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DESIGN OF ROLLOVER TEST-BED FOR HEAVY VEHICLES

Zhiguo Zhao[1, 2*], Min Chen[1], Chao Wang[2]

[1]School of mechanical engineering, Southeast University, Nanjing 210000, China
[2]School of Transportation Engineering, Huaiyin Institute of Technology, Huai,an 223003, China
****Corresponding Author E-mail: lnzzg98@163.com***

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ABSTRACT

Heavy vehicles rollover has become an important damage to life, property, and safety issues. For the problem of heavy vehicles side pour stability is poor, a rollover test bed is designed for the measurement of stable roll angle, the test-bed is consist of mechanical device, hydraulic lift liters system, measurement and warning system, and security protection device, meet GB/T14172-2009; for different side turned angle, force analysis about rollover test-bed is done, maximum lift liters thrust that needed by hydraulic system, which provides the basis for the design of the hydraulic system, hydraulic cylinders and hydraulic pump.

KEYWORDS

Heavy vehicles, rollover, stable roll angle, test-bed

1. INTRODUCTION

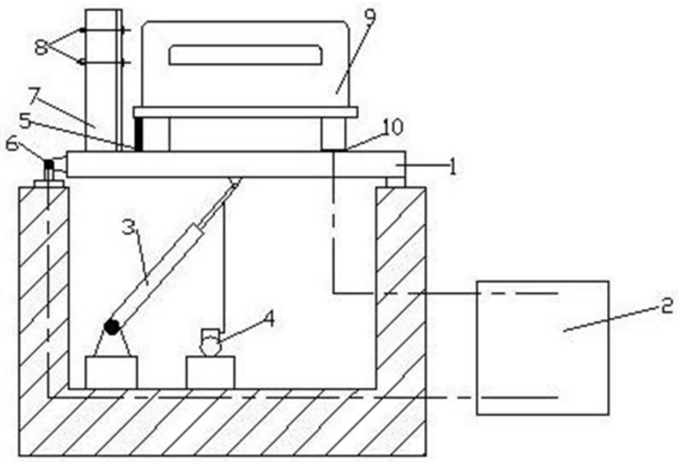
According to the University of Michigan Transportation Research Center statistics, during the period 2002-2006,heavy vehicles rollover accident average occur 5200 times annually in US (average deaths is 5, 300), the deaths due to heavy vehicles rollover accidents are increasing year by year. The deaths due to heavy vehicle rollover accidents are 4-6 times of European and American countries in our country. According to research, heavy vehicle rollover accidents are the major traffic accidents that cause the loss of life and property, which have become the important issues affecting transportation safety [1-3].

In recent years, scholars in domestic and abroad do much relevant research on rollover warning of heavy vehicles traveling on a curve. Rollover warning methods are mainly consist of rollover warning time TTR (time to rollover), rollover risk prediction and use of lateral acceleration and the lateral load transfer rate as the early warning indicators to determine the degree of risk of vehicle rollover warning and so on [4-8]. Although scholars has done a lot of research on vehicle rollover warning method, but in the view of to improve the accuracy and timeliness of rollover warning, there is still a lot of work to do by further exploration and research [9-14].

Roll stability is a regulatory item that should be mandatory for inspection in products qualitative testing of motor vehicle, The Standard make specific provisions about stable roll angle of vehicles that the maximum stable roll angle of heavy vehicles be not less than 35°, static ma ximum lateral stability determination of vehicle roll angle [15].This paper designed a test-bed for heavy vehicles rollover, which is used to measure stable roll angle of heavy vehicles, avoiding the low estimate accuracy of conventional calculation method.

2. COMPOSITION OF ROLLOVER TEST-BED

As shown in Figure 1, rollover test is composed of mechanical, hydraulic lifting system, measuring and warning system, safety protection device.



1- main platform; 2 - Test Console; 3- hydraulic cylinders; 4- pump; 5 - Anti-skid bezel; 6- roll angle sensor; 7- rollover bracket; 8- adjustable anti-roll support plate; 9- test vehicle; 10- pressure sensor

Figure 1: The overall structure of rollover test-bed.

