DEVELOPMENT OF SUSTAINABILITY PERFORMANCE MODEL FOR TURNING PROCESS BY USING NEURAL NETWORK MODEL

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SUPERVISOR'S DECLARATION

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 degree of Doctor of Philosophy.

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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

Konsep kemapanan alam sekitar pertama kali diperkenalkan oleh Harlem Brundtland pada tahun 1980-an, terdiri daripada tiga kriteria iaitu ekonomi, alam sekitar dan sosial. Penyelidikan terkini mengenai petunjuk prestasi yang digunakan pada masa kini semakin dipersoalkan oleh para penyelidik lain kerana ia sukar difahami dan di nilai. Keaslian kajian yang dijalankan adalah bertumpu kepada pembangunan kaedah penilaian kemampanan baharu berdasarkan situasi di malaysia; tertumpu kepada proses melarik dan pengoptimuman parameter pemotongan. Dari perspektif pembuatan, kos pengeluaran berfungsi mengukur kemampanan ekonomi sebuah syarikat dalam jangka masa panjang. Alam sekitar pula adalah ukuran impak kesan daripada aktiviti pembuatan terhadap alam sekitar. Aspek sosial adalah rumit untuk dinilai; tetapi apabila merujuk kepada aktiviti pengeluaran, kesihatan pekerja boleh dipertimbangkan. Tiga jenis penilaian digunakan setelah mendapat maklum balas daripada responden yang bekerja di bidang pembuatan iaitu kos pembuatan, impak kesan alam sekitar, impak ergonomik dan satu kriteria tambahan iaitu tenaga yang digunakan semasa proses pembuatan *pneumatic nipple hose connector*. Kriteria tenaga diperkenalkan bagi mengatasi kelemahan *pricipal component analysis (PCA)*. Jumlah kos pembuatan terdiri daripada enam jenis iaitu bahan mentah, alat pemotongan besi, cecair penyejuk pemotongan, cecair pelincir, tenaga elektrik dan tenaga manusia. Penilaian kesan alam sekitar yang digunakan adalah impak kitar semula bahan buangan dan tenaga terhadap alam sekitar. Impak mata alat, cecair penyejuk dan cecair pelincir terhadap alam sekitar tidak diambil kira kerana sumbangannya adalah terlalu kecil jika dibandingkan dengan jumlah bilangan produk yang boleh dihasilkan. Penilaian ergonomik yang digunakan adalah *The Revised NIOSH Weight Lifting Index* di mana ia mengukur impak kepada para pekerja semasa melakukan aktiviti mengangkat barang di dalam kilang. Pengiraan indeks ini mengambil kira data berat seunit bahan mentah yang digunakan dimana ianya juga digunakan di dalam pegiraan impak kitar semula bahan buangan dan kos bahan mentah. Kajian ini juga menggunakan kaedah *neural network* dan *inversed neural network*. Data yang diperolehi daripada kaedah pengiraan secara teori dan eksperimen dibandingkan bagi tujuan penentusahan di mana perbezaan penetusahan adalah kurang daripada 12%. Data eksperimen digunakan kerana model *neural network* menyediakan keputusan yang komprehensif berbanding data yang diperolehi melalui kaedah pengiraan secara teori. Data input yang digunakan untuk membangunkan model *neural network* dibandingkan dengan data eksperimen dengan penentusahan adalah kurang daripada 5%. Seterusnya, data *input* dan *output* eksperimen yang digunakan kemudiannya dibalikkan dengan *input* digunakan adalah sebagai *output* dan sebaliknya untuk mendapatkan parameter pemotongan optimum menggunakan model *inversed neural network*. Bagi mengoptimumkan parameter pemotongan, nilai minimum daripada setiap kriteria digunakan. Data tersebut diuji bagi tujuan pengesahan dan penentusahan dengan matlamat peratusan perbezaan kurang daripada 5%. Kelajuan pemotongan optimum dan *feedrate* adalah 55.25 m / min dan 0.10 mm / rev bagi Aluminium 6061 dan 82.00 m / min dan 0.10 mm / rev untuk bahan Tembaga C3604. Kesimpulannya, kajian ini membuktikan kaedah penilaian yang digunakan boleh mendapatkan parameter pemotongan optimum. Penambahan kriteria tenaga yang diperkenalkan bertujuan mengawal data tenaga semasa proses ramalan disebabkan kaedah penjumlahan yang digunakan di dalam setiap kriteria. Kaedah yang diperkenalkan ini boleh digunakan dalam menentukan parameter pemotongan bagi pelbagai proses pemesinan di masa hadapan.

