Int.J.Curr.Microbiol.App.Sci (2019) *8*(4): 2441-2447

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 8 Number 04 (2019)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2019.804.284

Development of Reciprocating Cutter Bar Test Rig for Measurement of Cutting Force of Finger Millets

N. Nisha[1*] and M. Saravanakumar[2]

[1]Agricultural Engineering College and Research Institute, Kumulur, 621 712 Tamil Nadu, India
[2]Department of Farm Machinery & Power Engineering, Agricultural Engineering College and Research Institute, Kumulur, 621 712- Tamil Nadu, India

**Corresponding author*

Keywords

Finger millet, Test rig, Cutting force, Power, Mechanical strength

Article Info

Accepted:
17 March 2019
Available Online:
10 April 2019

A B S T R A C T

It is important to find the cutting force required to cut the crop stalk in designing a harvester for finger millet. The selection of power source and optimization of pertinent machine parameters are very important design considerations. Therefore, a laboratory setup was required to measure the mechanical strength involved and the influence of attributing parameters in cutting the crop. A cutter bar test rig consisting of a main frame, cutter bar assembly, power transmission system, variable speed drive and load measuring set up was developed to measure the force required for cutting the finger millet crop. The load measuring set up comprises of a load cell and a load indicator. The average cutting force required for harvesting finger millet crop was observed as 3.75 kg. The result obtained was validated using a pendulum test rig.

Introduction

Finger millet (*Eleusine coracana*), which is also called as ragi is considered as a staple food in India especially in Karnataka, Andhra Pradesh, Tamil Nadu and in different hilly regions of the country. Among the minor millets, finger millet occupies largest area under cultivation in India. Due to the higher nutritional quality and outstanding properties as a subsistence food crop, finger millets stands unique among certain cereals such as oats, barley and rye. The finger millet straw has immense utility as fodder, containing high percentage of forage protein and is comparatively a good feed for graziery.

The variation in the physical properties of plant stalks and the resistance to cutting are important criteria to be studied to understand the force involved in harvesting operations. Increased interest in mechanization of finger millet harvesting and the usage of finger millet stalk as forage has prompted the need of data on stem properties. Reza *et al.*, (2007) developed an impact shear test apparatus for paddy which consists of a cutting blade attached to the end of a pendulum arm. Sushilendra *et al.*, (2016) developed a pendulum type impact test rig to measure the cutting force of chick pea stalks. Dange *et al.*, (2012) developed a pendulum type dynamic tester to determine the cutting force and energy required for cutting pigeon pea stems. The test rigs developed by earlier researchers could not provide continuous measurement of cutting force for cutting the crop stalk. Also the test rigs developed by earlier researchers are of impact type and they do not possess data logger to record the value of cutting force. Development of a reciprocating cutter bar test rig is of utmost importance for optimizing the parameters affecting the harvesting of crops such as cutting speed, which involves both impact and shear force. Hence a reciprocating type cutter bar test rig was developed to measure the dynamic peak cutting force required for cutting finger millet crop.

Materials and Methods

The cutter bar test rig consisted of main frame, cutter bar assembly, power transmission assembly, load measuring set up and variable speed drive (Fig. 1).

Main frame

The main frame was made of size 1790 × 500 mm using 32 × 32 × 6 mm mild steel 'L' angle. The power transmission system, electric motor (1 hp), crankshaft, connecting rod, cutter bar assembly and digital load measuring set up are mounted on the main frame.

Cutter bar assembly

A standard single knife reciprocating cutter bar used in commercial harvesting machines was identified for the investigation. Cutting knife of width 76.2 mm was used in the test rig for cutting finger millet stalk during force measurement. The single knife cutter bar has lesser weight and requires less power than double knife cutter bar (Triveni Prasad Singh, 2017).

Commercially available cutting knifes of size 76.2 mm was identified. Fourteen number of cutting knifes were riveted on a mild steel flat of size 25 × 6 mm of 1015 mm length to form a cutter bar and the cutter bar of length 1015 mm was mounted on the main frame at 500 mm height from the ground level using an 'L' angle of size 32 × 32 × 6 mm. The cutter bar assembly consists of cutter bar, knife guard and knife clip. An extension was provided on the cutter bar for attaching to one end of connecting rod. The knife guard consists of ledger plate and wearing plate. Eleven number of knife guards were mounted simultaneously at a distance of 76.2 mm on a mild steel 'L' angle of size 32 × 32 × 6 mm and length 1015 mm using bolt and nut. The ledger plates were inserted on the knife guard to facilitate the movement of cutter bar to give scissoring action. Two knife clips were mounted on the main frame using bolts. The front end of the knife clips touches the cutter bar to keep the knife sections very closely on the ledger plates for effective cutting action. Power to the cutter bar assembly was provided from the electric motor.

