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DESIGN OF PROTECTIVE HEADGEAR USING GSM TECHNOLOGY FOR MOTOR CYCLE RIDERS

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ABSTRACT

The primary purpose of the without helmet while driving is to develop a system that can reduce the number of accidents from without helmet driving. With our two monitoring steps, we can provide a more accurate detection. For the detecting stage, the eye blink sensor always monitoring eye blink moment. It continuously monitoring eye blink moment the monitoring stage is over, the collected data will be transmitted to a microcontroller, and the microcontroller digitizes the analog data. If the warning feedback system is triggered, the microcontroller makes a decision which alert needs to be activated. The second application in this paper was to detect the alcohol detection and also to track the vehicle to find the culprit and in intimation to the Control Room with their location, and also the vehicle can be stopped. In this we use of GSM modem to trace the vehicle and also to inform to the control room. And also the indicator is fixed in the front and back of the vehicle to show to the opposite vehicle by means of this the driver can able to identify that driver was drunk. For the alert systems, we have two devices a beeper and an electric shocker. The project code was developed in C language and then converted to hex code which was readable for the microcontroller.

1. INTRODUCTION

Motorcycle hasbecomes apopular way of traveling for traffic participants owing to its advantages. The ownership of motorcycles in China were 67.5 million in 2004 (63% in vehicle), and then rose to 90 million in2008(53% in vehicle), in 2011, this number surprisingly increased to 0.1 billion (46% in vehicle) [1]. Motorcycle accidents caused plenty of fatalities and injuries, as show in figure 1. Though the number of fatalities and injuries has decreased recently, the injuries percentage of motorcyclist in road accident was increased.

Head is a major fatally and seriously injured part of body in motorcycle accidents. Analysis of motorcycle riders died in accidents in 2001 Japan shows the head mortal trauma accounted for 48.9%. In Europe, the hurt of head in motorcyclist fatalities accounts for 75%. Statistics show that the head injury caused 75.71% and76.84% dead in motorcycle accident fatalities in 2006 and 2007 China whereas this number would be 88% in low-income countries

[2-4].

Wearing a helmet is the most effective and direct way of protecting motorcycle riders [5-6]. Extensive and comprehensive studies have been taken on abroad. Analyzing the data in Japan database shows that helmet wearing can decrease 70% head injury risk and 40% dead risk in motorcycle accidents [7] (liu et al). By modeling each layer of the composite material that builds the laminated structure of the helmet outer shell, V. Tinard, C. Deck et al. simulated the elastic and rupture properties of the laminate outer shell who also extracted experimentally [8].

N.J. Mills et al. researched the oblique impact of motorcycle helmet and analyzed the factors influenced the angular acceleration of head form [9]. MazdakGhajari studied the full-scale oblique impacts of motorcycle helmet with the FE model of the human body, founding that the presence of the body influences the head rotational acceleration components (up to 40% for the simulated impact configuration) [10].

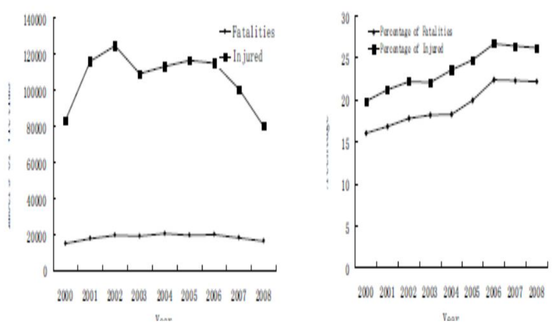


Figure. 1 Motorcyclist fatalities and injuries in china in 2002-2008

Researchers in China have done a great deal of works on helmet safety. At Guigang prefecture of Guangxi, Zhang Jun-hua et al. discovered that only 3% of riders wearied a qualified helmet correctly by roadside observation and questionnaires survey [11]. Wang Hao et al. conducted questionnaire surveys on 7482 people and found that 36.22% of motorcycle drivers or riders never wore a helmet [12]. A cross-sectional survey involving direct observation of motorcycle riders was conducted at 20 randomly selected intersections relating 13,410 motorcycle riders were observed by Yu Xuequn et al. They found the helmet prevalence was 72.6% among drivers and 34.1% among pillion passengers; the prevalence of helmet correct use was 43.2% and 20.9% for drivers and passengers respectively [13].

The aim of this paper is to analyze the craniocerebraltrauma by a motorcycle accident reconstruction which helps to understand the helmet protection mechanism and the mechanism of brain injury. The accident data was selected from a database: the In-Depth Investigation of Vehicle Traffic Accident in Changsha (IVAC). The orthogonal experiment design and comprehensive equilibrium methods were used to optimize the performance of helmet which is also useful in helmet design and manufacturing.

