Concept Design of an Active Headrest for Neck Injury Mitigation of Rear Impact

Chengyue Jiang, Hongyun Li, Shugang Xie,Xi Liu[1]

I. INTRODUCTION

Low severity rear vehicle impacts can cause whiplash associated injury which is one of the most common traumas leading to permanent medical impairment [1]. Previous studies have observed that the risk of sustaining whiplash injury in rear-end collisions was related to the occupant restraint status [2]. In order to reduce the possibility of neck injuries, it is essential to carry out research on active head restraints or energy absorbing seats.

The goal of this study was to evaluate an active headrest concept's effects on the BioRID-II dummy kinematics and injury results, based on a validated Finite Element (FE) model of the China New Car Assessment Program (C-NCAP)[3] whiplash load case.

II. METHODS

In this study, a correlated rear impact FE model of C-NCAP whiplash load case (a hydraulic controlled sled test) was introduced for further evaluation of the concept designed active headrest's effectiveness on dummy kinematics and injury index. In previous studies, the FE simulation model including the BioRID-II dummy (Version 7.5) correlated well with the physical sled test with MADYMO software [4], as shown in Figure 1.

Fig.1. Whiplash sled test at 60ms (left) and the sled test simulation at 60ms (right)

Based on the validated simulation model above, the concept pyrotechnic propelled active headrest was proposed as it was possible to move the headrest 42.9mm upward and 13.5mm forward in this case (see Figure 2 below). The propulsion system of the active headrest was linked with an electronic control unit for vehicle restraint systems, and trigger time of the propulsion system was defined at 20ms, according to the research of [5]. The active headrest replaced the original one for the kinematics comparison and injury index analysis.

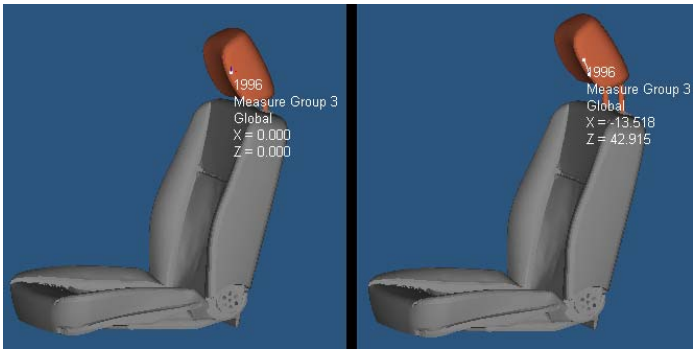

Fig.2. Initial position of active headrest (left) and final position of the active headrest (right)

Chengyue Jiang and Xi Liu are Vice Professors in Vehicle Engineering at Chonqging University of Technology, China. (+0086-15683751760, liuxi@cqut.edu.cn). Hongyun Li and Shugang Xie are Senior Engineers at China Automotive Technology and Research Center.

III. INITIAL FINDINGS

The simulation results showed that the active headrest could reduce both the upper neck tension force and the lower neck shear force (see Table 1), which significantly improved the scores of the upper neck and lower neck regions. These improvements were mainly due to the earlier contact between the BioRID II dummy and the active headrest. Take the lower neck shear force for example (as shown in Figure 3 below), the shear force rose earlier than those of the baseline simulation and test, while its peak force was reduced approximately 30%.

TABLE I
NECK INJURY INDEX COMPARISON

Injury index	Baseline model	Simulation with active headrest	Change
Upper Fz+	864.1N	334.1N	↓ 61.3%
Lower Fx	389.1N	272.9N	↓ 29.9%
NIC	12.9	15.2	↑ 17.8%
C-NCAP whiplash score	2.87	3.2	↑ 11.5%

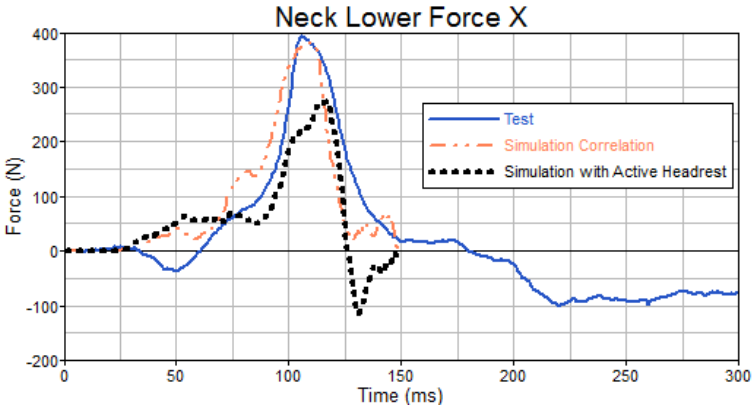

Fig.3. Neck lower shear force comparison

In summary, after the introduction of the active headrest, the whiplash score was improved from 2.87 to 3.2 (the total C-NCAP whiplash score is 4 point). However the Neck Injury Criterion (NIC) index was increased about 17.8%, which had a little negative influence on the C-NCAP whiplash evaluation result.

IV. DISCUSSION

To evaluate effects of the active headrest on neck injury results and kinematics, the headrest motion was pre-defined in this study (the trigger time was defined at 20ms according to certain research [5], while the movement from the initial position to final position took approximately 10ms by using the pyrotechnic technology), which needs further sled test validations. Whiplash injuries can be improved with the active headrest, but benefits of such active headrest may vary due to the different seating positions of occupants in real life, which require further study. The installation angle of the headrest's propulsion system can be adjusted for some other headrests which are already in contact with the occupant head in their design positions, therefore those headrests can move upward only in cases of rear impacts.

V. REFERENCES

[1] Gutsche A et al, IRCOBI, 2013.
[2] Galli R et al, SAE Paper 2008-01-0190, 2008.
[3] China Automotive Technology and Research Center, C-NCAP Test Protocol, 2015.
[4] TNO, MADYMO Model Manual Version 7.5, 2014.
[5] Bogenrieder R et al, ESV, 2009.

This project is supported by National Natural Science Foundation of China (Grant No. 51405050) and Chongqing Science and Technology person training program (cstc2013kjrc-qnrc60002).