Power transmission assembly

A one hp three phase induction electric motor was selected as the prime mover to operate the test rig. The power was transmitted from the electric motor to the cutter bar assembly through belt pulley system. The power transmission assembly consists of 4 inch B-type pulley mounted on the center shaft of the electric motor and another 4 inch B-type pulley fitted on the transmission shaft to maintain the speed ratio as 1:1. A transmission shaft of length 350 mm and 25 mm diameter was fitted vertically on one end of the first half of the main frame supported by pillow block bearings to facilitate the rotational movement of the shaft. The rotational movement of the shaft was transmitted to the cutter bar through a crank with an offset (h_c) of 120 mm and the crank radius 38.1 mm (r) fitted on the top of the transmission system with suitable supports (Fig. 2). A connecting rod of length 360.5 mm was fitted between the crank and cutter bar with suitable provision to convert the rotational motion of the shaft to reciprocating motion of the cutter bar.

A variable speed drive was used to vary the speed of the induction motor in turn the cutter bar. The variable speed drive is an electronic device that controls speed, torque and direction of induction motor. The variable speed drive was connected to the three phase induction motor through electric wires. A switch was provided to connect the circuit with the electrical motor. A control panel of alphanumeric type with LCD was used to control the variable speed drive. The control panel could be connected or disconnected from the converter any time based on requirement. The speed of induction motor was controlled by varying the frequency and voltage applied to the induction motor with frequency regulator in the control panel. The selected levels of linear speed of cutter bar were achieved by the frequency regulator.

Digital load measuring set up

Digital load measuring set up comprises of a load cell and a load indicator. Load indicator is a signal conditioner and amplifier used to indicate the load applied on the load cell. The strain gauges are bonded on the load cell and are connected in the form of Wheatstone bridge. Load measuring setup is a complete system which can be used to measure load applied on the load cell. The load indicator is provided with zero balancing facility and digital display enables to take error free reading.

Load cell

A load cell is a transducer that creates electrical signal in proportion to the magnitude of force applied. An S-type load cell was used to measure the cutting force. The S-type load cell consists of an elastic material, which is located on the centre beam of the load cell, which deforms under tensile and compression loads and recovers when the load is removed. This deformation or strain was sensed by strain gauges installed on the elastic material and the deformation is converted into an electrical signal.

The load cell with following specification was mounted on the middle of the connecting rod using screws (Fig. 3). A beam of a sectional thickness 6 mm and length 200 mm was bolted on the connecting rod with loose holes to guide the movement of the load cell during operation without disturbing the accuracy of measurement. S-type load cells was calibrated and checked for its accuracy before actual measurement.

Load indicator

A four digit display load indicator was used for the purpose of indicating the cutting force. The digital load indicator comprised of three parts viz., power supply, signal conditioning with amplifying unit and analog to digital converter.

Power supply

The load indicator consists of an inbuilt regulated power supply to provide sufficient power to all the electronic parts. A power supply of +12 to -12 V 500 mA was required to operate the digital integrated circuitry (i.e., signal conditioning and amplifying unit) and +5 to -5 V 250 mA to drive the Analog to Digital converter was required to operate the load indicator without interruption.

Signal conditioning and amplifying unit

The signal conditioner process the output signals of the strain gauge and provides linear DC voltage to the amplifier. The signal conditioner also buffers the input signal given to the differential amplifier. Amplifier amplifies the buffered signal to the required level as analog output.

Analog and digital converter

The output from the amplifier was a linearised analog DC voltage. This analog output was converted into digital output with the help of IC 7107 3.5 digit 200 mV Analog to Digital converter. Analog to digital converter converts the analog output to digital signals as calibrated and displays through seven segmented LED's.

