UNIVERSITI PUTRA MALAYSIA

IMPROVING MULTI-CRITERIA DECISION MAKING ALGORITHM FOR MATERIAL SELECTION

ALI JAHAN

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IMPROVING MULTI-CRITERIA DECISION MAKING ALGORITHM FOR MATERIAL SELECTION

By

ALI JAHAN

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

April 2011

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DEDICATION

"This thesis is dedicated to my ever-encouraging parents, my beloved wife and daughter for their love and support"

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia, in fulfilment of the requirements for the degree of Doctor of Philosophy

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April 2011

Chairman: Associate Professor Faizal Mustapha, PhD

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The selection of a material for a specific engineering purpose is laborious and expensive process. Approximately always more than one material is suitable for an engineering application, and the final selection is a compromise between some advantages as well as the disadvantages. Screening and ranking are two vital steps in the material selection and variety of quantitative selection procedures have been developed to solve this issue. In this research, after classifying the current methods for screening and choosing of materials, advantages and disadvantages of the approaches were discussed. Review of literature provided evidence that the multi-criteria decision making (MCDM) approaches have the potential to greatly improve the material selection methodology. In this regard, this research focused on three problematic

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aspects in material selection based on MCDM as described below.

Since existing tools and methods in material selection do not fully support designers during the preliminary design stages in which the designers encounter imprecise data (discrete or incomplete information) or in situations where material selection problems include intangible properties, multi-criteria decision making based on ordinal data (MCDM-BOD), which has root in linear assignment method, is proposed to rank the materials for a given engineering component.

In view of the fact that many of MCDM methods require quantitative weights for the criteria and it plays a very significant role in the ranking results of the materials, a framework for determining the importance degree of criteria was presented to overcome the shortcomings of this subject in material selection. Furthermore, the suggested framework covers the situation of interdependent relationship between the criteria which has not been surveyed yet in material selection.

Due to significance of compromising in material selection, VIKOR method (multi-criteria optimization and compromise solution) was extended in this research. It was performed by introducing a novel normalization method to address the shortcomings of the current methods for situation in which approaching the target values of criteria is important in material selection. The proposed comprehensive version of VIKOR, not only have covered all type of criteria effectively but also have been addressed the main error of traditional VIKOR by a simpler approach.

As a result, this study assists designers and engineers to make more reliable decisions in ranking stage of material selection.

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Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia untuk memenuhi syarat ijazah Doktor Falsafah

PENAMBAHBAIKAN KEPELBAGIAN KRITERIA ALGORITHMA DALAM PEMILIHAN BAHAN

Oleh

ALI JAHAN

April 2011

Pengerusi: Professor Madya Faizal Mustapha, PhD

Fakulti: Kejuruteraan

Pemilihan bahan untuk tujuan kejuruteraan tertentu adalah satu proses yang mengambil masa dan melibatkan kos yang tinggi. Selalunya lebih daripada satu bahan adalah sesuai untuk sesuatu aplikasi kejuruteraan dan pemilihan terakhir bahan lebih merupakan kompromi di antara aspek yang mendatangkan kelebihan dan kekurangan. Penapisan dan penyusunan tahap kedudukan adalah dua langkah penting dalam pemilihan bahan dan beberapa cara pemilihan kuantitatif telah dibangun untuk menyelesaikan isu tersebut. Kajian literatur menunjukkan bahawa pendekatan melakukan keputusan kepelbagaian kriteria mempunyai potensi untuk lebih meningkatkan metodologi pemilihan, tetapi juga membantu para penyelidik dan pembuat keputusan dalam menerapkan pendekatan yang lebih berkesan. Sehubungan

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dengan itu, kajian ini tertumpu kepada tiga aspek bermasalah dalam pemilihan bahan berdasarkan MCDM seperti yang dihuraikan di bawah.

Memandangkan alat-alat dan kaedah-kaedah masa kini dalam pemilihan bahan tidak membantu para pereka sepenuhnya di peringkat awal merekacipta di mana para pereka menghadapi data-data yang tidak tepat (maklumat diskrit atau tidak lengkap) atau dalam situasi di mana masalah-masalah pemilihan bahan yang tidak nampak sifatnya, pemilihan berdasarkan multi-kriteria oleh data ordinal (MCDM-BOD), di mana kaedah penugasan linier telah dicadangkan untuk menyusun bahan bagi komponen kejuruteraan tertentu.

Banyak kaedah MCDM memerlukan pertimbangan kuantitatif untuk kriteria dan memainkan peranan yang sangat penting dalam menentukan penyusunan kedudukan bahan. Satu kerangka untuk mengenalpasti darjah kepentingan kriteria telah diketengahkan untuk mengatasi kekurangan subjek ini dalam pemilihan bahan. Selanjutnya, kerangka yang disarankan meliputi situasi hubungan saling bergantung antara kriteria yang belum dikaji didalam pemilihan bahan.

Lanjutan kaedah VIKOR dipertimbangkan juga dalam tesis ini untuk mengatasi kaedah kekurangan dalam pendekatan ke arah sasaran nilai kriteria adalah penting dalam pemilihan bahan. Ia dijalankan dengan memperkenalkan kaedah baru normalisasi untuk mengatasi kekurangan kaedah masa kini yang mengambilkira nilai-nilai target untuk cirri-ciri penting dalam pemilihan bahan. Versi baru dari VIKOR yang ditawarkan dalam kajian ini meliputi kesalahan utama VIKOR tradisional yang diberi pendekatan

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yang lebih sederhana, sehingga mampu mengurangkan risiko yang terlibat dalam pemilihan bahan yang sesuai menurut semua kriteria yang telah ditentukan.

Hasilnya, kajian ini dapat membantu para pereka dan jurutera untuk membuat keputusan yang lebih tepat dalam penyusunan tahap proses pemilihan bahan.

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I certify that an Examination Committee has met on 29 April 2011 to conduct the final examination of Ali Jahan on his Doctor of Philosophy thesis entitled " IMPROVING MULTI-CRITERIA DECISION MAKING ALGORITHM FOR MATERIAL SELECTION PROCESS" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the PhD degree.
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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

_____

ALI JAHAN

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