
Internship Report

Tractor R&D Centre, Mahindra & Mahindra Ltd., Punjab

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Summary of Internship

This internship was about learning how R&D Centre works and elements of product development process in a large organisation. This also gave me experience of validation and testing process after design is converted into working prototypes. I experienced and understood testing and validation process for transmission, engines, clutch and brakes. I was fortunate to get hands on experience on performance testing of transmission and engine. I also witnessed durability and fatigue testing of clutch and brake systems. This exposure gave me a very good insights about how a new product design is tested before it reaches a stage of mass production. More importantly this gave me very good understanding about how engineers contribute to design and development process to give birth to new products.

Key Learning Areas

Day 1 & 2	Overview of R&D Organisation & product development process
Day 3	Understanding role of Computer Aided Engineering and Computer Aided Design in product development process
Day 4	Understanding importance of Testing and Validation process in product development and different testing facilities
Day 5 & 6	Practical exposure to testing and validation of clutch, brake & transmission

Overview of R&D Organisation



Product platform Teams - Responsible for delivery of new products. They are responsible for coordinating with different agencies right from design, development & testing. Overall responsibility of timely delivery of product is on platform teams.

Aggregate Teams – Responsible for design & technical support in a product development project. Different aggregates like Engine, Transmission, hydraulic have separate teams which are engaged in design and development activity.

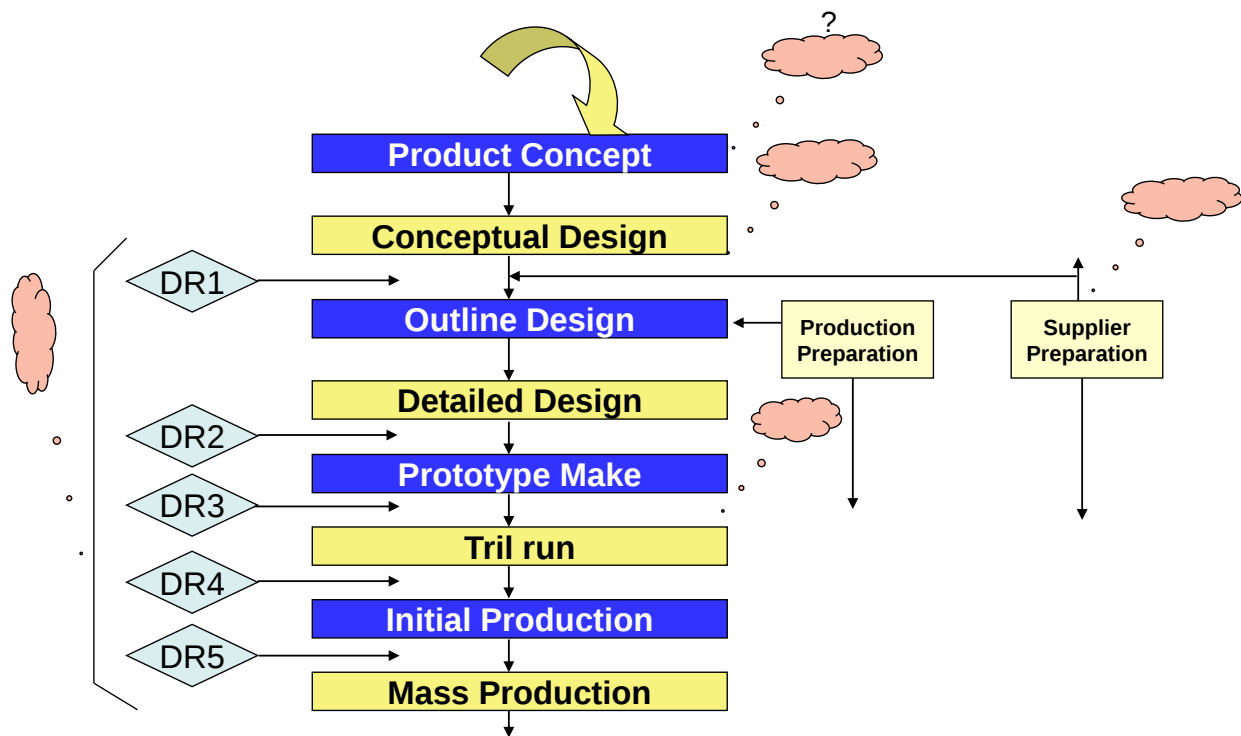
CAE support – Responsible for evaluating design for required performance. Once design teams complete the design, CAE team evaluates the same before making a photo for testing.

