International Journal of Advance Research in Science and Engineering
Volume No.07, Issue No.02, February 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

AUTOMATION AND UPGRADATION OF METALLIC FUEL TANK TEST FACILITY

Shantanu A. Apte[1], Hrishikesh Huddar[2], Siddharth Harpude[3]

[1,2,3]*Mechanical, RMD Sinhgad School of Engineering, Savitribai Phule Pune University,(India).*

ABSTRACT

Before launching a vehicle in the market, various tests are performed on it. Even if it fails one test, the company cannot launch the vehicle in the market. One of the major tests that the vehicle undergoes is that of its fuel tank. This test detects any kind of leakage that might happen in a fuel tank because of fault in its manufacturing. This test utilizes a setup which rotates the fuel tank, filled with nonflammable liquid (preferably water), in order to detect the leakage. This test setup, available now, is worked manually. In this project, the center of attention will be to make this test setup automatic with use of appropriate motor, gear drives and sensors. The outcome is expected to improve the efficiency and reduce the time invested in manual setup.

Keywords : Fuel Tank, Test Setup Automatic

I.INTRODUCTION

Everyone needs a car in today's world. There is a vehicle in every house now a days. We commute daily to workplace, to gym, to buy groceries using our vehicles. So our vehicles need to be maintained in a good condition for vehicle's and our own safety. There might be many flaws in vehicle that we might come across like flaw in suspension felt while crossing a speed bump, or in structure of chassis or in its fuel tank. And before we come to know about the flaws, damage is already done. Therefore it is necessary to take care of these flaws while manufacturing itself. And thus it is necessary to perform various tests on vehicle before its launch in the market.

If we talk about India, there are a few government institutes which conduct these tests on vehicles. The SHL department (Safety and Homologation Laboratory) conducts the overturn fuel tank leakage test. This is a new method of testingthe leakage in fuel tanks. The fuel tank is mounted on a rotating beam. The fuel tank is rotated manually by 360 degrees at an interval of 90 degrees. The fuel tank is filled with non-flammable fuel, preferably water. The tank is then rotated manually at 90 degrees and held there for minimum 5 minutes to check for any leakages from the tank.

1.1 Problem Statement

To design, develop and automate the existing overturn leakage test system of a fuel tank to minimize the human efforts along with increasing the efficiency of the test.

1.2 Objectives

- To automate the existing setup
- To stop the rotation of the fuel tank at the given instances (900,1800,2700,3600)
- To complete the one revolution of the fuel tank in 2-3 minutes
- To hold the fuel tank at the given instances for 3-5 minutes
- To increase the efficiency of the test.

1.3 Scope

- Automation of manual test set up by changing the drive system.
- In order to reduce the human efforts for carrying out the test, a worm gearbox facility will be provided
- Validation of test setup

1.4 Methodology

A motor, of pre-determined torque will be used for automation of the setup. As the speed of the motor is way to high that what we require for the fuel tank testing, worm gear box will be used to reduce the rpm. To stop the setup at exact 90, 180, 270 and 360 degrees, a locking system would be setup as well.

II.LITERATURE REVIEW

To put in simple terms, a leakage is basically a liquid escaping from a container or a tank. Any kind of leakage maybe a fuel leakage or a gas leakage is always unintentional and unwanted. Therefore, any container or fuel tank or vessels are tested for leakages before it is dispatched. There are many tests to find out leakages like Helium Test, Pressure Change Process Test, Overturn Leakage Test to name a few.

2.1 TYPES OF LEAKAGE TESTS

a) Hydrostatic leakage test

b) Helium leakage test

c) Non-Destructive Testing

2.1.1 Hydrostatic leakage test

To test pressure vessels, condensers for leakages, Hydrostatic leakage test is performed. In this test, a liquid, usually water is filled inside the condenser. A color maybe added to the liquid for better results. Then both the sides of the condensers are tightened and pressure is applied. After a pre-determined amount of pressure is reached, the entire setup is kept in the same way for about one to two hours. A visual inspection is done and the location of the leakage is identified with naked eye. Therefore the liquid is usually dyed for easier detection of the leakage.

2.1.2 Helium leakage test

In this type of test, Helium gas is used as the detector gas. Helium gas is introduced to test part which is connected to the leakage detector. Advantages of using Helium as leak detector gas is that it is non-toxic, inflammable, inert. Also using helium is comparatively cheaper than using any other gas. This test is also known as Mass Spectrometer Leak Detector (MSLD).

