COMPUTER AIDED DESIGN AND ANALYSIS OF ROTAVATOR BLADE

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ABSTRACT

The rotavator or rotary tiller is a tillage tool primarily comprising blades mounted on flanges, which are attached to a shaft that is driven by the tractor power-take-off (PTO) shaft through gears or chain drive. Nowadays, utilization of rotary tillers has been increased in agricultural applications because of simple structure and high efficiency for this type of tillage implements. By taking advantage of rotary tillers, the primary and secondary tillage applications could be conjugated in one stage.

Keywords: Rotary Tiller, Rotavator Blade, Finite Element Method.

I.INTRODUCTION

Tillage is done mainly to loosen the upper layer of soil to create seedbed, to mix the soil with fertilizer and to remove weeds. As a result of this processing the water-air, thermal and nutrient regimes of the soil are improved in the interest of the growth and development of crops.

Rotary tilling is a widely used tillage operation in farming because of its superior ability to mix, flatten and pulverize soil. Rotary Tiller or rotavator is a highly effective machine for intensive tillage. It is one of the most efficient tillage systems when looking for solutions to specific soil tillage problems. No matter the soil type, soil conditions or the amount of residue, Rotavating will always produce the best result. The Rotavator can be easily adjusted for various working depths and soil finishes. The rotating blades chop and mix the residues evenly throughout the working depth, outperforming any other implement [1]. It offers an advantage of rapid seedbed preparation and reduced draft compared to conventional tillage. It saved 30-35% of time and 20-25 % in the cost of operation as compared to tillage by cultivator. It gave higher quality of work (25-30%) than tillage by cultivator [2].

Rotary tillers are classified as active implements. In these machines, power is transferred to the tiller from the tractor via the power-take-off drive. A shaft containing blades is located at 90° to the line of travel and rotates in the same direction as the forward travel of the tractor. Since the shaft turns at a rate that is considerably faster than the corresponding tractor speed, soil pulverization is accomplished. Power to operate the rotary tiller is restricted by available tractor power [4].

1.1 Finite Element Analysis

Finite element method (FEM) or Finite Element Analysis (FEA) is a contemporary research tool. Finite Element Method (FEM) is a mathematical method where in the shape of complex geometric objects and their physical properties are computer constructed. Finite Element Analysis (FEA) is a modern tool for numerical stress analysis, which has the advantage of being applicable to solids of irregular geometry that contain heterogeneous material properties Finite Element (FE) is one of those methods which used for evaluation of a structure under static and dynamic loads before making the main model. This leads to improve the strength of our design. ANSYS is a general purpose software package based on the finite element analysis. This allows full three-dimensional simulation without compromising the geometrical details. Finite element method was used by many researchers in order to design the tillage tools or investigate the interaction between soil and tillage implement. Most investigation used a blade as the object studying the interaction between soil and tool, because its geometric simplicity made the corresponding FEM analysis relatively easier [5].

Basic steps involved in carrying out FEA are [2]:

- Pre-processing.
- Conversion of geometric model into finite element model.
- Assembly/Material Property data representation.
- Defining the boundary conditions.
- Loading Configuration.
- Processing.
- Post-processing.

II. LITERATURE SURVEY

The Rotavator is the most efficient means of transmitting engine power directly to the soil with no wheel slip and a major reduction in transmission power loss. The Rotavator will produce a perfect seedbed in fewer passes. It is the ideal implement for cash crop farmers who need to bury and incorporate crop residues quickly, between crops. Tillage tools direct energy into the soil to cause some desired effect such as cutting, breaking, inversion, or movement of soil. Soil is transferred from an initial condition to a different condition by this process [6]. The rotavator is mounted on three point linkage system of tractor and the power to the tilling unit provided through tractor PTO. The rotating blades of the rotavator give impact on soil surface and throw soil upward because of its rotational speed and pulverize soil by breaking clods. A leveler is provided on the rear of the machine. Rotavator Assembly consists of following parts [2].

Figure1: Rotavator Parts

1. Independent Top Mast: one end of shaft will be connected to tractor P.T.O. and another end to rotavator.

2. Single / Multi Speed Gear Box: A gear box with bevel gears, main shaft, pinion shaft, heavy duty roller bearings combine form a unit to reduce standard P.T.O. rpm 540 rpm to 204 rpm. It enables the rotor shaft to rotate in the direction of travel.

