UNIVERSITI PUTRA MALAYSIA

MANUFACTURING PROCESS AND MATERIAL SELECTION USING MODIFIED MULTI CRITERIA DECISION MAKING FOR BRAKE DISC

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By

NANANG FATCHURROHMAN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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DEDICATION

This work is dedicated to Allah SWT,

the Creator and Master of the Universe,

the Most Merciful and the Most Gracious.

Abstract of dissertation presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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Chairman : Professor Shamsuddin Sulaiman, PhD
Faculty : Engineering

In today's overwhelming competition, the knowledge on product development represents a very significant aspect for companies to survive in the market. Among these sectors is the automotive industry, where it is one of the most fast growing, highly demanding and stiff competition marketplaces. Intensive research in this field is targeted to produce light weight and high performance components which can increase fuel efficiency and sustainability of an automobile. One of the recent avenues is the investigation of increased performance engineered materials to replace the conventional materials. In this study product development of engineered material - metal matrix composites (MMCs) component is explored. To achieve a sound product development, new integrated product development framework which utilised simultaneous approach is developed. The framework is referred to as Integrated Conceptual Selection (ICS) which streamlines the phases in the product development process, including product investigation, product specification and conceptual design. Consequently, in this study a new decision making tool for concept selection process which employed concurrent strategy and combination of techniques i.e. analytical network process (ANP), quality function deployment (QFD) and analytical hierarchy process (AHP) is developed and referred as "CoNQA" technique. By using this new framework and tool, a development of an automotive product - MMCs brake disc is performed. The investigation includes the conceptual selections for the best manufacturing process and material for MMCs brake disc rotor. The conceptual selection of manufacturing process involved 14 criteria and 8 alternatives; meanwhile, the material selection incorporated 14 criteria and 21 alternatives. Permanent mould casting was chosen as the best decision for manufacturing process with priority vector of 0.1431. The next alternatives were plaster mould casting and centrifugal casting with priority vectors of 0.1318 and 0.1240 respectively. Furthermore, within the material selection process, MMCs 2124Al alloy-SiCp (10%) was preferred as the best material with priority vector of 0.53629. The next choices were 2124Al alloy-SiCp (15%) and 2124Al alloy-SiCp (20%) with priority vectors of 0.53166 and 0.53050 respectively. The conceptual selections were verified using sensitivity analysis during the selection process. At the final stage of this study, a validation work for the conceptual design study is presented. The validation method is proposed based on sustainable product performance analysis, where it performed parameter analysis and compared between the MMCs and conventional cast iron brake disc. The validation results confirmed that the MMCs brake disc have the potential to outweigh the

conventional iron brake disc in terms of sustainability and performance. Hence it validated the proposed concept of MMCs brake disc to be further developed into the next design level aiming for prototyping.

Abstrak tesis dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PEMILIHAN PROSES PEMBUATAN DAN BAHAN MENGGUNAKAN MULTI KRITERIA PEMBUAT KEPUTUSAN UNTUK CAKERA BREK

Oleh

NANANG FATCHURROHMAN

November 2013

Pengerusi : Profesor Shamsuddin Sulaiman, PhD
Fakulti : Kejuruteraan

Dalam persaingan pesat hari ini, pengetahuan mengenai pembangunan produk merupakan satu aspek yang sangat penting bagi syarikat untuk terus hidup di pasaran. Antara sektor ini adalah industri automotif, di mana ia adalah salah satu yang paling cepat berkembang, persaingan pasaran sangat mencabar dan sengit. Penyelidikan intensif dalam bidang ini disasarkan untuk menghasilkan komponen berprestasi tinggi yang boleh meningkatkan kecekapan bahan api dan kemampanan kereta. Salah satu saluran baru-baru ini adalah siasatan prestasi peningkatan bahan kejuruteraan untuk menggantikan bahan konvensional. Dalam kajian pembangunan produk bahan kejuruteraan, komponen logam matrik komposit (MMCs) telah dikaji. Untuk mencapai pembangunan produk yang kukuh, telah diperkenalkan rangka kerja pembangunan produk bersepadu yang baru yang menggunakan pendekatan serentak. Rangka kerja ini disebut Pemilihan Konsep Bersepadu (ICS) yang termasuk di dalamnya adalah proses pembangunan produk, penyiasatan produk, spesifikasi produk dan proses pemilihan. Oleh itu, dalam kajian ini yang membuat alat untuk proses pemilihan yang menggunakan pendekatan serentak dan gabungan teknik iaitu proses analisis rangkaian (ANP), penggunaan fungsi kualiti (QFD) dan proses hierarki analisis (AHP) sehingga proses keputusan yang telah diubah suai dicadangkan dan dirujuk sebagai teknik "CoNQA". Dengan menggunakan rangka kerja baru ini dan alat, perkembangan sesuatu produk automotif - MMCs cakera brek dilakukan. Penyiasatan termasuk reka bentuk konsep dan pemilihan untuk proses pembuatan yang terbaik dan bahan untuk MMCs cakera brek. Pemilihan konsep proses pembuatan melibatkan 14 kriteria dan 8 alternatif; sementara itu, pemilihan bahan melibatkan 14 kriteria dan 21 alternatif. Penuangan logam dengan acuan tetap dipilih sebagai keputusan yang terbaik untuk proses pembuatan dengan keutamaan vektor 0,1431. Alternatif seterusnya adalah penuangan logam acuan plaster dan penuangan logam memusat dengan keutamaan keutamaan vektor masing-masing 0.1318 dan 0.1240. Dalam proses pemilihan bahan, MMC 2124Al aloi SiCp (10%) telah pilihan sebagai bahan yang terbaik dengan keutamaan vektor 0,53629. Pilihan seterusnya adalah 2124Al aloi SiCp (15%) dan 2124Al aloi SiCp (20%) masing-masing dengan keutamaan vektor 0.53166 dan 0.53050. Keputusan konsep disahkan menggunakan analisis sensitiviti semasa proses pemilihan. Pada peringkat akhir kajian ini, kerja-kerja pengesahan untuk kajian reka bentuk konsep dibentangkan. Kaedah pengesahan adalah dicadangkan berdasarkan produk analisis

kemampanan dan prestasi unjuk kerja di mana ia melakukan analisis parameter dan membandingkan antara MMCs dan besi konvensional cakera brek. Keputusan pengesahan mengesahkan bahawa cakera brek MMCs mempunyai potensi untuk melebihi besi konvensional cakera brek dari segi kemampanan dan prestasi unjuk kerja. Oleh itu, ia mengesahkan konsep cadangan MMCs cakera brek untuk dimajukan lagi ke tahap reka bentuk seterusnya mensasarkan prototaip.

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I certify that a Thesis Examination Committee has met on 13 November 2013 to conduct the final examination of Nanang Fatchurrohman on his thesis entitled "Manufacturing Process and Material Selection using Modified Multi Criteria Decision Making for Brake Disc" in accordance with the Universities and University College Act 1971 and the Constitution of Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of requirement for the degree of Doctor of Philosophy. The Members of the Supervisory Committee were as follows:

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TO BE SIGNED

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Date: *TO BE ADVISED*

DECLARATION

I hereby declare that the 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 Putra Malaysia or any other institutions.

SIGNED

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NANANG FATCHUROHMAN

Date: 13 November 2013

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