UNIVERSITI PUTRA MALAYSIA

SYSTEM INSTRUMENTATION AND MODELING OF POWER AND ENERGY DEMAND FOR TILLAGE OPERATIONS IN MALAYSIA

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By

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Dedication
To
My mother's soul

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

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Malaysia stands as a world's pertinent producer of palm oil, rubber and cocoa. An increase in food imports coupled with limited agricultural workers have driven the need for the development of integrated system for agriculture database to manage the country's limited resources. The development of a database on power and energy demand of various agricultural field operations is a prime concern for an economical management of input resources for agricultural production.

A complete tractor instrumentation and data acquisition system was developed and installed on a Massey Ferguson 3060 agricultural tractor for power and energy demand mapping of the agricultural field operations in Malaysia. The built-in instrumentation system is able to measure and display information on engine speed, PTO speed, forward speed, drive wheel slippage, acres worked, fuel consumption per hour, fuel consumption per hectare, flied capacity, cost factor, fuel consumed, fuel remaining, and distance. The developed data acquisition system is able to measure and monitor horizontal pull at the tractor drawbar point, torques at both tractor rear drive wheels, torque at the tractor PTO output, and the horizontal and vertical forces on the implement at the 3-point hitch. Static calibration tests on

all the designed transducers for the required measurements showed excellent linearity (i.e., correlation coefficients closed to 0.99). The field trials demonstrated that the datalogger and associated transducers were able to function successfully without giving problems under the harsh field environments. The stored data in the memory card of the datalogger from the field trials was able to be down loaded into the hard disk of the host computer at the laboratory for post processing.

Draft and energy requirements measurements were made with the instrumented tractor for moldboard plowing, disk plowing, disk harrowing and rotary tilling in Serdang sandy clay loam soil. The effects of travel speed and tillage depth or rotor speed upon the measured data were investigated. Four polynomial draft and power models from orthogonal regression analysis were formulated based on linear and quadratic functions of travel speed and tillage depth or bite length. Furthermore, the predictions by the developed draft models for moldboard plow and disk harrow were within the acceptable variations recommended by ASAE D497.4. Comparison on the draft model for disk plow and power model for rotary tiller with the ASAE D497.4 could not be made simply because their models were not listed. Four linear fuel models from regression analysis were formulated based on drawbar power or PTO power as well as equivalent PTO power. Fuel consumptions predicted by ASAE D497.4 were found to be 17% to 33% overestimated of the values predicted by the developed fuel models. However, fuel consumptions reported by OECD Tractor Test were found to be 91% to 106% of the values predicted by the developed fuel models. Almost 37% to 52% of the measured fuel consumptions for the various plowing operations were required to propel the tractor and the remaining percentage were meant for the actual task of working the soil.

Finally, average draft, fuel consumption, wheel slip, drawbar power, tractive efficiency and overall energy efficiency for positive draft implement as well as average PTO power, fuel consumption, wheel slip, wheel power and specific energy for negative draft implement were presented. Disk harrow was the most energy efficient implement in terms of fuel consumption and specific energy followed by rotary tiller, disk plow and moldboard.

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

SISTEM INSTRUMENTASI DAN PEMODELAN KEPERLUAN KUASA DAN TENAGA BAGI KERJA PEMBAJAKAN TANAH DI MALAYSIA

Oleh

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Malaysia merupakan pengeluar utama kelapa sawit, getah dan koko di dunia. Peningkatan nilai import makanan ditambah pula dengan kekuragan tenaga buruh telah mendesak ke arah pembangunan satu sistem intergrasi pengkalan data pertanian bagi mengurus sumber-sumber negara yang terhad. Pembangunan satu pengkalan data mengenai keperluaan kuasa dan tenaga bagi pelbagai kerja perladangan merupakan satu perkara yang tersangat penting dalam pengurusan secara lebih ekonomikal input-input sumber bagi pengeluaran pertanian.

