Faculty of Manufacturing Engineering

PREDICTIVE MODELLING OF MACHINING PARAMETERS OF S45C MILD STEEL

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DECLARATION

I declare that this thesis entitled "Predictive Modelling of Machining Parameters of S45C Mild Steel for CNC" 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:…………………………………….

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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 in Manufacturing Engineering.

Signature :

Supervisor Name :

Date :

DEDICATION

To my beloved mother, brothers, wife and kids

ABSTRACT

The determination of the ideal parameters and performance are among the most crucial and complex factors in the process planning and economics of metal cutting operations. Minimization of undesired parameters in production operations is very necessary to increase the productivity and reduce the costs. Turning process is one of complicated operations to control its cutting parameters because it depends upon several conflicting cutting parameters that must be adjusted at the same time accurately. In this research, minimization of cutting temperature, work piece surface roughness, cutting time and cutting tool flank wear are achieved in CNC turning operation. A mild steel material type JIS S45C and a tungsten carbide insert type SPG-422 Grade E30 are used as workpiece and cutting tool materials via dry machining respectively. The temperature of primary plastic deformation zone which called shearing zone, and secondary deformation zone which called chip slides on the rake face zone are measured. This research adopts the utilization of three types of heurestic algorithms to achieve the minimization operation; Genetic Algorithm (GA). Particle Swarm Optimization (PSO) and Artificial Immune System (AIS). Four objective functions are used as input for the intellegent algorithms for minimization purpose, two objective functions for temperature minimization and one for surface roughness minimization and one for cutting time minimization. The outputs of huerestics algorithms are; minimum temperature, minimum surface finish, minimum cutting time. This research includes simulation and experimental work results. The simulation operation is executed by PSO, AIS and GA to find the ideal results, then the these results are tested by CNC turning experimental work to find the accuracy percentage of algorithms and seleceting the ideal one. The simulation results of GA, PSO and AIS showed that the GA1 algorithm which used the first main temperature objective function gives the best temperature value (35. 7 °C) compared with other algorithms, followed by PSO1 (70.2 °C), then AIS1 (112.8 °C). The PSO1 algorithm which used first main temperature objective function gives the best roughness value (0.52 µm) compared with other algorithms, followed by the AIS2 and PSO2 that give (0.86 µm). In cutting time estimation, it is shown that the results of the second main objective functions estimations are better than the first main objective function results. The AIS2 algorithm gives the best time value (3.22 min) compared with the other algorithms, followed by AIS1 (5.05 min), then PSO2 (5.16 min). The experimental results indicate that the best value of cutting temperature which ranged between (150.2-175.3 °C) can be obtained with the combination of input parameters- cutting speed (40 m / min), feed rate (0.05 mm / rev) and depth of cut (0.6 mm). In addition, the best value of surface roughness which ranged between (0.26-1.63 µm) can be obtained with the combination of input parameters-cutting speed (140 m / min), feed rate (0.05 mm/rev) and depth of cut (0.9 mm). Also, the best value of flank wear which ranged between (0.07-0.16mm) can be obtained with the combination of input parameters-cutting speed (40m/min), feed rate (0.05mm/rev) and depth of cut (0.6mm). The artificial neural network type Network Fitting Tool (NFTOOL) is used as a modeling technique for manipulating the ideal algorithm parameters. The results of NFTOOL indicates that (9-6-3) network is the ideal type because it gives lower testing (MSE) equal to ($3.97214 * 10^{-12}$). The effects of cutting parameters on performance characteristics are studied using the signal-to-noise (S/N) ratio method. Finally, selection the better algorithm that gives the best and ideal results of temperature, roughness

and cutting time is selected as an ideal network for prediction the ideal cutting performance for future works.