The load indicator has the provision to indicate the peak value and normal value. By selecting the peak and the normal mode of the load indicator the peak load and normal load, respectively, could be measured during the cutting process. A buzzer fitted to the circuit communicates while indicating the peak load. The power supplied to the load indicator was 230 volt alternating current. The load indicator consists of tare system for zero balancing to eliminate measurement errors. The measurements were indicated in kg. The circuit diagram of the digital load measuring setup is illustrated in Figure 4.

Measurement of cutting force

Samples of finger millet stem, which was ready for harvesting, were collected and their physical characters such as diameter, thickness, length etc were recorded. The stem diameter and thickness were measured at 10 and 46 cm height from the ground level. In the cutter bar test rig the stem was fed between the two cutting knifes of the dynamic cutting apparatus. Due to the dynamic actuation of the knife, the stem was sheared into two pieces. The readings were indicated in kilogram in the load indicator.

Results and Discussion

Experiments were carried out for different stem diameters (6, 9 and 12 mm) and at various moisture contents (moisture content of crop at harvesting stage, ten days before harvesting stage and ten days after harvesting stage). It was found that the maximum peak cutting force required to cut a finger millet stalk of 12 mm diameter at 63.75 per cent moisture content was 3.75 kg (36.79 N) (Table 1).

Table.1 Specifications of load cell

S. No	Specifications	Values
1	Capacity	50 kg compression load 50 kg tensile load
2	Normal sensitivity	2 ± 0.25 mV/V
3	Zero signal tolerance	0 ± 2%
4	Input resistance	350 ± 5 ohm
5	Output resistance	350 ± 5 ohm
6	Recommended excitation voltage	10 vdc
7	Maximum excitation voltage	15 vdc
8	Operating temperature range	-20° to 70° c

Fig.1 Cutter bar test rig

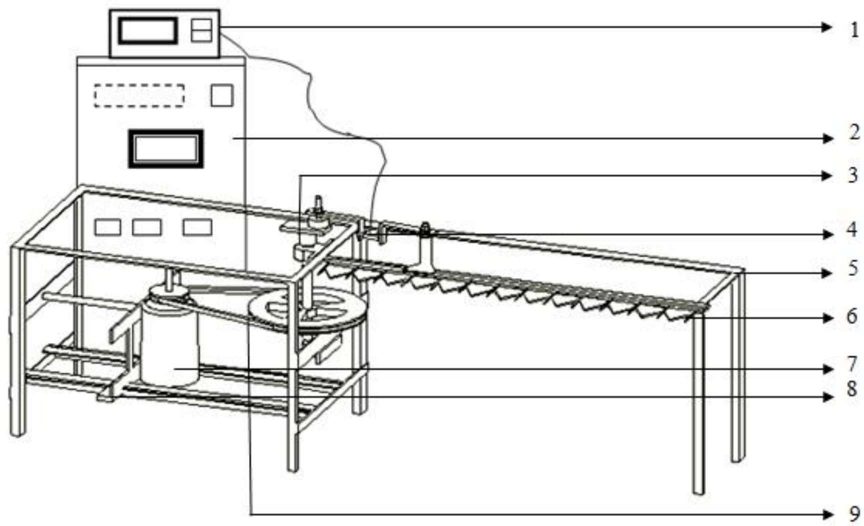


Fig.2 Mechanism to convert rotary motion of shaft to reciprocating motion of the cutter bar

