UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF A SELF-PROPELLED COMPOST TURNING MACHINE FOR COMPOSTING OIL PALM EMPTY FRUIT BUNCHES

MOHAMAD FIRDZA BIN MOHAMAD SHUKERY

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By

MOHAMAD FIRDZA BIN MOHAMAD SHUKERY

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

November 2011

Dedicated
To
My

Late Father, Mother
Wife,
and Family.

Abstract of thesis presented to the Senate of University Putra Malaysia in fulfillment of the requirements for the degree of Master of Science.

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Chairman : Assoc. Prof. Ir. Azmi Haji Yahya, PhD

Faculty : Engineering

As a better way of utilizing agricultural waste and reducing fertilizer cost, the rich nutrient of empty fruit bunches (EFB) could be used in the production of compost and returned back to the soil as bio-organic fertilizer. However, the present turning machines that been employed in the production of EFB compost are unsuitable to employ due to the characteristic of EFB. The EFB are fibrous with high lignin and bulky in size giving higher tendency for the material to entangle and finally stalled the rotational rotor of turning machine. In addition, these turning machines are huge in physical size and engine capacity, high operation cost, and generally designed to work on animal and general agriculture wastes with have different properties from EFB. With current high fertilizer cost, abundant amply of EFB, utmost benefits of using organic fertilizers, and the unavailable of proper turning machine for EFB, it thus necessary for the oil palm plantation industry in Malaysia to be provided with a proper compost turning machine to produce compost from the EFB. A self-propelled turning machine for windrow composting of empty fruit bunches (EFB) had been designed,

developed and tested. Conceptual design of the machine has been drawn in 2-D and 3-D drawing. Estimation of engine power requirement of the developed turning machine and computations of total hydraulic pressure to operate all actuators within the hydraulic system are also determined. A 60 kW diesel engine was used as the power source to generate hydraulic driven tires, hydraulic driven rotor and blade assembly and power steering system. The overall size of the machine was 1700 mm in length, 3600 mm in width and 3000 mm in height. Total weight of the developed turning machine was 3.83 tonne. The developed compost turning machine was designed to work with maximum windrow size of 2500 mm in width and 1500 mm in height. The rotor size was 2500 mm in length and 275 mm in diameter excluded the blade. The rotor contains a total of 30 blades that make-up of 25 straight blades at the center portion and 5 inclined tip blades placed at end portion of the rotor. All these blades were at 90º upright position and evenly placed in a spiral order at 70º direction towards to the centre of rotor so that the windrow will be rebuilt during the turning operation. The developed compost turning machine designed to overcome most of turners faced at the side which were flexibility in movement and transportation. The steering system of the machine has been design with capability to turn the wheels in 90°. This rare mechanism in the turner enables the machine to move sideway especially in the limited space.

Data from field evaluation shows that the developed self-propelled compost turning machine was able to demonstrate functions as windrow turner under an actual composting production of EFB. The mean actual velocity of turning machine during the test was 7.78 cm/s with mean wheel slippage of 36. 87 %. The mean mass

throughput capacity of the turning machine was 84.83 tonne/hr and total mass production of composting plot was 47.29 tonne/hr. The mean C/N ratio of EFB reduced from 66.30 to 29.34 or about 55.57% at the week-12 of composting period. The developed self-propelled compost turning machine showed high potential to be used in windrow composting for empty fruit bunch (EFB) as another step forward to empowering oil palm industry in Malaysia.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi syarat ijazah Master Sains.

PEMBANGUNAN SEBUAH MESIN PEMBALIK KOMPOS BERGERAK SENDIRI UNTUK MENGEMPOS TANDAN KOSONG KELAPA SAWIT

Oleh

MOHAMAD FIRDZA BIN MOHAMAD SHUKERY

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Pengerusi : Prof. Madya Ir. Azmi Haji Yahya, PhD

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Untuk cara yang lebih baik menguruskan bahan buangan pertanian dan mengurangkan kos baja, bahan yang kaya nutrien iaitu tandan kosong segar (TKS) boleh digunakan dalam penghasilan kompos dan dikembalikan kepada tanah sebagai baja bio-organik. Walaubagaimanapun, mesin pembalik sedia ada yang digunakan di dalam penghasilan kompos TKS tidak sesuai digunakan di sebabkan oleh ciri-ciri TKS. TKS berfiber dengan kandungan lignin yang tinggi dan besaiz besar akan memberi kebarangkalian yang tinggi untuk melekat dan akhirnya memberhentikan putaran rotor mesin pembalik. Ditambah pula, kebanyakan mesin pembalik ini sangat besar dari segi fizikal dan kapasiti engine, kos operasi yang tinggi, dan secara umumnya direka untuk bekerja dengan bahan buangan haiwan dan pertanian yang mempunyai keadaan yang berbeza dengan TKS. Dengan kos semasa baja yang tinggi, TKS sedia ada yang terbiar, kelebihan penggunaan baja organik, dan ketiadaan mesin pembalik yang sesuai untuk TKS, jadi adalah menjadi keperluan untuk industri ladang kelapa sawit di Malaysia untuk dibekalkan dengan sebuah mesin pembalik kompos yang sesuai untuk

