CAIRO UNIVERSITY **FACULTY OF AGRICULTURE**

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By

TAREK HUSSEIN ALI MOHAMED
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Thesis
Submitted In Partial Fulfillment of
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Supervised by:-

Prof. Dr. Samy Mohamed Younis
(Principle supervisor)

Prof., Agric. Eng. Dept., Faculty of Agriculture, Cairo University

Dr. Mohamed Ibrahim Ghonimy

Assoc. Prof., Agric. Eng. Dept., Faculty of Agriculture, Cairo University

(APPROVAL SHEET)

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THIS THESIS FOR Ph.D. DEGREE
IN
AGRIC. ENGINEERING
HAS BEEN APPROVED BY:

Prof. Dr. Mohamed Saed- El-Deen El-Shal
Prof. and head of Agric. Engineering , Faculty of Agriculture, Zagazig University ……………………

Prof. Dr. Aly Ahmed Mostafa Khattab
Prof. of Mechanical design, Faculty of Engineering, Cairo University ……………………

Dr. Mohamed Ibrahim Ghonimy
Associate Prof. of Agric. Engineering, Faculty of Agriculture, Cairo University ……………………

Prof. Dr. Samy Mohamed Younis
(Principle supervisor)
Prof. of Agric. Engineering, Faculty of Agriculture, Cairo University ……………………

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2006

Name of Candidate: Tarek Hussein Ali Mohamed degree: Ph.D.

Title of thesis : DEVELOPMENT OF A POTATO DIGGER

Supervisors : Prof. Dr. Samy Mohamed Younis
Dr. Mohamed Abrahim Ghonimy

Department : Agricultural Engineering Department
Branch : Farm Mechanization Approval :

ABSTRACT

The aim of this study was to develop a local machine that deals with the root crops, using the theory of vibratory digging blades to decrease the required drawbar pull. This aim was planned to be realized through the following stages:-

1) Study some characteristics of some potato varieties. These characteristics were tuber length, tuber diameter, tuber height, tuber weight, tubers surface are, tubers volume and firmness.

2) Evaluation the performance of the original digger. 3) Modification steps:- A vibratory device was fitted to the digger. The vibratory device was consists of 3 subsystems added to the original digger:-

(1) Beam holder. (2) Vibrating device. (3) Vibrating transmission system.

Technical and economical evaluation of the developed digger.The technical evaluation showed that :-

- The developed digger success to decrease the drawbar pull at forward speeds of 0.9,1.5,1.9 and 3.2 km/h with decreasing percentage of 25.17% ,25.91%,28.43% and 30.47% respectively comparing with the original digger records at amplitude and frequency (A=10 mm & (ω) =1200 rpm).
- The optimum amplitude was 0.6 mm with frequency of 800 rpm that give suitable draw bar pull with low bruising ratio. The drawbar pull was reduced with decreasing percentage of 15.42, 16.93, 19.7 and 12.29 %at forward speeds of 0.9, 1.5, 1.9 and 3.2 km/h respectively comparing with the original digger records.
- The results shows that a mathematical relation ship can be equated with the performance parameters (λ , k and T) and the drawbar pull.
- The developed digger can operate with 110 hp tractors instead of 140 hp tractors or more thus the harvesting costs would decrease.
- The modification success to increase the digger field capacity by 8.3% and decrease the operation costs per feddan by 28.98%.
- The economical evaluation showed that the total cost of the machine with a tractor 110 hp was 74.5 LE/h. the IRR is 72 % and NPV of 4579 LE. The pay back period was 2.1 years.
- The modification success to decrease the bruising from 7.98 to 7.88 by 1.25 % and decrease the un-harvested tuber from 1.76 to 1.69 % by 0.07%. These values can be translated to extra economical losses that could be added on the using of excess high power of the tractors.

ACKNOWLEDGEMENT

The author wishes to express his sincere thanks and appreciation to ***Dr. SAMY MOHAMED YOUNIS***, Professor of Agricultural Engineering, Faculty of Agriculture, Cairo University, for his continuous supervision, advice, encouragement and guidance.

The author wishes to express his deep and sincere thanks to ***Dr. MOHAMED IBRAHIM GHONIMY,*** Associate Professor of Agricultural Engineering, Agricultural Engineering Department, Faculty of Agriculture, Cairo University for his valuable assistant in particular.

The author wishes to express his deepest thanks to the staff members of Agricultural Engineering Department, Faculty of Agriculture, Cairo University especially ***Dr. AHMED EL-RAIE and Dr .MOHAMED OMRAN.***

Also, the author wishes to express his deep and sincere regards to the members of Agricultural Engineering Sector – Ministry of Agriculture for their valuable assistance.

