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A Comparison of Different Forms of Small Overlap Tests

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Abstract: Small overlap crash covers 48% of all road accidents every year and is being a most common form of accidents.Analysis of different test methods of NHTSA RMDB offset oblique, IIHS small overlap and car-car 25% small overlap is made. A mid-level sedan is chosen for the test of three kinds of offset impact. Through the comparative analysis of car body deformation, body motion state and dummy injury, differences among these tests are figured out. The causes of the differences are put forward: impact velocity, overlap rate and barrier material, etc. In this way, a reference guide is given for the improvement of car crash safety.

Keywords:offset impact, overlap rate, differences

1 Introduction

At present, it is mainly National New Car Assessment Program (NCAP) which is used for the assessment of car crash safety except for the mandatory reguiations, including C-NCAP in China, E-NCAP in Europe, A-NCAP in Australia, NTHSA and IIHS in the USA, etc. The main conditions in NCAP are 100% full width rigid barrier impact, 40% offset deformable barrier impact, side mobile deformable barrier impact, whiplash test and pedestrian protection. Frontal impact is the most common form of traffic accident, so it is the focus of the examination content in the NCAP regulations in various countries.Frontal impact can be devided into full-width impact and non full-width impact. According to a IIHS survey, full-width impact covers only 6% of all accidents while the number of offset impact is 48%[1]. Therefore, the development of vehicle safety in a offset impact has been the focus and difficulty of automotive OEMs.

At present, there are few studies on small overlap tests in China. IIHS small overlap regulation which is issued in 2012 put forward higher requirement for automotive OEMs. Compared to vehicle-barrier collision, car to car collision can better represent the actual accident conditions. Due to the lack of relevant regulations in China and the high cost of this test, the research of small overlap tests is still blank. This paper selects NTHSA RMDB offset oblique, IIHS small overlap and car-to-car overlap tests for tests. In-depth analysis and comparison are made in the aspects of vehicle body deformation, vehicle motion state and dummy injury.

2 Test Method

This test selects a mid-size sedan, the kerb weight is 1.6t, as shown in Figure1.

Figure.1 Collision vehicle

Three kinds of collision forms are selected,NTHSA RMDB offset oblique, IIHS small overlap and car-to-car overlap tests. NHTSA offset oblique test uses a deformable barrier to crash into the front of the car. The velocity of barrier is 90.1km/h , the angle is 15 degree and the overlap rate is 35%[2], as shown in Figure 2.

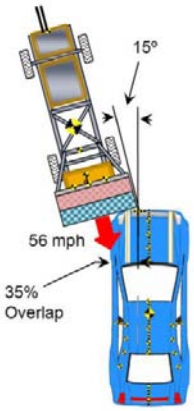


Figure.2 Sketch map of NHTSA RMDB offset oblique

In a IIHS small overlap test, the barrier is fixed on the floor while the car keeps moving until reaching the barrier. The velocity of the car is 64.4km/h. The end of rigid barrier is a circular arc shape. The overlap rate is 25%, as shown in Figure 3.

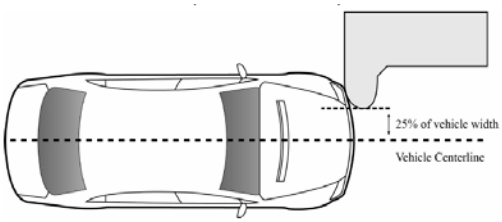


Figure.3 Sketch map of IIHS small overlap

Car-to-car small overlap test is done with the form of head-on collision. The angle of two cars is 15 degree, the velocity of each car is 56km/h and the overlap rate is 25%,as shown in Figure 4.

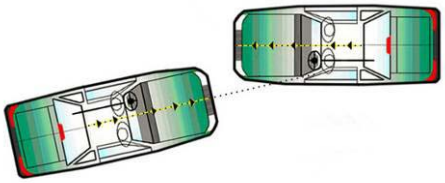


Figure.4 Sketch map of car-to-car small overlap

A Hybrid Ⅲ 50th dummy is placed in the driver seat in each test. With the test going on, the sensor will record the dummy injury.

