EVALUATION OF SPOTWELD FAILURE MODEL IN RADIOSS TO ROOF RESISTANCE TEST (FMVSS216)

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (AUTOMOTIVE TECHNOLOGY) WITH HONOURS

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Faculty of Mechanical and Manufacturing Engineering Technology

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A thesis submitted
in fulfillment of the requirements for the degree of
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DECLARATION

I declare that this Choose an item. entitled "Evaluation of Spotweld Failure Model in RADIOSS to Roof Resistance Test (FMVSS216)" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : Mohammad Daniel Bin Mohd Rehan

Date : 18/01/2022

APPROVAL

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 Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours.

Signature :

Supervisor Name : Mohammad Hafizi Bin Abdul Rahman

Date : 18/1/2022

DEDICATION

This project report is dedicated with humbleness to my parents, Mr Mohd Rehan bin Khamis and Mdm. Rohani binti Asmuni for giving their never ending support and always be myside to motivate me during my tougher times. Moreover, I would like to include my siblings in the success of this project. Their unlimited support and love shows me that I should never give up easily and should be try harder in everything I do. Beside, i would like take this oppoturnity to dedicate this project report to my classmates because of their teamwork for willing to share information related to this project. Not going to forget my supervisor, Mr. Mohammad Hafizi Bin Abdul Rahman, who play a vital role in the completion of this project. My appreciation to share this success with him as he always supervise me constantly in using the simulation software from the beginning even the simulation software is quite new for me. I always appreciate his generosity in guiding me when i am stucked using the software.

ABSTRACT

Over the past decade, reducing the severity of roof crash impact collisions has been an emerging area of research by a variety of organizations and research communities. The roof crash simulation normally does not use Altair Radioss as the programme medium. This is because a crash test organisations such as the National Highway Traffic Safety Administration (NHTSA) are using an older applications software such as Ls-Dyna to run the simulation and plus, the Altair Radioss was still very new in the crash simulation study. The main purpose of this research study is to find the right spotweld failure model behavior to replace the spotweld failure that has been allocated in roof crash simulation in RADIOSS. This objective include to simulate the spotweld failure model comparable to the actual roof resistance test according to FMVSS216 within 20% of error. It also to compare strength to weight ratio(SWR) result between current Finite Element model and updated spotweld failure model. In this research in particular, a test and simulation were carried out in order to evaluate the Finite Element Model (FEM) for car roof crash simulation. This simulation is to find the right spotweld failure model for get close result to actual test. This simulation was done by using HYPERCRASH and HYPERMESH software. The spotweld failure that was used was spotweld rupture in spotweld failure model because using this spotweld failure the result SWR was 4.91, close to actual test which is 19.76% of percentage error. This spotweld failure model just apply to the critical part of the roof such as B-pillar, A-pillar and roof. Using this type of analysis can reduce cost for the industry of automotive because they just used the simulation for the get close to actual test

ABSTRAK

Sepanjang dekad yang lalu, mengurangkan keterukan perlanggaran hentaman bumbung telah menjadi bidang penyelidikan yang baru muncul oleh pelbagai organisasi dan komuniti penyelidikan. Penyelidikan ini akan mengkaji model kegagalan bahan yang tepat yang digunakan dalam analisis ujian penghancuran bumbung. Simulasi ranap bumbung biasanya tidak menggunakan Altair Radioss sebagai medium program. Ini kerana organisasi ujian ranap seperti National Highway Traffic Safety Administration (NHTSA) menggunakan perisian aplikasi lama seperti Ls-Dyna untuk menjalankan simulasi dan selain itu, Altair Radioss masih sangat baharu dalam kajian simulasi ranap. Tujuan utama kajian penyelidikan ini adalah untuk mencari gelagat model kegagalan bahan yang sesuai untuk menggantikan kegagalan kimpalan yang telah diperuntukkan dalam simulasi kemalangan bumbung di RADIOSS. Objektif ini termasuk untuk mensimulasikan model kegagalan kimpalan yang setanding dengan ujian rintangan bumbung sebenar mengikut FMVSS216 dalam 20% daripada ralat. Ia juga untuk membandingkan hasil nisbah kekuatan kepada berat (SWR) antara model Elemen Terhad semasa dan model kegagalan kimpalan yang dikemas kini. Dalam penyelidikan ini khususnya, ujian dan simulasi telah dijalankan untuk menilai Model Elemen Terhad (FEM) untuk simulasi kemalangan bumbung kereta. Simulasi ini adalah untuk mencari model kegagalan kimpalan yang sesuai untuk mendapatkan keputusan yang hampir kepada ujian sebenar. Simulasi ini dilakukan dengan menggunakan perisian HYPERCRASH dan HYPERMESH. Kegagalan kimpalan yang digunakan adalah model kegagalan kimpalan pecah kerana menggunakan kegagalan kimpalan ini keputusan SWR adalah hampir dengan ujian sebenar iaitu 19.76% daripada peratusan ralat. Model kegagalan kimpalan ini hanya digunakan pada bahagian kritikal bumbung seperti tiang B, tiang A dan bumbung. Menggunakan analisis jenis ini boleh mengurangkan kos untuk industri automotif kerana mereka hanya menggunakan simulasi untuk menghampiri ujian sebenar.

