DESIGN OPTIMISATION OF OUTER HOOD PANEL OF ESEMKA R2 CAR TO IMPROVE PEDESTRIAN PROTECTION

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Abstrak

Kecelakaan lalu lintas adalah momok yang mengerikan yang terjadi di banyak negara, khusus untuk negara-negara berkembang di mana urusan transportasi seperti benang kusut. Selain berfungsi sebagai penutup kompartemen mesin, kap SUV kompak yang modern juga dapat membantu untuk mengelola energi dampak kepala pejalan kaki di dampak kendaraan-pejalan kaki. makalah ini menyajikan desain kap luar Esemka R2 yang memiliki potensi untuk meningkatkan kemampuan hood dan juga untuk menyerap energi benturan kepala pejalan kaki ini. Metode yang dikembangkan untuk desain konfigurasi hood luar bertujuan untuk memberikan desain yang kuat dan homogen Head Injury Criterion (HIC) untuk posisi di WAD 1000 dan tiga ketebalan yang berbeda (1,25 mm, 1,35 mm & 1,50 mm) dari panel kap luar Esemka R2 kompak SUV, dengan mempertimbangkan ruang terbatas yang tersedia untuk deformasi. Software Non-linear Analisis Elemen Hingga (Dynamics Explicit) yang digunakan dalam penelitian ini untuk mensimulasikan prosedur dasar pengujian impak kepala untuk pejalan kaki anak. Hasil penelitian menunjukkan bahwa rata-rata perbandingan dimensi panel kap luar Esemka R2 adalah 4,89 mm. Minimum ruang deformasi memenuhi persyaratan dengan nilai HIC yang homogen serta mendapatkan kinerja impak kepala yang aman. ketebalan hood luar dan bahan diidentifikasi sebagai faktor yang mempengaruhi stres dan nilai HIC pada kap. Dengan membandingkan semua panel kap luar, paduan aluminium sebagai bahan yang dipilih terbaik yang memiliki nilai persentase terendah adalah 32,78% untuk perlindungan pejalan kaki.

Kata kunci : HIC; panel kap luar; FEA; keamanan pejalan kaki.

Abstract

Traffic accidents are terrible scourge that occur in many countries, specially for developing countries where transportation affairs like tangled yarn. Besides functioning as an engine compartment cover, the hood of modern compact SUV can also help to manage the impact energy of a pedestrian's head in a vehicle-pedestrian impact. This paper presents outer hood design of Esemka R2 that has a potential to improve hood's ability and also to absorb the impact energy of a pedestrian's head. The developed method for the design of an outer hood configuration aims to provide a robust design and homogeneous of Head Injury Criterion (HIC) for impact position at WAD 1000 and three different thicknesses (1.25 mm, 1.35 mm & 1.50 mm) of outer hood panel of Esemka R2 compact SUV, taking into consideration the limited space available for deformation. The non-linear Finite Element Analysis (FEA) software (Explicit Dynamics) was used in this research to simulate the testing procedurs of head impact for child pedestrian. The results show that the average of comparison dimensional of outer hood panel of Esemka R2 was 4.89 mm. The minimum of deformation space meet the requirement for HIC value which required obtaining robust and homogeneous head impact performance. Outer hood thickness and materials were identified as the factors to influence the stress and HIC value of the hood. By comparing all outer hood panels, aluminium alloy as the best selected material which has the lowest value is 32.78% for the pedestrian protection.
Keywords : *Head impact; HIC; outer hood panel; FEA; pedestrian protection*

1. Introduction

The latest data released by the World Health Organization (WHO) showed that India ranks first country with the highest number of deaths caused by traffic accidents, while Indonesia was reported to have an increase in the number of traffic accidents by more than 80 percents, where the death toll from traffic accidents reached 120 people per day (Marbun, 2014). In those days, the belief was that the only way to reduce pedestrian fatalities and injuries was to prevent pedestrian– vehicle collisions. Several previous researchers (Ahmed & Wei, 2016; Huang, Liu, & Long, 2014; Masoumi, Hassan, & Najibi, 2011; Min, Kim, Chae, & Hong, 2016; Samaka & Tarlochan, 2013) proposed improvements of hood panel based on pedestrian head protection which hood designs and materials created in finite element model. Explicit dynamics of FEM have proved to be useful for sheet metal simulation (Anggono, Riyadi, & Siswanto, 2014). Consideration of modification of vehicle design for pedestrian protection was not an option at that time. From this sequence of events, it can be stated that typically the colliding vehicle runs under the pedestrian and the severity of injuries vastly depend on the vehicle shape and certain characteristics such as energy absorption. In the Australian New Car Assesment Program (ANCAP), the pedestrian tests are carried out to estimate head and leg injuries to pedestrians struck by a vehicle at 40 km/h or (approx. 11.1 m/s) (Krishnamoorthy, Takla, Subic, & Scott, 2013).

Literature Review and Theory

However, the mechanism of injury is complex. The Head Injury Criterion (HIC) indicates a measure of the likelihood of head injury arising from an impact, which is evaluated by the impactor in terms of the simulation of child head. HIC includes the effects of head acceleration and the duration of the acceleration (Masoumi et al., 2011). The impacts of standard child headform on nine different designs have been simulated in this study. ANSYS, an explicit finite element code was used to simulate the impacts. At first, the development and validation of numerical child headform impactors based on ANCAP standards are discussed. Subsequently this impactor was used for head to hood impact analysis. The research aims to comparison of outer hood design of Esemka R2 between photo and using manual Coordinate Measuring Machine, in addition, an implicit finite element code was developed to perform analysis for comparing the deformation, equivalent stress and HIC of three different materials.

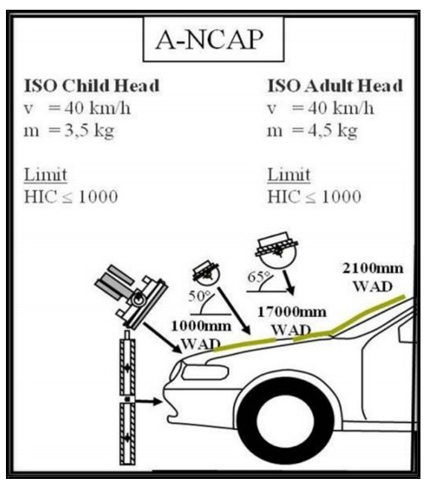
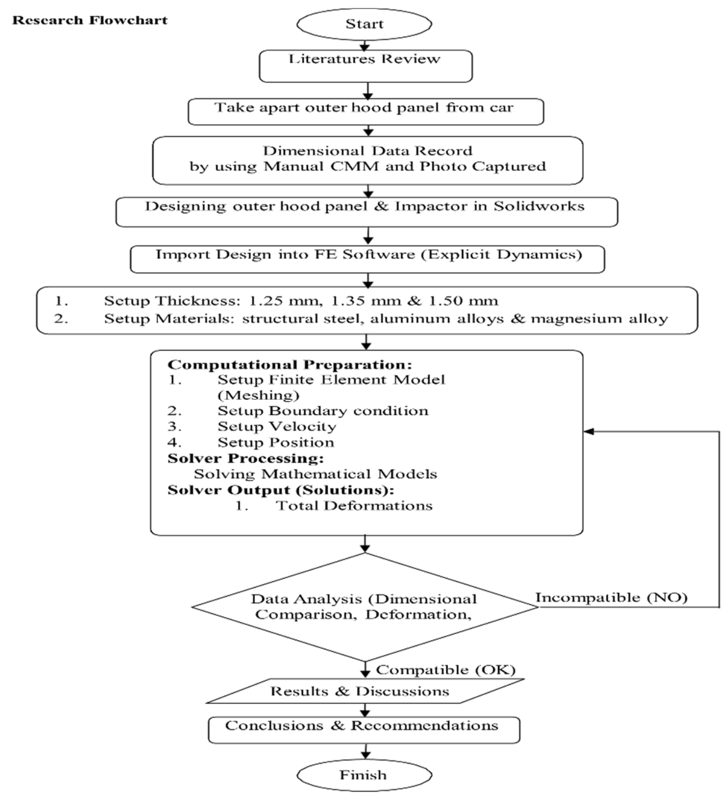


Figure 1. Standards of ANCAP pedestrian protection head impact requirements (Krishnamoorthy et al., 2013) ANCAP (Figure1.) provides measures for the assessment of pedestrian protection performance of a passenger car experimentally by firing subsystem impactors representing a child head, adult head, upper leg and lower leg at a specified angle and speed to the front end of a stationary vehicle. The resulting injury measures from these physical tests are assessed against the bounds specified by the protocols shown in Figure 1. This study focuses only on child pedestrian head impact to the outer hood panel and do not include inner hood, upper or lower leg impacts defined in these protocols.

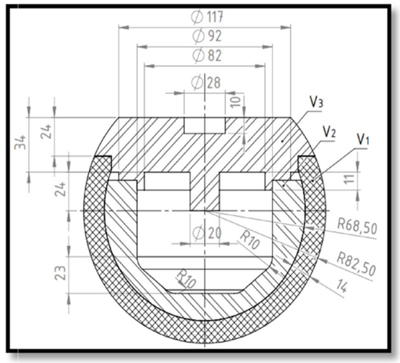
As a result of the implementation of these regulations, vehicle manufacturers face technical challenges associated with the investigation of optimal hood panel configuration to meet the requirements of ANCAP while retaining or maximising styling flexibility with minimal modifications to the general architecture of the design. HIC criteria are used to predict the risk of engine hood to the pedestrian of collision and the level of severity of engine hood design when the collision occurs (Cruz, PM; Vinyals, J., 2004). The value of HIC depends onthe engine hood design, materials, impactor type and structure. HIC is calculated according to equation (Shojaeefard, Najibi, & Ahmadabadi, 2014)

1. METHODOLOGY



Details and properties of Child Headform

The child headform made from aluminum alloy and polyethylene, which is a homogenous construction in a spherical shape. The sphere covered with 14±0.5 mm thick synthetic skin (polyethylene). The outer skin indicated by V_1, the inner aluminum part V_2 and the cover plate V_3 (see Figure 4). From Figure 4., the diameter of the cylinder on which the accelerometers were positioned was 20 mm, and its height was 24 mm; the diameter of the hole on cover plate was 28 mm, and its depth was 10 mm; the thickness of the outer synthetic skin was 14 mm; the radius of the whole headform was 82.5 mm, and radius of the inner aluminum sphere was 68.5 mm. The outer skin was made of polyethylene (PE) with density 930 kg/m^3 (see Table 1). The inner part



and the cover plate were made of aluminum with a density of 2770 kg/m^3 (see Table 2).Figure 4. Detail of child headform impactor
The inner part and cover plate of child headform were aluminum alloy, which is extremely stiff compared to its polyethylene skin. Numerical model of child headformwas created in Solidworks 2014 and considered as a rigid body element as shown in Figure 5.

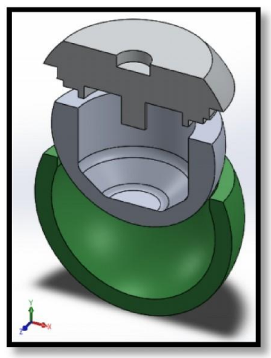


Figure 5. Numerical model of child headform

It can be seen that Table 1 and Table 2 show the detail of material properties used for designing childhead impactor which mainly consist of aluminum alloy and polyethylene.

Analysis of Pedestrian Protection Property

According to the requirements of the Australian New Car Assessment Program (ANCAP) for pedestrian protection, it needs to define zones of car hood for analysis, as shown in Figure 6. It can be noted that when the collision projection point locates between (Wrap Around Distance) WAD 1000 and WAD 1500, the head type will use the children head type. The adult head type will be used while the collision projection point locates between WAD 1700 and WAD 2100. In the current study, the collision projection point located at WAD 1000 when the children head type will be used.

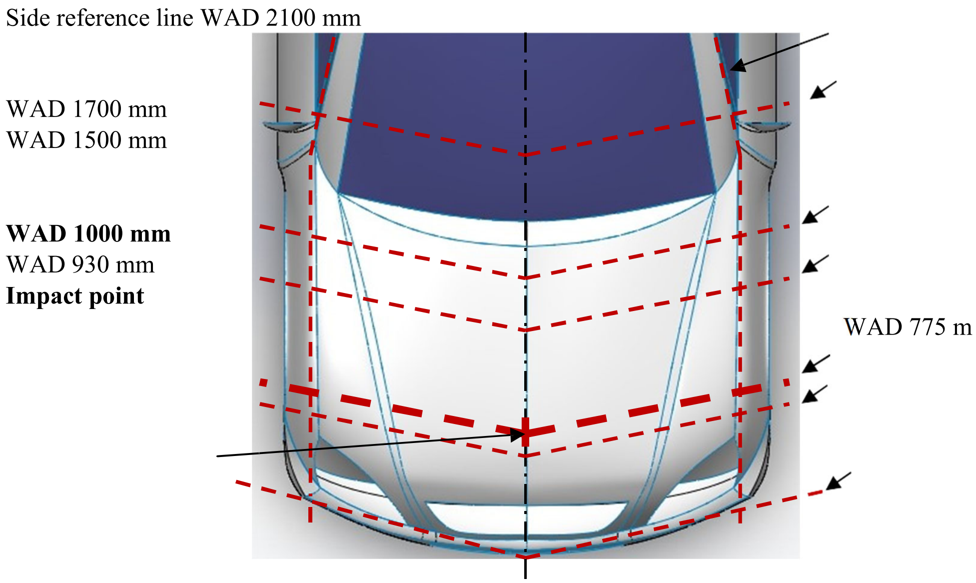

Side reference line WAD 2100 mm
WAD 1700 mm
WAD 1500 mm
WAD 1000 mm
WAD 930 mm
Impact point
WAD 775 m

Figure 6. Zoning of pedestrian head impact protection for ANCAP

Deformation of Outer Hood Panel

In this section, pedestrian head impact simulations were investigated using three selested materials, which consist of three difference thicknesses. The effect of plate thickness on the deformation, equivalent stress, and Head Injury Criterion value were investigated. The deformation pattern of outer hood panel for aluminum alloy (1.25 mm) are shown in Figure 10. The deformation occured in the child headform impact area (WAD 1000) starting from t = 5.0003E-004 to 1.5E-002 sec. The result show that the panel thickness has a significant role on the deformation value. The value of displacement varied according to material properties and thickness that can be identified by the occurence of the deformation in the outer hood panel after the impact.

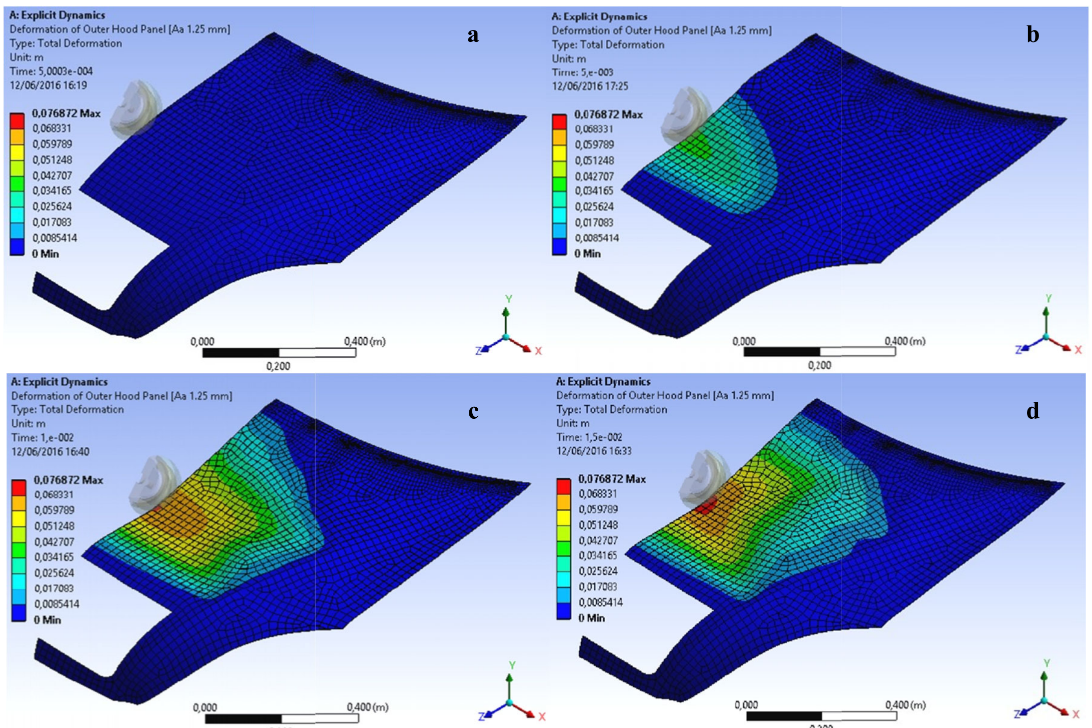


Figure 10. Deformation pattern of outer hood panel of aluminum alloy (1.25 mm) at different time in FE models

It can be observed that magnesium alloy (NL) (1.25 mm) stacking squence shows the highest deformation among all the models (Figure 9). However, the HIC value achieved the lowest. In this case, the design of the engine hood according to this finite element model roposes to use soft

material, especially in th engine hood structure to avoid or mitigate the impact injury of the head. Among all the models, the deformation should not be significant to maintain the style of the engine hood after the collision. When the structure absorbs greater energy and then leads to decrease the acceleration of the headform and consequently the HIC value decreases. Otherwise, greater deformation is not recommended for the engine hood in this case because this will increase the acceleration when the head be in contact with the rigid bodies of the vehicl .e seen that from Figure 9 the highest maximum deformation at 85.6 mm was belong to magnesium alloy (NL) (1.25 mm). It mean that, this material properties has lowest density and

highest ductilitty from all, therefore it can absorb more impact energy which occuring at collision and can be minimized HIC value. Otherwise, from Figure 11 the lowest maximum deformation at
51.5 mm was belong to structural steel (1.50 mm). For more result of other maximum deformations can be seen in Table 7. It mean that, this material properties has highest density and lowest ductilitty from all, so it can not absorb more impact energy which occuring at collision and can produce highest HIC value (more see Figure 14).

