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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Manufacturing Engineering

PRIORITIZING LIFE CYCLE COST IN DESIGN FOR REMANUFACTURING USING INTELLIGENT TOOL

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PRIORITIZING LIFE CYCLE COST IN DESIGN FOR REMANUFACTURING USING INTELLIGENT TOOL

AHAMAD ZAKI BIN MOHAMED NOOR

A thesis submitted
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DECLARATION

I declare that this thesis entitled "Prioritizing Life Cycle Cost in Design for Remanufacturing Using Intelligent Tool" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	....
Name	:	....
Date	:	....

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Doctor of Philosophy.

Signature :………………..

Supervisor Name :……………………… ....

Date :…………………….. ....

DEDICATION

I would like to give a very special appreciation to my beloved friends and family for always being there in my time of need. Thank you for giving me continuous support in order for me to fulfil the needs of my PhD research. To my beloved Mother, Father, Family and Friends, thank you all for this.

ABSTRACT

Sustainable practice is needed in every manufacturing industry. There are three indicators and problem arising with the economy indicator is that the variable used is not finalised during substitution value. Decisions made by decision makers are not synchronised and staff from different departments tend to argue until final decision is made. Different industries prioritize different cost resulting different in final answer. Therefore, this research will make the staff from the industry to substitute value and utilised well the Life Cycle Cost (LCC) equation to identify the suitability of Design for Remanufacturing (DFReM) practice. First objective was to determine parameter's weightage concerning LCC equation. The data obtained from industries are direct overhead cost, indirect overhead cost, spare parts cost and packaging cost. Survey forms were distributed among 20 decision makers resulting in different perceptive and their answers were recorded. To make best cost prioritization from 20 different companies' expenses, second objective is to propose three methods that are used in this experiment. The methods proposed are Fuzzy Analytic Hierarchy Process (FAHP), Artificial Neural Network (ANN) and combination of both techniques. Before the main research was conducted, a preliminary experiment was carried out to identify which FAHP will give answer almost same as AHP. AHP is compared because other FAHP are created based on AHP, therefore AHP will give almost correct but not as accurate as FAHP. The findings of this experiment show that Triangular AHP gives the near sequence and suitable material selection to fabricate a table fan. From this preliminary experiment, Triangular FAHP is implemented for cost selection in DFReM. Next part of experiment is to make decision using ANN. Before this part of experiment is carried out, a small experiment was carried out to determine the number of hidden neuron. The outcome of this experiment for this application, the suitable hidden neuron is 2. The last proposed method for cost prioritizing is combination of both FAHP and ANN. The improvement made is used as output from FAHP and introduced as target file. Input remained the same as previous part of ANN experiment. Final objective is to validate life cycle cost prioritizing through comparison of proposed decision making tool outputs. All proposed method's output were identified and result shows that combination of FAHP and ANN will make the company save more expenses compared to carrying single technique. FAHP manage the company to save up to RM 91,353. The result from ANN makes the company to save up to RM 95,093. However the combination method saves the company to a total of RM 95,633. To conclude, combination of FAHP and ANN is the best technique used for cost selection before substituting in an economy indicator for DFReM. Contribution made towards body of knowledge is to adapt FAHP answer as target file for neural network simulation. Contribution made to industry is that by introducing AI technique, LCC equation gives out profit and make DFReM practice suitable for any manufacturing industry.

