



UNIVERSITI PUTRA MALAYSIA

***DESIGN, DEVELOPMENT AND PERFORMANCE OF A
DISC PLOUGH COMBINED WITH ROTARY BLADES***

ALI HASHEMI

FK 2012 76

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UNIVERSITI PUTRA MALAYSIA**

2012

**DESIGN, DEVELOPMENT, AND PERFORMANCE OF A DISC PLOUGH COMBINED
WITH ROTARY BLADES**



By
ALI HASHEMI

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

May 2012

DEDICATION

*This thesis is especially dedicated to my late father, dear mother and dear family,
Ashraf, Mohammad, Arman and Mobin.*



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

**DESIGN, DEVELOPMENT, AND PERFORMANCE OF A DISC PLOUGH
COMBINED WITH ROTARY BLADES**

By

Ali Hashemi

May 2012

Chairman: Professor Desa Bin Ahmad, PhD, P.Eng.

Faculty: Engineering

This research focused on the development of a new combined tillage machine for adequate clod breaking/pulverizing in a single pass. A disc plough combined with rotary blades (Comboplow) for land preparation was designed, fabricated and tested at Universiti Putra Malaysia (UPM) Research Farm. The machine consists of a chassis, three point hitch, transmission system (universal joint with safety clutch, gear box, input shaft, output shaft, chain, sprockets, main shaft, and holder of blades), disc, rear wheel, rotary blades and adjusting mechanism.

The Comboplow includes two units of tillage tool comprising of a disc plough and several rotary blades. The disc plough cuts partially or completely inverts a layer of soil to bury surface material. The soil in contact with the surface of disc would be cut and pulverized by the rotary blades. Multiple tillage operations are reduced to a single pass and thus reduce the number of field trips as compared to conventional tillage practices resulting in reductions of soil compaction, labour, fuel cost and operation time. The rotary blades can be adjusted to certain speed and depth with the help of changing the sprockets and nuts, respectively. The Comboplow, was tested in

the Serdang sandy clay loam soil texture for energy consumption and some soil characterization parameters. The tests were performed based on 2×3 factorial treatment in RCBD experimental design with three replications. Block dimensions were 25m×27m. The treatments were three types of blade (straight, curved, and L-shaped) and three rotary speeds (130 rpm, 147 rpm and 165 rpm). The parameters measured were consumption of energy, bulk density, moisture content, Mean Weight Diameter dry basis (MWD_{dry}), Mean Weight Diameter wet basis (MWD_{wet}), Stability Index (SI), Instability Index (II), 2<Aggregate Size Distribution<8mm (ASD_{d8}) and 0<Aggregate Size Distribution <100mm (MWD_{d100}). The analysis of variance (ANOVA) and Duncan's new multiple range test were used to analyze the data using the statistical analysis systems. The results showed that MWD_{dry} was significantly affected by types of blades. However the highest MWD_{dry} was obtained from L-shaped blade.

The rotational speed of blade was found to have significant effect on the percentage of soil bulk density (dry basis) at the lowest percentage of 15.63% for the speed of 130 rpm. MWD_{dry} and MWD_{wet} were found to be significantly affected by the rotational speed of blade with the lowest values of 3.12 mm and 1.39 mm for the rotational speed 165 rpm and 130 rpm, respectively.

Stability index, instability index, means weight diameter of soil aggregates<100 mm and percentage of aggregates >2 mm were found to be significantly affected by the rotational speed of blade. The lowest value of stability index was 0.52 for the rotational speed of 130 rpm. Also the lowest values of instability index, mean weight diameter of soil aggregates<100 mm and percentage of aggregates >2 mm were 1.40, 20.72 mm, and 56.36% for the rotational speed of 165 rpm, respectively.

The draft force for tillage by the disc plough without rotary blade was 4.24 kN. The force needed to till with Comboplow working with three straight blades, three curved blades, three L-shaped blades and nine straight blades were 3.40 kN, 3.39 kN, 3.75 kN and 3.70 kN, respectively. The disc plough combined with rotary blades operated well at the field speeds of 6-7.2 km/h. In the field tests, the average values of the effective filed capacity (EFC) and field efficiency (FE) of the machine were found to be 1.09 ha/8h day and 75.06% , respectively.



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

**REKABENTUK, PEMBANGUNAN, DAN PRESTASI GABUNGAN BAJAK
BIRING BESERTA BILAH PUTAR**

Oleh

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Penyelidikan ini menumpukan kepada pembangunan mesin bajak baru bertujuan menghancurkan tanah dalam satu laluan. Bajak Piring yang digabung dengan bilah putar (Bajak Kombo) untuk penyediaan tanah telah direka, dibina dan diuji di Taman Penyelidikan Universiti Putra Malaysia (UPM). Mesin terdiri daripada casis, sambungan tiga sangkut, sistem penghantaran (sambungan universal dengan cekam keselamatan, kotak gear, aci masuk, aci keluar, rantai, gegancu, aci utama dan pemegang bilah), piring, roda belakang, bilah berputar dan mekanisme pelarasan.