ABSTRAK

Penentuan parameter yang ideal dan prestasi adalah antara faktor paling penting dan kompleks dalam proses perancangan dan ekonomi dalam operasi pemotongan logam. Pengurangan parameter yang tidak diingini dalam operasi pengeluaran adalah sangat perlu untuk meningkatkan produktiviti dan mengurangkan kos. Proses Turning adalah satu daripada operasi rumit untuk mengawal parameter pemotongan kerana ia bergantung kepada beberapa parameter pemotongan yang perlu diselaraskan pada masa yang sama dengan tepat. Dalam kajian ini , meminimumkan suhu memotong, permukaan kasar bahan kerja, masa memotong dan haus rusuk alat memotong telah dicapai dalam operasi beralih CNC. Bahan keluli jenis ringan JIS S45C dan tungsten karbid jenis masuk SPG -422 Gred E30 telah digunakan sebagai bahan kerja dan bahan-bahan memotong melalui mesin pengering. Suhu zon utama ubah bentuk plastik yang dipanggil zon ricih, dan zon ubah bentuk kedua yang dipanggil slaid cip pada zon meraih muka diukur. Penyelidikan ini menggunakan tiga jenis huerestics algoritma untuk mencapai operasi pengurangan iaitu; Algoritma Genetik (GA), Particle Swarm Optimization (PSO) dan Artificial Sistem Imun (AIS). Empat fungsi objektif digunakan sebagai input bagi algoritma intellegent untuk tujuan pengurangan, dua fungsi objektif untuk meminimumkan suhu dan satu untuk meminimumkan permukaan yang kasar dan satu lagi untuk meminimumkan masa pemotongan. Output huerestics algoritma adalah; suhu minimum, kemasan permukaan minimum, masa memotong minimum. Kajian ini termasuk simulasi dan hasil kerja eksperimen. Operasi simulasi dilaksanakan oleh PSO, AIS dan GA untuk mencari keputusan yang ideal, kemudian keputusan ini diuji menggunakan kerja eksperimen beralih CNC untuk mencari peratusan ketepatan algoritma dan pemilihan yang ideal. Keputusan simulasi GA, PSO dan AIS menunjukkan bahawa algoritma GA1 yang digunakan suhu utama fungsi objektif pertama memberikan nilai terbaik suhu (35.7 °C) berbanding dengan algoritma yang lain, diikuti oleh PSO1 (70.2 °C), dan AIS1 (112.8 °C). Algoritma PSO1 yang menggunakan suhu utama fungsi objektif pertama memberikan nilai kekasaran terbaik (0.52 mikronmeter) berbanding dengan algoritma yang lain, diikuti dengan AIS2 dan PSO2 yang memberikan (0.86 mikronmeter). Dalam anggaran masa pemotongan, ia menunjukkan bahawa keputusan kedua utama fungsi objektif anggaran yang lebih baik daripada yang utama hasil fungsi objektif pertama. Algoritma AIS2 memberikan nilai masa terbaik (3.22 min) berbanding dengan algoritma yang lain, diikuti oleh AIS1 (5.05 min), kemudian PSO2 (5.16 min). Keputusan eksperimen menunjukkan bahawa nilai terbaik untuk suhu memotong yang berkisar antara (150.2-1753 °C) boleh diperolehi dengan menggabungkan input parameter-kelajuan pemotongan (40 m/min), kadar suapan (0.05 mm/putaran) dan kedalaman pemotongan (0.6 mm). Di samping itu, nilai terbaik kekasaran permukaan yang berkisar antara (0.26-1.63 mikronmeter) boleh diperolehi dengan menggabungkan input parameter kelajuan pemotongan (140 m/min), kadar suapan (0.05 mm/ putaran) dan kedalaman pemotongan (0.9 mm). Juga, nilai terbaik haus rusuk yang berkisar antara (0.07-0.16mm) boleh diperolehi dengan menggabungkan input parameter kelajuan pemotongan (40 m/min), kadar suapan (0.05 mm/putaran) dan kedalaman pemotongan (0.6 mm). Jenis rangkaina neural tiruan iaitu rangkaian alat pemasangan (NFTOOL) digunakan sebagai teknik pemodelan untuk memanipulasi parameter algoritma yang ideal. Keputusan NFTOOL *menunjukkan bahawa rangkaian (9-6-3) adalah jenis yang ideal kerana ia memberi ujian yang lebih rendah (MSE) sama dengan ($3.97214*10^{-12}$). Kesan parameter memotong terhadap ciri-ciri prestasi dikaji menggunakan kaedah nisbah isyarat-kepada-bunyi (S/N). Akhir sekali, pemilihan algoritma yang lebih baik yang memberikan hasil yang terbaik dan ideal terhadap suhu, kekasaran dan masa memotong dipilih sebagai rangkaian ideal untuk ramalan prestasi pemotongan yang ideal untuk kerja-kerja masa depan.*

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