3 Test result analysis

The analysis of test result will follow the three aspects: vehicle body deformation, vehicle motion state and dummy injury[3].

3.1 Vehicle body deformation

As shown in Figure 5, from the view of top camera, the car in NHTSA RMDB offset oblique has the largest deformation while the car in IIHS small overlap has the minimum. This is largely due to diifferent velocity change.

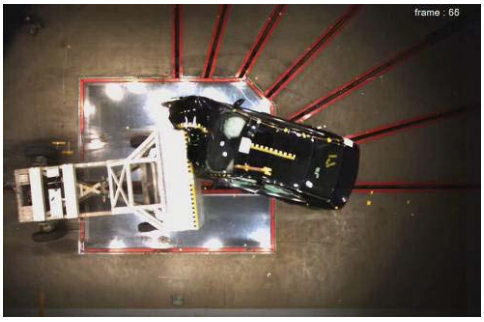


Figure.5 Top view of NHTSA offset oblique collision

Different from the other two forms of collision, the overlap rate pf IIHS small overlap collision is only 15%, so the phenomena of sideswipe can easily occur[4]. The car wipes off the barrier and the contact time lasts for 150ms. In this process, the car keeps longitudinal motion, as shown in Figure 6, which will contribute to the reduction of dummy injury.

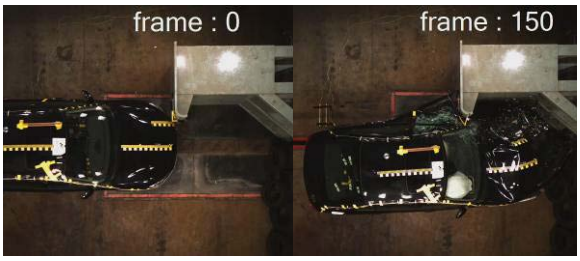
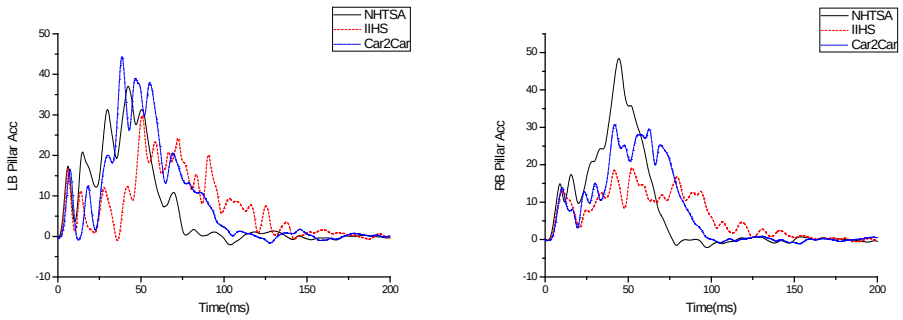


Figure.6 The contact time of car and barrier

3.2 Vehicle motion state

The car motion states can be different in these three kinds of collisions due to different velocity, crash angle, overlap rate and contact way. Especially the crash angle is a key factor of different lateral movement.

Figure 7 shows the lower vehicle B-pillar x-direction acceleration curve. From the curves we can see that the peak of car-to-car collision acceleration curve is the highest. This is mainly due to that the collision concentrates in the left front corner of the vehicle and the relative velocity of the two cars is 112km/h. As to the right B-pillar curve, NHTSA is much higher than the others.



a) Left B-pillar b)Right B-pillar

Figure.7 Lower B-pillar acceleration

Figure 8 shows the y-direction acceleration. From the curves we can see the vehicle's substantially horizontal movement starts from 30ms. This is due to the plastic deformation of vehicle and barrier. That process does not stop until the barrier reaches the high strength part which will cause the vehicle's rebound and lateral movement. The lateral movement starts much earlier in a car-to-car collision. The lateral velocity of IIHS small overlap test is the highest, which is mainly due to the rigid barrier and more energy need to be absorbed by the vehicle. This process lasts until 100ms. After that, A-pillar gets closer to the barrier and the vehicle appears to rebound. Eventually, the car gets separated with the barrier.