2.1.3 Overturn leakage test

2.1.3.1 Experimental Procedure

- The tank along with its accessories must be mounted on to a test fixture in a mannercorresponding to the mode of installation on the vehicle for which the tank isintended; this also applies to a system for the compensation of the interior excesspressure.
- The fuel tank to be tested is fixed on the test fixture with the help of elasticstrapping belts.
- The test fixture shall rotate about an axis lying parallel to the longitudinal vehicleaxis.
- The test shall be carried out with the tank filled to 90% of its capacity and also30% of its capacity with a non-flammable liquid having a density and a viscosity close to those of the fuel normally used (water may be accepted).
- The tank must be turned from its installed position 90° to the right. The tank mustremain in this position, for at least five minutes. The tank is turned manually withthe help of a handle. The handle is connected to a pair of worm gear. The tankremains in its position due to the self-locking system of the worm gear. Also, forsafety a fulcrum pin is inserted in the holes provided to lock the tank at certainangles.
- The tank must then be turned 90° further in the same direction. The tank must beheld in this position, in which it is completely inverted, for at least another 5minutes.
- The tank must be rotated back to its normal position. Testing liquid which has notflowed back from the venting system into the tank must be drained andreplenished if necessary.
- The tank must be rotated 90° in the opposite direction and left for at least 5minutes in this position.
- The tank must be rotated 90°further in the same direction. This completely inverted position must maintained for at least 5 minutes. Afterwards, the tankmust be rotated back to its normal position.
- The rotation rate for each successive increment of 90° shall take place in any timeinterval from 1 to 3 minutes.

The cars experience accidents due to rash driving. The cars may get tumbled and overturned. The tank may experience leakage if overturned. Or even when the car is stationary, due to evaporation the fuel may get wasted. Thus to avoid this wastage of fuel overturn leakage test is used. The overturn test ensures that the tank will not leak in the event of a roll-over.

The utility model provides an overturn testing machine for a fuel tank. The overturn testing machine for the fuel tank includes a support. A rotary plate is arranged on the support. One end of the rotary plate is fixed on the support while the other end is rotatable. A rotary shaft is installed on a rotary end of the rotary plate. A fuel tank support is arranged in the center of the rotary shaft. Two ends of the supports are provided with handles. The fuel tank support can be rotated through rotating the rotary shaft, so that the fuel tank is driven to rotate in 180 degrees. Therefore, tightness of the fuel tank can be detected conveniently. And the overturn testing machine for

IJARSE
ISSN: 2319-8354

the fuel tank is also provided with a collecting groove for collecting spilled detection liquid, so that convenience is made for recycling and reusing the detection liquid. And the overturn testing machine for the fuel tank is environment-friendly, resource-saving and high in working efficiency.

This utility model relates to a rollover test machine, in particular, relates to a method for detecting the fuel tank is leaking fuel tank rollover test machine.

The fuel tank is mounted on automobiles. The tank is loaded with nonflammable liquid, so the safety of the tank is particularly important. When an accident happens, the vehicle gets overturned. If the tank sealing performance is poor, it will lead to oil spills and thus endanger the safety of the driver's life. In present, the tank tightness testing is done usually manually rotating the tank and then checks whether the tank is sealed completely, but due to manual rotation, inefficiency, and the case sealed well, it is easy to detect liquid spilled on the body or on the ground operator, pollution. Thus, the tank tightness inspection and testing inconvenience, when rotating liquid spilled out of the tank isparticularly important. The present invention aims to provide a method for detecting leakage of the tank by rotating the tank through 180 ° [1] [2].

III.SIMULATION

The figure above is the fixture of the test setup. This fixture rotates about the rotating shaft shown in the figure. Thus to calculate the downward force acting on the rotating shaft we need to calculate the weight of the fixture.