Testing & Validation – Responsible for testing and validating design by undertaking different tests to prove the design before it goes in the hands of customers.

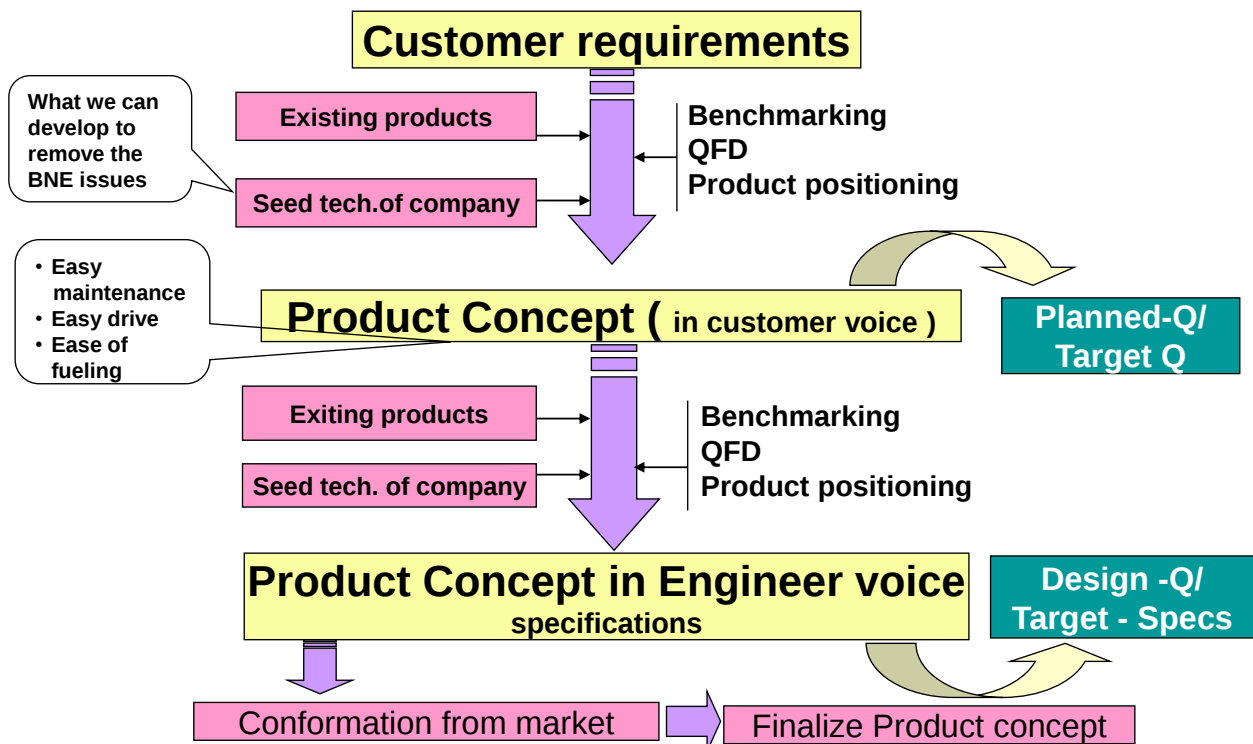
Key Learning

Roles of different engineers are divided into different activities of Research and development process. Each role needs to develop specific skill set for that activity. To become good R&D engineer one has got exposure to different roles during his work experience in the organisation which needs continuous learning attitude.

Understanding New Products Development Process

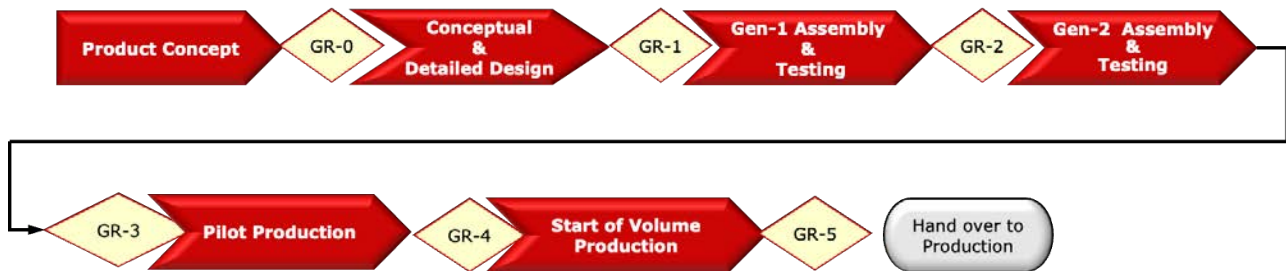


Evolving Product Concept



Understanding New Products Development Process

Process followed for tractor product development



Key Learning

Product development process starts from understanding customer requirements to prepare product concept, finalise the specifications to start the process of detailed design. CAE analysis is done to evaluate the design before it is released for development. Two stages of proto assembly and testing happens. First set of testing identifies improvements needed to be done in product. Second set of proto is then build by by incorporating these improvements and then second set of testing is done before mass production starts.

Practical exposure in Computer Aided Engineering (CAE) & Computer Aided Design

The benefits of CAE

- Reduced product development cost and time, with improved product quality and durability.
- Design decisions can be made based on their impact on performance.
- Designs can be evaluated and refined using computer simulations rather than physical prototype testing, saving money and time.

Difference between CAE & CAD

- CAD is for designing a product and CAE is for testing and simulating it.

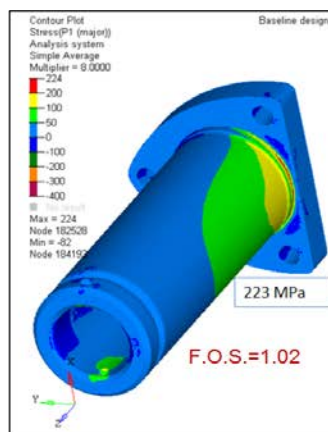
Practical study : Evaluating sensor tube design for improving the strength

Practical Study

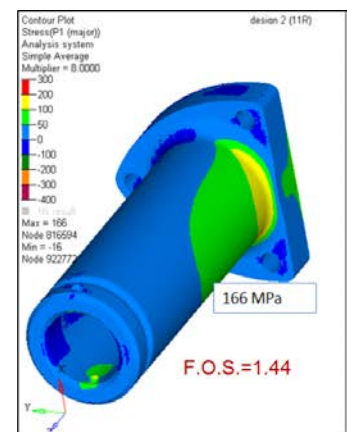
Evaluating sensor tube design for improving the strength



Crack



CAE of Existing Design



Modified Design

Machining eliminated
11R – Fillet radius

Importance of testing and validation in development process

Validation testing is an evaluation of a new product or a product improvement's ability to meet the criteria defined for acceptance in the marketplace.

By testing during the design process, the manufacturer can potentially save costly modifications that may occur after the product is in production, avoid possible failures or repairs, and hopefully avoid returns because the product doesn't work properly in the hands of customer.

Validation testing helps to ensure that the product meets the intended needs of the end use customer.

Types of Testing

Lab testing : Testing is done by using inhouse machines inside R&D centre

Field Testing : Testing is done in real life usage conditions, the way customer will use it

Performance testing : It is done to ascertain whether the component / assembly is working as per the defined range of parameters that it is supposed to deliver within the defined scope of application specification. It is the first level check done to ensure delivery of specified output and only after ensuring this further validation is taken up.

Durability testing :It is done to ascertain the ability of component / assembly to remain functional during normal operation over its design lifetime. Durability can be measured in terms of hours of life, number of operational cycles and years of life. Extended testing is done for various assemblies to check the durability.