3. Chain / Gear Cover Part Flange: A chain and gear cover part flange is a supporting element on which chain and gears are mounted.

4. Blades: The L shaped will be most common due to L shape is usually superior to others in heavy trash.

5. Chain / Gear Cover Part: A chain and gear cover part is a covering element in which chain and gears are safely protected from outside.

6. Frame and Cover: By adjusting the position of rear cover; the degree of pulverization of soil will be controlled.

7. Adjustable depth skids: It is fixed on adjustable frame to fix up a distance a gap between soil and Blade contact i.e. depth skid.

8 .Offset adjustable frame: There is fixed rigid support to side parts mounted on rotary blade mounted shaft.

Rotavators are available in different sizes of width and suitable to tractor HP.

Table1: Selection of the rotavator according to tractor hp [7]

Sr. No	Tractor Power (HP)	Working Width (mm)	Working Depth for Blade (mm)	Weight (kg)
1	25 to 35	836	152	230
2	35 to 40	1042	152	260
3	40 to 47	1248	152	280
4	50 to 60	1455	152	310

The rotavator was field tested in heavy and light soils at Dr. PDKV, Akola (MH) centre of AICRP on FIM. The field performance tractor mounted rotavator is given in Table 2 [7].

III. FACTORS AFFECTING ENERY REQUIREMENTS OF ROTAVATOR

During rotavator tillage operations various factors affect its energy requirements. These factors can be divided into three categories, viz. the soil condition, operational conditions and rotavator configuration. One of the ways for evaluating the performance of such rotavator can be obtained by determining the energy requirements resulting from each group of these factors and their interaction with the tool. In attempts to quantify the energy requirement of tillage tools, a number of models a tillage tool is by determining the tool's total energy requirements.

3.1 Tillage tool parameters

3.1.1 Blade configuration

(a)

(b)

Figure2: (a) C – Shape Blade, (b) L –Shape Blade

Many types and shapes of blades have been developed for rotavators. Currently, some of the commercially available blade configurations include the L shaped the C- shaped, the C-L hybrid, and the hook-shaped or pick type blades, and the hoe type. Because these blades have different soil-tool interaction systems, they affect both the power performance and the quality of work of rotavators. The development of rotavator blades is an ongoing process and new blades, particularly in the Asian subcontinent and Japan, where the rotavator is widely used in the preparation of paddy rice fields, has been reported in the recent past.

3.1.2 Direction of Rotation

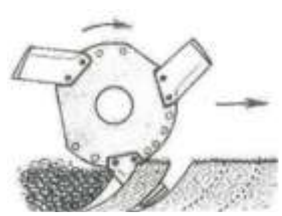

Figure 3: Direction of rotation of rotavator

In case of reverse rotor rotation direction more energy is consumed in tillage because of the higher speed and cutting length. That was concluded based on the observation of soil as a homogenous material. Salokhe and Ramalingam [6] have discovered that, in the case of reverse rotor rotation direction, the cutting principle is completely changed, thus affecting the soil resistance and quality of soil breaking. Salokhe and Ramalingam [6] examined the influence of rotor rotation direction on the PTO power consumption, depending on the working speed. Those investigations were conducted in the field conditions. During the mentioned research, two rotary tillers of different constructions were compared. They had different rotor rotation directions and were equipped with different types and shapes of the blades (C-type and scoop blades). Therefore, that study does not offer precise assessment of the influence of rotor rotation direction on PTO power consumption because of the influence of the blade's shape. During the up-cut process, the tilled soil was scattered out of the seeding furrow and a seedbed was not formed. The up-cut soil process left open furrows instead of a seedbed, and hence was considered inappropriate for strip tillage. In down-cut process soil scattering was minimal and the seedbed was well prepared.

3.1.3 Depth of Tillage

Tillage depth has an important effect on physical properties of the soil layer and power requirements of the tillage tool. Tillage depth is an important parameter in the design of tillage implements. For pull-type tillage implements, the ratios of tillage depth to tillage width, and for rotary tillers, the ratio of rotor diameter to tillage depth are considered in evaluating tillage performance. For practical working conditions, the set tillage depth of rotary tillers is less than the rotor radius. The tillage depth of a pull-type tillage implement that has straight-cutting edges in a single horizontal plane is relatively constant. A combination of deep depth of tillage, with increasing blade rotational velocity, results a rapid increase in specific energy. While the energy demand increased with depth, the specific energy requirements, i.e., energy per unit volume of tilled soil, decreases. Hendrick and Gill, after reviewing a number of past researches, concluded that the optimum rotor diameter-to-depth ratio appeared to be in the range of 1.1 to 1.4 since this is the range in which the minimum specific energy requirement occurs.