ABSTRAK

Amalan mampan sangat diperlukan oleh kilang pembuatan. Terdapat 3 sektor tetapi masalah yang timbul adalah pada sektor ekonomi adalah pembolehubah digunakan ketika proses pemindahan. Keputusan yang dibuat oleh pembuat keputusan tidak selari dan staf dari jabatan lain akan bercanggah pendapat sehingga keputusan terakhir yang muktamad di buat. Industri lain akan mengkhususkan kos yang lain menyebabkan perbezaan pada jawapan terakhir. Oleh itu, kajian ini akan membuatkan staf dari industri memindahkan harga dan menggunakan persamaan kos kitaran hayat (KKH) untuk mengenalpasti kesesuaian Design for Remanufacturing (DFReM). Objektif pertama adalah untuk mengenalpasti pemberat parameter yang berkaitan dengan persamaan KKH. Data yang diperlukan dari industri ialah kos perbelanjaan langsung, kos perbelanjaan tidak langsung, kos barang ganti dan kos pembungkusan. Borang kaji selidik diedarkan dan pemberat parameter diberikan oleh 20 pembuat kebutusan adalah berbeza dan jawapan mereka direkod. Bagi mengkhususkan satu daripada 20 kos berlainan, objektif kedua harus dijalankan iaitu mencadangkan tiga cara untuk eksperimen ini. Caranya adalah "Fuzzy Analytic Hierarchy Process" (FAHP), Artificial Neural Network (ANN) dan gabungan kedua – dua cara. Sebelum eksperimen utama dijalankan, satu eksperimen sampingan dibuat untuk mengenalpasti FAHP yang memberikan jawapan yang hampir sama seperti AHP. AHP dibandingkan kerana FAHP yang lain dicipta berdasarkan teknik AHP dimana akan memberi jawapan tepat tapi tidak setepat FAHP. Hasil daripada eksperimen ini menunjukkan FAHP jenis segi tiga memberikan susunan dan pemilihan bahan paling sesuai untuk menghasilkan kipas meja. Daripada eksperimen sampingan ini, FAHP jenis segi tiga akan digunakan bagi tujuan memilih kos untuk dibawa ke DFReM. Bahagian seterusnya adalah untuk membuat keputusan menggunakan ANN. Cadangan cara yang terakhir yang diperkenalkan adalah penggabungan 2 cara iaitu FAHP dan ANN. Penambahbaikan yang dilakukan adalah hasil daripada eksperimen FAHP dimasukkan sebagai fail sasaran. Input adalah sama seperti sebelum iaitu eksperimen ANN. Objektif terakhir adalah untuk mengesahkan jawapan pengkhususan KKH melalui perbandingan jawapan oleh tiga cara yang dicadangkan. Semua jawapan dikenalpasti dan didapati bahawa gabungan 2 cara FAHP dan ANN membuatkan kilang jimatkan pembelanjaan daripada menggunakan teknik FAHP dan ANN secara sendirian. FAHP membuatkan kilang jimat sebanyak RM 91,353. Hasil daripada ANN membuatkan kilang jimat sebanyak RM 95,093. Manakala kombinasi 2 teknik menjimatkan sebanyak RM 95,633. Kesimpulannya, Kombinasi FAHP dan ANN adalah teknik terbaik untuk pengkhususan kos sebelum di bawa ke dalam persamaan KKH untuk DFReM. Sumbangan terhadap ilmu adalah mengadaptasi jawapan FAHP sebagai fail target untuk simulasi ANN. Manakala sumbangan terhadap industri adalah memperkenalkan teknik AI membuatkan persamaan KKH memberi jawapan dalam bentuk keuntungan membuatkan DFReM sesuai dijalankan di mana – mana kilang pembuatan.

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DFReM	-	Design for Remanufacturing
AHP	-	Analytic Hierarchy Process
FAHP	-	Fuzzy Analytic Hierarchy Process
ANN	-	Artificial Neural Network
NN	-	Neural Network
MSE	-	Mean Square Error
AI	-	Artificial Intelligence
LCC	-	Life Cycle Cost
LCA	-	Life Cycle Assessment
CD	-	Compact Disk
TOPSIS	-	Technique for Order Performance by Similarity to Ideal Solution
VIKOR	-	VlseKriterijumska Optimizacija I Kompromisno Resenje
MOORA	-	Multi – Objective by Ratio Analysis
ELECTRE	-	Elimination and Choice Expressing Reality
PROMETHEE	-	Preference Ranking Organization Method for Enrichment Evaluation
CR	-	Consistency Ratio
CI	-	Consistency Index
RI	-	Random Index
PP	-	Polypropylene
HDPE	-	High – Density Polyethylene
LDPE	-	Low – Density Polyethylene
C	-	Company
DM	-	Direct Material

RM	-	Ringgit Malaysia
DMs	-	Decision Makers
DL	-	Direct Labour
DOSD	-	Direct Overhead Supplier Distance
A	-	Accounting
AS	-	Admin Salary
P&P	-	Postage and Printing
OE	-	Office Expenses
SPC	-	Spare Part Cost
SPSD	-	Spare Part Supplier Distance
MS	-	Material Strength
PPC	-	Packaging Purchase Cost
PS	-	Packaging Supplier
MSE	-	Mean Square Error