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CATIA V5 based Design of Water Test Rig for Validation of Shifter Cable according to JIS D0203 Standard

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Abstract*:* The system is designed for the gear shifter assembly of 4-wheeler. Design of test rig is based on CATIA V5 to give detail dimensional assembly of system. The gear shifter lever is connected to pneumatic cylinder to move shifter as per vehicle routing condition. The water is sprayed on shifter cable with the help of slurry pump at a constant flow of 25 LPM & pressure of 0.1 MPa. This paper provides comparison of force required for gear shifter in Characterization Test Bench before & after testing shifter cable under water.

Keywords*:* CATIA V5, Gear shifter, Water test rig, Characterization test bench.

I. INTRODUCTION

A. *Brief Overview*

This system is designed for gear shifter of 4-wheeler.The component to be tested is mounted on the test bed replicating the final application in the 4 wheeler as per JIS D0203 specifications. Once mounted, the gear shift lever is connected to a pneumatic cylinder which will be used to move the gear shifter as per the given procedure for 10000 cycles. While the gear shifter is being actuated, muddy water is to be sprayed onto the areas that are to withstand any seepage. There are two areas where more chances of water contamination, one is the grommet and the other is the boot area of the shifter cable.

B. *CATIA V5 based model*

Modelling & design of the Water Test Rig is done using CATIA V5. Fig.1 below shows the model which is manufactured & used to test component i.e. shifter cable.

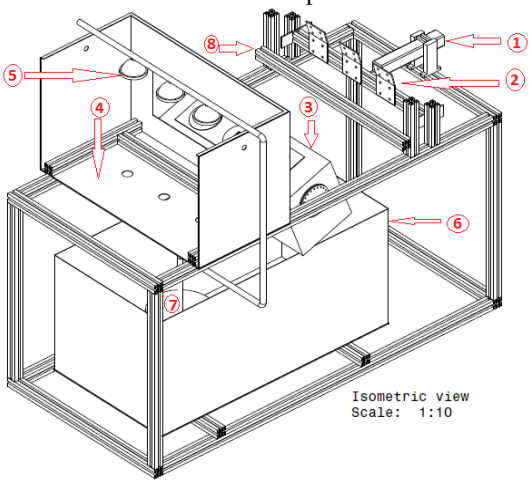

Fig.1 Isometric View of Water Test Rig

Numbering in Fig.1 gives the functional description of parts:

1. Pneumatic Cylinder for actuation of testing
2. Angle plate to fix one side of cable
3. Grommet zone to fix Grommet of shifter cable
4. Seal boot zone other side of cable rests
5. Water Nozzle to spray water
6. Water Sump to store water
7. Water pump to supply water at 25 LPM
8. Rod to fix shifter cable on shifter housing

Fig.2 & Fig.3 shows Front view & Top view of Water Test Rig respectively.

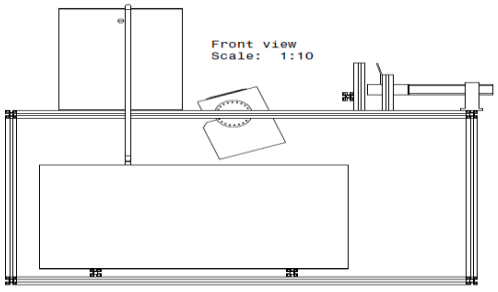

Fig.2 Front View of Water Test Rig

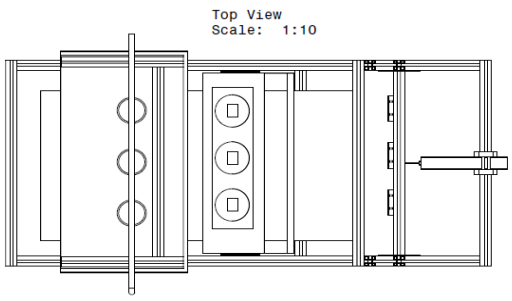

Fig.3 Top View of Water Test Rig

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C. *Performance Specification*

This test will be conducted at a speed of 0.5Hz for 10000 cycles after which the spraying and actuation will stop for a period of 12 hours after which it will go through a repeated cycle of 10000 actuations with spraying. This is considered as one cycle and will be repeated 5 times or a total of 100000 actuations. At the end of each cycle, there will be a visual check while the system halts. After completing the test procedure same shifter cable is kept in cold chamber at -20^{o} C for 3 hours & then on characterization test rig to calculate friction generated for shift & select on shift lever against force required.

II. TESTING

The test rig is consist of number of parts which are assembled together to form complete test bench for testing the component i.e. shifter cable. The two main areas on which test performed are Grommet test zone & Seal Boot test zone.