Existing system:

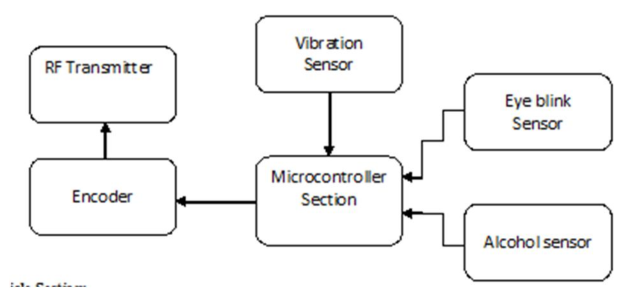
- No security for riders
- No intimation system

Proposed System:

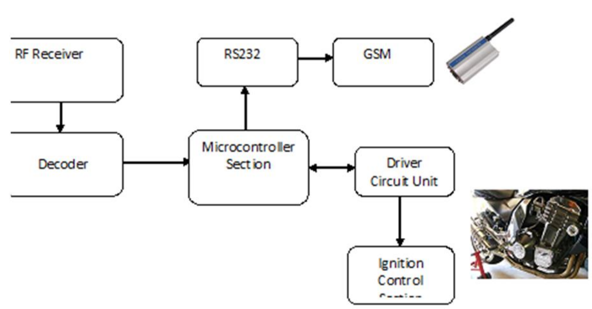
- Wireless technology
- Easy way to control vehicle

2. BLOCK DIAGRAM

Helmet Section



Vehicle Section:



Hardware Tools:

- Microcontroller
- RF module
- Sensor unit

- GSM modem

Software Tools:

- Keil C Compiler
- Flash Programmer
- Languages Used: embedded C

Applications:

- Vehicle Application

3. METHODS AND MATERIALS

The comprehensive use of FEA and multi-body method is an effective way in research of helmeted head protection. The multi-body method can simplify the large displacement and nonlinear problems to acquire the movement of dummy head in considerable calculating time. Finite element analysis can precisely reflect the strain-stress of helmet and brain during the impact, coupling with the finite element human head model reflect the way approach to helmeted head injury protection in-depth research.

Accident reconstruction

In a frontal impact motorcycle-car accident, two vehicles ran into each direction without avoiding. The front wheel of the motorcycle collides with the bumper of an elantra, causing the driver throw over the roof then felled on the ground. The distance between the rider and car front wheel is 5.4m and that between the front wheels of two vehicles is 4.5m. The height and weight of rider is1.72m and 70kg respectively. According to the records ofpolice, the velocity of car and motorcycle was 40 ± 5 km/h and 10 ± 3 km/h respectively. Rider suffered cerebral concussion, fracture of C7 and penetration injury of left eye. Figure 2 shows the situation of accident scene.

Construction of impact model

The human multi-body system (MBS) used in this paper was developed and validated in Chalmers university [14]. The model was scaled according with the victim using the 'GE-BOD' code within MADYMO.A kind of widely used man's motorcycle was selected as the prototype model which uses a free joint to connect with the global system and a revolute joint to simulate the steering device. Parameters such as distance and mass were measured and ellipsoids were used to matching its appearance. The contact characteristic was referenced to the data in COST327's final report [15].

In the accident, front bumper and windshield were the contact surface between the participators. The matchingof car model should focus on these two surfaces and its contact characteristic referenced to the Euro NCAP subsystem tests [16].

Reconstruction validation

According to the simulation results, a relative velocity was generated between the rider and motorcycle after the contact of two vehicles. The velocity direction was changed from horizontal to upwards due to the oblique of oil tank, which means to impose a torque on the rider's hip. Owing to this torque, the rider was rotated and impact to the windshield. Finally, the rider flies over the roof and felled on the ground. The distance from rider to car front wheel is 6m; distance between two vehicles' front wheels is 3.6m. Impact location in simulation is very similar to the damaged car (fig. 3).

Figure.2 Comparison impact location and simulation results

Establish and validation of helmet FE model

The helmet used in the research is a full-face motorcycle helmet which certificated by national standard,1400 ± 50g, median size. EXAscan was used to acquire the cloud information of point then processed by Geomagic Studio program into geometry CAD data. Check pad, hanger plate, chin strap, those features were ignored because it will not influence the helmet performance. However, the real helmet contains three other parts: a low density comfort padding, a visor, a retention system. The influence of the comfort liner on the dynamic response to the impact was assumed negligible. Moreover, the influence of the visor and its attaching system was also deemed not relevant so they were also not included. Owing to the lack of neck system, the retention system was not constructed in this paper.

