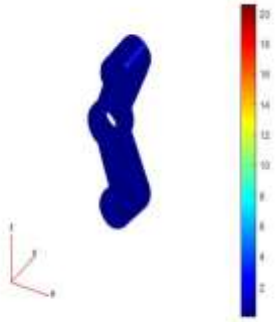
```
model = createpde;
importGeometry(model,'Front Fork Tube.STL');
mesh=generateMesh(model,'Hmax',20,'GeometricOrder','linear');
pdeplot3D(model)
structuralmodel=createpde('structural');
importGeometry(structuralmodel,'Front Fork Tube.STL');
pdegplot(structuralmodel,'FaceLabel','on','FaceAlpha',0.5)
axis equal
generateMesh(structuralmodel);
structuralProperties(structuralmodel,'PoissonsRatio',0.3,'YoungsModulus',210E3);
structuralBC(structuralmodel,'Face',6,'Constraint','fixed');
structuralBoundaryLoad(structuralmodel,'Face',5,'SurfaceTraction',[0;0;-2]);
generateMesh(structuralmodel);
structuralresults = solve(structuralmodel);
figure
pdeplot3D(structuralmodel,'ColorMapData',structuralresults.VonMisesStress,'Deformation',structuralresults.Displacement)
figure
pdeplot3D(structuralmodel,'ColorMapData',structuralresults.VonMisesStress,'Deformation',structuralresults.Displacement,'DeformationScaleFactor',5
00)
```

Similarly, by changing the part model we can do the analysis for other parts too.

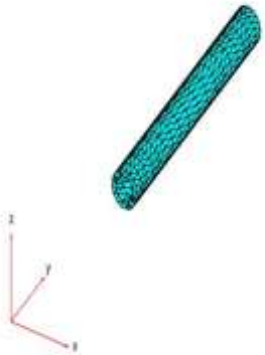
Front Fork Connector Mesh(i)



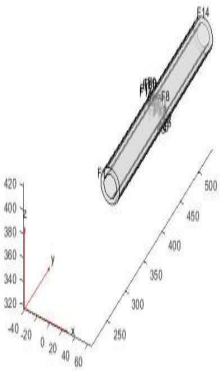
Front Fork Connector Plot(ii)



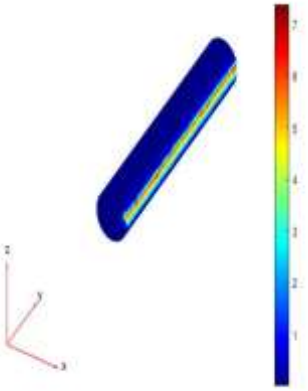
Front Fork Connector Analysis(iii)



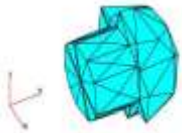
Front Fork Piston Rod Mesh(i)



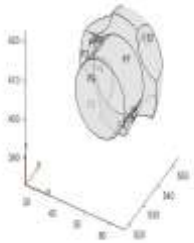
Front Fork Piston Rod Plot(ii)



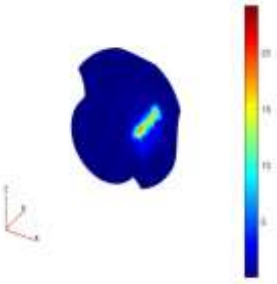
Front Fork Piston Rod Analysis(iii)



Front Fork Socket Bolt Mesh(vii)

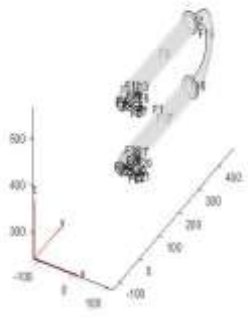


Front Fork Socket Bolt Plot(viii)

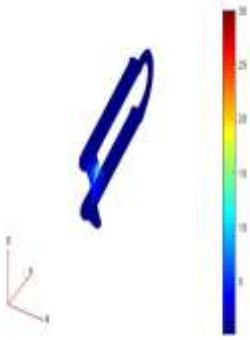


Front Fork Socket Bolt Analysis(ix)

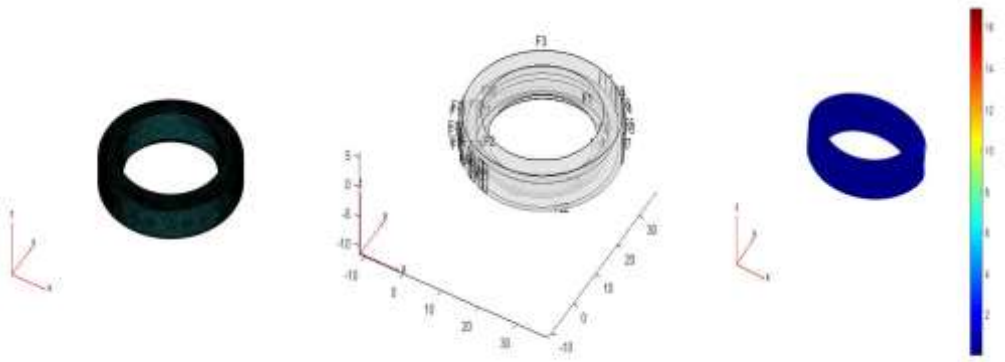
Front Fork Tube Mesh(x)



Front Fork Tube Plot(xi)



Front Fork Tube Analysis(xii)



Front Fork Oil Seal Mesh(xiii) Front Fork Oil Seal Plot(xiv) Front Fork Oil Seal Analysis(xv)

Figure.3.3.Front Fork Parts and Oil Seal Analysis in MATLAB

4. CONCLUSION AND FUTURESCOPE

- This study project was carried out in GABRIEL INDIA LIMITED, NASHIK.
- The identification and analysis of various parameters which affects the leakage in front fork assembly is studied and out of this, two parameters which is majorly contributing to leakage was studied deeply and subsequent solution is found.
- By applying that solutions, the leakage which was 5% of the total production is reduced to 1% of the total production.
- Thus, the aim of the study project was to help company to increase their productivity by solving the leakage problems.
- Theoretical and Analytical analysis of Oil Seal and Different Materials effect on Oil Seal manufacturing has been carried out.
- Also the analysis of Front Fork and Oil Seal carried out in Ansys Workbench 2022 version and MATLAB too.

Conclusion:- The identification and analysis of various parameters which affects the leakage in front fork assembly is studied and out of this, two parameters which is majorly contributing to leakage was studied deeply and subsequent solution is found.

Future Scope:-

This project monitoring can be used to design a real-time intelligent pipeline leak detection and localisation system.

Extensive simulation and practical experiments can be conducted to study the effects of leakage parameters, like size and shape, on the flow mechanism and validate different material models.

The COVID-19 pandemic has negatively impacted the oil seals market, witnessing a significant plunge in 2020. With a number of end users affected in regions like North America, Europe and Asia-Pacific, the supply and shortage in demand are expected to result in a significant drop in Y-O-Y growth, yet FMI expects global oil seals market to grow at 3.3% CAGR through 2031.

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