A. *Grommet test zone*

Grommet is made of Ethylene Propylene Diene Monomer (EPDM) material having good corrosion resistance property. Grommet is fixed in 4-Wheeler to hold & position shifter cable assembly. Cable is passed through grommet & passage inside the grommet & outer side of the cable having gap which can be filled by water at the time of testing. Due to this water can come inside the cable & there are more chances of corrosion inside the cable because it is made of High carbon spring steel wire 70 MN/SWRH 72B. Fig.4 below shows the attachment of grommet on test rig.

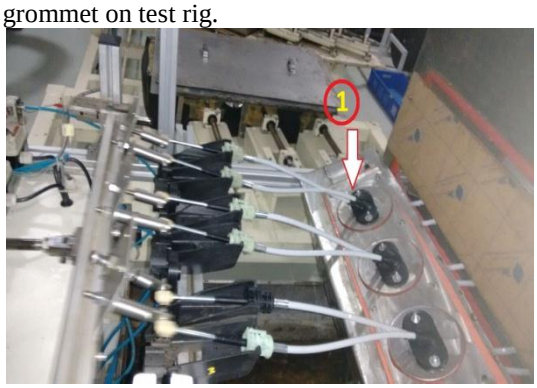

Fig.4 Grommet Test Zone

It is prescribed that this test is being done with the spray of water from the bottom. This automatically necessitates good sealing of the covering around the grommet to prevent leakage. The fixture is set in such a way that it creates the natural angles of the shifter assembly. The grommet is mounted onto a stainless steel plate which is then fixed onto the fixture. Fixture assembly is made up of stainless steel sheet metal to cover up the sides and the top hence restricting the spray within the required area. At the gap between covers, think rubber strip is used as seal. This is necessary to ensure a better seal against water leaking. It is important that the shifter and selector cables do not get interchanged. But as the positions of the rubber bushes do no match, any interchange will naturally be avoided.

B. *Seal Boot test zone*

Seal boot is fitted at the gear box end. Also there is a chance of penetration of water inside the cable through seal boot. Seal boot is made of Ethylene Propylene Diene Monomer (EPDM) material. The zone is designed to house the shifter and selector boots at the desired orientation .It is positioned in such way that it satisfies the vehicle routing condition. End rod & Metallic Insert used inside the seal boot made up of metal having more chances of corrosion. End Rod is made up of EN10088 & Metallic Insert EN 1A. Fig.5 below shows the final assembly of seal boot.

Fig.5 Seal Boot Test Zone

In this assembly blocks are machined with the required angles to create the desired end positions. Simple brackets are clamped onto the angle blocks onto which the boots can be clipped on. This whole assembly is housed in a sheet metal and acrylic enclosure to prevent any spray of water around the machine. The spraying system is made according to Japanese Industrial Standard (JIS) D0203 specifications. In which it is mentioned that the water should be spray at a rate of 24 LPM & at pressure 0.1 MPa.

III. VALIDATION OF RESULT

After completing the test procedure on Water Test Rig shifter cable is removed on it then it is placed in cold chamber at -20^{o} C temperature for 3 hours. Check shifter cable by hand whether it is jammed. If found jammed, it means water is contaminated inside the shifter cable in such case put same shifter cable in Characterization test bench. The function of a Characterization test bench is to calculate force required for shift & select pattern.

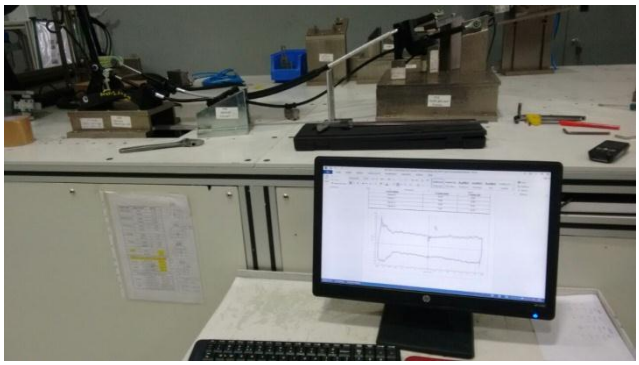

Fig.6 Characterization Test Bench

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The characterization test rig gives approximate value of force which can fill by driver when changing gear. Shifter cable is kept in such a way that it gives the replicate same as that it is used in actual practice. The result analysis is shown in graphs. Fig.6 shows setup of shifter cable on characterization test rig & data generated on a computer. As it is comparative study giving details of force required by shifter cable for shift & select of gear before & after water testing done on it, we can compare results.

A. Before Water Test

1. *Gear select pattern result* :

Before water testing shifter cable sample is put on Characterization test to calculate the amount of force required. TABLE I below contains average force for pushing & pulling of shift lever at driver end.