penghasilan kompos daripada TKS. Sebuah mesin pembalik bergerak sendiri untuk mengkompos secara longgokan bagi TKS telah direka, dibagunkan, dan diuji. Rekabentuk konsep mesin tersebut telah dilukis dalam bentuk lukisan 2-D dan 3-D. Anggaran keperluan kuasa enjin dan pengiraaan actuators hidraulik untuk operasi semua actuators di dalam sistem hidraulik juga ditentukan. Sebuah enjin diesel 60 kW digunakan sebagai punca kuasa untuk menghasilkan pacuan hidraulik roda, pacuan hyadraulik rotor dan bilah, dan sistem pengemudi berkuasa. Saiz keseluruhan mesin adalah 1700 mm panjang, 3600 mm lebar dan 3000 mm tinggi. Jumlah berat mesin pembalik yang dibangunkan adalah 3.83 tan. Mesin pembalik yang telah dibangunkan direka untuk bekerja dengan maksimum saiz longgokkan 2500 mm lebar dan 1500 mm tinggi. Saiz rotor adalah 2500 mm panjang dan 275 mm diameter tidak termasuk bilah. Rotor mempunyai sebanyak 30 bilah yang terdiri daripada 25 bilah lurus di tengah dan 5 bilah hujung bengkok di hunjung bahagian rotor. Semua posisi bilah adalah 90º tegak dan disusun secara sama banyak dengan lilitan dengan sudut 70º menghala ke tengah rotor supaya longgokan akan dibina semula semasa operasi putaran. Mesin pembalik yang dibangunkan juga direka untuk mengatasi masalah utama yang dihadapi oleh kebanyakan mesin pembalik di ladang iaitu fleksibiliti di dalam pergerakan dan pengankutan. Sistem pengemudi telah direka dengan kebolehan untuk memutar roda sehingga 90°. Mekanisma yang jarang terdapat di mesin pembalik ini membolehkan mesin ini bergerak secara sisi terutama di kawasan yang sempit.

Data dari ujian ladang menunjukkan mesin pembalik bergerak sendiri yang dibangunkan berjaya menunjukkan fungsi sebagai mesin pembalik windrow untuk

mengempos TKS tanpa menghadapi sebarang masalah major. Purata halaju sebenar mesin pembalik semasa ujian adalah 7.78 cm/s dengan purata kegelinciran roda sebanyak 36. 87 %. Purata kapasiti berat kebolehlaluan mesin adalah 84.83 tan/jam dan jumlah berat penghasilan plot kompost adalah 47.29 tan/jam. Purata nisbah C/N bagi TKS berkurang dari 66.30 kepada 29.34 atau sebanyak 55.57 % pada minggu ke-12 masa mengkompos TKS. Mesin pembalik kompos bergerak sendiri yang dibangunkan menunjukkan potensi tinggi untuk digunakan di dalam windrow kompos bagi TDS sebagai langkah permulaan untuk memperkasakan industri kelapa sawit di Malaysia.

ACKNOWLEDGEMENTS

"In the name of Allah, the beneficent, the most merciful"

All praise to Allah SWT the Most Gracious to give me the strength and desire to complete my study.

Deepest appreciation to my beloved wife and family for their unending moral support, great sacrifices, and continuous prayers to my achievement in life and studies. Special thanks are due to all those, whom I could not mention here, and contribute to the completion of this study through their physical, moral or spiritual support.

I wish deepest acknowledgement to my supervisor, Assoc. Prof. Ir. Dr. Azmi Dato' Haji Yahya for his valuable guides, patience, encouragement and strong support throughout this study. My gratitude also extended to my supervisory committee members, Prof. Ir. Dr. Desa Ahmad and Dr. Hadi Suryanto for their advice, comments and contributions during this study.

My special thanks are also extended to the staffs and friends in the Department Biological and Agricultural Engineering, Faculty of Engineering, UPM particularly Mr. Mohd Rosdi Zamri, Mr. Hamed, Mr. Sabri and friends Dr. Darius, Mr. Tajudden, Oh Yun Ju, Mr.Paiman, Mr. Siamak and those have contributed in this research. Thanks are also due to Mr Ah Soon and Mr. Ah Hoon from Sheva Engineering Sdn. Bhd for their assistance in fabricating, repair and modification process. I also acknowledge with great

gratitude to Dr. Lee, Mr. Robert Yiew and Mr. Yanto for granting us the permission to conduct field test in their indoor composting mill.

Acknowledgement is due to Department of Biological and Agricultural Engineering, Faculty of Engineering, University Putra Malaysia and Ministry of Higher Education, Malaysia for granting the financial support for my Masters studies in UPM.

I certify that an Examination Committee met on __/__/__ to conduct the final examination of Mohamad Firdza bin Mohamad Shukery on his Master Degree thesis entitle " Development of A Self-Propelled Compost Turning Machine for Composting Oil Palm Empty Fruit Bunches " in accordance with Universiti Putra Malaysia (Higher Degree) Act 1980 and Universiti Putra Malaysia (Higher Degree) Regulation 1981. The Committee recommends that the candidate be awarded the relevant degree. Member of the Examination Committee are as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisor Committee were follows:

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

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MOHAMAD FIRDZA MOHAMAD SHUKERY

Date: 29 Novermber 2011

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