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NOMENACLUTRE

Symbol	Meaning
A	Blade area
A_0	Harvested area
A_1	Tuber projected area in x axes
A_2	Tuber projected area in y axes
A_3	Tuber projected area in z axes
A_c	Cutting area
a	Dimension of the tuber in x axes
a_{max}	Max. dimension of horizontal axes of the tuber
a_1, a_2, a_3	The dimensions of the tubers
AC	Area of the minimum circle can surround the shape.
AP	Projection area.
b	Blade width
b	Dimension of the tuber in y axes, m;
b_1, b_2, b_3	Constants for volume equation
b_{beam}	Beam width
b_{max}	Max. dimension of vertical axes of the tuber
b_si	Width over which a cluster of tubers lies;
C	Oil price
C_b	Bearing load rating capacity
c	Dimension of the tuber in z axes, m.
DC	Radius of the minimum circle can surround the projection of the shape.
DE	Radius of a circle its area equal of the projection of the shape.
D_{beam}	Outer diameter
d_{beam}	Inner diameter
d_{shaft}	Shaft diameter
d_s	Diameter of the shaft
E	Modules of Elasticity for steel blades
$e_{max.}$	Max. distance between cam center and max. stroke point.
e_c	Eccentricity
F	Applied force

Symbol	Meaning
F_f	Force due to friction between the root and the cutting edge.
F_s	Shearing force for the key
FC_d	Digger performance rate
F_r	Redial load acting on the bearing
F_a	Axial load acting on the bearing
F_c	Digging force
F_C	The maximum reading of the dynamometer at digging angle of 40^o
$F.S$	Factor of safety
$F_{follower}$	The max. load on the arm
f	Coefficient of sliding friction between the root and the cutting edge of the share.
f_p	Potato tubers firmness for Spunta variety
fc	Fuel price
G_1	Normal components of the inertia force
h	Tubers height
h_w	Weld size
h_k	Height of the key
h_s	Depth of under-cutting
h_e	Depth at which a cluster of tubers lies at the extreme ends of the share
I	Bending Moment of inertia
IRR	Internal rate of return
i	Interest rate
J_1	Normal components of the inertia force
K_b	Combined shock and (0) fatigue factor applied to bending moment
K_t	Combined shock and fatigue factor applied to torsional moment
k_{pt_1}, k_{pt_2}, k_{pt_3}	Tubers stiffness in x, y, z axes respectively
k_b	Blade stiffness
k_{pt}	Tubers stiffness

Symbol	Meaning
k_s	Soil stiffness
k	Ratio between the acceleration of the vibrating blade to the gravitational acceleration
L	Blade length from the blade edge to the supporting point
L_c	Labor cost
L_r	Beam length
L_k	Length of the key
M_b	bending moment applied on the blade
$M_{b\max.}$	The max. bending moment on the beam
m_b	Blade weight
m_{pt}	Average tuber weight
m_s	Soil weight
M_t	Torsional moment
M_b	Bending moment
N	Number of labors
N_{fb}	Blade natural frequency
N_s	Soil natural frequency
n_{beam}	The beam, rpm
n	yearly working hours
N_{pt}	Tubers natural frequency
n_{t1}	Number of teeth of the drive
NPV	Net present value
Oc	Oil consumption
P	Blade force per unit length
P_b	Bearing equivalent dynamic load
P_c	Purchase price
Pt	Tractor power
PBP	Pay back period
Q	Force acts in the direction of motion of the soil layer
r_1	Tuber max. radius
r_2	Tuber the base radius

Symbol	Meaning
r	Crank radius
r_c	Coefficient of repair and maintenance
S	Surface area
Sv	Salvage value
S_y	Yield strength
S_{Sallow}	Allowable shear strength of the key material
T	Over all parameter for drawbar pull
Tc	Total cost
T_m	Max. torque on follower
T_t	Transmitted torque for the key
T_{beam}	Beam thickness
t	Blade thickness
t_c	Total consumed time
U	Unit draft of soil
V	Predicted volume of the tuber
V_m	forward speed of the machine
V_0	speed of oscillations
v_1	speed of the drive (for sprockets and idlers)
v_2	The speed of the driven(for sprockets and idlers)
$v_{ho,}$	The initiation of cutting corresponds to that instant when the horizontal component of the oscillatory motion of the share
w	Blade width
w_k	Width of the key
Y	Anticipated length of time owned
δ_S	force of the ridge axis relative to that of the share
σ_s	Shear stress
σ_b	Blade bending stress
σ_{allow}	Allowable stress of the blade
δ_b	Maximum deflection of the reciprocating ruler
σ_c	Compression stress

Symbol	Meaning
σ_{cr}	Crushing stress
φ_r	Angle of repose of the soil.
φ	Angle of sliding friction between the root and the cutting edge of the share
ω	Angular velocity of the crank
α	Digging angle
α_c	The digging angle
α_s	Angle subtended by the share with respect to the horizontal.
ε	Angle which acts at with respect to the horizontal
λ_c	Ratio between the crank radius to the oscillating radius
τ_k	Direct shearing stress for the key
τ	Shear stress induced in the welded joint
$\sum l$	Total length of the welded joint of the arm end .
λ	Ratio between vibrating and forward speed
ρ	Ratio between the max. acceleration of the vibrating blade and the forward speed