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LIST OF SYMBOLS AND ABBREVIATIONS

SWR	-	Strength to Weight Ratio
FE	-	Finite Element
NHTSA	-	National Highway Traffic Safety Administration
CEM	-	Crash Energy Management
FEA	-	Finite Element Analysis
FMVSS	-	Federal Motor Vehicle Safety Requirements
SAE	-	Society of Automobile Engineer
IIHS	-	Insurance Institute for Highway Safety
Mm	-	Millimeter
DOF	-	Degree Of Freedom
RSW	-	Resistance Spot Weld
BIW	-	Body In White
HAZ	-	Heat Affected Zone
FSSW	-	Friction Stir Spot Weld
P2P	-	Point to Point
ACM	-	Area Contact Model
HSS	-	High Strength Steel
UHSS	-	Ultra High Strength Steels
IF	-	Interstitial Free
BH	-	Brake Hardenable
C-Mn	-	Carbon-Mn
DP	-	Dual Phase
CP	-	Complex Phase
MS	-	martensitic steel
HSLA	-	High Strength Low Alloy Steels
AHSS	-	Advanced High-Strength Steels
TRIP	-	Transformation Induced Plasticity

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CHAPTER 1

INTRODUCTION

1.1 Background

Spot welds are generally used to join panels in the automotive industry, and car bodies contain hundreds of thousands of them. For various types of analysis, different finite element models of spot welds have been developed. When analysing structures with a large number of spot welds, these detailed models have far too many degrees of freedom to be suitable for this project. Instead, simple models with few elements should be used (Palmonella et al., 2005).

In the automotive industry, fatigue resistance and durability are extremely important. The failure of some spot welds and joints in a vehicle's body can result in unwanted noise and vibrations inside the vehicle as well as a reduction in crashworthiness. For static and dynamic structural analysis, there are numerous models of spot welds. Spot weld modelling is difficult because finite element modelling ignores many local effects like geometrical irregularities, residual stresses, material inhomogeneities, and defects caused by the welding process (Farrahi, Ahmadi, et al., 2020).

Current crash simulation software offers a range of ways to model these spot welds. The prediction of the failures in the simulations are of great importance for the safety of the vehicles. If accurate results are produced in early stages of the production then safer vehicles can be manufactured. This project deals with development of a new spot weld modeling technique and using a different material modelling to reduce the computational time (Adhinthan Srinivasan Rajalakshmi, 2017).

1.2 Problem Statement

Nowadays, in Asia, most of the accidents that occurred on the road involving cars, especially the type of car accident known as a roll-over. Rollover is a vehicle crash that is very dangerous because this accident mostly tipping the vehicle turns over on its roof. Most of the accident in roof crash usually has higher dead ratio. According to national statistics, only 2% of vehicles were involved in all traffic crashes from 2014 to 2018, but 24% of all deaths were caused by overhead collision roll-over (Kweon, 2020). One of the causes is because of the material used. The right material will reduce the injuries to a passenger. Three types of material failure models will be tested in RADIOSS to get the best material used for roof cars.

In order to find the right spotweld, this research will be study in RADIOSS simulation. The roof crash simulation normally does not use Altair Radioss as the programme medium. This is because a crash test organisations such as the National Highway Traffic Safety Administration (NHTSA) are using an older applications software such as Ls-Dyna to run the simulation and plus, the Altair Radioss was still very new in the crash simulation study. Despite this fact, most of the researches that related to the crashing impact done from Universiti Teknikal Malaysia Melaka (UTEM) are using Altair Radioss. The main purpose of this research study is to find the right spotweld failure model behavior to replace the spotweld failure that has been allocated in roof crash simulation in RADIOSS.

