ANALYSIS SEDAN VEHICLE STRUCTURE IN FRONTAL IMPACT USING COMPUTER MODEL

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ABTRACT

This paper presents an overview of Sedan vehicle structure based on frontal impact. The analysis results include parameters on the degree of deformation, the collision absorption ability of the Sedan vehicle structural model in accidents. The purpose is based on the comparison results to simulate the Sedan vehicle structure model that collides with other car chassis models at different speed levels, based on that, compares the crash analysis simulations to find the textures the frame absorbs the maximum impact energy and minimizes the deformation so as not to affect intrusion into the safe space of the passenger compartment of the vehicle. The results of this paper show that the frame structures such as the A-Pillars and Horizontal brace between the engine compartment and the passenger compartment need to be improved to increase the safety for the passengers inside. The study results are expected to be expanded in to optimize the engineering structures and improve the efficiency in various fields included shipbuilding, offshore structures, marine aquaculture structures, etc.

Keywords: *Structural, analysis, Sedan, vehicle structure, fontal impact.*

I. INTRODUCTION

Numerical tools are increasingly acknowledged as crucial and adaptable tools for improving design efficiency and substantially decreasing materials and energy consumption. Employing these tools in the structure design holds the potential to improve the environmental impact, both onshore and offshore. In 2012, according to the Vietnam Automobile Manufacturers' Association (VAMA), vehicle sales continued to grow well, reaching 30,065 units nationwide, including 7,382 sedans [1]. With the increasing variety of cars and the proportion of collisions between different types of vehicles also increasing, compatibility for different types of cars is becoming an important topic. According to the National Traffic Safety Committee's statistics, of the 1,382 accidents in 2001, 741 were frontal collisions, accounting for 53.6% in Vietnam [2]. Studies on collisions have shown that the safe speed for a frontal collision between two cars is between 32.5 km/h and 35.2 km/h, and the dangerous speed is between 48.4 km/h and 68.6 km/h [3]. The dangerous speed for a collision in the US is 56 km/h with 100% frontal collisions with a rigid barrier according to the US- NCAP (US-New Car Assessment Program) [4]. According to the Insurance Institute for Highway Safety (IIHS), 51% of fatalities occur in frontal collisions [5]. When there is a collision, the car frame absorbs 50% of the impact, while the engine and other parts absorb the remaining 50% [6]. Some studies use LS-DYNA collision simulation soft- ware to calculate the stiffness and geometric height under different overlap ratios through finite element simulation (FE) [7]. Most collision simulations focus on the front frame to improve incomplete energy absorption, while too much intrusion into the dash- board can easily damage the front passenger [8]. Experimental collision tests calculate the time of small overlap collision occurring within 120ms to 150ms [9]. Some exper- imental projects test the ability of frame absorption of collision force using hydraulic and pneumatic mechanisms, ensuring passenger safety [10].

The main objective of this article is to focus on collision simulation and analysis of deformation and absorption capabilities of the car frame. The sedan is a special-purpose car model that is completely built and simulated on LS-DYNA software, aiming to analyze and test the breakdowns [11][12], through simulation for future improvements.

II. MATERIAL AND METHODS

When colliding head-on with an obstacle, the front structure of a vehicle tends to deform, reducing the safe space for the driver with the front structure. At the same time, it also moves forward due to inertia. In the event of an accident, the driver and passenger bodies are severely impacted against the front interior structure. This is difficult to avoid with the design of most vehicles today. However, based on the above hypothesis, the topic is proposed for simulation to study human injury when a vehicle collides head-on with an obstacle. From there, proposals are made to enhance human safety and minimize casualties.

1. Finite element model (FEM)

This research model uses a Sedan car with the finite element (FE) model of a Dodge Neon car [13] developed by the National Crash Analysis Center (NCAC) and corre- spondingly undertaken by the US National Highway Traffic Safety Administration (NHTSA). The model has been tested for collision with a rigid wall in both experiments and simulations, making it suitable for use in this paper as shown in Figure 1.

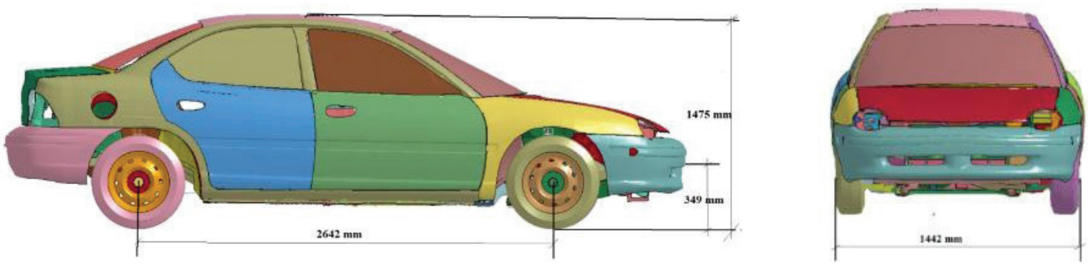
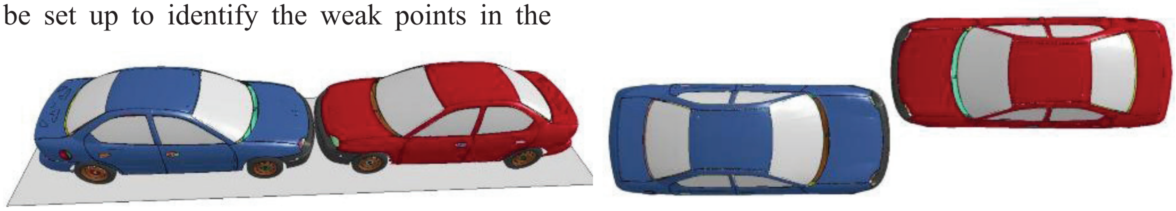


Figure 1. Dodge Neon 1997 FEM model.

2. Collision simulation

This section will establish collision cases at a speed of 56 km/h according to NHSTA and IIHS standards with 100% frontal collision. The collision simulation between two Sedan cars consisting of car A (blue on the left side) and car B (red on the right side) (Figure 2) will be set up to identify the weak points in the Sedan car frame. Adjusting the two collision models to fit the frontal collision display for the frame cases on the Dodge Neon car [13], the final case checks the deformation of both frame types when offset collision occurs by 40% according to European and Asian standards. Shown in **Figure 2**.



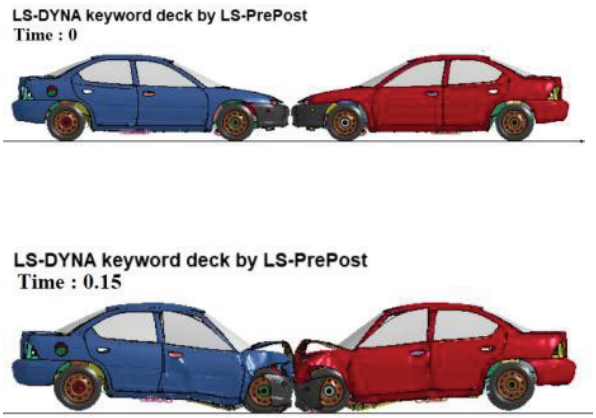
a. Full frontal impact b. Moderate frontal impact

Figure 2. Car to car frontal impact simulation.

III. RESULTS AND DISCUSSION

Scenario 1: A finite element (FE) model simulation is carried out between two Dodge Neon (Sedan) cars colliding head-on at a speed of 56 km/h, with a model taken from NHSTA and tested by NCAC. Both cars are simulated to collide at a speed of 56 km/h for 150ms and the collision process is performed using LS-DYNA software for approximately 20 hours (Figure 3). In this scenario, both cars collide at the same speed and their frame structures are crushed inwards and bent towards the vehicle body, causing significant collapse. The passenger compartment shows deformation in the door and windshield section A. The maximum deformation is reached at 65ms, and the process gradually diminishes until 100ms when the cars begin to slightly move backward, and the simulation ends at 150ms. Shown in **Figure 3**.

Moving velocities VA=VB=56km/h within 150ms



Vehicle structure pre-crash and post-crash

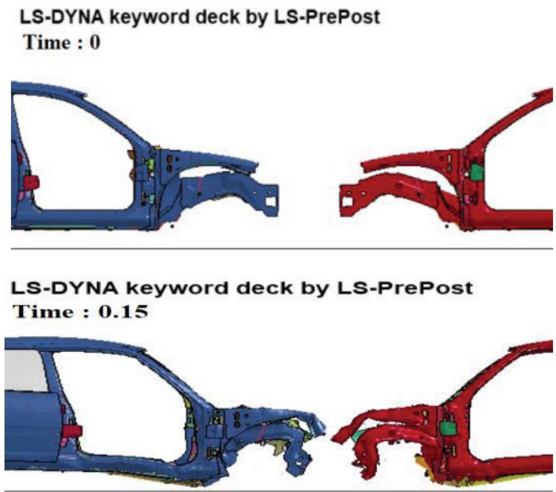
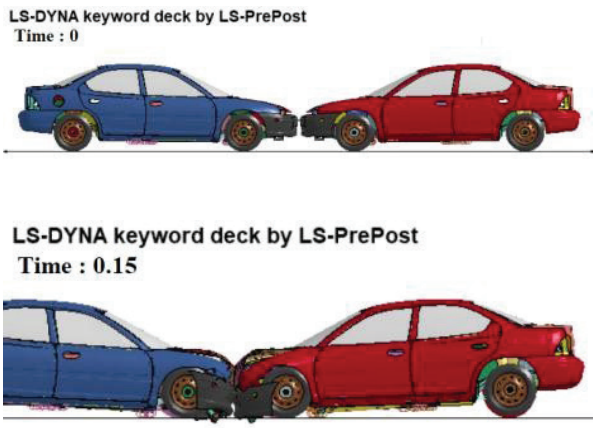


Figure 3. Car to car full frontal impact simulation with VA=VB=56km/h.