2.1 Mechanical Installation

Mechanical device consists of tester platforms side and hinge components. One side of the Tester platform is supported on a pedestal by hinged, with two single-acting cylinders, one hinges at the test bench supports, the other one hinges on longitudinal welded of the other side of platform. When vehicle rollover tests, take tests vehicles parked on the main platform smoothly, electrical control unit controls the motor to drive hydraulic pump station working, put oil into the fuel tank and jacked up on one side of the platform to make the hinge supports rollover smoothly, until it reaches the necessary lifting angle, and down to the level location depending on platform and gravity of the vehicl e after the test is completed.

2.2 Hydraulic Lifting System

Hydraulic lifting system consists of a hydraulic cylinder and hydraulic components like hydraulic pumps, hydraulic valves. Lift mechanism is the important part of vehicle rollover test bed; it is directly related to the performance and the overall layout of rollover test-bed.

2.3 Measurement and Warning System

Measurement and warning system is composed of sensors, amplifiers, industrial control computers and other components. The sign of test vehicle roll angle achieving maximum value is that the pressure of tire of the other side of anti rollover bracket on the platform is 0 during the experiment. The signal is provided by the tire pressure sensor installed on the ground, after conversion and amplification, sent to the computer, the computer real-time process the signal and monitor.

2.4 Safety Devices

Safety protection devices consist of device preventing vehicle from rolling device by accident and skid block. The device preventing vehicle from rolling device by accident is composed of vehicle anti rollover bracket and adjustable supporting plate. When the vehicle running into platform, the adjustable safety protection device makes it contact with the side of the test vehicle, its role is to prevent the vehicle lateral overturning when the test value reaches or exceeds the stable roll angle in rollover test.

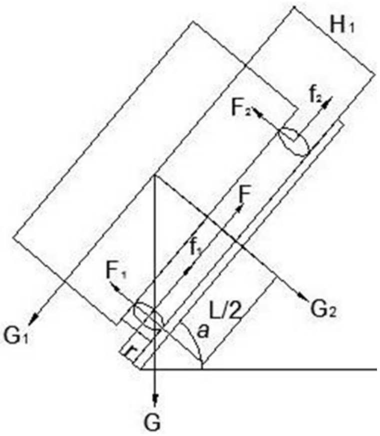


Figure 2: Force analysis for rollover.

3. FORCE ANALYSES FOR TEST-BED

3.1 Force Analyses of Rollover

As shown in Figure 2, suspension deformation of the vehicle in the stationary state can be ignored. When the overturning flip angle of test-bed is a, Gravity G can be divided into the force G1 parallel to the platform and the force G2 perpendicular to the platform, skid plate on the wheel force is F, friction force is f, the wheelbase is L, the vertical height form the center of gravity to the main platform is H1, wheel radius is *r*.

Rollover process is analyst as follows:

With the critical state when the outer wheel is just off the ground and the inner wheel as the bearing point, the overturning moment is equal to the moment of stability, as $G_1H_1 = G_2 \times \frac{L}{2} + F \times r$, the vehicle is in the state of equilibrium.

When the angle a increases further, $G_1 = G \sin\alpha$ larger, $G_2 = G \cos\alpha$ smaller, the overturning moment is higher than that of the stable torque, as $G_1H_1 > G_2 \times \frac{L}{2} + F \times r$, vehicle is going to rollover.

3.2 Force Analyses of the Main Platform Placed Horizontal

As Figure 3. shown is the test-bed section at the roll angle of 0°, the main technical parameters are as follows: the rollover test bench turning platform size (length and width) is 14000 mm 3500 mm, maximum load weight is 40 (not including the quality of platform), maximum turning angle is 50°, rated working pressure for hydraulic system P=10 MPA, the inner diameter of cylinder D=250mm. Considering the pressure loss of resistance, piping and components of sliding parts, the value of loss coefficient β is 0.8.

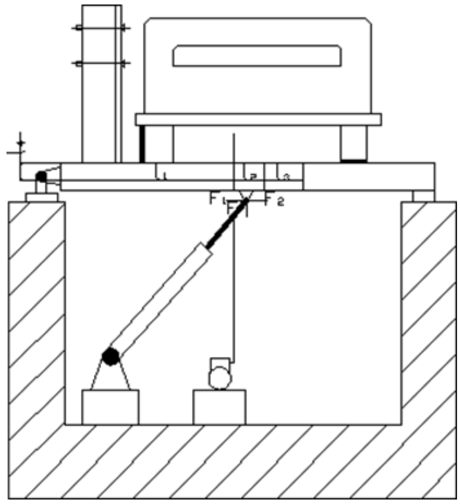


Figure 3: The test-bed section at the roll angle of 0°.