3.1.4 The rotavator kinematic parameter, λ

The kinematic parameter, λ is the ratio of the blade peripheral velocity to the forward travel velocity of the tractor. It is perhaps the most important rotavator operational parameter for quantifying this tool's tillage performance because it influences both the energy requirements and the resultant tilth quality of a rotavator. Being a ratio of the blade peripheral velocity to the forward travel velocity, λ can be varied in the following ways: (1) changing the rotor radius, (2) changing the rotor velocity, and (3) changing the machine travel velocity. In practice the rotor radius for a rotavator of given configurations remains unchanged and the manufacturer only provides means of varying the ratio between the tractor PTO and the rotor velocity as a means of changing the λ. This provision is usually by means of suitable gearing mechanism. Depending on the parameter(s) that is being changed to change λ, the accompanying changes in the specific energy or power requirements are significantly different. Kisu et. reported that when λ is changed by holding V_f constant and decreasing the rotational rotor velocity ω, the power required decreases to a minimum value and then increases as the clearance angle approaches zero.

IV. CONCLUSIONS

It is observed from the above literature survey that, Computer Aided Design (CAD) is an effective tool for the design and development of rotavator blade.

After comprehensively reviewing research literature of past studies the following general conclusions are drawn:

- L-shaped blades are better than C or J type blades in trashy conditions as they are more effective in killing and they do not pulverize the soil as much.
- At the forward rotation of the rotary tiller shaft, the tillage power consumption is decreased 10-15 %, in comparison with the shaft reverse rotation.
- With the rotor blades cutting upwards, the tilled soil was scattered out of the seeding furrow and a seedbed was not formed.
- Decreasing λ by increasing forward travel speed, results in an increase in the power requirement, but a reduction in the specific power (provided the geometry of the soil-tool system is not significantly varied).
- Increasing λ results in a greater value of the ratio between cutting area and the volume of the soil slice cut.

REFFERENES

[1] Subrata Kr. Mandal, Basudeb Bhattacharyya, Somenath Mukherjee, Priyabrata Chattopadhyay Design & Development of Rotavator blade: Interrogation of CAD Method, ISSN: 2322-4541; ©2013 IJSRPUB

[2] Gopal U. Shinde And Shyam R. Kajale, Design Optimization in Rotary Tillage Tool System Components by Computer Aided Engineering Analysis, International Journal of Environmental Science and Development, Vol. 3, No. 3, June 2012

[3] Kaveh Mollazade, Hojat Ahmadi, Reza Alimardani, Optimal design of rotary tiller's rotor and width proportionate to Tractor power using energy method, Int J Agric & Biol Eng Vol.2 No.2, June, 2009

[4] Mohammad Shekofteh, Hosein Shekofteh, Mohammad Razahojati, Modeling the Soil Cutting Process in Rotary Tillers Using Finite Element Method, International Journal of Agriculture: Research and Review. Vol., 2 (5), 595-607, 2012 ISSN 2228-7973 ©2012 ECISI Journals

[5] Kaveh Mollazade , Ali Jafari , Ebrahim Ebrahimi ,Application of Dynamical Analysis to a Choose Best Subsoiler's Shape using ANSYS,New York Science Journal, 2010; 3(3)

[6] V.M. Salokhe, N. Ramalingam , Effect of rotation direction of a rotary tiller on draft and power requirements in a Bangkok clay soil , Journal of Terramechanics 39 (2003) 195–205

[7] All India Coordinated Research Project on Farm Implement and Machinery, Central Institute of Agriculture Engineering, Bhopal, Tractor Mounted Rotavator, CIAE/FIM/2002/26

[8] Moses Okoth Marenya, Performance characteristics of a deep tilling rotavator Faculty of Engineering, Built Environment and Information Technology University of Pretoria, Pretoria, September, 2009

[9] Subrata Kr Mandal and Dr. Basudev Bhattacharya Proceeedings of the 1st International and 16th National Conference on Machines and Mechanisms, IIT Roorkee, India, Dec 18-20, 2013