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Development of Overhead Gantry as Complementary Equipment to Indoor Soil Bin Facility

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Abstract: The facility for teaching and research in the nations Universities has been overstretched due to the increase in students enrollment, obsolescence of equipment and unaffordable high cost of imported equipment due to improper funding of education. This has negatively affected teaching and research in engineering generally and agricultural engineering in particular and by extension, sustainable agricultural productivity. An attempt has been made at FUTA to develop indoor soil bin facility that enabled studies in soil-machinery systems and interaction. This study reports the development of an overhead gantry for the indoor soil bin using locally sourced materials. The gantry has enhanced the versatility of the indoor soil bin by saving time and labour (about 33%) required for soil preparation and experimentation. It has also created working space as equipment can be suspended in the air above the soil bin. The features of the overhead gantry are the stand, consisting of four legs; the runway; the rails; rack and pinion; reduction gear box; pulleys; chain hoist; electric motors (two) the trolley and the electrical system control unit.

Key words: Development, description, overhead gantry, soil bin facility, agricultural engineering, Nigeria

INTRODUCTION

Soil dynamics research is sinequanon for the development of tillage implements, the optimization of tillage and the appropriate matching of implements with power sources and the selection of optimum operating conditions in agricultural mechanization for food production. However, the facility for soil dynamics research until recent past were scarce and even non-existent in Nigeria's tertiary institutions due to high cost of equipment and inadequate funding by stakeholders. This has posed serious challenge to researchers in this specialized area of power and machinery of agricultural engineering.

Soil bin investigation of tillage tools is essential for the development and improvement in the performance of tillage implements. Soil bin systems enable tests to be performed under controlled or specific soil conditions (Kepner *et al.*, 1980). In developed countries, soil bins with adequate instrumentation for force measurements have been developed.

Such facilities include those at Silsoe College, Cranfield University, United Kingdom and the National Tillage Machinery Laboratory, NTML at Auburn, Alabama, USA. Ademosun (1990) initiated soil tillage dynamics research in the Department in the late 1980s and since, efforts have been made to upgrade items of equipment and develop others that are necessary for in-depth laboratory studies in soil implement interaction.

The main objective of this study therefore is to describe the development of a soil bin overhead gantry facility for soil tillage dynamics research at the Department of Agricultural Engineering of The Federal University of Technology Akure (FUTA), Nigeria.

Earlier developments of soil tillage dynamics equipments: Soil dynamics research started in the department with the development of soil tillage dynamics equipment consisting of a small wooden-box soil bin, a mini-track laying tractor (with hitch) and a power transmission system and a spring dynamometer for draught measurement. Features of the power transmission system include a 5 kW 3-phase electric motor with driving pulley, an intermediate driven pulley, an intermediate driving pulley and a final driven pulley. Other components of the transmission system include belts, wire rope and shafts. The facility enabled scaled models of tillage tools to be evaluated for performance in terms of draught and soil disturbance. The details of the description and operation of the equipment were found by Ademosun (1990).

In the late 1990s, the need to upgrade the facility became necessary and was accomplished. The length of the bin was increased to 9.0 m and railings were installed

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on the side walls. Other components that were added, include tool carriage and tool carriage sub frames, soil processing trolley, compaction roller and soil leveling board. Details of description of these equipments are described by Manuwa (2002). By this upgrade of facility, soil bin investigations and soil-tool interactions were conducted using tillage tools (tines and blades) (Manuwa and Ademosun, 2004, 2007; Manuwa and Ogunlowo, 2005; Ademosun *et al*., 2006). Other items of equipment that have been developed to make the facility more versatile include a rotary tiller for soil preparation and performance evaluation of rotary tiller blades. Details of description and performance are reported by Adewale (2005).

MATERIALS AND METHODS

The location of the soil bin: The soil bin is suitably located in the soil dynamics laboratory of the Department of Agricultural Engineering of the Federal University of Technology, Akure, Nigeria. The laboratory is adjacent to the machine shop. It was assumed that the proximity would minimize labour requirements and maintenance jobs that could arise in the course of usage of the soil bin facility.

The terrain of the land is plain thus minimizing labour requirement that could arise when the soil in the bin needed to be changed. The dimensions of the laboratory that is length, width and height are 12×9×3.5 m. The laboratory is supplied with 3-phase alternating current. This would enable 3-phase machinery and equipment to be used along with the soil bin as may be required from time to time.

Description of the overhead gantry components: Present development is an overhead gantry for the soil bin to facilitate effective maneuverability of the machines in the preparation of soil for the different tests and experimentation as required. Details of the brief description of parts shown below are reported by Ajisafe (2008).

The standing support: The standing supports eight in number and equispaced were made of galvanized hollow pipe of diameter 101.6 mm. Each support is of length of 2230 mm. Flat rectangular steel plates 200×300 mm were wielded to the ends of the standing supports for the purpose of installation in order to ensure rigidity and stability.

Railings: The steel rails (two in number) run parallel to each other along the whole length of the bin. They were made from mild steel angle section 75×75 mm and supported by vertical hollow pipes steel supports of diameter 101.6 mm. The section width of the horizontal railing was compatible with the designed running wheels of the trolley (40 mm) thus with a clearance of about 10 mm on the other side. The distance between the railings was 900 mm.

