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Performance Testing on Adaptive Scooter for Design Optimization

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Abstract - Mobility is a prime need of all human beings in today's world. Many original equipment manufacturers are designing such vehicles for special abled people also who cannot walk. Such people are also interested in getting an automobile either a car or a scooter. Adaptive scooters is a concept designed for such people who cannot walk by adding side wheels by an attachment of side swing arm. Such scooters can be easily seen on roads, however such modifications are done at outside workstations. Objective of this experiment is to verify the performance of the vehicle in terms of its braking as per IS: 14664. Testing is done at higher speeds as mentioned in the standard as a worst case scenario to ensure better safety to such people.

Vehicle used in the experiment is of more than 50 cc and therefore it has good pickup, acceleration and speed. Therefore in future power of such vehicles can be reduced to improve safety of the user.

Key Words: *Differently-Able, Adaptive Scooter, CMVR, Brake.*

1. INTRODUCTION

Lot of regulations and standards are being envisaged by Government of India to make transportation easier and safer for people with disabilities. Commercial vehicles, mainly intracity buses are being mandated to have ramp for wheel chairs as per AIS-052 and AIS-153. Special seats are being reserved for such people in buses and space to fix the wheel chairs and crutches. Similarly for the people who want to drive a two wheeler themselves are getting the modification done at outside workstations with two side wheels. There are the aftermarket fitments where safety of end user is compromised. Such vehicle may lack in handling, stability and performance. Original equipment manufacturers can modify these vehicles in-house with help of design software and testing to ensure better safety to the user. Therefore such optimization is done for this experiment and then the vehicle is tested for brake performance as per IS: 14664 to ensure the safety of end user.

In a general configuration of a scooter it has step through chassis with a platform for rider feet. The engine is hinged about the middle of the frame through a toggle link and forms and integral part of the rear suspension. There is always a shift in center of gravity due to presence of continuously variable drive which makes it yet more unstable. The scooter dynamics keeps on changing with

change in vehicle RPM. The scooter wheels having a specification of 3.5x 1 0 ensure less steering effort, however there is a drop in the self-aligning torque of the wheels as well. The vehicle track width along with side wheels is kept at a minimum such that the side wheels do not hamper the servicing requirements of the scooter and ensure a minimum turning circle radius. [8]

First and foremost is safety of scooter. Main important parameter of safety in automobile is brake. Improper location of side wheels drops the brake performance. Stopping distance should meet the Indian industry standard IS: 14664. Next one is maneuverability which is being characterized by large turning radius and lack of roll stability. There is need to apply constant steering correction in order to ensure vehicles does not deviate from its path.

These are safety concerns as differently able people cannot react in the same way as others. These limitations are cause of concern and need proper design solution for its feasibility. This must also meet safety standards as are being guided by central motor vehicle rules. Under central motor vehicle rules there is a notified standard IS: 14664 which needs to be met in any vehicle has to get registered.

Figure 1 - Picture of adaptive scooter [8]

2. Vehicle Parameters

Original manufactured scooter is taken for research work where two side wheels are fabricated. The handling characteristics of a scooter are influenced by several parameters which are derived from the individual sub-systems.

Unlike four wheelers two wheelers are generally consider to be unsafe. It is an unstable system due to tendency of its capsizing. As in scooter engine mass is one side therefore its center of gravity becomes offset. It is under influence of centrifugal forces.

The vehicle used is having engine capacity of 100 cc, wheel base of 1260mm.

3. Instrumentation

S.no	Instrument
1	V-Box 3i
2	Brake pedal force meter
3	Tough Book
4	Trigger
5	GPS antenna
6	V-Box 3i software for data analysis

1. **With VBOX 3i** data can be acquired for measurement of speed and position of moving vehicle through integrated GPS antenna. VBOX 3i data loggers will measure speed, distance, acceleration, braking distance, heading, slip angle, lap times, position, cornering forces and more with high accuracy.

VBOX 3i can be used for a multitude of test applications such as:

1. Brake Testing
2. Handling & Dynamics
3. Safety Systems Testing
4. Performance Testing

Figure 2 – Vbox 3i

2. Pedal Force Meter comes with Force Sensor within built rechargeable battery, Adapter for measuring hand brake force and charging adapter.

Specifications:

1. Nominal Load 0-1500 N.
2. Accuracy Class: 0.5%
3. Protection : IP-65
4. Operating Temp Range: -10°C to +50°C.

Applications:
Vehicle foot pedal force measurements.
Hand Brake Hand force measurements.