Satu sistem peralatan dan perolehan data yang lengkap telah dibangunkan serta dipasang pada sebuah traktor pertanian Massey Fergusson 3060 untuk tujuan pemantauan keperluaan kuasa dan tenaga bagi kerja-kerja perladangan di Malaysia. Sistem peralatan yang sedia terbina boleh mengukur dan memapar keterangan mengenai laju enjin, laju PTO, laju pergerakan, kegelinciran roda pemacu, luas terkerja, penggunaan bahanapi sejam, penggunaan bahanapi sehektar, kemampuan ladang, faktor kos, penggunaan bahanapi, bahanapi yang tertinggal, dan jarak pergerakan. Sistem perolehan data yang dibangunkan boleh mengukur dan merakam

daya mendatar di titik bar penarik traktor, beban kilas di kedua-dua roda pemacu belakang traktor, daya kilas di PTO traktor, dan daya-daya mendatar serta menegak pada alat pertanian di 3-titik pautan traktor. Ujian-ujian penentukuran statik ke atas kesemua penderia yang telah direkabentuk untuk pengukuran menunjukan kelelurusan yang sangat baik (iaitu pekali sekaitan bersamaan 0.99). Ujian di ladang menunjukkan sistem perolehan data dan penderia dapat berfungsi dengan baik tanpa sebarang permasalahan di dalam persekitaran ladang yang tidak menentu. Data-data dari ujian ladang yang tersimpan dalam kad ingatan sistem perolehan data dapat dipindahkan ke dalam cakera keras komputer perumah di makmal untuk tujuan pascapemprosesan.

Suatu kajian pengukuran keperluanan deraf dan tenaga telah dijalankan dengan menggunakan traktor yang dilengkapi peralatan dan sistem perolehan data yang dibangunkan untuk kerja pembajakan sepak, pembajakan piring, pembajakan sikat bercakera, dan pembajakan putar di tanah liat lom berpasir Serdang. Kesan laju pergerakan dan kedalaman bajak atau laju rotor ke atas data-data terukur telah diselidiki. Empat model polinomial deraf dan kuasa telah dibentuk dari analisis regrasi ortogonal berdasarkan kelelurusan dan kuadratik laju pergerakan dan kedalamam bajak atau panjang potongan. Seterusnya, model deraf yang dibangunkan untuk bajak sepak dan bajak sikat berpiring didapati berada dalam variasi yang diterima dalam Piawai ASAE D497.4. Perbandingan model deraf untuk bajak piring dan model kuasa untuk bajak putar dengan Piawai ASAE D497.4 tidak dapat dilaksanakan oleh kerana model-model nya tidak tersenarai. Empat model lelurus bahanapi dari analisis regrasi dibangun berdasarkan kuasa bar penarik atau kuasa PTO serta juga kuasa PTO setara. Bahanapi ramalan Piawai ASAE D497.4

didapati 17% hingga 33% lebih tinggi daripada nilai ramalan model bahanapi yang dibangunkan. Walau bagaimanapun, bahanapi yang terlapor dari Ujian OECD Traktor didapati 91% hingga 106% lebih tinggi dari nilai ramalan model bahanapi. Hampir 37% hingga 52% daripada bahan api yang terukur untuk kerja-kerja pembajakan terbabit diguna untuk mengerakkan traktor and peratus bakinya diguna untuk melaksanakan tugas mengerjakan tanah .

Purata deraf, penggunaan bahanapi, kegelinciran roda, kuasa bar penarik, kecekapan tukisan, dan keseluruhan kecekapan tenaga bagi alatan berderaf positif telah dipersembahkan. Ianya begitu juga dengan purata kuasa PTO, penggunaan bahanapi, kegelincir roda, kuasa roda, dan tenaga tentu bagi alatan berderaf negatif. Bajak sikat berpiring merupakan alat membajak yang paling tenaga berkesan berdasarkan kepada penggunaan bahanapi dan tenaga tentu diikuti oleh bajak putar, bajak piring, dan bajak sepak.

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