Moreover, this research in line with Masoumi (2011) reported aluminum bonnet has more displacement than steel. This means that aluminum has better crashworthiness regarding to its light weight. In addition from other researchers, Ahmed and Wei (2016) had investigated composite laminate and sanwich stucture materials for engine hood found that composite laminate [0/90,
±45]2 had higher deformation but lower HIC than sandwich structure [[0/90, ±45]2 0/90, Core, [0/90]4] were 219.3 mm, 354, 84.7 mm and 820 respectively.

Although the intense of collision is crucial, but the displacement of head is also important which may lead to extreme acceleration in the second impact, or rebound. It means that this structure not only must be strengthened in front of static and dynamic forces such as aerodynamic, slam and dent, it also should be able to reduce the intense of impact and avoid extra deformation of hood.

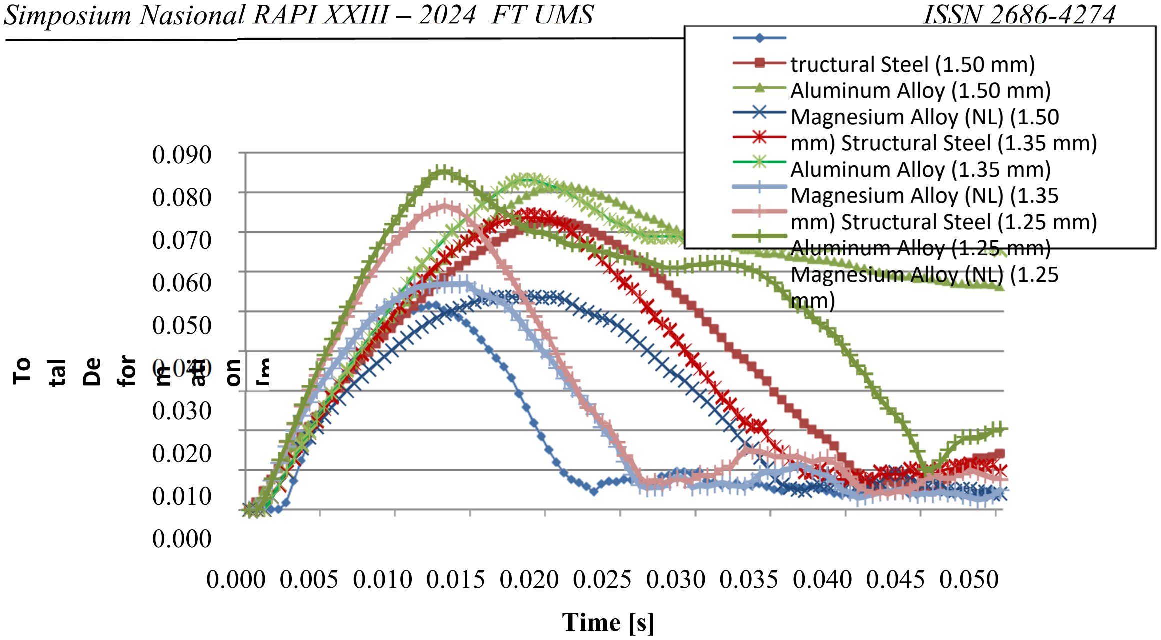


Figure 11.Comparison of outer hood panel deformation vs. time of three difference materials with 1.25 mm, 1.35 mm and 1.50 mm thicknesses

The deformation was observed, however, greater displacement is not recommended due to more modifications are needed for the hood structure and materials properties. In addition, soft structure and new composite materials are required to reduce the head injury at collision. Accordingly, the design of rigid bodies which located under hood is recommended to be at an acceptable distance to maintain the style of the engine hood and control the deformation at collision.

CONCLUSIONS

The results show that the average of comparison dimensional of outer hood panel of Esemka R2 was 4.89 mm. Beside that the minimum deformation space is 51.5 mm and maximum HIC of 687. That values are required to obtain robust and homogeneous head impact performance. Moreover, hood thickness and materials are the factors which can influence stress and HIC value. It is shown that the pedestrian safety is greatly improved up to 32.78% for aluminium alloy model. As the requirements of the friendliest car, the structure of the engine hood should be soft to easy to form and to absorb more energy and also provide lower deformation, lower HIC and less displacement of the headform impactors. Thus, possible improvements in lower HIC and deformation could be studied, as well as materials, selection of engine hood structures should be considered in the future studies.

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