TABLE I: Gear select pattern result

Parameter	Measured	Unit
Average Pull Force	0.2	N
Average Push Force	0	N
Total Average	0.15	N
Motor Velocity	5	mm / sec

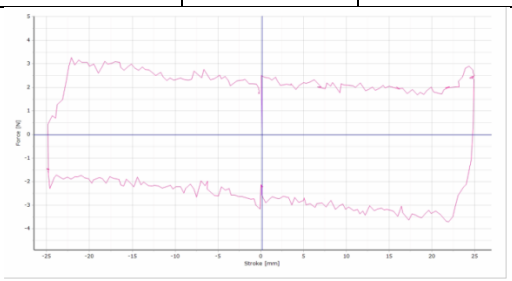

Fig.7 Graph of Force (N) Vs Stroke (mm) of gear shifter for select pattern

Fig.7 shows graph in which X- axis gives value of stroke (mm) of a shift lever & Y-axis gives amount of force required throughout travel of shift lever. The result above is taken from the graph.

2. *Gear shift pattern result* :

A result for gear shift pattern is also taken from the characterization test bench. Below table gives details of push & pull force required for shifting the gear.

TABLE II: Gear shift pattern result

Parameter	Measured	Unit
Average Pull Force	2.07	N
Average Push Force	0	N
Total Average	1.03	N
Motor Velocity	5	mm / sec

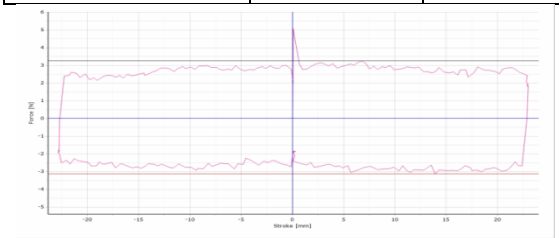

Fig.8 Graph of Force (N) Vs Stroke (mm) of gear shifter for shift pattern

Fig.8 shows graph for shift pattern. Values in TABLE II are taken from same graph.

B. *After Water Test*

3. *Gear select pattern result* :

TABLE III & Fig.9 shows the force required at a time of shifting gear. Below result gives force requirement at a time of select pattern of a gear.

TABLE III: Gear select pattern result

Parameter	Measured	Unit
Average Pull Force	5.38	N
Average Push Force	0	N
Total Average	2.69	N
Motor Velocity	5	mm / sec

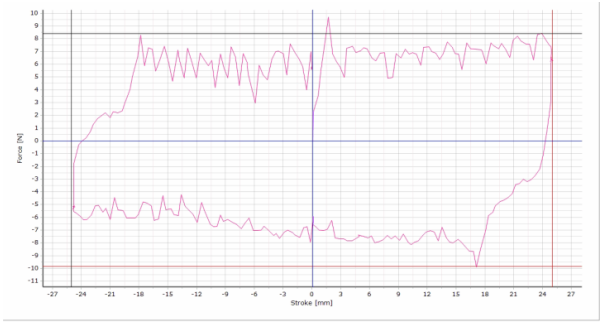

Fig.9 Graph of Force (N) Vs Stroke (mm) of gear shifter for select pattern

When we compare the graphs of Fig.7 & Fig.9 for select pattern before & after water testing, pull force required for selecting gear increases from 0.2 N to 5.38 N which means that water is contaminated inside shifter cable.

4. *Gear shift pattern result* :

TABLE IV & Fig.10 shows amount of pull & push force required for shifter in shift pattern to change gear after water testing. Amount of pull force required at time of shift pattern is comparatively high as select pattern.

TABLE IV: Gear shift pattern result

Parameter	Measured	Unit
Average Pull Force	5.42	N
Average Push Force	0	N
Total Average	2.71	N
Motor Velocity	5	mm / sec

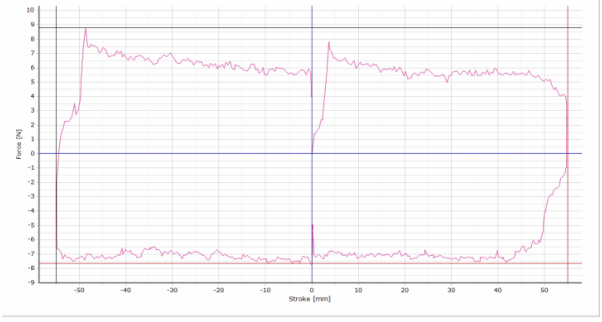

Fig.10 Graph of Force (N) Vs Stroke (mm) of gear shifter for shift pattern

If we compare a graph between shift pattern before & after water testing it also shows that pull force required is increased from 2.07 N to 5.42 N. From above results we

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can say that due to water contamination force required for gear shifting & gear selecting is increases but it comes under predefined value of force requirement.

III. CONCLUSION

CATIA V5 R20 based design of the Water Test Rig is done according to JIS D0203 standard. The results from the characterization test rig shows that shifter cable is validate to a given JIS D0203 standard. This result also gives the comparative study of shifter cable before & after the water testing. Pull force required by driver in shift & select pattern of gear change after water testing is 5.42N & 5.38N approximately.

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