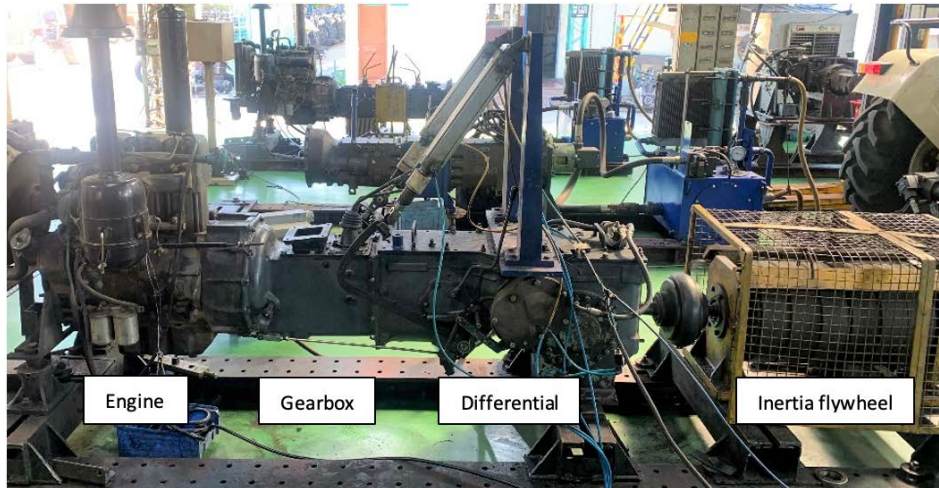
Understanding different lab testing facilities

	Facilities Description	Intended Components / Systems
Vibration Testing	Electrodynamic Shaker	Vibration testing of Sheet Metal components, Electrical systems, Seats, Accelerated Testing, Shock and Bump
Fatigue Testing	Fatigue Rated Linear Actuators (5 Nos)	Fatigue Testing Of Chassis Related Components, Durability and breakage of sub assemblies
Transmission Endurance Testing	Transmission Test Rig(5 Nos.)	System Level Endurance of 15-80 HP Transmission
Engine Testing	Engine Dyno, Inlet Air Conditioning System, Fuel Conditioning System, Smoke Meter, Blowby meter, PM Analyzers, Coolant Conditioner, Lube Oil Consumption	Engine Testing Facility at aggregate and component level
Environmental Testing	Climatic Chamber, Rain Test Chamber(2 Nos)	Component Level Validation , Switches, Lamps, Gear knobs
Hydraulic Testing	Durability Testing (6 Nos)	Hydraulic assembly Durability
Steering Performance Testing	Steering Rig (1 Nos)	Leakage, Steering unit Performance
Gear Shift Testing	Gear Shift Rig	Testing of H-M-L gears
Data Acquisition	DA and NVH Facility	Durability Recording, 6 Channel Noise Analyzer

Experiencing lab testing of clutch & brake

Brake & Clutch test rig

The complete test rig includes Engine, Gear box, Differential and set of inertia weights. Engine is coupled with gearbox which in turn is coupled with differential and PTO shaft is loaded through a set of inertia weights (flywheels).



This test rig is used for durability validation of the following components:

- Clutch plate assembly, Clutch Cover assembly & Brake liner

Testing of Clutch System

The function of clutch is to transmit torque produced in the engine to the transmission. When we press the clutch this causes the clutch to release the bearing which engages or disengages the clutch, releasing the pressure.

The pressure plate causes two types of loads clamp load and release load.

- Clamp Load :- It helps in transferring engine power through drive plate to transmission
- Release Load :- It is when clutch pedal is disengaged.

The durability of clutch is tested on clutch testing rig with the help of actuators.