Bajak Kombo ini terdiri daripada Bajak Piring dan beberapa bilah putar. Bajak Piring memotong sebahagian atau membalikkan sepenuhnya lapisan tanah untuk menutup bahan di permukaan. Tanah yang bersentuhan dengan permukaan Bajak Piring akan dipotong dan digembur oleh bilah putar. Kerja pembajakan yang berulang-ulang dapat dikurangkan dengan satu laluan dan mengurangkan jumlah perjalanan berbanding amalan biasa serta dapat mengurangkan kemampuan tanah, tenaga, kos bahanapi dan masa kerja. Bilah putar boleh diselaraskan kelajuan dan kedalaman dengan menukar gegancu dan nat. Bajak Kombo ini telah diuji pada tanah liat loam

berpasir siri Serdang untuk menentukan penggunaan tenaga serta perbezaan pada parameter tanah. Ujian telah dilakukan berlandaskan 2x3 berfaktor dalam reka bentuk ujikaji RCBD dengan tiga ulangan. Ukuran blok adalah 25m x 27m. Parameter ujikaji adalah tiga jenis bilah (jenis lurus, jenis bengkok dan bentuk-L) dan tiga kelajuan putaran (130 psm, 147 psm dan 165 psm). Data yang diambil adalah penggunaan tenaga, ketumpatan pukal, kandungan kelembapan, garispusat berat min asas kering dan asas basah, (MWD_d, MWD_w), Indeks Kestabilan (SI), Indeks Ketidakstabilan (II), 2<Taburan saiz agregat <8mm (ASD_{d8}) dan 0<Taburan Saiz Agregat <100mm (MWD_{d100}). Analisis sisihan dan ujian kepelbagaian Duncan telah digunakan untuk menganalisis data. Keputusan menunjukkan tiada perbezaan bererti antara jenis bilah. Walau bagaimanapun kelajuan putaran mempunyai kesan bererti ke atas parameter yang diambil.

Kelajuan putaran bilah mempunyai kesan bererti ke atas peratus ketumpatan pukal tanah dengan jumlah peratus terendah 15.63% pada kelajuan 130 psm. Garispusat berat min asas kering dan basah (MWD_d dan MWD_w) dipengaruhi oleh kelajuan putaran bilah dengan nilai terendah 3.12 mm pada kelajuan putaran 165 psm dan 1.39 mm pada kelajuan putaran 130 psm . Keputusan garispusat berat min asas kering (MWD_d) menunjukkan perbezaan bererti antara jenis bilah. Garispusat berat min (MWD_d) tertinggi diperolehi dari bilah berbentuk L Indeks kestabilan, indeks ketidakstabilan, Taburan Saiz Agregat <100mm dan peratus agregat >2 mm dipengaruhi dengan berkesan oleh kelajuan putaran bilah. Nilai indeks kestabilan terendah adalah 0.52 bagi kelajuan putaran 130 psm. Nilai indeks ketidakstabilan, taburan saiz agregat < 100 mm dan peratus agregat >2 mm adalah masing-masing 1.40, 20.72 mm dan 56.36% pada kelajuan 165 psm.

Daya tarikan Bajak Piring tanpa bilah putar adalah 4.24 kN manakala daya untuk membajak tanah menggunakan Bajak Kombo dengan tiga bilah putar jenis lurus, tiga bilah putar jenis bengkok, tiga bilah putar bentuk L dan sembilan bilah putar jenis lurus adalah masing-masing 3.40 kN, 3.39 kN, 3.75 kN dan 3.70 kN. Bajak Piring yang digabungkan dengan bilah putar beroperasi dengan baik pada kelajuan 6-7.2km/jam. Dalam ujian ladang nilai purata keupayaan ladang berkesan (EFC) dan kecekapan ladang (FE) adalah masing-masing 1.09 ha/8 jam-hari dan 75.06% untuk satu barisan Bajak Kombo dengan kelebaran baris 30 cm (satu bilah putar).

ACKNOWLEDGEMENTS

In the name of God, The most beneficent, the most merciful, all praises be to HIM for providing strength and inspiration to reach this stage in my life. I would like to express the maximum and earnest appreciation to Professor Ir. Dr. Desa Bin. Ahmad, the chairman of my supervisor committee for his invaluable encouragement, generous assistance, guidance and support throughout the period of my study. I am also obliged and grateful to Professor Dr. Shamsuddin B. Sulaiman and Dr. Jamarei Othman, members of my supervisory committee for their enormous assistance. I really appreciate them for serving on my supervisory committee.

I would like to thank all the staff of the Department of Biological and Agricultural Engineering, Faculty of Engineering, Universiti Putra Malaysia (UPM) especially Zainal Abidin Bin Abd Ghani, Mr Hairul Anuar b. Abd Mubin, Mr Shoib, the technician of soil and water laboratory; Mr. Tajul Urus b. Osman, the tractor operator; Mr Abdul-Aziz, the technician of soil management laboratory whose valuable assistance have contributed in the successful completion of this study. I want to give utmost appreciation to all my friends especially Mohammad Reza Bakhtiari, Mohammed S. Abubakar, Fatai B. Akande and Dauda Solomon Musa.

I would like to also thank the VC chancellor of Persian Gulf University, Professor Dr. H. Tajik for both moral and financial support throughout the study, which without the financial assistance the research would have been a big problem to me and my family.

Lastly, I want to thank my family members; Ashraf (wife), Mohammad, Arman and Mobin (sons) who have been a source of inspiration during my study, supplying an endless amount of love, prayers, support and sacrifices. Thanks also to my late father who passed away during my fifth semester (July 2010) of my study. Big thanks to my mother, brothers and sisters for their love, prayers and encouragement throughout my life.



APPROVAL

I certify that a Thesis Examination Committee has met on (17 May 2012) to conduct the final examination of Ali Hashemi on his thesis entitled “Design, development and performance of a disc plough combined with rotary blades” in accordance with the 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 student be awarded the Doctor of Philosophy.

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

ALI HASHEMI

Date: 17. May. 2012



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