1.3 Research Objective

In this research, the effect on Chevrolet Silverado 2014 towards the roof characteristic from the roof crash test is to be studied. Thus, this study will highlight on the following objectives:

a) To optimize the spotweld failure model available in the RADIOSS definition library comparable to the actual roof resistance test according to FMVSS216.

b) To compare strength to weight ratio (SWR) result between current FE model and updated spot weld failure model.

1.4 Scope of Research

The scope of this research are:

a) To use Altair HYPERWORK as a medium in converting the Finite Element (FE) of the chevrolet Silverado model from LS-Dyna to Radioss format in order to run a crash simulation.

b) To describe the parameter setup by FMVSS 216 that has been used in roof crash impact simulation and modified to the actual position car roof side during an accident.

c) To optimize the vehicle behaviour and deformations properties that been analyzed from simulation.

1.5 Summary

Spot welds are generally used to join panels in the automotive industry, and car bodies contain hundreds of thousands of them. The failure of some spot welds and joints in a vehicle's body can result in unwanted noise and vibrations inside the vehicle as well as a reduction in crashworthiness. Spot weld modelling is difficult because finite element modelling ignores many local effects like geometrical irregularities, material inhomogeneities, and defects caused by the welding process. This project deals with development of a new spot weld modeling technique and using a different material modelling to reduce the computational time. Three types of material failure models will be tested in RADIOSS to get the best material used for roof cars.

The right material will reduce the injuries to a passenger and reduce the number of injuries caused by a car roll-over. The car crash that is most dangerous because this accident mostly tipping the vehicle turns over on its roof has a higher dead ratio. According to national statistics, only 2% of vehicles were involved in all traffic crashes from 2014 to 2018, but 24% of all deaths were caused by overhead collision roll-overs. This project aims to get to the best possible results in early stages of the production of safer vehicles. In this research, the effect on Chevrolet Silverado 2014 towards the roof characteristic from the roof crash test is to be studied.

Altair Hyperwork is used as a software medium in converting the Finite Element (FE) of the schevrolate silvarado model from LS-Dyna to Radioss format. The roof side crashing impact simulation is based on the parameter setup by the FMVSS 216 regulation. Some properties have been modified to describe the actual position of the car's roof side during an accident. This study implements the spot weld failure model that will increases the frame crashing impact force.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Real roof crush test has been widely used to evaluate the safety integration of vehicle structure, where there are specified standards such as FMVSS 208 and 216. Despite the different road condition, Europe is trying to accomplish the same safety target. However, complete tests have shown themselves to be very expensive and unrepeatable in many cases. With computer technology advancement, several codes have been crashed such as LS-DYNA3D, PAMCRASH and RADIOSS, are used for vehicle impact simulations.

These codes were primarily created based on explicit time integration, analysis-specific shell elements, and assumptions about dynamic behavior. Despite enormous experience over the last few years, the quasi-static simulation of roof crush remained the most difficult of these simulations Just before greater speed is used in the quasi-static simulation, inertia effects are caused which smooth the solution algorithms' nonlinearities and deficiencies. But even though implicit solvers may address whereas almost static impact scenarios, the large deformation of the roof and pillar areas and the multi-vehicle parts contact makes convergence in implicit solvers extremely difficult and sometimes unstable (Chirwa, 2005).

2.2 Statistics

Rollovers are the most serious and dangerous crashes among all types of traffic crashes. This because rollover have complex dynamic event and like other traffic accidents consists of the vehicle, human and environmental elements, and their interactions. For rollover, the transition between the precrash and crash phase (tripping phase), the vehicle has reached its unstable equilibrium position. The dynamic relationship between tyres and road causes unpredicted vehicle cinematics and a sequence of chaotic events.

A crash involves a vehicle that is pivoting about its longitudinal axis in at least two quarters (≥180◦). While roll-over crashes are less common than frontal, side, or rear impact crashes, they are more likely than any other type of crash to cause injury and fatality. Compared with planar crashes (front, back and side), rotary components are included in occupant cinematics, which leads to a variety of types of injuries. The most vulnerable to rollover crashes are head and neck injuries. A significant controversy resulting from these efforts is whether the degree of vehicle roof crash, the vertically intrusion into the occupant's car roof or ceiling is a risk factor of injury to the head and neck.

By using population-based data, the relationship between roof crush and head, neck and spine injuries in rollover crash has been added in NASS-CDS data on rollover crashes, but it added to the existing literature in several, ways. The injuries that have been included in our analyses been decided by a NHTSA crash investigator to have resulted from contact with an overhead vehicle component at the occupant’s position, that reduced the potential for confounding due to ejection-related injuries. Figure 2.1 shown the data percentage rollover in killed occupants (Chikazawa et al., 2012).