UNIVERSITI PUTRA MALAYSIA

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Thesis Submitted to the School Of Graduate Studies, Universiti PutraMalaysia, inFulfilment of the Requirements for the Degree of Doctor of Philosophy

September 2013

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DEDICATION

This thesis is dedicated to my dearest Family

My late father (God bless him)

My Mother for her extraordinary love

My Brother, Azad for his patience and endless care

My Aunt, Sisters and Wife for their support, encouragement and prayers

My Children, Zainab, Chra, Hana and Hayder

Thank You

Abstract of the 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 ROTARY SLASHER (PULVERIZER) BLADES FOR SWEET POTATO HARVESTING MACHINE

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September2013

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

Faculty: Engineering

Mechanized harvesting operations of sweet potato until now, are done in two steps at different times, at least 1 to 5 days between the two operations, or harvested manually. The presence of foliage or insufficient soil preparation can make this kind of harvesting more difficult and cause high percentage of damage more than 50%. Furthermore, the high costs of labour, harvesting time and high fuel consumption by using the conventional method were the reasons to find a new technique to harvest the sweet potato. The study focuses on the design and development of a rotary slasher (pulverizer) blade for a sweet potato harvesting machine. The newly designed machine for cutting and fragmentation of stems and leaves (vegetative portion) for the crop to facilitate the process of harvesting and extraction of tubers was fabricated in combination with the digger-harvester, to pulverize and harvest tubers in a single pass.

A model slasher was first designed and fabricated at the Workshop Technology Laboratory, Department of Biological and Agricultural Engineering, Faculty of

Engineering, Universiti Putra Malaysia, Serdang, Selangor, Malaysia. It consists of a rotary shaft, main support frame, ball bearings, blades, cover plate and its components. The main frame supports the shaft and carriage rails in position. The overall dimension of the slasher was 30 cm long, 26 cm wide and 26 cm high. The shaft is driven by a sprocket roller chain transmission powered by an electric motor type A4234M having 1 kW power, maximum speed of 3000 rpm, 220 to 240 Voltage, 50 Hz frequency, and 5.4A current. The parameters that have major influence on the design of the prototype sweet potato harvesting machine include three types of blade (smooth, serrated edge blade with 0° inclination angle and serrated edge blade with 45° inclination angle), different cutting speeds (1830, 2066, 2385, 2440 and 2533 rpm, respectively), five blade cutting angles of 20°, 30°, 40°, 50° and 60° and two different feeding angles (45^0 and 90°). Mild steel with material density of 7850 kg/m^3 was used to fabricate the blade which was designed using Solidworks 2009 software. Length and width of blade were 140 and 160 mm respectively while the total weight of blade was 0.535 kg.The percentage of sweet potato vine pulverized that passed through thesieve (< 28mm) and the power consumption in Watts of the designed slasher was evaluated.

The laboratory results indicated that the best performance was obtained from the 0° serrated edge blade type and 30° blade cutting angle. Also, the best value of the cutting and power consumption was recorded with 45° and 90° feeding angles, respectively. In addition, the best performance for interaction effects between shape of the blade and the cutting speed was at 2440 rpm cutting speed with Y-shaped blade giving the highest percentage of 92.62% of pulverized sweet potato vine passing through the sieve (< 28mm). However, the L-shaped blade gave the lowest power consumption of 47.23 Watt at 1830 rpm.

The field experimental results on the influence of different cutting speeds on percentage of sweet potato vine pulverization for different varieties of sweet potato vine having different moisture contents indicated that all the treatments were significant at $p < 0.01$ significance level for percentage of sweet potato vine pulverized passing through the sieve (< 28mm) and the fuel consumption. On interaction effects between the moisture content of plant, sweet potato varieties and the mower cutting speeds, the Stone variety gave the highest percentage of sweet potato vine pulverized with 89.16% passing through the sieve (< 28mm) and fuel consumption of 1.49 ml/m when tested at 22.4% moisture content and a mower speed of 2300 rpm.

Analysis of variance (ANOVA) and L.S.D tests were used to analyse the data using the statistical analysis systems (SAS 9.2) 2010 software.

The major impact of this research is that farmers can benefit from the advantage of combining two operations into one (the rotary slasher with the sweet potato digging machine) which would greatly reduce the labour cost incurred in sweet potato production and maximize their profit.

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

REKABENTUK DAN PEMBANGUNAN BILAH PENEBAS (PENGHANCUR) PUTAR BERSEPADU UNTUK JENTUAI UBI KELEDEK.

