UNIVERSITI PUTRA MALAYSIA

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

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DOCTOR OF PHILOSOPHY
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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

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May 2012

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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<8 mm (ASD_{8}) and 0<Aggregate Size Distribution <100 mm (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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Mei 2012

Pengerusi: Prof Desa Bin Ahmad, PhD. P.Eng.

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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 giar, aci masuk, aci keluar, rantai, gegancu, aci utama dan pemegang bilah), piring, roda belakang, bilah berputar dan mekanisme pelarasan.

berpasir siri Serdang untuk menentukan penggunaan tenaga serta perbezaan pada parameter tanah. Ujian telah dilakukan berlandaskan 2x3 berfaktor dalam reka bentuk uji kaji RCBD dengan tiga ulangan. Ukuran blok adalah 25m x 27m. Parameter uji kaji 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, \( \text{MWD}_d, \text{MWD}_w \), Indeks Kestabilan (SI), Indeks Ketidakstabilan (II), \( 2<\text{Taburan saiz agregat }<8 \text{mm} (\text{ASD}_{d8}) \) dan \( 0<\text{Taburan Saiz Agregat }<100 \text{mm} (\text{MWD}_{d100}) \). 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 (\( \text{MWD}_d \) dan \( \text{MWD}_w \)) 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 (\( \text{MWD}_d \)) menunjukkan perbezaan bererti antara jenis bilah. Garispusat berat min (\( \text{MWD}_d \)) 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 6-7.2 km/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).
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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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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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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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