Testing Brake System

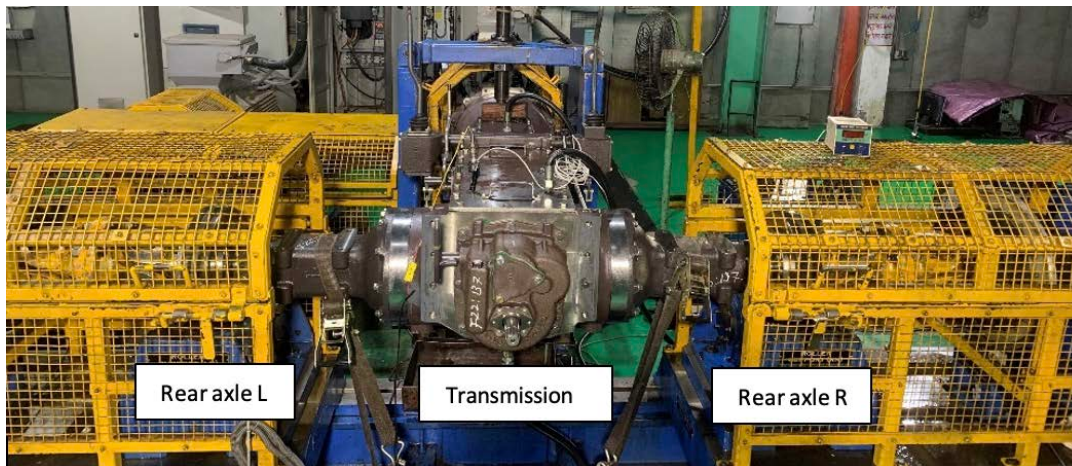
A brake is a mechanical device that inhibits motion by absorbing energy from a moving system. When a brake pedal is pushed, a piston moves into the cylinder and it squeezes hydraulic fluid. Hydraulic brake fluid is forced around the entire braking system within a network of brake lines and hoses. Pressure is transmitted equally to all four brakes. This force creates friction between brake pads and disc brake rotors which is what stops the vehicle.

The performance of brake is checked by how much distance it takes to stop the vehicle. The durability of the brake is tested on the brake testing rig for number of cycles it takes for brake to wear out.

Experiencing Lab Testing of Transmission

Transmission test rig

Complete transmission drivetrain is mounted onto the test rig. An AC motor is used as the prime mover & provides input to the transmission (as per the engine power rating). The transmission is further loaded at both the rear axles through AC motors to achieve the rated load condition.



This test rig is used for durability validation of the complete drivetrain components.

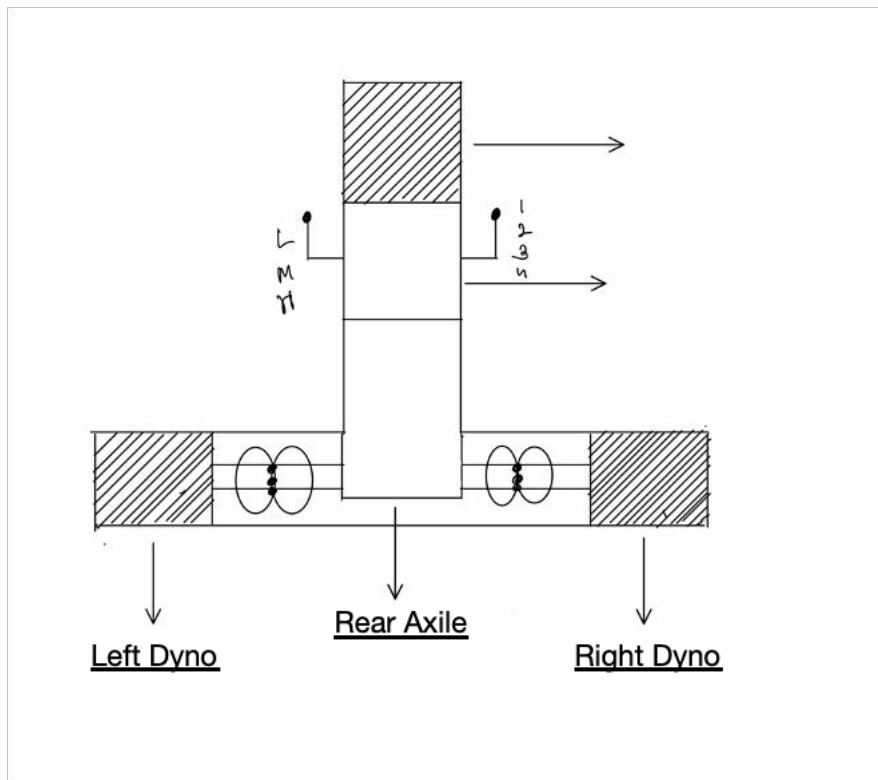
Testing of Transmission

The function of transmission is to transfer power from the engine to the drive shaft on rear wheel.