Scenario 2: An FE model simulation is carried out between two Dodge Neon cars colliding head-on at a speed of 56 km/h, where car A (blue) is stationary, and car B (red) is moving at 56 km/h taken from NHSTA and tested by NCAC. Both cars are simulated to collide head-on for 150ms, and the collision process is performed using LS-DYNA software for approximately 19 hours (Figure 4). In this scenario, the frame elements of car A deform less than car B due to being stationary. When the head-on collision occurs, the front of car B is pushed down more, causing more frame deformation than car A. The maximum deformation is reached at 65ms and gradually decreases until 100ms when car B begins to push car A backward slightly. The simulation ends at 150ms. Shown in **Figure 4**.

Moving velocities VB=56 Km/h, VA=0 km/h within 150ms



Vehicle structure pre-crash and post-crash

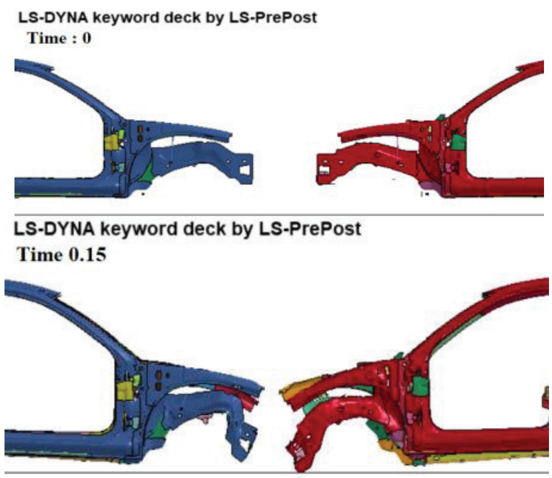
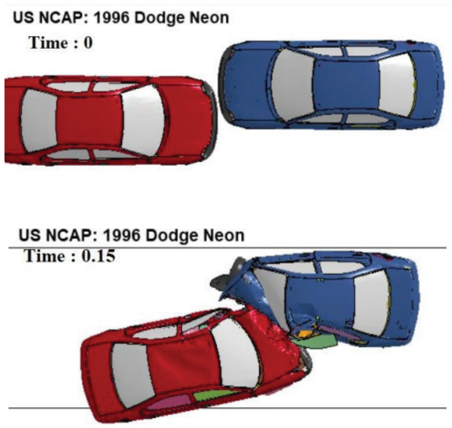


Figure 4. Car to car full frontal impact simulation with VB=56 Km/h, VA=0 km/h

Scenario 3: An FE model simulation is carried out between two Sedan cars colliding head-on at a speed of 56 km/h and at an offset of 40% using NHSTA and tested by NCAC. Both cars are simulated to collide head-on, and the collision process is performed using LS-DYNA software (Figure 5). In this scenario, car B collides with car A at a speed of 56 km/h and at an offset of 40%, causing both cars' frame elements to be crushed inwards and collapse significantly towards the passenger compartment. The car doors are completely deformed. The maximum deformation is reached at 65ms and gradually decreases until 100ms when both cars start to rotate and deflect from the simulation plane. The simulation ends at 150ms. Shown in **Figure 5**.



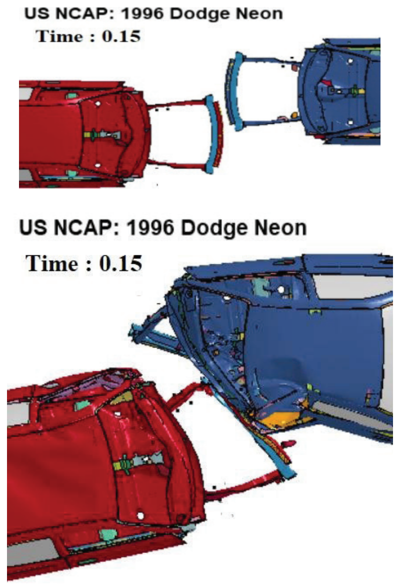


Figure 5. Car to car moderate frontal impact simulation with VA=VB=56km/h.

IV. CONCLUSION

The finite element (FE) simulations showed that in both Scenario 1 and Scenario 2, although the front of the cars experienced significant deformation, they still demonstrated good energy absorption capability during the collision, ensuring passenger safety. However, Scenario 3 showed insufficient energy absorption, leading to significant deformation in the passenger compartment and posing a danger to passengers in the car, with a high possibility of intrusion into the dashboard and compression of front seated occupants. The weight on the car is also a matter of concern when the two cars collide, as shown by the noticeable rotation in Scenario 3. Improvements to the car's frame during the collision are necessary to maximize passenger safety. The findings of this research could be extended to other marine sturcuture in collisions to enhance efficiency and contribute to marine sustainable development.

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