Injury metrics comparison between 50th percentile male Hybrid III and GHBMC finite element (FE) models in potential seating positions of the Automated Driving Systems (ADS) equipped vehicles

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I. INTRODUCTION

In the future, the use of vehicles equipped with SAE level 4 or level 5 Automated Driving Systems (ADS) may lead to a reduction in vehicle crashes that are attributable to human error [1]. However, even if ADS technology matures to the point where it can safely and consistently perform the driving task without human intervention [1], it is likely that some crashes that cannot be avoided will still occur. For this reason, occupant protection will continue to be an important aspect of vehicle safety. In current vehicles, occupant in certain seating locations (e.g. front passenger) can sit in non-traditional seating positions (different seatback recline angles), whereas, all the occupants in level 4 or level 5 ADS equipped vehicles may sit in non-traditional seating positions such as different seatback recline angles and seating orientations. This study compares the injury metrics between 50th percentile male Hybrid-III (H-III) and simplified Global Human Body Models Consortium (GHBMC) finite element (FE) models in different seatback recline angles under six different impacts.

II. METHODS

The FE model environment used in this analysis comprised of an occupant, a Honda Accord driver seat, a rigid vehicle floor, and an integrated seatbelt restraint system (Figure 1).

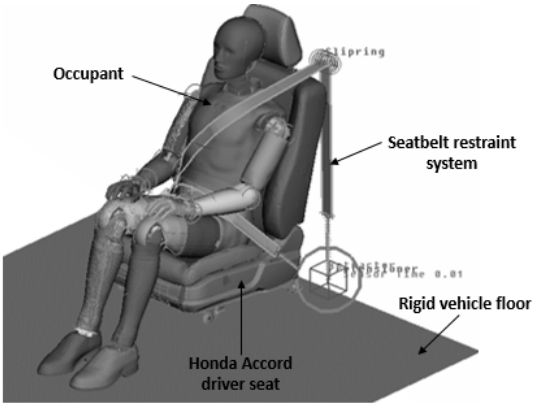

Figure 1. ADS model setup

Validated GHBMC and H-III FE models were analyzed individually at two different seatback recline angles: a) 20° (driving position) and b) 45° (relaxed position). Relaxed positioning for GHBMC and H-III was carried out in two steps. Gravity was first applied at 45° to settle the back followed by gravity in Z direction (vertical) to settle the pelvis, thighs, and feet. Six different impacts were simulated namely frontal, far and near side 20° oblique-frontal, rear, far and near side 20° oblique-rear. A crash pulse taken from a NHTSA oblique-frontal crash test (Delta-V ~ 35mph) was applied to the model. Overall, 24 simulations were run. The injury metrics computed were the Brain Injury Criterion (BrIC) [2], Head Injury Criterion (HIC_{15}) [3], and chest deflection (CD) [3]. Due to modeling limitations, obtaining neck injury metric (Nij) from GHBMC model was not possible, so Nij was not analyzed in this study.

III. INITIAL FINDINGS

Injury metrics for frontal and oblique-frontal impacts are summarized in Table 1, while, injury metrics for rear and oblique-rear impacts are summarized in Table 2. HIC_{15} values were lower than 330 for GHBMC and H-III in all

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impact cases except for frontal impact with GHBMC in driving position, where HIC_{15} value was 900 because the head contacted the knee. For frontal and oblique-frontal impacts (Table 1), GHBMC showed lower BrIC values in relaxed position as compared to driving position, but no chest deflection trend was seen, whereas, H-III showed higher BrIC and lower chest deflection values in relaxed position as compared to driving position. BrIC was consistently higher for H-III than GHBMC. For rear and oblique-rear impacts (Table 2), GHBMC and H-III showed higher BrIC but lower chest deflection values for relaxed position as compared to driving position. Chest deflection was consistently higher for GHBMC than H-III.

Table 1: Summary of injury metrics for GHBMC and H-III under frontal and oblique-frontal impacts

Position	Impact	Model	HIC_{15}	BrIC	CD (mm)
Driving position	Frontal Impact	GHBMC	900	0.78	42
		H-III	251	0.86	44
	Far Side Oblique-Frontal Impact	GHBMC	171	0.78	35
		H-III	310	0.94	37
	Near Side Oblique-Frontal Impact	GHBMC	329	0.8	44
		H-III	252	0.90	39
Relaxed position	Frontal Impact	GHBMC	170	0.73	46
		H-III	237	1.14	35
	Far Side Oblique-Frontal Impact	GHBMC	140	0.72	26
		H-III	307	1.03	36
	Near Side Oblique-Frontal Impact	GHBMC	157	0.72	43
		H-III	318	1.08	33

Table 2: Summary of injury metrics for GHBMC and H-III under rear and oblique-rear impacts

Position	Impact	Model	HIC_{15}	BrIC	CD (mm)
Driving position	Rear Impact	GHBMC	126	0.26	26
		H-III	197	0.11	8
	Far Side Oblique-Rear Impact	GHBMC	141	0.43	26
		H-III	155	0.53	5
	Near Side Oblique-Rear Impact	GHBMC	140	0.50	26
		H-III	151	0.49	9
Relaxed position	Rear Impact	GHBMC	142	0.37	19
		H-III	150	0.34	3
	Far Side Oblique-Rear Impact	GHBMC	154	0.67	20
		H-III	117	0.58	2
	Near Side Oblique-Rear Impact	GHBMC	138	0.57	20
		H-III	123	0.61	3

IV. DISCUSSION

The study shows that there are differences in injury metric values between GHBMC and H-III FE models for the various impacts analyzed. Differences in BrIC values between GHBMC and H-III might be due to the different neck structures. For frontal and oblique-frontal impacts, the upper body of GHBMC rotates more about the pelvis but the neck rotations are lower, whereas, the upper body of H-III rotates less about the pelvis but the neck rotations are higher. In frontal and oblique-frontal impacts, both the models show similar shoulder belt loading, while, for rear and oblique-rear impacts, GHBMC shows earlier shoulder belt loading compared to H-III model. Differences are also seen in the lap belt forces between the two models. The FE models (GHBMC and H-III) have been validated in standard seating but not in non-standard seating. PMHS tests in non-standard seating may be carried out in future to validate the models and to evaluate the reliability of the results of this study.

V. REFERENCES

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