There are three ranges in the gear system in the transmission Low, Medium, High. High is for providing speed to the tractor to move on roads. Low is for providing torque to the tractor to perform heavy duty work in the field.

To test the transmission, it is connected to dynamometers on both sides of the rear axle. To put load on the transmission an input motor is used which runs at a rated rpm which in turn runs the transmission.

Schematic diagram of Transmission test Rig



Input	LH	RH
2000 RPM	30 RPM	30 RPM
184 N/m	4300 N/m	4300 N/m
50 HP	18.4 HP	18.4 HP

Power lost in transmission = 15.6 hp

Total axle power = 36.7 hp

Experiencing Lab Testing of Engine

Engine test rig

Complete engine assembly is mounted onto the test rig. Engine is coupled with the hydraulic loading motor through propeller shaft and is run at fly up rpm. Load is applied by adjusting the delivery line pressure till the engine speed gets stable at its rated rpm i.e full load.

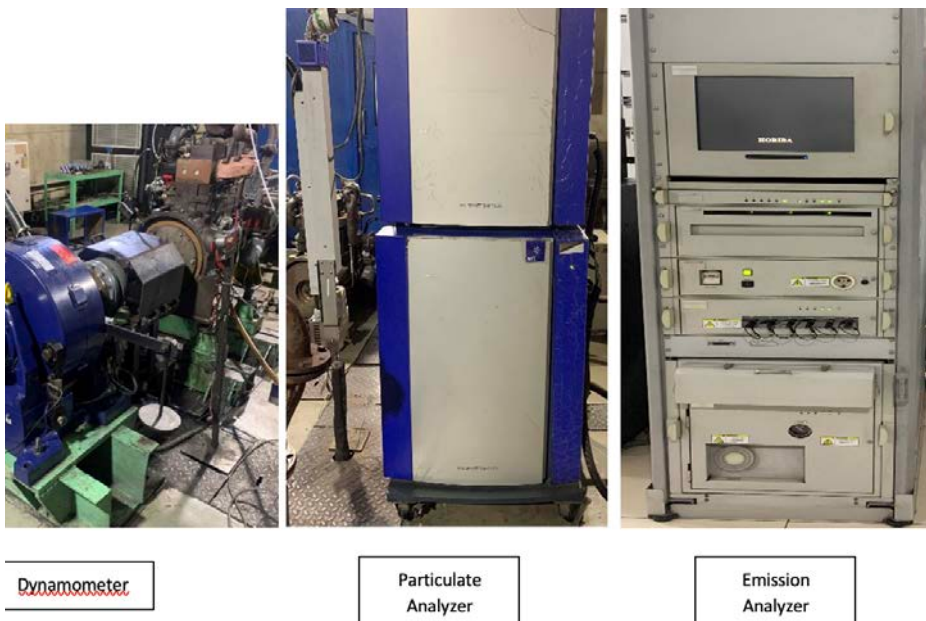


This test rig is used for durability validation of the following components:

- Engine assembly including all components
- Intake system components i.e Air cleaner, intake manifold.
- Exhaust system components i.e Silencer, exhaust manifold.

Other Engine testing equipment

- Emission Analyser (M/s Horiba) for measurement of exhaust gases comprising of NO_x, CO, THC, CO₂.
- Particulate Analyser (M/s AVL) for measurement of suspended carbon particles in exhaust gas.



Other testing equipment

- Electro-dynamic Shaker for Vibration Testing of Sheet metal & electrical components –



- Fatigue Rated Actuators for fatigue testing of chassis & other load bearing components –