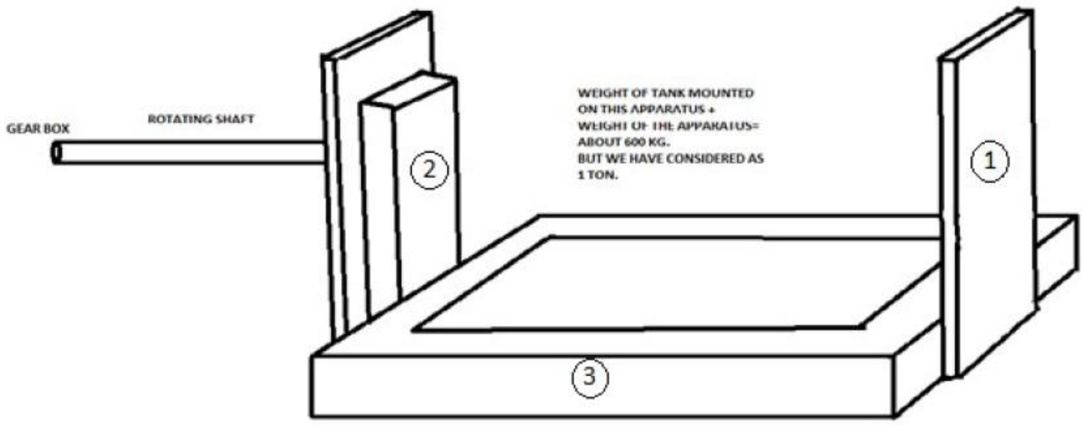

Fig. 1: Rotating Bracket

3.1. Finding the weight of the rotating fixture

We know,

Weight = volume × density ×9.81 …..(3.1.1)

Calculating the volume

1.1 Volume of Part 1:

IJARSE
ISSN: 2319-8354

Volume = l×b×h

where,

l = length

b = breadth

h = height

Volume = [0.02×0.1×0.655]

Volume = 0.00131 m3

Since, we utilize 2 parts, therefore total volume becomes,

Volume = 0.00262 m3

1.2 Volume of Part 2:

Volume = l×b×h

where,

l = length

b = breadth

h = height

Volume = [0.535×0.09×0.05]

Volume = 0.00241 m3

Since, we utilize 2 parts, therefore total volume becomes,

Volume = 0.00482 m3

1.3 Volume of part 3:

Volume = l×b×h

where,

l = length

b = breadth

h = height

Since the part has gap,

Volume of part 3= volume of outer – volume of inner ……(3.1.2)

volume of part 3= (l×b×h)o – (l×b×h)i

volume of part 3= (1.935×0.353×0.1) – (1.83×0.258×0.1)

volume of part 3 = 0.00177 m3

Total volume,

V= V1 + V2 + V3

V=0.00262 + 0.00482 + 0.00177

V = 9.2065 × 10-3 m3

Calcuting Mass,

Mass = Density × Volume ……(3.1.3)

M = ρ× V

M = 7850 ×9.2065 ×10-3

M=72.27 Kg

Therefore,

Weight = Mass × 9.81

W = M×g

w = 72.27 × 9.81

F = 708.98 N

The maximum weight of the tank to be mounted is given as 500 kg. Adding the weight of the apparatus itself it goes to about 600 kg. But for safety the combined weight is considered as 1 ton i.e. 1000 kg. The speed we desire is 1 rpm or less. Since the speed requires is so less, the torque due to inertia is very less. Thus can be neglected during calculation.

Since all the weight is being rotated on the rotating shaft, we shall imagine the setup as follows:

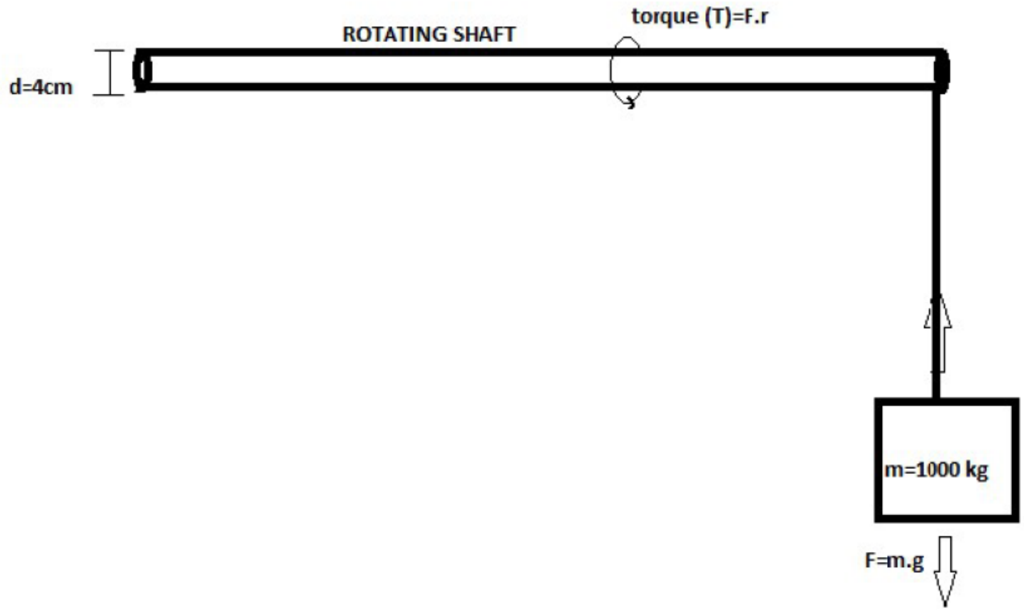

Fig. 2: Assumed loading on shaft

3.2. Motor Selection

3.2.1 Torque (T) calculation:

Given:

F=1000×9.81

r=0.02 m

T = F×r

Where,

T- Torque, N.m

F- Force, N

r- Radius of the rod.

Therefore,

T= (1000×9.81)×0.02

T= 196.2 N.m

3.2.2 Power (W) calculation:

Given:

Torque (T)= 196.2 N.m

Output R.P.M (N)= 1 rpm

W= Torque×speed……(3.2.1)

W= T×2×pi×N/60

W= 196.2×2×3.14×1/60

W= 20.53 Watts

×cross verification of this calculation.

W= m×g×h/t ……(3.2.2)

Where,

h- Height through which the weight is lifted i.e 2×pi×r = 0.1257m

t- Time in seconds= 60 sec, pi = 3.14

W= 1000×9.81×0.1257/60

W= 20.55 Watts

Thus the calculation is verified as correct. This concludes that power required to lift a weight of 1000 kg is 20.55 watts. Therefore, we require a motor having power more than 20.55 watts. Thus a standard motor of 746 watts (1 hp) is selected.

1 hp= 746 watts

also, 1 hp= 33,000 ft.lbs/min.

Thus, we deduce that 1 hp motor can lift 33,000 pounds (approximately 15,000 kg) till a height of 1 foot (0.3048 meter) in 1 minute. Thus, a weight of 1000 kg can be lifted till a height of 1 foot in 0.066 minutes. This speed obtained is fast for our application. The speed can be reduced by the usage of speed reduction gear boxes.

3.3. Selection of Gear Boxes

Since the speed of motor is 1500 rpm and output speed required to us is 1 rpm, the reduction ratio should be 1500:1. We have decided to use worm gear box since it has high efficiency and high reduction ratios. But still we cannot have just a single worm gear box give such a high reduction ratio as 1500:1. Hence, there is a requirement for TWO worm gear boxes of following reduction ratios:

1) 50:1

2) 30:1

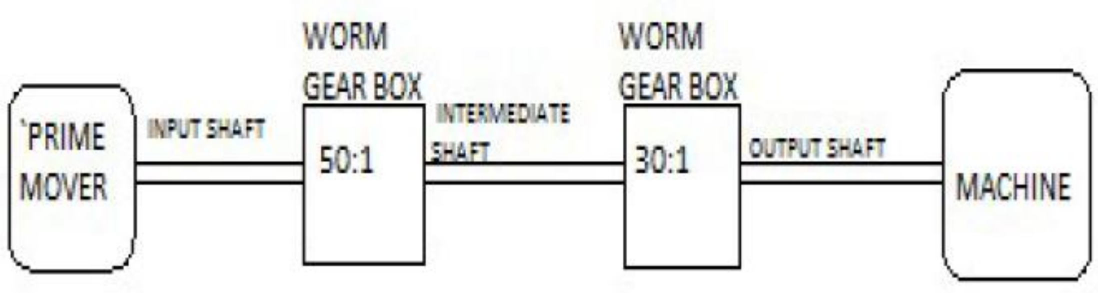

Fig. 3: Proposed Model for Automation

Given:

N1= 1380 rpm N2=?

T1= 4.745 N.m T2=?

To find:

N2, T2, T3.

Solution:

Considering first worm gear box having reduction ratio 50:1

N1/N2=50/1

1500/N2=50/1

N2= 30 rpm

N1×T1=N2×T2

1500×4.745=30×T2

T2= 237.25 N.m

Considering second worm gear box having reduction ration 30:1

N2/N3=T3/T2

30/1=T3/237.25

T3= 7117.5 N.m

Thus, final torque obtained is more than required torque. Also, the required rpm at the output shaft is achieved. Hence the gear boxes selected are feasible.