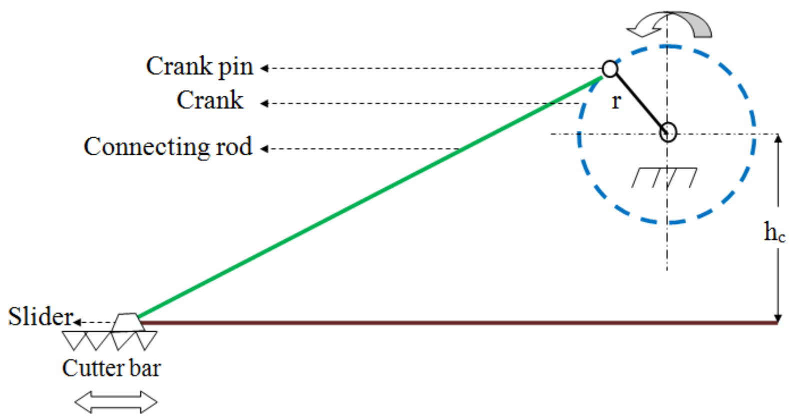


Fig.3 Circuit diagram for load measurement

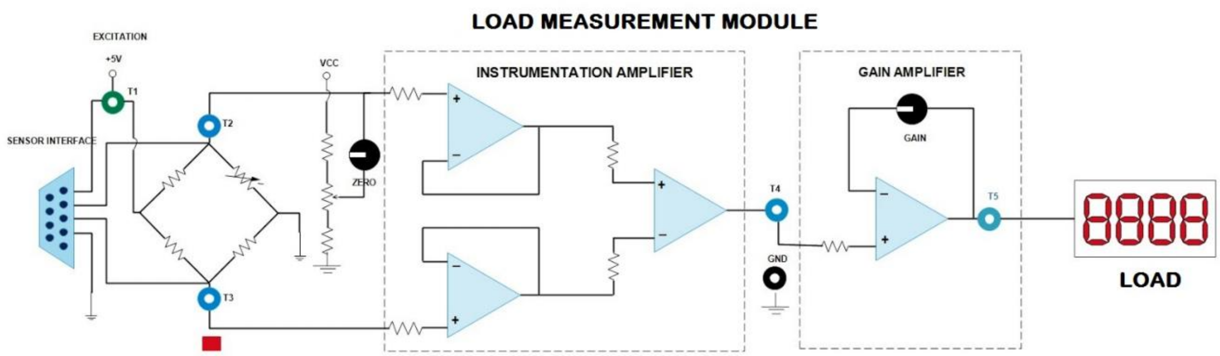
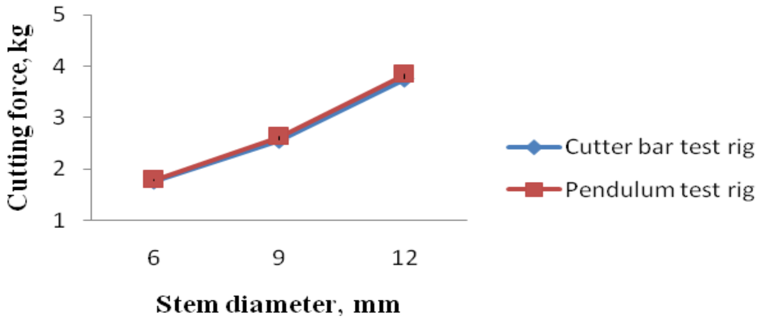


Fig.4 Developed cutter bar test rig

Fig.5 Comparative results of cutting force measured from reciprocating cutter bar test rig and pendulum test rig



The result obtained with the developed reciprocating type cutter bar test rig was compared with the cutting force measured with impact type pendulum test rig and there was no significant difference between the cutting forces measured by both the test rigs. The comparative difference between the results obtained from both test rigs is presented in Figure 5.

In conclusion, the developed test rig measures the dynamic peak cutting force accurately for cutting finger millet stalks. The effect of pertinent parameters affecting harvesting of finger millet by reciprocating cutter bars can be investigated and optimized using reciprocating cutter bar test rig. The cutting force measured using the test rig could be used to carry out power calculations while designing a harvest for finger millet crop.

References

Dange, A.R., Thakare S.K., I.Bhaskarrao and Momin U. 2012. Design of front mounted pigeon pea stem cutter. *Journal of agricultural technology*, 8(2): 417-433.

Reza Tabatabae koloor and Ghaffar Kiani. 2007. Soyabean stems cutting energy and the effects of blade parameters on it. *Pakistan Journal of Biological Sciences*, 10(9): 1532-1535.

Singh T.P. 2016. Farm Machinery. PHI

Learning Pvt. Ltd., Rimjhim house, Patparganj Real Industrial Estate, Delhi. Pp. 178.

Sushilendra, Veerangouda M., Anantachar M., Prakash K.V., Desai B.K and Vasudevan S.N. 2016. Effect of blade type, cutting velocity and cross sectional area of chickpea stalks on cutting energy, cutting force and specific energy. *International Journal of Agricultural Sciences*, 8(53): 2658-2662.

How to cite this article:

Nisha, N. and Saravanakumar, M. 2019. Development of Reciprocating Cutter Bar Test Rig for Measurement of Cutting Force of Finger Millets. *Int.J.Curr.Microbiol.App.Sci.* 8(04): 2441-2447. doi: https://doi.org/10.20546/ijcmas.2019.804.284