UNIVERSITI PUTRA MALAYSIA

DESIGN AND DEVELOPMENT OF AN INTEGRATED INFIELD COLLECTION-TRANSPORTATION MACHINE FOR OIL PALM FRESH FRUIT BUNCH

MUTASIM ELTAYEB ALI

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By

MUTASIM ELTAYEB ALI

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

August 2002

Dedicated

to

My

Parents, for their Doa~ ,
Brothers, sisters and relatives, for their support,
Wife, Alawia .. son, Mohamed, and
Daughters, Omaima and Nusaiba, for their motivation

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

DESIGN AND DEVELOPMENT OF AN INTEGRATED INFIELD COLLECTION-TRANSPORTATION MACHINE FOR OIL PALM FRESH FRUIT BUNCH

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MUTASIM EL TAYEB ALI

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Chairman : **Assoc. Prof. Dr. Azmi Haji Yahya, Ph.D.**

Faculty : **Engineering**

A prototype oil palm FFB Collector-transporter was designed, developed, modified and tested at the Department of Biological and Agricultural Engineering, Universiti Putra Malaysia (UPM), Malaysia. This four-wheeled, hydrostatic drive, integrated machine was designed for collecting and transporting oil palm fresh fruit bunches in the field and unloading them directly into mainline transporters or trucks at the roadside. The overall dimension of the machine was 4750 mm for length, 2040 mm for width and 2725 mm for height. The overall construction of the machine was consisted of a main chassis and driving unit, collection assembly, operator cab, scissors lift-type fruit bin and associated hydraulic control unit. Various functional components of the machine were hydraulically operated through a solenoid control system. ACAD2000 package was employed to develop the 3D model of the prototype machine. A 29.8 kW @ 2200 rpm KUBOTA V2203-E 4-cylinder diesel engine, a 21.5 gpm @ 1000 rpm VICKERS TA1919 main hydrostatic pump, and a 14.5 gpm @ 1000 rpm SAMHYDRAULIC HIC55 driving motor were

selected based on the computations made to determine the machine total engine power and total hydraulic pressure requirements for the machine to operate under local terrain conditions.

A laboratory test was held on a flat asphalt surface for a controlled performance comparison between the FFB Collector-transporter and the Mini Tractor Trailer with Grabber. Similar comparison test between the modified FFB Collector-transporter and the Mini Tractor-trailer with Grabber was also conducted. Results from these tests showed that the FFB Collector-transporter could give 8.8% output improvement over that of Mini Tractor-trailer with Grabber. The mean expected machine outputs for both systems were found to be 40.98 and 38.10 ton/day, and the difference was significant at 5% level. The FFB Collector-transporter took on average of 11.01 minutes per trip compared to 12.13 minutes per trip by the Mini Tractor-trailer with Grabber in collecting the fresh fruit bunches. The machine gave a loose fruit loss of 62.8% less than that of the Mini Tractor-trailer with Grabber, and consumed 34.1% more fuel.

The modified FFB Collector-transporter was 42.50% faster in the fruit bunch collection than the earlier FFB Collector transporter under the controlled laboratory test. The mean expected output for the modified FFB Collector-transporter was found to be 60.01 ton/day and the difference with the Mini Tractor-trailer with Grabber was statistically significant at 1% level. The modified FFB Collector-transporter had loose fruit loss of 130.9% less than that of the Mini Tractor-trailer with Grabber, and consumed 16.1% less fuel.

A field test was held on a flat, soft, and soggy terrain of 2 hectare area size to evaluate the actual performance of the machine in the plantation. The achievable machine outputs for the modified FFB Collector-transporter in the field were in the range from 18 and 34 ton/day under the described conditions. The measured machine output was found to be very much dependent on the crop yield of the plots. The mean field total collection time per trip for the machine was 11.4 minutes and its achievable capacity was between 2.3 to 4.2 ton/h. Based on the maximum machine capacity of 4.2 ton/h and the machine R&D cost of *RM*77708.3 (*USD*20558), the expected infield collection-transportation operation cost with the machine was *RM*4.5/ton (*USD*1.19/ton). Consequently, a cost saving of *RM*1.13/ton (*USD*0.30/ton) was obtained with the machine over the Mini Tractor-trailer with Grabber. Further increase in the cost saving could be obtained with the reduction in the machine initial cost when it was produced in a mass scale.

System evaluation in the harvesting and handling of fresh fruit bunch for a plantation area of 800 ha under steady state condition showed that the FFB Collector-transporter had 17.4% higher system capacity, 16.7% higher labour efficiency, 23% lower system cycle time, and 36% lower idle time than that of the Mini Tractor-trailer with Grabber.

