DYNAMIC DAMAGE ASSESSMENT OF RESISTANCE SPOT WELDING FOR DISSIMILAR PLATES BY USING MODEL UPDATING APPROACH

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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 kepingan ‘top hat’ yang direkabentuk di dalam kajian ini adalah untuk menyerupai bahagian dalam lantai struktur badan kenderaan (BIW), dengan menggunakan dua bahan berbeza, iaitu keluli ringan dan keluli tahan karat yang dicantumkan melalui proses kimpalan bintik (RSW). Objektif kajian ini adalah untuk menentukan dan membandingkan sifat-sifat modal struktur kepingan ‘top hat’ yang menggunakan bahan-bahan asas berbeza melalui pendekatan FEA dan EMA. Pelaksanaaan analisis sensitiviti dan prosedur pengemaskinian model adalah untuk meminimumkan percanggahan antara FEA dan EMA. Akhir sekali, kajian perbezaan dalam sifat modal apabila terdapat kerosakan pada RSW dilakukan melalui pendekatan eksperimen dan simulasi. Struktur yang ingin diuji dimodelkan di dalam perisian CAD dan analisis mod biasa FEA menggunakan MSC Nastran Patran dilakukan untuk mencari sifat modal, beserta ujian kesan tukul dengan kaedah menggerakkan sensor yang mempunyai 50 titik pengukuran. Kajian ini diteruskan dengan menjalankan analisis strategi penyambung dengan menggunakan elemen utuh (RBE), elemen bar (CBAR), elemen kimpalan (CWELD) dan elemen rasuk (CBEAM) untuk menyerupai sambungan kimpalan sebenar pada struktur dan hasilnya dibandingkan dengan EMA. Setelah mendapatkan cara sambungan yang paling diyakini, pengemaskinian model dijalankan untuk mengurangkan percanggahan antara FEA dan EMA. Terakhir sekali, kerosakan telah diperkenalkan dengan membuang empat kimpalan bintik di bucu struktur pada struktur FEA dan EMA yang utuh dan sebarang perubahan dalam sifat modal diperhatikan. Melalui analisis yang dijalankan, terdapat beberapa penemuan yang dijumpai iaitu CWELD telah dikenalpasti sebagai sambungan yang paling diyakini untuk mewakili sambungan RSW dan dari analisis sensitiviti, Modulus Elastik dan ketumpatan untuk keluli ringan dan keluli tahan karat ringan telah dipilih sebagai parameter yang sensitif menjadikannya terlibat dalam pengemaskinian model. Untuk kajian kerosakan, didapati bahawa nilai frekuensi tabii mempunyai penurunan ketara selepas kerosakan diwujudkan pada struktur bagi FEA dan EMA. Selain itu, terdapat pergerakan kehadapan terhadap graf frekuensi tabii dalam FRF. Kesimpulannya, CWELD adalah elemen penyambung yang paling sesuai untuk mewakili kimpalan bintik dan kewujudan kerosakan dalam sesebuah struktur dalam mengurangkan nilai frekuensi tabii yang memberi kesan terhadap sifat modal struktur tersebut.

ABSTRACT

Top hat plate structure was fabricated in this study to represent floor pan compartment of body in white (BIW) structure, by using two dissimilar materials which are mild steel and stainless steel that were joined together through resistance spot weld (RSW) process. Objectives of this study were to determine and compare modal properties of RSW between dissimilar materials using FEA and EMA approaches, to minimize the discrepancies between FEA and EMA using sensitivity analysis, model updating procedure and lastly, to evaluate the damage assessment of RSW through experiment and simulation study. The tested structure was designed in CAD software, and normal mode analysis of FEA using MSC Nastran Patran was performed to find modal parameter along with modal testing using impact hammer with roving accelerometer method which was carried on to the specimen by having 50 measurement points. This study was continued with joining strategy analysis by applying Rigid Body Element (RBE), Bar Element (CBAR), Weld Element (CWELD) and Beam Element (CBEAM) at the real spot weld connection and their results were compared with EMA. After finding the most reliable joining strategy, model updating was conducted to reduce discrepancies between FEA joining and EMA. At the end, damage was introduced on both intact FEA and EMA structure and any changes in modal parameters were observed by removing four spot welds at the edge of tested structure. From the analysis, CWELD has been found as the most reliable joining to represent RSW connection and for sensitivity analysis, Young's Modulus and density for both mild steel and stainless steel were selected for model updating, which was successfully performed on this joining. For damages study, it was observed that the value of natural frequencies has significant decrement after the damage was rendered in both FEA and EMA studies, which also resulted in a shift of frequency to a lower value in FRF graph. As the conclusion, CWELD was the most suitable joining to represent RSW and the presence of damage reduced natural frequency values which affected the modal properties of a structure.

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LIST OF SYMBOLS

E	Young's Modulus
ρ	Density
υ	Poisson Ratio
Q	Heat generated
I	Current
R	Resistance in electrical welding
t	Time duration
H(f)	Frequency response function
G(f)	Output in frequency domain
X(f)	Input in frequency domain
$\boldsymbol{\lambda_i}$	Vector of Eigenvalues
S_i	Eigenfrequency sensitivity
K	Stiffness matrix
M	Mass matrix
ω	Circular natural frequency
$\boldsymbol{\phi}$	Eigenvector
f	Natural frequency
W	Mode weighting factor

LIST OF ABBREVIATIONS

ACM	Area Contact Model
AWS	American Welding Society
BIW	Body in White
BNC	Bayonet Neill-Concelman
CBAR	Bar Element
CBEAM	Beam Element
CBUSH	Fastener Element (bolt and nuts)
CELAS	Elastic Element (spring)
COMAC	Coordinate Modal Assurance Criterion
CQUAD4	Four quadrilateral nodes shell element
CWELD	Weld Element
DAQ	Data Acquisition System
DOF	Degree of Freedom
EMA	Experimental Modal Analysis
FEA	Finite Element Analysis
FFT	Fast Furious Transform
FRF	Frequency Response Function
MAC	Modal Assurance Criteria
OMA	Operational Modal Analysis
PWELD	Property of weld element
RBE	Rigid Body Element
RSW	Resistance Spot Welding

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