In Figure 3, L1 is the horizontal distance form rollover test-bed center to center of the rotating stand, 2090 mm; L2 is the horizontal distance from the centroid of rollover test-bed to the cylinder rotating bracket, 370 mm; L3 is the vertical distance from rollover table to the rotating support center, 450 mm; L4 is the vertical distance from the centroid of rollover test-bed, to cylinder rotation support =40°; θ =110 mm.

The maximum weight main platform table can bear is 40 *t*, the weight of table is 10 *t*, the total quality M=50 *t*, so vertical lift force cylinder required is:

$$Ml_1 = F_N \sin 40°(l_1 + l_2) + F_N \cos 40°$$

$$F_N = \frac{Ml_1}{\sin 40°(l_1 + l_2) + \cos 40° l_3} = 529\ KN$$

3.3 Force Analyses at Roll Angle of 50 °

As shown in Figure 4 is the force analysis at the roll angle of 50°.

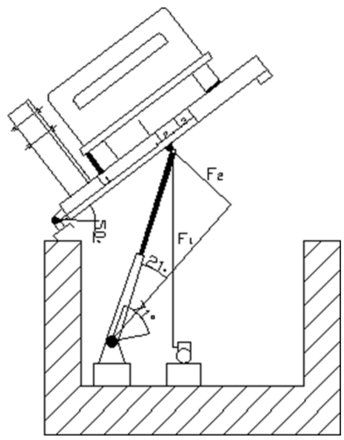


Figure 4: The force analysis at the roll angle of 50°.

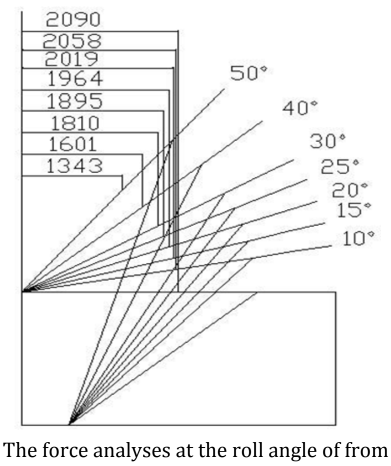


Figure 5: The force analyses at the roll angle of from 0 to 50°.

As shown in Figure 4, when the main platform turning 50 degrees, vertical lift force cylinder required F_J is:

$$M \sin 40° l_1 - M \cos 40° l_4 = F_J \sin 21° (l_1 + l_2) + F_J \cos 21° l$$

$$F_J = \frac{M \sin 40° l_1 - M \cos 40° l_4}{\sin 21° (l_1 + l_2) + \cos 21° l_3} = 460\ KN$$

With Calculation we know that when the main platform table turns 50 degrees, the thrust each cylinder required is 230 KN, smaller than the cylinder thrust, and in this state, when the 40t is the main platform of vehicle load, the table can be turned over 50 deg.

The maximum stroke of cylinder get by drawing method l is: $l = l_{max} - l_{min}$ = 1445 mm.

In the type, l_{max} is full extension length of cylinder, l_{max} =3720 mm; l_{min} is full time-lapse length of cylinder, l_{min} =2275 mm.

3.4 Force Analyses at Roll Angle of 0 ° -50 °

The force analyses at the roll angle of from 0 to 50° is shown as Figure 5, when the main flat surface turn about 15°, the maximum bearing capacity of cylinder is about 545 KN.

4. CONCLUSIONS

Rollover test is the most effective method to test the side tilt angle of stability of the heavy-duty vehicle and the height of center of mass. To solve this problem, this paper puts forward a design of heavy vehicle rollover test research of heavy vehicle rollover through the system, which lays the foundation for the research of vehicle, rollover warning algorithm and the control system. For poor rollover stability of heavy vehicles, a rollover test-bed is designed to measure the stable roll angle, the test-bed is applicable to all types vehicles that quality ≤50000 kg, wheelbase ≤10 m, track≤ 2.7 m to do rollover test. Force analysis on the rollover test-bed was taken in different roll angle, which get the lift thrust and maximum thrust stand for test-bed. Through the experimental stress analysis, it provides the basis for the design of hydraulic system and the section of hydraulic cylinder and hydraulic pump.

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