MODEL UPDATING OF CRASH BOX STRUCTURES FOR CRASHWORTHINESS STUDY

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis, and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Struktur kotak rempuhan merupakan struktur penting bagi bahagian hadapan badan kereta. Ia menyerap tenaga kinetik semasa berlakunya perlanggaran dengan berubah bentuk secara plastik untuk menyerap daya hentaman dengan berkesan. Pelbagai reka bentuk diterapkan ke atas struktur ini dengan menggunakan bahan, konfigurasi, dan ketaksempurnaan atau mekanisme pemicu yang berbeza. Kotak rempuhan dengan mekanisme pemicu sering menjadi subjek dalam kajian ketahan perlanggaran, namun, penyelidikan ini akan menggunakan pendekatan ujian modal untuk mengendalikan struktur ini melalui analisis eksperimen dan pengkomputeran kerana struktur tersebut terdedah kepada getaran kenderaan juga. Apabila ketidakseragaman berlaku, teknik pengemaskinian model digunakan untuk mengenal pasti dan mengemaskini parameter-parameter sensitif yang menyebabkan ketidakseragaman tersebut. Parameter-parameter ini kemudiannya digunakan dalam analisis ketahanan perlanggaran untuk menentukan kesan mereka terhadap hasil ketahanan perlanggaran struktur kotak rempuhan. Struktur kotak rempuhan dimodelkan dalam model unsur terhingga sebelum dianalisis dengan analisis mod biasa dalam MSC Patran dan MSC Nastran dan analisis kuasi-statik dalam Abaqus. Lima struktur yang diperbuat daripada dua bahagian yang dihubungkan dengan menggunakan kimpalan bintik beserta reka bentuk mekanisme pemicu yang berbeza telah dibuat. Tiga pendekatan penyambungan elemen digunakan untuk model unsur terhingga: CWELD, CBEAM, dan CBA. Perilaku modal untuk semua pemodelan dikenal pasti dengan menggunakan SOL 103, sementara Analisa eksperimen modal dilakukan dengan menggunakan ujian kesan tukul dengan kaedah tukul bergerak untuk mendapatkan respon modal. Kaedah pengemaskinian model dilakukan untuk mengurangkan ketidakseragaman antara data eksperimen dan data komputeran. Analisa kepekaan dijalankan untuk mencari parameter pengemaskinian model yang paling sensitif. Hasil kajian ini menunjukkan bahawa penggunaan elemen penyambungan CBAR adalah yang terbaik untuk menggantikan penyambungan kimpalan bintik, di mana untuk semua jenis struktur kotak rempuhan, elemen CBAR menunjukkan peratusan ralat yang bererti berbanding dengan CWELD dan CBEAM untuk semua jenis struktur kotak kemalangan, manakala parameter yang paling sensitif yang mempengaruhi perilaku modal struktur adalah modulus Young AA-6061, diikuti dengan ketumpatan AA-6061 dan modulus Young penyambungan kimpalan bintik. Dalam analisis ketahanan perlanggaran, dikenal pasti bahawa penggunaan parameter yang dikemaskinikan dalam analisa ketahanan perlanggaran berbanding dengan hasil awal keluaran ketahanan perlanggaran menunjukkan perubahan yang kecil di mana hasil ketahanan perlanggaran sedikit lebih tinggi untuk kedua-dua puncak utama dan sekunder serta untuk magnitud tenaga yang diserap. Keputusan penyelidikan ini akan menyumbang kepada bidang getaran mekanikal dan ketahanan perlanggaran, terutamanya dalam industri automotif, di mana penyelidikan ini memberi tumpuan kepada kaedah pengoptimuman pemodelan untuk meningkatkan ketepatan dan kebolehpercayaan ramalan pengkomputeran.

ABSTRACT

The crash box structure is an essential structure of the front side members of a car body structure. It absorbs the kinetic energy during the event of a collision by plastically deform to absorb the impact energy efficiently. Various designs are applied towards the structure with different materials, configurations, and imperfections or trigger mechanisms. Crash box with trigger mechanisms is often a subject in crashworthiness studies, however, this research will have an approach to dealing with the structure with modal testing through experimental and computational analysis due to the location of the structure that exposed to vehicle vibration as well. As discrepancies occur, the model updating technique is utilised to identify and update the sensitive parameters that cause the discrepancies. The parameters are then used in the crashworthiness analyses to determine their effect towards the crashworthiness output of the crash box structure. The crash box structures are modelled in finite elements before being analysed with the normal mode analysis in MSC Patran and MSC Nastran and quasi-static analysis in Abaqus. Five different fabricated structures are made up of two parts attached using a spot weld with different designs of trigger mechanisms. Three approaches to joining elements are used for the finite element model: CWELD, CBEAM, and CBAR. The modal behaviour for all modelling is identified by using SOL 103, while the experimental modal analyses are conducted with the use of an impact hammer test with the roving hammer method to obtain the modal responses. The model updating method was conducted to reduce the discrepancies between the experimental and the computational data. Sensitivity analyses are executed to find the most sensitive model updating parameters. The results obtained by this study demonstrate that the use of CBAR joining element is the best to replicate the spot weld joining, where for all five types of crash box structures, the CBAR elements did show a significant percentage of error compared to CWELD and CBEAM for all types of crash box structures, while the most sensitive parameters that affect the modal behaviour of the structures are Young's modulus of AA-6061, followed by the density of AA-6061 and Young's modulus of spot welded joint. In terms of crashworthiness analyses, it is identified that the use of updated parameters in crashworthiness analyses compared to the initial results of crashworthiness output did show a small change where the crashworthiness output of the structure is slightly higher for both primary and secondary peaks as well as for the magnitude of the absorbed energy. The outcome of this research will contribute towards the field of mechanical vibration and crashworthiness, especially in the automotive industry, in which this research focuses on the optimization method of the modelling to improve the accuracy and reliability of the computational prediction.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

REFERENCES

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