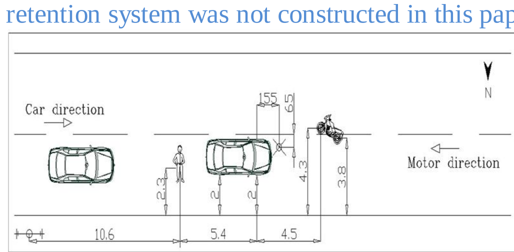


Figure 3 the sketch of accident scene

The Crushable Foam material model (MAT63 in DYNA) was employed to simulate the EPS foam which is similar to closed cell cellular solids. This material model requires the definition of the Young's modulus, Poisson's ratio and the compressive stress-strain characteristic curve of the foam. The classic curve of stress-strain of EPS is characterized by three main stages: the elastic zone for strain below 5%; the plateau zone in which the curve level out and a densification zone for high strain. Gibson and Ashby using a simplified model for the single cells present in the material [17], so the three stages can be expressed by equations show as followed:

$$\sigma = E\varepsilon + \frac{p_o\varepsilon}{1-\varepsilon-R} \quad \sigma = \sigma_y + \frac{p_o\varepsilon}{1-\varepsilon-R}$$

$$\sigma = \sigma_y \frac{1}{D}\left[\frac{\varepsilon_D}{\varepsilon_D-\varepsilon}\right]^m + \frac{p_o\varepsilon}{1-\varepsilon-R}$$

The composite outer shell was defined as Laminated Composite Fabric material model (MAT 58 in DYNA). This material based on the principle of continuum damage mechanics developed by Matzenmiller et al. (1995). The elastic properties required for this material model are Young's module in fiber and matrix direction, one in-plane Poisson's ratio and in-plane shear modulus. For failure, it is assumed that the lamina fails under tension and compression in plane shear. The parameters see as in table 1:EPS main liner was meshed into 47187 solid elements and the shell was meshed into 6741 shell element. The element size of them is 5. The whole model is 967g.

Headform assessment

The head form used in the paper is hybrid III dummy head which is not in accord with the regulations. It is necessary to assess the effectiveness of the head form. Thedummy head is size J, 570mm, 4.81Kg and the moment of inertia about z axis is 19.2kg.mm2, which the physical property is similar to the aluminum headform.

Helmet validation

According to ECER22.5, the helmet should couple with the head form then set free to impact the steel anvil with the impact velocity at 7.5m/s [18]. The helmet model coupled with head form which use surface to surface contact type available in DYNA. A simulation of frontal impact (Fig.4a) was used in validation and the liner acceleration time histories was produced to compare with the experimental one (test in COST327). See figure 4b.

Coupling with the HBM-head model

Hunan University has developed the HBM human head FE model (Yang and Xu 2008) [19] represented in figure 5. The validated model includes 38 main anatomical features: scalp, skull, CSF, falx, cerebrum, cerebellum, brain stem. Adjust the head model into the helmet and minimum the clearance between head and helmet (Fig. 5).

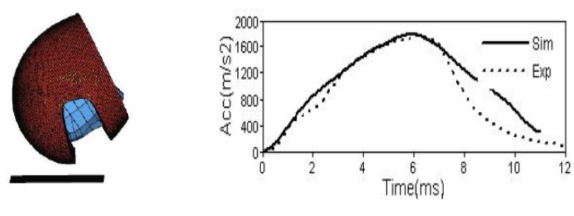
Table 1 material properties of helmet shell

ρ	E_1	E_2	G	σ_{11C}	σ_{11T}	σ_{22C}	σ_{22T}	τ_1	γ_U	ν_{21}	ε_{11C}	ε_{11T}	ε_{22C}	ε_{22T}
1400	110	10	4.2	1700	49	400	130	90	0.022	0.033	0.016	0.009	0.007	0.013

Table 2 test result of project COST327

	APRA(	APRA(1	APTF(	APTF(1
Hybrid	2815	917	5622	1781
Alumin	2239	1133	5325	2083

APRA means average peak rotational acceleration;APTF means average peak tangential forces



(a) (b)