IV.EXPERIMENTAL VALIDATION

Using Solidworks software, we found out theCenter of Gravity of the setup and the fuel tank. The CG of setup and fuel tank did not match. There was a gap of 46.43mm between CGs of setup and fuel tank. Due to this, the torque required to rotate the setup was very high. We calculated the torque to be 140.35Nm. To produce such high torque high rating motor and large gear boxes were required. Then we came up with the idea of adjusting

International Journal of Advance Research in Science and Engineering
Volume No.07, Issue No.02, February 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

center of gravity of fuel tank and the test setup. We did some changes and made CGs of fuel tank and test setup co-axial to each other. Due to this the torque required to rotate the fuel tank came down to 0 N-m. The only torque required was to overcome the friction of bearings which was quite negligible. The same principle is used in cement concrete mixer. In order to bring CGs co-axial to each other, we had to use a denser material. EN24 AISI 4340 was the most optimum material available. We calculated the dimensions of the shaft as we had to change the material of the setup.

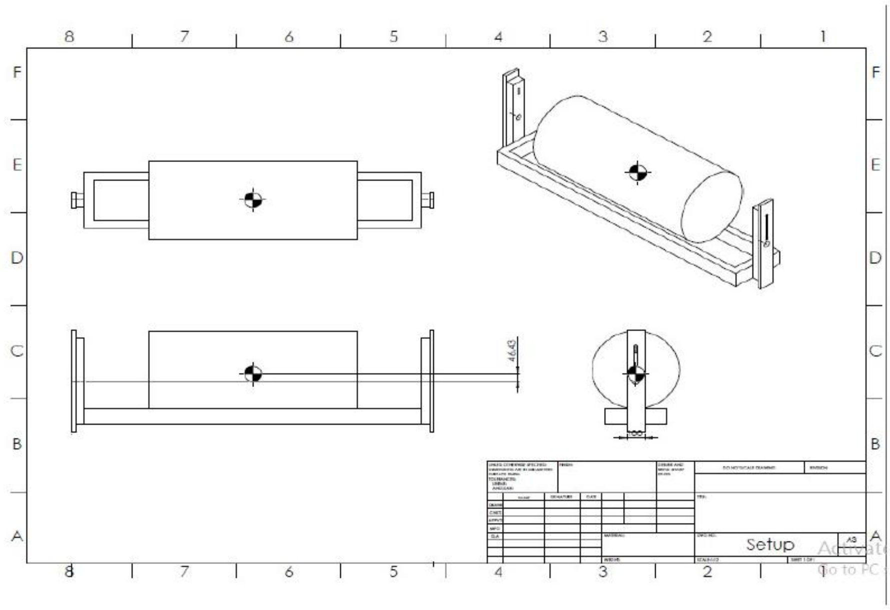

Fig. 4: CAD Drawing of Existing Setup showing CG

Modified Test Setup:

By using the calculated diameter, we produced the CAD Model on Solidworks software. We observed that CGs of setup and fuel tank was almost co-axial, which was the purpose behind changing the material.

Design of shaft EN24

S_{ut} = 1110 N/mm2

S_{yt} = 710 N/mm2

D= 500 mm= 0.5m

$T = W \times D/2$

$T = 1000 \times 0.5/2$

T= 250 N.m

$P_{drum} = 2\pi \times N \times T / 60$ ……(4.1)

P_{drum} = 24.073 W

$\eta = 0.52$

$\eta = P_d / P_{motor}$

P_{motor} = 46.29 W

Tangential load

$T = f_t \times d_g/2$

$d_g = m \times z_g$

$d_g = 12 \times 50$

$d_g = 600mm$

$250 \times 103 = ft \times 600/2$

$f_t = 833.33$ N

$f_t = f_g \times \cos(\Phi)$

Assume $\Phi = 14.5^o$

$f_g = 833.33/\cos(14.5)$

$f_g = 860.75$ N

Max Bending moment

$M = 860.75 \times 150$

$M = 1.291 \times 105$

$\tau = 0.3 \times Syt$ or $\tau = 0.18 \times Sut$

$\tau = 213$ or $\tau = 199.8$

therefore,

$\tau = 199.8$

keyway effect = 0.75×199.8

keyway effect = 149.85

$\pi/16 \times d^3 \times \tau_{per} = [(Kb \times M)^2 + (Kt \times T)^2]^{(1/2)}$ ……(4.2)

$\pi/16 \times d3 \times 149.85 = [(2 \times 1.29 \times 10^5)^2 + (1.5 \times 250 \times 10^3)]^{(1/2)}$

$29.422 \times d3 = 456.2935 \times 103$

$d = 24.91mm \cong 25mm$

Design of shaft based on Shear stress

$\sigma = P/A$

$P = \pi/4 \times d^2 \times \sigma$

$P/\sigma = \pi/4 \times d^2$

$d^2 = 1000x9.81x4 / 225 x \pi$

$d = 55.51$ mm

$d \cong 60$ mm

From the above two dimensions, we select whichever is greater value.