Oleh

AMER NAJAT NAJMALDEEN KAKAHY

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Operasi penuaian ubi keledek secara mekanikal sehingga kini dilaksanakan dalam dua operasi pada waktu berbeza antara 1 hingga 5 hari antara keduanya atau secara manual.Penggunaan jentera sepenuhnya tidak sesuai bagi keadaan di Malaysia disebabkan oleh kehadiran tumbuh-tumbuhan atau penyediaan tanah yang tidak mencukupi.Ini boleh menyebabkan kerosakan yang boleh melebihi tahap 50%.Kos buruh, tempoh penuaian dan penggunaan bahapi yang tinggi dalam operasi kaedah biasa memberi justifikasi untuk mencari kaedah baru dalam operasi penuaian ubi keledek.Kajian ini menumpukan kepada rekabentuk dan pembangunan bilah penebas (penghancur) putar bersepadu untuk jentuai ubi keledek. Bilah yang direka bentuk mampu memotong dan menghancurkan batang dan daun tanaman bagi memudahkan proses penuaian dan penggalian ubi keledek dan sesuai digabungkan dengan jentuai bagi operasi satu laluan.

Sebuah pencantas berskala kecil telah direka bentuk dan dibina di Makmal Bengkel Teknologi, Jabatan kejuruteraan Biologi dan Pertanian, Fakulti Kejuruteraan, Universiti Putra Malaysia, Serdang, Selangor, Malaysia. Ia mengandungi sebuah aci putar, kerangka bantuan utama, pegas jara, bilah, plat penutup dan komponen. Kerangka utama membantu aci dan landasan pergerakan.Ukuran pencantas adalah 30 cm panjang, 26 cm lebar dan 26 cm tinggi. Aci diputar oleh rantai roller sprocket yang menerima penghantaran kuasa dari sebuah motor elektrik jenis A4234M berkuasakuda 1 kW, kelajuan maksimum 3000 psm, 220 hingga 240 Voltan, 50 Hz frekuensi dan arus 5.4 A.Kajian menumpukan pada parameter yang mempunyai kesan pada rekabentuk prototaip jentuai ubi keledek.Ini termasuk tiga jenis bilah (licin, bilah bergerigi pada sudut 0 darjah dan bilah bergerigi pada sudut 45 darjah), kelajuan pemotongan (1830, 2066, 2385, 2440 dan 2533 psm), lima sudut pemotongan bilah terdiri daripada 20, 30, 40, 50 dan 60 darjah serta dua sudut suapan (45 dan 90 darjah).Besi keluli dengan ketumpatan pukal bahan setinggi 7850 kg/m^3 telah digunakan untuk menghasilkan bilah berdasarkan hasil model perisian Soloidworks 2009.Panjang dan lebar bilah adalah masing-masing 140 dan 160 mm manakala jumlah berat bilah adalah 0.535 kg.Peratus daun dan batang tanaman ubi keledek yang dihancurkan dan melepasi jaring <28mmserta penggunaan tenaga dalam kiraan Watts bagi prototaip tersebut telah dinilai.

Keputusan ujian makmal tersebut menunjukkan bahawa prestasi terbaik dicapai oleh bilah bergerigi sudut sifar dengan sudut pemotongan pada 30 darjah.Sudut suapan terbaik bagi pemotongan adalah 45 darjah manakala penggunaan kuasa terbaik adalah pada sudut suapan 90 darjah.Prestasi kesan salingtindak terbaik antara bentuk bilah dan kelajuan adalah bagi bilah bentuk Y yang memberikan 92.62% penghancuran tanaman

melepasi jaring <28mm pada kelajuan 2440 psm.Walau bagaimanapun bilah berbentuk L menghasilkan penggunaan kuasa terendah sebanyak 47.23 Watt pada kelajuan 1830 psm.Keputusan ujian ladang mengenai kesan kelajuan keatas peratus penghancuran tanaman ubi keledek berlainan jenis dan kelembapan menunjukkan kesemua faktor memberikan kesan bererti pada tahap signifikan $p < 0.01$ bagi penggunaan bahanapi dan peratus penghancuran tanaman melepasi jejaring < 28 mm.Kesan interaksi antara kelembapan tanaman, jenis ubi keledek dan kelajuan pemotongan menunjukkan ubi keledek jenis Batu menghasilkan 89.16% penghancuran dedaun tanaman yang melepasi jejaring < 28 mm dan 1.49 ml/m apabila diuji pada kelembapan 22.4% dan kelajuan pemotongan pada 2300 psm.Analisis varian (ANOVA) dan ujian LSD telah digunakan untuk menganalisis data menerusi perisian sistem analisis statistik SAS 9.2, 2010.

Faedah terbesar penyelidikan ini adalah pengurangan tenaga dengan menggabungkan dua operasi dalam satu laluan (Gabungan pencincang putar beserta bilah bergerigi yang dihasilkan dengan mesin penggali ubi keledek) yang akhirnya dapat menjimatkan kos operasi dan meningkatkan keuntungan.

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APPROVAL

I certify that a Thesis Examination Committee has met on (20/9/2013) to conduct the final examination of Amer Najat Najmaldeen Kakahy on his thesis entitled "Design and Development of Rotary Slasher (Pulverizer) Bladesfor Sweet Potato Harvesting Machine" 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.

AMER KAKAHY

Date: 20 September 2013

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