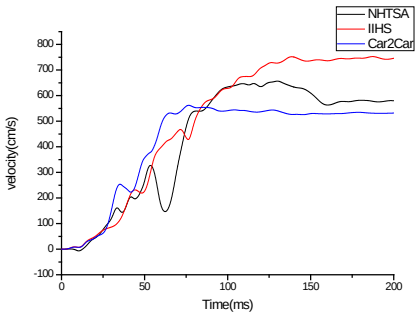
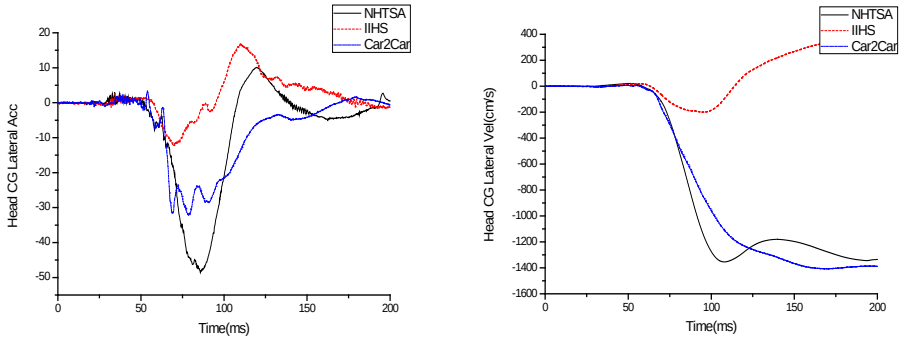


Figure.8 Lateral velocity of the vehicle

3.3 Dummy injury

The difference between vehicle movement will lead to the difference in dummy movement. Among these three forms of collision, the most significant difference shows in the dummy's upper body. The differences can be divided into two aspects: lateral movement of the dummy and HIC of the head.

Figure 9 shows the lateral acceleration curve and velocity curve of dummy's head. From this picture we can see in the NHTSA collision, movement of dummy's head is more violent than the other two and the peak of lateral acceleration has reached 50g.



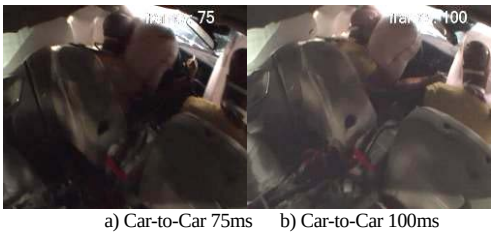
a) Lateral acceleration of head CG b) Lateral velocity of head CG

Figure.9 Lateral movement of dummy's head

From the on-board camera we can get a clear view of dummy's movement. In the NHTSA offset oblique, dummy's head starts to contact with airbag at about 55ms. But in IIHS small overlap test, this contact doed not occur until 85ms, as shown in Figure 10. In NHTSA test, the displacement of dummy's head is larger and this process is followed with torsion. The main influence factor is the lateral force which comes from barrier[5]. That is to say, the material, hardness and overlap rate is of vital importance.

a) NHTSA 75ms b) NHTSA 100ms

a) IIHS 75ms b) IIHS 100ms



a) Car-to-Car 75ms b) Car-to-Car 100ms

Figure.10 Dummy position in 75ms and 100ms

From the value of HIC36, we can see NHTSA is 527, IIHS is 87 and car-to-car is 306. NHTSA offset oblique test brings more harm on the dummy.

4 Conclusion

Through the analysis of NTHSA RMDB offset oblique, IIHS small overlap and car-to-car overlap tests, we get the main differences in three aspects: vehicle body deformation, vehicle motion state and dummy injury.

1) NHTSA collision is more severe, resulting in the most severe deformation of vehicle body.

2) In comparison with the other two forms of collision, the deflection of IIHS test is more severe and the lateral velocity is much bigger.

3) The lateral velocitiy in IIHS test is the biggest, HIC is the highest and contact time is the earliest.

4) It is the relative velocity between vehicle and barrier that leads to the difference of body deformation while the material and overlap rate will lead to the difference of dummy's lateral movement.

This paper discusses the differences among NTHSA RMDB offset oblique, IIHS small overlap and car-to-car overlap tests. This paper will provide reference for more detailed studies of car crash safety improvement in the future.

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