Therefore,

d= 60mm

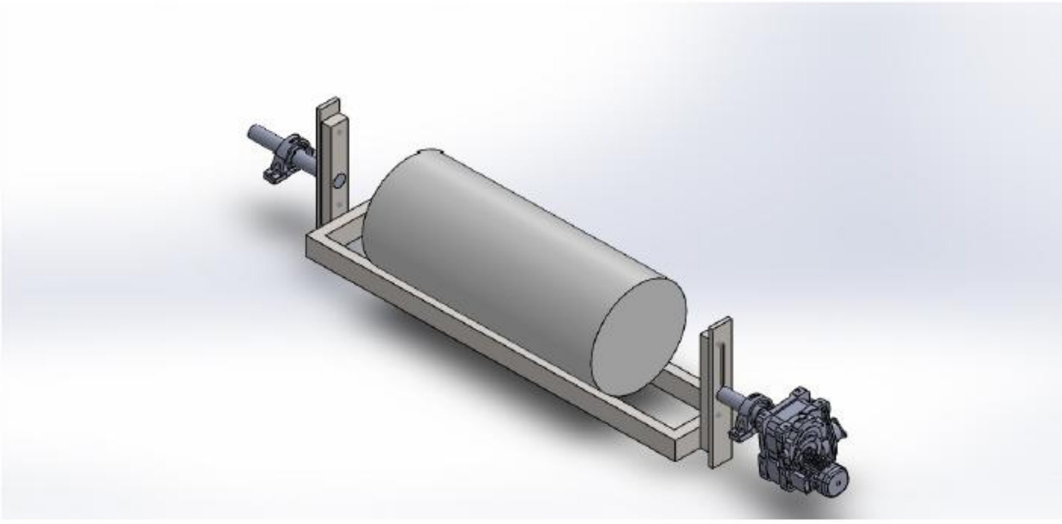

Fig. 5: Final Setup

V.RESULTS

The Fuel tank test facility is automated successfully and experimental results obtained are as follow:

1. The automated test facility requires less man power.
2. The person working on the test setup undergoes less fatigue.
3. The time required to complete one test has been reduced to 20 mins, which is comparatively less than the manual operated test facility.
4. The automated test setup gives more accurate results.

VI.CONCLUSION

The present work includes automating the existing test setup. The model has been developed and tested successfully. With this development the two major problems of more manpower and testing time as well as labour's fatigue can be reduced. Through the trials, it is noted that the machine is more productive and the quality achieved is superior as compare to the manual operated test setup.

VII.FUTURE SCOPE

1. The present model is semi-automatic and it does not have an automatic stopping of tank at different angles.
2. The center of gravities of test setup and fuel tank are not co-axially aligned. Thus they can be aligned and the torque requirement can be reduced significantly.
3. PLC can be used which can automatically sense the angles, and stop the setup at required angle.
4. For speed reduction, other than worm and worm gear drive, microcontrollers and variable frequency drives can be used.

IJARSE
ISSN: 2319-8354

REFERENCES

[1] IS 15547 (2005): Automotive Vehicles- Plastic Fuel Tank for Four wheelers, Bureau of Indian Standards [TED 6: Body, Chassis, Accessories and Garage Equipments].

[2] Mohd. Tanveer Akhtar, R.J. Dahake "Analysis and design modification of fuel tank" IJRITCC Vol. 3 Issue 2 [Pg. No. 038-039].

[3] V.B.Bhandari, "Design of machine elements", 3rd Edition, McGraw-Hill Education (INDIA) Private Limited, 2007.

[4] R.S.Khurmi and J.K.Gupta, "Machine design", 14th Edition, Eurasis Publishing House Private Limited, 2005.

[5] Gitin.M.Maitra "Hand book of gear design", 2nd Edition, Published by Tata McGraw-Hill Education Private. Limited. 2010.

[6] Automotive Research Association of India (ARAI)

[7] Bureau of Indian Standards [IS 13152, Part I, 2013]

[8] https://www.araiindia.com/facilities_safety.asp