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

MEREKABENTUK DAN MEMBANGUN JENTERA BERSEPADU MENGUMPUL-MENANGKUT TANDAN SEGAR KELAPA SAWIT DALAM LADANG

Oleh

MUTASIM EL TAYEB ALI

Ogos 2002

Pengerusi : Profesor Madya Dr. Azmi Haji Yahya, Ph.D.
Fakulti : Kejuruteraan

Satu jentera prototaip mengumpul-mengangkut tandan segar kelapa sawit telah direkabentuk, dibangun dan diuji di Jabatan Kejuruteraan Biologi dan Pertanian, Universiti Putra Malaysia (UPM), Malaysia. Jentera empat roda, pacuan hidrostatik, dan bersepadu ini mampu mengumpul-menangkut tandan-tandan segar kelapa sawit dalam ladang dan memunggahkan tandan-tandan tersebut terus ke dalam pengangkut utama atau lori di tepi jalan. Dimensi keseluruhan jentera ialah panjang 4750 mm, lebar 2040 mm dan tinggi 2725 mm. Pembinaan keseluruhan jentera terdiri daripada casis utama dan unit pemacu, pemasangan pengumpul, kabin operator, bekas tandan dengan penaik gunting, dan unit kawalan hidraul yang berkaitan. Kesemua komponen berfungsi pada jentera dikendalikan melalui sistem kawalan solinoid. Pakej perisian ACAD2000 telah digunakan untuk membangun model 3D jentera protototaip ini. Enjin diesel KUBOTA V2203-E 4-silinder 29.8 kW @ 2200 psm, pum utama hidrostatik VICKERS TA1919 21.5 gsm @ 1000 psm, dan motor pacuan SAMHYDRAULIC HIC55 14.5 gsm @ 1000 psm telah dipilih berdasarkan kepada pengiraan yang telah dibuat untuk menentu jumlah keperluaan

kuasa enjin dan jumlah tekanan hidraul bagi jentera untuk dikendalikan di atas permukaan bumi tempatan.

Satu ujian makmal dalam keadaan terkawal telah dijalankan di atas permukaan berasfalt yang rata untuk membolehkan perbandingan pretasi tak pincang diantara jentera mengumpul-mengangkut tandan segar kelapa sawit dengan traktor-trailer mini dengan Grabber. Ujian perbandingan yang sama juga telah dijalankan ke atas jentera mengumpul-mengangkut tandan segar kelapa sawit yang telah diubahsuai dengan traktor-trailer mini dengan Grabber. Keputusan ujian menunjukkan bahawa jentera mengumpul-mengangkut tandan segar kelapa sawit dapat memberikan 8.8% peningkatan dalam pengeluaran daripada traktor-trailer mini dengan Grabber. Purata anggaran pengeluaran bagi kedua-dua jentera adalah 40.98 dan 38.10 tan metrik/hari dan perbezaannya adalah nyata di peringkat 5%. Jentera mengumpul-mengangkut tandan segar kelapa sawit mengambil purata 11.03 minit per trip manakala traktor-trailer mini dengan Grabber mengambil 12.13 minit per trip untuk mengumpul tandan-tandan segar kelapa sawit. Jentera tersebut memberikan kehilangan buah terlerai 62.8% kurang dari traktor-trailer mini dengan Grabber, dan mengguna 34.1% lebih bahanapi.

Jentera mengumpul-mengangkut tandan segar kelapa sawit yang telah diubahsuai didapati 42.50% lebih cepat dalam kerja mengumpul tandan-tandan segar jika dibandingkan dengan jentera sebelumnya. Purata anggaran pengeluaran bagi jentera mengumpul-mengangkut tandan segar kelapa sawit yang telah diubahsuai adalah 60.01 tan metrik/hari dan perbezaannya manakala traktor-trailer mini dengan

Grabber dengan adalah nyata di peringkat 5%. Jentera mengumpul-mengangkut tandan segar kelapa sawit yang telah diubahsuai memberikan kehilangan buah terlerai 130.9% kurang dari traktor-trailer mini dengan Grabber, dan mengguna 16.1% kurang bahanapi.

Satu ujian ladang telah dijalankan di atas permukaan rata, lembut, lagi basah pada kawasan seluas 2 hektar untuk menilai prestasu sebenar jentera dalam ladang. Pengeluaran maksima yang tercapai bagi jentera mengumpul-mengangkut tandan segar kelapa sawit yang telah diubahsuai dalam ladang dengan kedaaan permukaan pada kawasan cerun yang rata dan lembek berukuran 2 hektar, bumi yang basah adalah 34 tan/hari. Pengeluaran yang terukur bagi jentera didapati sangat bergantung kepada hasil tanaman bagi plot yang terbabit. Purata jumlah masa pengumpulan per trip dalam ladang bagi jentera ini adalah 11.4 minit dan kemampuan yang tercapainya adalah diantara 2.3 hingga 4.2 tan/jam. Berdasarkan kepada kemampuan maskima jentera bersmaan4.2 tan/jam dan kos R&D jentera bersamaan *RM*77708.3 (*USD*20558), dianggarkan kos bagi kerja pengumpulan-pengangkutan dalam ladang dengan jentera ini adalah *RM*4.5/tan (*USD*1.19/ton). Dengan ini, penjimatan kos sebanyak *RM*1.13/tan (*USD*0.30/ton) boleh didapati dengan jentera ini ke atas penggunaan traktor-trailer mini dengan Grabber. Peningkatan dalam penjimatan kos dapat diperolehi dengan pengurangan pada harga permulaan jentera tersebut apabila pengeluaran nya dibuat dalam kuantiti yang banyak.

Penilainan system dalam penuaian dan pengendalian tandan segar kelapa sawit bagi perladangan yang luasnya 800 ha dalam keadaan mantap menunjukkan jentera

mengumpul-mengangkut tandan segar kelapa sawit masa mempunyai 17.4% lebih tinggi muatan system, 16.7% lebih tinggi kecekapan ladang, 23% lebih rendah masa kitar system, dan 36% lebih rendah masa melalu dari traktor-trailer mini dengan Grabber.

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(May Allah S.W.T. bless all those who kindly helped the author … A~min.)

This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirements for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES