UNIVERSITI PUTRA MALAYSIA

DESIGN AND DEVELOPMENT OF A FOURWHEELED DRIVE MULTIPURPOSE PRIME MOVER FOR OIL PALM PLANTATION MECHANIZATION

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By

DARIUS EL PEBRIAN

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

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Dedicated to

His late father Yulius Amadin
His late mother Rosma
His elder brother and sister in law, and all their children

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

DESIGN AND DEVELOPMENT OF A FOUR-WHEELED DRIVE MULTIPURPOSE PRIME MOVER FOR OIL PALM PLANTATION MECHANIZATION

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November 2009

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Faculty : Engineering

A new completely integrated machine system for mechanizing the field operations in the oil palm plantation in Malaysia has been successfully designed, developed and evaluated. The machine system consists of a 4WD multi purpose prime mover associated with its machine attachments for circle spraying, blanket spraying and in-field FFB collection-transportation operation and provisions for the other future machine attachments.

Computations were made to predict the overall performances of the proposed 4WD multi purpose prime mover based on the terrain parameters obtained from the study on the mechanical terrain properties. Computations also were made to estimate on the overall hydrostatics efficiency of the prime mover, and the required hydraulic pressure for operating all actuators within the respective machine attachments. Besides, a study on machine and human performances in oil palm cultivations in Malaysia has been sucessfully conducted to identify the critical field operations or tasks within the nursery and field stage operations prior to establishing the design

concept of the 4WD multipurpose prime mover with its respective machine attachments. The greater priority was given to the identified critical field operations and the identified tasks within the operation in designing and developing the types of machine attachments for the 4WD multi purpose prime mover. The attachments for spraying operations and in-field FFB collection-transportation operation were given a greater priority to be designed and developed to complete the functionality of the prime mover in order to be a universal prime mover.

Results from field evaluations had showed that the average effective field capacity for the circle spraying operation with the machine system was found to be 0.98 ha/hr or equal to 7.89 ha/man-day with 8 committed working hours per day or increments of average effective machine field capacity of 1.97 over the Serena LT16 knapsack sprayer.

The average effective field capacity for the blanket spraying operation with the machine system was found to be 3.82 ha/hr or equal to 30.61 ha/man-day with 8 committed working hours per day or increments of average effective machine field capacity of 1.53 times over the mini-tractor with fully mounted 10 m boom sprayer.

The average machine output of in-field FFB collection-transportation operation with the machine system operating on gently undulating terrain was 2.620 ton/hr or equal to 20.965 ton/day with 8 committed working hours per day. An average machine output increment of 3.58% higher than average machine output of 2.526 ton/hr or equal to 20.213 ton/day was obtained when the machine system operating on sloping terrain.

A spraying cost increment per hectare of 24.90% or an additional cost of RM5.36/ha (1.53 USD/ha) was obtained in circle spraying operation with the prime mover over the Serena LT16 knapsack sprayer. Increasing the effective field capacity of the machine system to a value equal or greater than 1.33 ha/hr (i.e. 26.3% increased) or reducing the initial cost of the machine system to RM27,500 (USD 7714.28) or 0.41 times reduction would qualify the machine system to be cost effective over the Serena LT16 knapsack sprayer for circle spraying operation.

A spraying cost reduction per hectare of 19.54% or a cost saving of RM1.54/ha (0.44 USD/ha) was obtained in blanket spraying operation with the prime mover over the mini tractor with fully mounted 10 m width boom sprayer.

An operating cost reduction in the range of 6.74% to 14.25% per ton or cost savings in the range of RM0.62/ton (0.18 USD/ton) to RM1.31/ton (0.37 USD/ton) were obtained in in-field FFB collection-transportation operation with the prime mover over the mini tractor-trailer with grabber.

In-field FFB collection-transportation operation by the prime mover with in-field FFB collection-transportation attachment was 63.35 times more exhausting on basis of the measured human energy expenditure, 1.59 times more demanding on basis of the measured mean increase in heart rate, and 1.16 times less dawdling on basis of the measured average field capacity than the operation by the mini tractor-trailer with grabber.

Circle spraying operation by the prime mover with circle spraying attachment was 0.89 times less exhausting on basis of the measured of the human energy expenditure, 0.32 times less demanding on the basis of the measured mean increase in heart rate and 1.78 times less dawdling on the basis of the measured average field capacity than the operation by the Serena LT16 knapsack sprayer.

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

MEREKA BENTUK DAN MEMBINA SEBUAH PENGGERAK UTAMA PACUAN EMPAT RODA PELBAGAI GUNA UNTUK MEKANISASI PERLADANGAN KELAPA SAWIT

Oleh

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Sebuah sistem jentera baru dan terpadu untuk mekanisasi kerja-kerja ladang di perladangan kelapa sawit di Malaysia telah berjaya direka bentuk, dibina dan diuji kaji. Sistem jentera ini terdiri dari penggerak utama pacuan empat roda yang dilengkapi dengan sangkutan jentera untuk kerja-kerja semburan bulatan, semburan selimut, dan pengumpulan-pengangkutan buah segar kelapa sawit di ladang.

Pengiraan dibuat untuk meramal prestasi keseluruhan daripada penggerak utama empat roda yang dicadangkan. Pengiraan juga dibuat untuk menganggarkan prestasi keseluruhan penggerak hidrostatik dan jumlah tekanan hidraul yang diperlukan untuk mengendalikan semua penggerak dalam sistem hidraul untuk semua sangkutan jentera. Sebelum memulakan kerja-kerja mereka bentuk penggerak utama pacuan empat roda pelbagai guna dengan sangkutan-sangkutan mesinnya, satu kajian tentang prestasi manusia dan jentera dalam penanaman kelapa sawit di Malaysia telah dilaksanakan untuk mengenal pasti kerja-kerja atau tugas-tugas yang kritikal

dan genting dalam kerja-kerja di tapak semaian dan di ladang. Keutamaan yang lebih besar diberikan pada kerja-kerja atau tugas-tugas yang kritikal dan genting dalam kerja reka bentuk dan membina jenis sangkutan jentera yang diperlukan untuk penggerak utama pacuan empat roda tersebut. Sangkutan mesin untuk penyemburan dan pengumpulan-pengangkut tandan buah segar kelapa sawit di dalam ladang telah dikenalpasti untuk diberi keutamaan direka bentuk dan dibina untuk melengkapi fungsi penggerak utama tersebut sebagai sebuah penggerak utama yang universal.

Keputusan-keputusan dari ujian di ladang didapati purata kecekapan ladang daripada penggerak utama dengan sangkutan semburan bulatan untuk kerja semburan bulatan ialah 0.98 ha/jam atau setara dengan 7.89 ha/hari-pekerja dengan masa kerja yang diwajibkan 8 jam setiap hari atau 1.97 kali ganda peningkatan berbanding purata kecekapan ladang dengan penyembur galas Serena LT16.

Purata kecekapan ladang dari pada penggerak utama dengan sangkutan semburan selimut untuk kerja semburan selimut adalah 3.82 ha/jam atau setara dengan 30.61 ha/hari-pekerja atau 1.53 ganda peningkatan berbanding purata kecekapan ladang dengan mini traktor 21 kW dengan 10 m lebar penyembur bertangan.

Purata keluaran kerja pengumpulan-pengangkutan buah segar di ladang dengan sistem jentera ini ketika bekerja di atas tanah tidak rata ialah 2.620 tan/jam atau setara dengan 20.965 tan/hari dengan masa kerja yang diwajibkan 8 jam setiap hari. Sebuah purata peningkatan keluaran 3.58% lebih tinggi dibandingkan dengan keluaran 2.526 tan/jam atau setara dengan 20.213 tan/hari ketika jentera bekerja di tanah cerun.

Satu peningkatan kos semburan setiap hektar 24.90% atau tambahan kos RM5.36/ha (1.53 USD/ha) didapati dalam kerja semburan bulatan dengan penggerak utama berbanding dengan penyembur galas Serena LT16. Peningkatan keupayaan efektif ladang sistem jentera hingga sama atau besar dari 1.33 ha/jam (iaitu peningkatan 26.30%) atau pengurangan kos awal sistem jentera hingga RM27,500 (USD 7714.28) (atau 0.41 ganda pengurangan) akan melayakan kos efektif sistem jentera ini berbanding dengan penyembur galas Serena LT16 untuk kerja semburan bulatan.

Satu pengurangan kos setiap hektar 19.54% atau penjimatan kos RM1.54 (0.44 USD/ha) setiap hektar diperolehi dalam kerja semburan selimut dengan penggerak utama berbanding dengan mini traktor 21 kW dengan 10 m lebar penyembur bertangan.

Satu pengurangan kos dalam banjaran 6.74% hingga 14.25% setiap tan atau penjimatan kos dalam banjaran RM0.62/tan (0.18 USD/tan) hingga RM1.31/tan (0.37 USD/tan) diperolehi dari kerja pengumpulan-pengangkutan tandan buah segar di ladang dengan penggerak utama berbanding dengan mini traktor- treler dan pengaut buah.

Kerja pengumpulan-pengangkutan tandan buah segar di ladang dengan penggerak utama ialah 63.35 kali ganda memenatkan berasaskan ukuran pemakaian tenaga manusia, 1.59 kali ganda meletihkan berasaskan ukuran purata peningkatan denyutan jantung, dan 1.16 kurang lambat berasaskan ukuran purata keupayaan ladang berbanding dengan mini traktor-treler dengan pengaut buah. Kerja semburan bulatan dengan penggerak utama ialah 0.89 kali kurang memenatkan berasaskan

ukuran pemakaian tenaga manusia, 0.32 kali kurang meletihkan berasaskan purata peningkatan denyutan jantung dan 1.78 kali kurang lambat berasaskan ukuran putara keupayaan di ladang berbanding dengan penyembur galas Serena LT16.

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I certify that a Thesis Examination Committee has met on 17 November 2009 to conduct the final examination of Darius El Pebrian on his Doctor of Philosophy thesis entitled "Design and Development of a Four-Wheeled Drive Multipurpose Prime Mover for Oil Palm Plantation Mechanization" in accordance with Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A)] 106] 15 March 1998. The Committee recommends that the candidate be awarded the relevant degree.

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DECLARATION

I hereby declare that the 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 UPM or other institutions.

_____

DARIUS EL PEBRIAN

Date: 1 July 2009

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