行政院國家科學委員會補助專題研究計畫成果報告

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※ 機車安全帽防護頭部傷害改良之研究 ※

※ **The Improvement of Protective Performance of** ※

※ **Motorcycle Helmets Against Head Injuries** ※

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計畫類別：■個別型計畫 □整合型計畫

計畫編號：NSC 89－2218－E－041－004－

執行期間：89 年 12 月 01 日 至 90 年 07 月 31 日

計畫主持人：張立東

共同主持人：

本成果報告包括以下應繳交之附件：

□赴國外出差或研習心得報告一份

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□國際合作研究計畫國外研究報告書一份

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中 華 民 國 90 年 7 月 31 日

The Improvement of Protective Performance of Motorcycle Helmets Against Head Injuries

機車安全帽防護頭部傷害改良之研究

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主持人： 張立東 嘉南藥理科技大學 嬰幼兒保育學系
計畫參與人員：莊智宏 國立成功大學醫學工程研究所
計畫參與人員：張志涵 國立成功大學醫學工程研究所
計畫參與人員：張冠諒 國立成功大學醫學工程研究所

Abstract

The outer shell and energy-absorbing liner of motorcycle helmet are mainly to distribute the contact forces and to absorb the impact energy, respectively. A finite element model based on realistic helmet geometric features and material properties has been established to evaluate the protective performance of helmet. The results showed that a more-pliable shell with a less-dense liner provides better protection at lower impact velocities, but a stiffer shell is better for higher-velocity impacts. To improve the protective performance of the helmet during higher-velocity impacts, the complex structure of the liner should be a feasible way.

Keywords: Head injury, Motorcycle helmet, Finite element analysis

Introduction

Wearing a motorcycle helmet is the best method to prevent head injuries in motorcycle accidents. A helmet generally consists of a hard outer shell and an energy-absorbing liner. The outer shell is mainly to distribute the contact forces, while the energy-absorbing liner is to absorb the impact energy. The objective of this study was to evaluate the protective performance of a helmet by varying the complex structure of the energy-absorbing liner and using different degrees of shell stiffness.

Methods

A finite element (FE) model based on realistic helmet geometric features and material properties has been established (Fig. 1). The liner was composed of three layers with material densities of 30, 40, 50, 60, and 70 kg/m^3. HDPE, ABS, and GRP were used as the study materials for the shell component.

An explicit FE code, LS-DYNA, was employed to simulate the dynamic responses of the helmet at impact velocities of 5.6, 8.3, and 11.1 m/s. The maximum acceleration and head injury criterion (HIC) [1,2] of the headform were employed to assess the protective performance of the helmet.

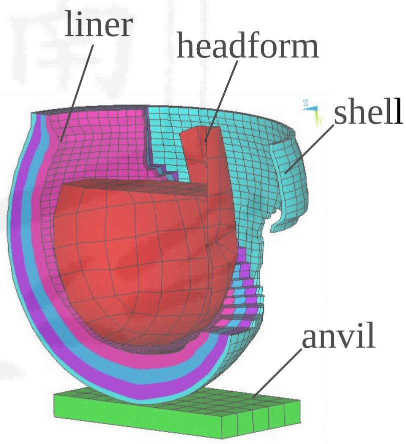

Fig. 1. Cross-sectional view of the FE model.

Results

For impacts of 5.6 m/s, the peak acceleration and HIC values increased as the shell stiffened, and the maximum differences were 34% and 95%, respectively (Fig. 2). Nevertheless, the stiffer shell had smaller index values than the more-pliable shells at an impact of 11.1 m/s (Fig. 3). The maximum differences of both indices were 9% and 55%, respectively.

When the liner density was increased form 30 to 70 kg/m^3, both index values increased by a range of 20%~50% regardless of the shell stiffness or impact velocity (Fig. 4). For all investigated parameters in the simulations, the complex structure of the liner, in which the liner density was increased from the side of the helmet shell to the head (30 to 40 to 60 g/l), had the lowest values for both indices at the higher-velocity impacts (8.3 and 11.1 m/s) (Fig. 5).