Gantry trolley: The gantry trolley was designed for rigidity, stability, maneuverability, flexibility and maintainability. It was designed to run on four wheels. It is basically supported by a rectangular steel main-frame. It has over all dimensions of length, width and height of 800×600×400 mm, respectively. It consists of chain hoist, reduction gearbox, electric motors and pulleys.

Chain hoist (winch): It consists of the chain, sprocket, wheel which is keyed to a shaft. Its design was intended to actuate the block and tackle system (hoisting and pulling down system). It was designed to raise to maximum height of 3 m. The chains operate over a 3-sprocket wheel with a pitch diameter of 6 times the chain wire diameter. The alloy load wheel chain is made with link inside dimension of pitch 3 diameter and width 1.25 diameter.

Rack and pinion: The rack and pinion device enables the trolley system to move horizontally on the railings from left to right or vice versa as may be required in tests and experimentation. The load is thus moved from one point to another by moving the trolley back and forth along the gantry path the manually or with aid of instrumentation control.

Gear reduction motor: This is a single-phase synchronous gear motor whose speed remains constant under varying loads. It is used for actuating the drawn work assembly at constant speed as is the case in this design because its load carrying capacity must exceed the weight of the heaviest lifting and movement. It has a speed ratio 1:40 so that the gear arrangement reduces the speed of the electric motor to manageable level.

RESULTS AND DISCUSSION

The result of this study was the development of the overhead gantry shown in Fig. 1 and 2. Figure 1 shows the overhead gantry and its components: the system trolley, the railings, the electric motors for vertical and horizontal movements and parts of the soil bin facility below the gantry. Figure 2 shows the side view of the

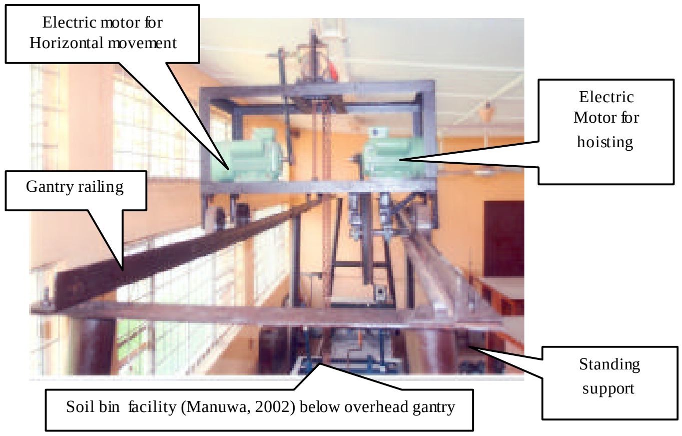

Fig. 1: The overhead gantry showing system trolley, railings and parts of soil bin facility below it

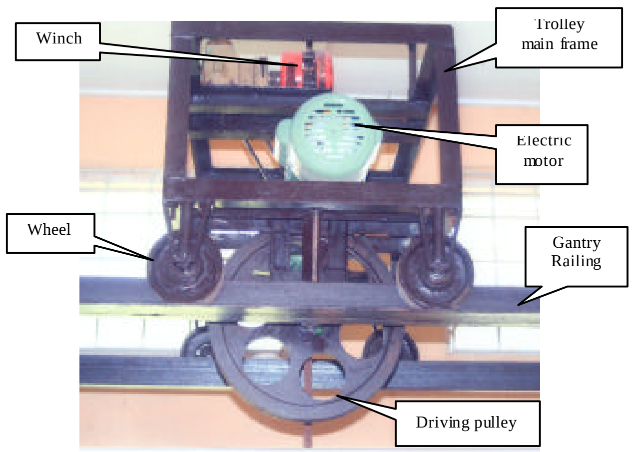

Fig. 2: Side view of the overhead gantry trolley

gantry trolley and its component parts in perspective. The gantry has enhanced soil bin experimentation in terms of labour and time saving.

Components of soil bin facility and gantry: The components of the existing indoor soil bin facility include tool carriage and tool carriage sub frame, compaction roller and rotary tiller. The functions and use of these components are described by Manuwa (2002).

During experimentation, there was the need to raise, hoist and move any of these components in order to have sufficient space for an experimental test run especially when the researchers has very limited assistance. This makes the overhead gantry complementary in its function. Before the development of the gantry, the researcher needed two other hands to enable him prepare soil for an experimental test run which takes between 30-50 min depending on the length of soil to be prepared in the soil bin. With the development of the soil bin, the researcher was able to prepare the same amount of soil with just one additional hand in the same period of time or a little less. The usage of the overhead gantry in the last two years has been very rewarding and has removed a lot of drudgery associated to the usual preparation of soil in the soil bin.

CONCLUSION

A brief description of an overhead gantry is presented in this study. It is still in the developmental stage though it has been used successfully to remove drudgery associated with preparation of soil for soil bin experimentation and has also reduced labour by 33%.

It is capable of hoisting and horizontal movement of components of the soil bin facility already developed for soil dynamics research in the soil dynamics laboratory of the department of Agricultural engineering of the Federal University of Technology, Akure, Nigeria.

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