Tillage Characteristics Estimation of Crank-type and Rotary-type Rotavators by Motion Analysis of Tillage Blades

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Abstract

Purpose: This study has been conducted to investigate the applicability of motion analysis of tillage blade for estimation of tillage characteristics of crank-type and rotary-type rotavators. Methods: The interrelation between tillage traces from motion analysis and field test results including rotavating depth, pulverizing ratio and inversion ratio at the same work conditions were analyzed for both crank-type and rotary-type rotavators. The work conditions include working speed of prime mover tractor and PTO speed of rotavators. For the motion analysis, joint conditions of main connecting component were specified considering the actual working mechanism of rotavator. Results: There were important correlations for the trend between motion analysis and field test results. Conclusions: Although further study is needed for applying motion analysis to estimate the accurate tillage related parameters such as rotavating depth, the soil pulverizing ratio and inversion ratio, it could be used to compare the tillage characteristics of various rotavators quickly and simply.

Keywords: Crank-type, Motion analysis, Rotary-type, Rotavator, Tillage blades, Tillage characteristics

Introduction

In Korea, the mechanization rate of farm work is continuously increasing every year. Among these, 99% of tillage operation depends on machine, especially rotavator and tractor which have good tillage and pulverizing performances as well as fast working speed (RDA, 2011).

Most of the rotavators currently supplied to domestic market are rotary-type which using ‘C’ or ‘L’ shaped tillage blades to rotavate the soil in a circular trace. Since the rotavating work is conducted at subsurface soil, tillage blades could be worn out or broken by foreign matter such as gravel (Choi et al., 1993), and they have shallow rotavating depth of 100~200 mm. In contrast, crank-type rotavator has equally spaced several spades as tillage blade that enable deeper tillage of 300~400 mm depth, and it has advantage of less abrasion and more safe against the failure by obstacles because of their shovelling-like operational mechanism (Cellicorea, 2008). Also, crank-type rotavator is suitable for Korean farm working style which is the way of conducting only one time of tillage operation without separating plowing and rotavating work for the saving of work hours and labor (Lee et al., 2000).

In Korea, there have been many studies on work characteristics of rotary-type rotavator (Lee et al., 2000; Lee et al., 2003; Myung and Lee, 2009; Kim et al., 2011), but there are almost no published papers about crank-type rotavator (NIAE, 2004) and also there is little actual applied experience in Korean soil conditions. The understanding of work characteristics of crank-type rotavator should be preceded to develop crank type rotavator that is suitable for Korean soil conditions. Actual field test is reliable method to investigate work characteristics of certain type of rotavator at a fixed operational condition. It needs, however, many times and cost as well as large manpower, so more simple method is needed to verify work characteristics of a
rotavator quickly and easily.

In this study, the comparative analysis between motion analysis of tillage blade and actual field test results at the same work conditions have been conducted to investigate the applicability of motion analysis to estimate tillage characteristics of crank-type and rotary-type rotavators.

**Materials and Methods**

**Test equipments**

Rotary-type and crank-type rotavators with same nominal rotavating width and rated power were selected. 'C' shaped tillage blades which require less power and torque compared to 'L' shaped blades (Beeny & Khoo, 1970; Salokhe et al., 1993) were used for the rotary-type rotavator. Configurations and specifications of each rotavator are shown in Figure 1 and Table 1, respectively.

Prime mover tractor for the operation of each rotavator was T720s model of Tongyang Moolsan, and its specifications are shown in Table 2. Rated working speed of T720s for each tractor gear is shown in Table 3. Commonly used gear conditions by Korean farmers are L1/1 and L2/1 (tractor/PTO) for rotary-type rotavator, and LL3/2 and LL4/2 for crank-type rotavator.

**3D Model and motion analysis**

Commercial softwares were used to construct 3D rotavator model and to analyze tillage characteristics of each rotavator. Pro Engineer (R5.0, PTC, USA) and CATIA (V6, Dassault Systems, France), and RecurDyn (V7R5, Functionbay, Korea) were used for modeling and analysis, respectively. 3D model for each rotavator is shown in Figure 2. Information about component size and material property were reflected to the models. For motion analysis, joint conditions of main connecting component were specified considering