ABSTRACT

Sustainability concept was introduced by Harlem Brundtland in the 1980s, consists of three evaluation criteria's; namely economics, environmental and social. However, recent research on the indicator used had increasingly called into question where the indicator is difficult to be assessed and the measurement is indirect. The novelty of the present study is to focus on the development of new sustainability assessment methods based on Malaysia industry scenario, demonstrating the new sustainability assessment model focusing on a turning process and optimized the assessment model to obtain the optimum cutting parameter. In the manufacturing industry perspective, manufacturing costs criteria is known to measure the company economic sustainability. Whilst, environmental criteria is a measure of the impact of manufacturing activities on the environment. The social criteria can be measured by using the production operator health. In the present study, three main sustainability evaluation methods are used after getting feedback from the survey respondents which mostly works in the manufacturing industry. They are the total manufacturing costs, environmental impact, ergonomics impact and combined with energy criteria used during the manufacturing process of a pneumatic nipple hose connector. Energy criteria was introduced because of the implementation of principal component analysis (PCA) disadvantage. The total manufacturing costs consists of six cost assessments which include raw material, tool, coolant, lubricant, energy and manpower. The environmental impact assessments used are chip recycling impact and energy impact. Cutting tool impact, coolant impact and lubricant impact did not take into account as the contribution of impact to the environment is too small when compared to the number of the produced product. The ergonomic assessment used is The Revised NIOSH Weight Lifting Index as the method measures the potential impact of the worker during lifting activities. The index calculation requires raw material mass data as this also used either in chip recycling impact and raw material cost assessment. The present study also highlights the usage of neural network and inversion of the neural network model assessment. The data obtained from both theoretical and experimental methods were compared for their validity which is proved to be less than 12%. The experimental data used for the development of neural network model provides comprehensive results in comparison to the theoretical data. Additionally, inputs data tested using the developed neural network model produced the predicted neural network results for all the four criteria. These data were compared with the experimental data for validation and showed the value of less than 5%. Later, the input and output experimental data used are then inversed with the input is used as an output and (vice-versa) to obtain the optimum cutting parameters by using the inversion of neural network model method. For optimization of cutting parameters, the minimum values from each criteria were selected. These parameters were tested for verification and validation purpose in both experimental and theoretical assessment methods. The targeted percentage difference used at this stage is 5%. The results of optimum cutting speed and feedrate obtained in this project is 55.25 m/min for cutting speed and 0.10 mm/rev for Aluminum 6061 and 82.00 m/min and 0.10 mm/rev for Brass C3604 material. As a conclusion, this study proved that sustainability assessment method can be used to select optimum cutting parameters. Additional energy criteria being introduce able to specifically control the energy data since the summation of all assessment data being used in each criterion. In the future, the proposed method can be applied in other machining process for a better machining parameter optimization in others machining process.

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LIST OF SYMBOLS

V_b	Flank wear
E_e	Machine power consumption impact
LCI(e)	Electricity emission intensity
PSm	Spindle motor power consumption
PFM	Feed motor power consumption
ΣPP	Feed motor power consumption
C_e	Coolant impact consumption
LCI(cp)	Coolant production emission intensity
LCI(cd)	Coolant disposal emission intensity
Tc	Total coolant amount
LCI(w)	Water distribution emission intensity
Tw	Total water amount
Mt	Machining time
MTTR	Mean time to replenish coolant
LO_e	Lubricant oil impact consumption
MTTD	Mean time to discharge lubricant
Ld	Amount of lubricant discharge
LCI(lp)	Lubricant production emission intensity
LCI(LD)	Lubricant disposal emission intensity
Ch_e	Chip recycling impact
WpV	Workpiece volume
pV	Product volume
d	Material density
LCI(M)	Metal chip recycling emission intensity
RWL	Recommended weight limit
LC	Load constant = 23kg
HM	Horizontal multiplier
VM	Vertical multiplier
DM	Distance multiplier
AM	Asymmetric multiplier
FM	Frequency multiplier

CM	Coupling multiplier
b	The bias term / the neuron's threshold
w	vector
x	Vector
N_h	Number of hidden neuron
N	Number of input
H	The approximation and the gradient
J	Jacobian matrix
W	The connection weight
E_ω	The sum of squared network weights
E_D	The sum of network error
P(A|B)	The posterior probability of A conditional on B
P(B|A)	The prior of B conditional on A
P(B)	The non-zero prior probability of event B
P(D|α, β,M)	The likehood function of D for given α, β, M
P(α, β|M)	The uniform prior density for the regularization parameters
P(D|M)	The normalization factor
V_c	Cutting speed
a_p	Depth of cut
f_n	Feedrate
K_c	Specific cutting force (N/mm2)
D_c	Material diameter
l_m	Cutting / machined length
n	Spindle speed

LIST OF ABBREVIATIONS

A1	Aluminium machined with cutting parameters option 1
B1	Brass machined with cutting parameters option 1
CNC	Computer Numerical Control
DOSH	Department of Safety and Health
EPA	Environmental Protection Agency
EPEAT	Electronics Product Environmental Assessment Tool
ETT	Energy Tracking Tool
GLM	Generalized Linear Model
GPR	Gaussian Process Regression
HSS	High Speed Steel
ISO	International Organization for Standardization
kg	Kilogram
$kgCO_2$	Kilogram Carbon Dioxide
kW	Kilo Watt
kWh	Kilo Watt Hour
L	Liter
LCA	Life Cycle Assessment
LCE	Life Cycle Costing
MSE	Mean Square Error
NIOSH	National Institute of Occupational Safety and Health
OECD	The Organization for Economic Co-operation and Development
Ra	The arithmetic mean roughness
REBA	Rapid Entire Body Assessment
RULA	Rapid Upper Limb Assessment
RM	Ringgit Malaysia
Rpm	Revolution Per Minute
SEM	Scanning Electron Microscope
SVM	Support Vector Machine
UMP	Universiti Malaysia Pahang

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