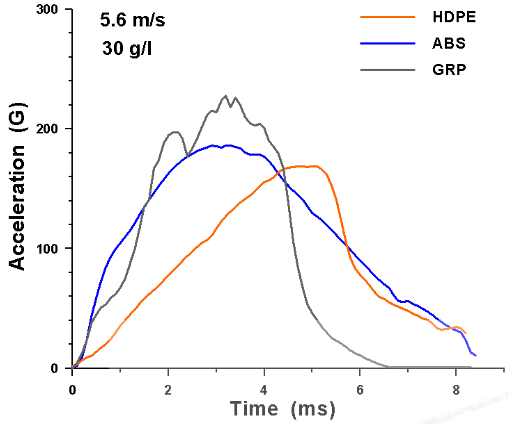

Fig. 2. Acceleration-time traces of the headform in different shell materials at 5.6 m/s.

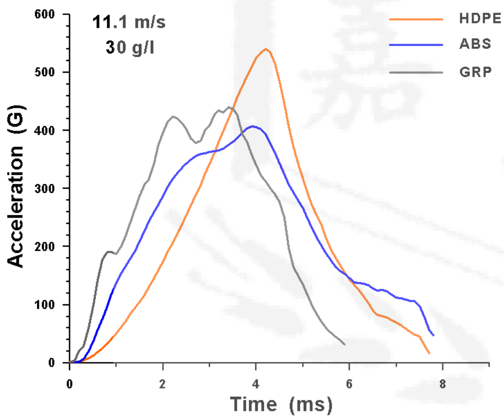

Fig. 3. Acceleration-time traces of the headform in different shell materials at 11.1 m/s.

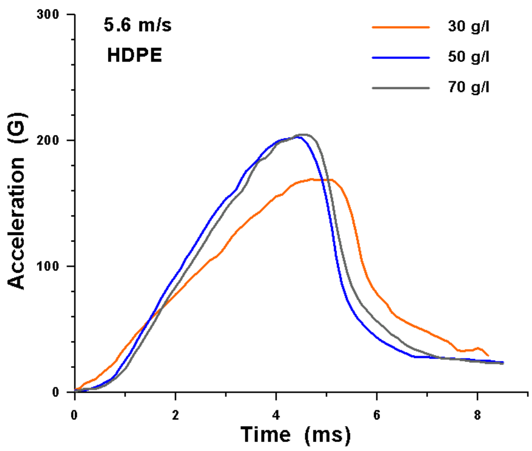

Fig. 4. Acceleration-time traces of the headform in different liner densities (HDPE shell; 5.6 m/s).

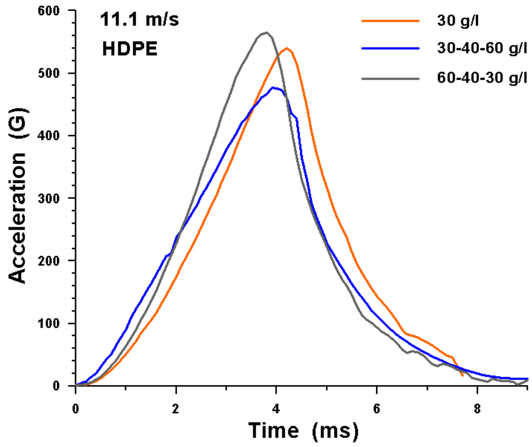

Fig. 5. Acceleration-time traces of the headform in the complex structure of the liner (HDPE shell; 11.1 m/s).

Conclusions

For helmet design, a more-pliable shell with a less-dense liner provides better protection against head injury at lower impact velocities, but a stiffer shell is better for higher-velocity impacts. To improve the protective performance of the helmet during higher-velocity impacts, the complex structure of the liner should be a feasible way, and the liner density should be increased from the side of the helmet shell to the head.

Reference

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[2] J. Versace, A review of the severity index, Proceedings of 15th Stapp Car Crash Conference, New York, 1971.