Understanding different field testing facilities

Field Test Facilities

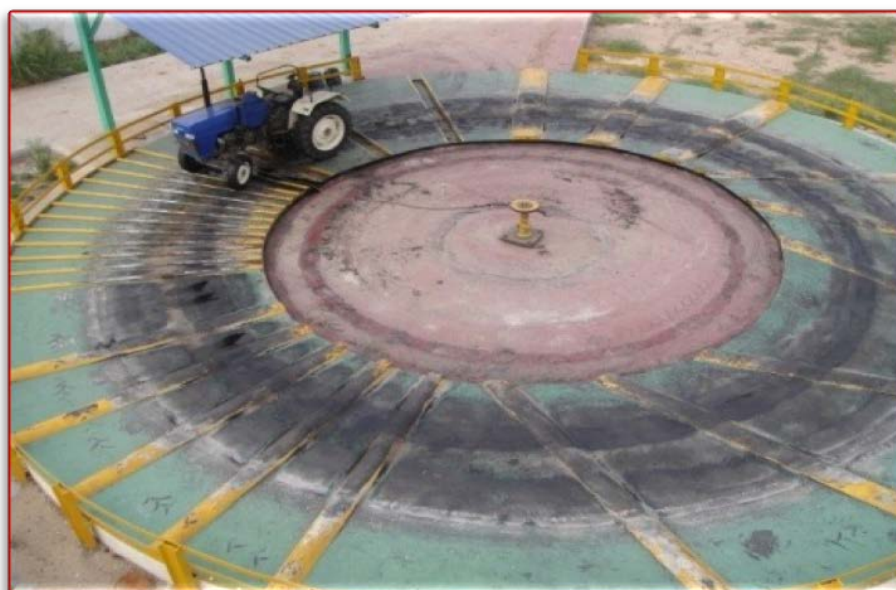
Facility Name	Facilities Description	Intended Components/ Systems
Torture Track	0.7 G- 4 G @5.5 Kmph(2 Nos)	Sheet Metal Testing, Structural testing
Skid Testing	Tractor Running under Loaded Condition(4 Nos)	Structural testing, Transmission testing, Engine Durability
Load Car Track	Tractor Running under Loaded Condition	Structural testing, Transmission testing, Engine Durability

Vibration testing for a tractor

The vibration of a tractor experienced by the different parts of a tractor in the field are tested with the help of electrodynamic shakers.

These vibrations are caused by the uneven landscape and soil type of the farm as well as the engine.

Un-manned Torture Test Track



Details

of

Validation Details

Component validation is done under 2 categories namely performance & durability.

Performance Validation

It is done to ascertain whether the component / assembly is working as per the defined range of parameters that it is supposed to deliver within the defined scope of application specification. It is the first level check done to ensure delivery of specified output and only after ensuring this further validation is taken up.

For e.g.-

a.Engine performance: Parameters for the engine would be the power output in terms of horsepower & the exhaust emissions as per the specified norms for the engine horsepower category.

We check the engine performance in terms of power output over the defined rpm range using the eddy current dynamometer wherein the engine is run at Flyup rpm without load (e.g 2150 rpm) and is gradually loaded to attain the Rated rpm (e.g 2000 rpm). At this rated point rpm the torque is noted, which gives us the actual power generated by engine. This power is checked against the specification - $x \text{ hp} \pm 5\%$.

Similarly emission is measured over an 8 mode cycle & subsequent HC+NO_x, CO and particulate matter is checked against the prevailing emission norms of TREM 3A.

a.Power Take Off (PTO) performance: It's used to transmit power from the tractor engine to an application such as an attached implement or machine & parameters would be power output in terms of horsepower.

We check the PTO performance in terms of power output over the defined rpm range using the eddy current dynamometer.

a.Hydraulic lift performance: Parameter for the lift would be the lifting capacity (in kg.), power range, lifting time & lowering time (in sec).

a.Hydraulic pump performance: Parameters for the pump would be flow in liters per minute (lpm) against different delivery pressures.

Validation Details

Durability Validation

It is done to ascertain the ability of component / assembly to remain functional during normal operation over its design lifetime. Durability can be measured in terms of hours of life, number of operational cycles and years of life. Extended testing is done for various assemblies to check the durability.

For e.g-

a.Engine Durability: After ascertaining the performance of the engine it is checked for durability under rated load conditions i.e 2000 rpm under full load. The engine is run at this condition for 1000 hours and during this testing performance is checked @ '0' hour, '500' hour & '1000' hour. Further it is extended for 2000 hours.

a.Transmission Durability: The complete transmission assembly is run at rated load condition with the prime mover (engine / motor)@ 2000 rpm and drive axle loading through ac motors corresponding to design axle torque. Load cycle is derived from the field duty cycle to cover the life cycle of transmission.

End of Report