Figure 3 – Pedal force meter

3. Tough book is PC meets IP 65 standard and is useful for data storage of test vehicles in dynamic condition. It is useful for Recording Data and On Board Display during performance testing of vehicle. It can operate for 9.5 hrs. continuously without charging with new batteries/ fully charged batteries

Figure 4 – Toughbook

$Ss = 0.1Vs + (Sa - 0.1Va) \cdot Vs^2/Va^2$ where
Ss = corrected stopping distance, in m;
Vs = specified vehicle test speed, in km/h; Sa = actual stopping distance, in m; and
Va = actual vehicle test speed, in km/h.

4. Test conditions and methodology

1. Applicable to all dynamic brake tests excluding the ABS tests where a low friction surface is specified.
2. The test area is a clean, dry and level surface.
3. The surface has a nominal peak braking coefficient (PBC) of 0.9, unless otherwise specified.

Brake Tests:

1. Dry Stop Performance tests – Vehicle is run at 60 km/hr (Worst case considered) and brake is applied. This is done for both front and rear brakes. It should meet the brake performance requirements.
2. Combined brake tests – Vehicle is run at 90% speed (Worst case considered) of Vmax and then combined brake is applied. It should meet the brake performance requirements.
3. Heat Fade tests – 10 stops are made before final tests. Finally brake is applied and should meet the required performance criteria.

Performance Requirements:

Table 1 - Performance requirements (Ref IS: 14664)

Vehicle category	Stopping Distance	MFDD
Front Brake		
2W	S ≤ 0.1 V +0.0087 V2	4.4 m/s²
Rear Brake		
2W	S ≤ 0.1 V +0.0133 V2	2.9 m/s²

1. MFDD (Mean fully developed deceleration)

$$\text{MFDD}\,(d_m)\ \frac{V_b^2 - V_e^2}{25.92\ (S_e - S_b)}\ m/s^2$$

dm = mean fully developed deceleration
Vb = vehicle speed at 0.8 V1 in km/h
Ve = vehicle speed at 0.1 V1 in km/h
Sb = distance travelled between V1 and Vb in metres
Se = distance travelled between V1 and Ve in metres

2. Stopping Distance

To calculate the corrected stopping distance using the actual vehicle test speed, the following formula is used:

5. Test results

Table 2 – Front Brake performance

Front Brake (Dry Performance)					
Sr. no	Initial speed km/h	Dist. (Mts)	MFDD (m/s²)	Force (Kgf)	Result
1	59.51	34.73	4.45	16.16	O.K
2	59.09	33.71	4.47	16.26	O.K
3	59.13	33.99	4.41	15.28	O.K
Front Brake meets the requirements as per limits prescribed in IS: 14664					

Table 3 – Rear Brake performance

Rear Brake (Dry Performance)					
Sr. no	Initial speed km/h	Dist. (Mts)	MFDD (m/s²)	Force (Kgf)	Result
1	59.12	47.22	2.93	17.43	O.K
2	59.22	49.14	2.90	17.97	O.K
3	59.60	47.77	2.96	18.65	O.K
Rear Brake meets the requirements as per limits prescribed in IS: 14664					

Table 4 – Combined Brake performance

Combined Brake (Dry Performance)					
Sr. no	Initial speed km/h	Dist. (Mts)	MFDD (m/s²)	Force (Kgf)	Result
1	68.54	25.20	7.42	10.89-Rear	O.K
2	69.47	25.38	7.52	10.89-Rear	O.K
3	69.46	25.43	7.56	11.28-Rear	O.K
4	68.76	25.36	7.42	10.55- F	O.K
5	70.29	26.33	7.72	11.34-F	O.K
6	69.30	26.34	7.77	13.67-F	O.K
Combined Brake meets the requirements as per limits prescribed in IS: 14664					

Table 5 – Heat Fade test

Heat Fade Test					
	Initial speed km/h	Dist. (Mts)	MFDD (m/s²)	Force (Kgf)	Result
F	60.24	38.05	3.67	12.74	O.K
R	62.03	49.40	3.01	18.42	O.K
C	61.67	30.37	5.16	11.40	O.K
Meets the requirements as per limits prescribed in IS: 14664					

6. CONCLUSIONS

Test shows that vehicle meets all the requirements specified in IS:14664 and confirms to the virtual simulation done on the adaptive scooter. This generates the confidence to designer that if the vehicle is optimized than it will provide better safety in terms of brakes to the end user.

Brake test is one of the critical tests in CMVR. If vehicle clear this test then vehicle can be manufactured by OEMs and can be easily registered.

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