Figure. 4 comparison of experimental and numerical headform acceleration

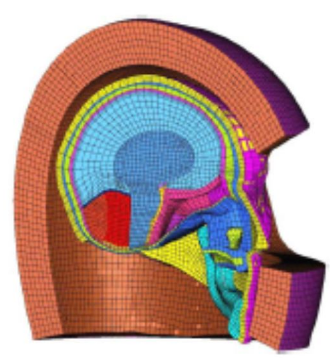


Figure. 5 coupling of head and helmet

4. RESULTS

Analysis of impact process

Curve of rider's head velocity was acquired from accident reconstruction (fig. 6). The result indicate that the impact of head between ground is much fierce than the impact between head and windshield. The head collide with the windshield at velocity of 6m/s at 303ms after the contact of motorcycle's front wheel with bumper. At time of 1157ms, the head strike on the ground with linear velocity and angular velocity 3.82m/s, -0.34m/s, -8.09m/s, 0.484rad/s, 6.975rad/s, -2.375rad/s about X, Y, Z direction. The angular velocity is too small to induce enough relative displacement.

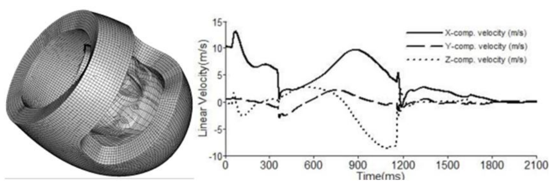


Fig.ure 6 curve of ride's head velocity and its impact posture

Three point positioning method was used to acquire the posture 2ms before impact and then load the initial velocity and gravity. Increase the friction factor to simulate the abrasive paper on the anvil. There are three phases in the process of helmet impactelastic deformation of outer shell and EPS foam, plastic deformation and fail of shell and foam, rebound of the helmet. Considering the strain of energy absorption foam, the maximum strain value 3.57MPa of outer shell interface emerged 5ms after impact while the strain of inside interface is -2.08 MPa. At 6.3ms, maximum strain on interface of inside foam is -2.13MPa while the outer interface strain reduces to 1.98 MPa (fig 7). We can deduce that the helmet delayed to release 60% of crash energy, which means transfer the energy mildly. It avoid the over high peak force which benefit to reduce the probability of getting injured.

Arachnoids in both left and right side showed remarkable pressure because the impact happended at parietal bone. The left and right side pressure time histories are shown in figure 8. The pressure was uniformly distributed across the brain from left to right which accompany compression emerged up at the left region and tension at right. The rises trend of the curve is gentle that also reflects the protection of the helmet, besides, the peak value of the curve is acceptable. A pressure field was created and encircle around the head leads to the maintained pressure on intracerebral due to the modality of the helmet. Peak acceleration of head centroid appear at 5ms, but there are two crest shown in figure 8, it illustrate that the maximum trend of relative motion not accrued at the time of peak acceleration. Figure 9 shows the equivalent stress of the brain at 8ms after impact, the maximum value is 11.6KPa which appears at the brain stern. This is the main reason lead to cerebral concussion.

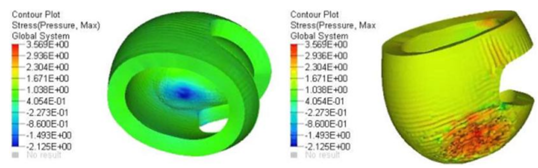


Figure. 7 maximum stress of the interface

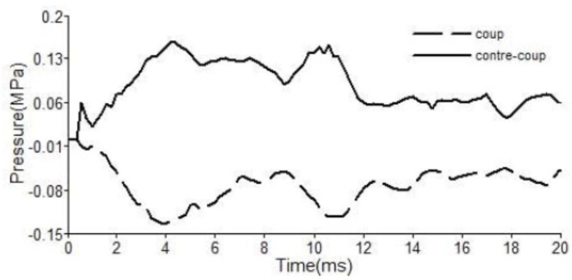


Figure.8 maximum pressure and countercoup pressure

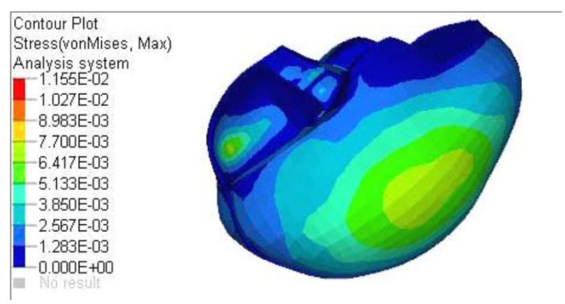


Figure.9 Vonmises pressure of brain

5. CONCLUSIONS

Established an effective helmet model and coupling with a FE human head model, analyzed the brain trauma in a real accident, discovered the pressure field generated by the helmet caused plateau pressure in brain which not brings about injury. Cerebral concussion of rider's head result from the Vonmises in brain stern, the impact between the edge of helmet with neck leads to C7 fraction.

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