PIN PENETROMETER INDEX OF ARGICULTURAL MATERIAL

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Agricultural material is a viscoelastic material. The mechanical properties of which varies with time, moisture content and different location. There is a great necessity to have a simple and quick measuring device to detect comparable information for a specific mechanical behavior not only in the Laboratory but also in the field. Penetrometer is a widely accepted device to serve for such purpose. Depending on different interests various penetrators or indentors have been used for measuring composite mechanical properties [1]. The main interest of this study is to obtain the information on the cutting resistance of stalks of sugar cane, banana, pineapple, etc. The size of which are above 25 mm (diameter) and the cutting force required for harvesting is high. Cochran and others at the Louisiana State University [2] used the Durometer (used for measuring hardness of rubber) to measure the stalk hardness of sugar cane, but it does not reflect sufficient information for cutting resistance which is a composite behavior of used of a pin penetrator to measure the penetration resistance.

A commercial stainless steel pin of 1.7 mm diameter with a tip length of 13 mm and a tip angle of 14° at the point, to 20° on the base is used in this study. The actual shape multiplied by 10 and traced from an optical screen is shown in Fig. 1. A laboratory test was carried out.

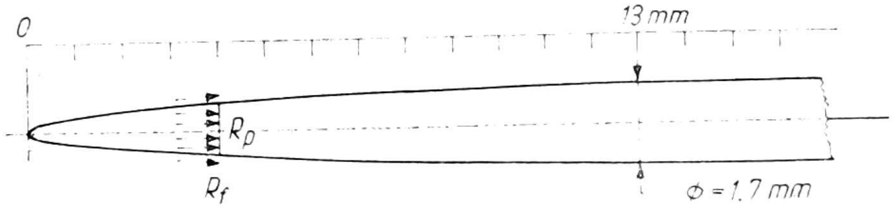

Fig. 1. The actual shape of the tested pin multiplied by 10 and traced from optical screen

A specially designed testing device is shown in Fig. 2 which consists of a high sensitive strain gauge dynamometer and a penetrating speed control system. A constant penetrating speed of 0.56 cm/sec was used for

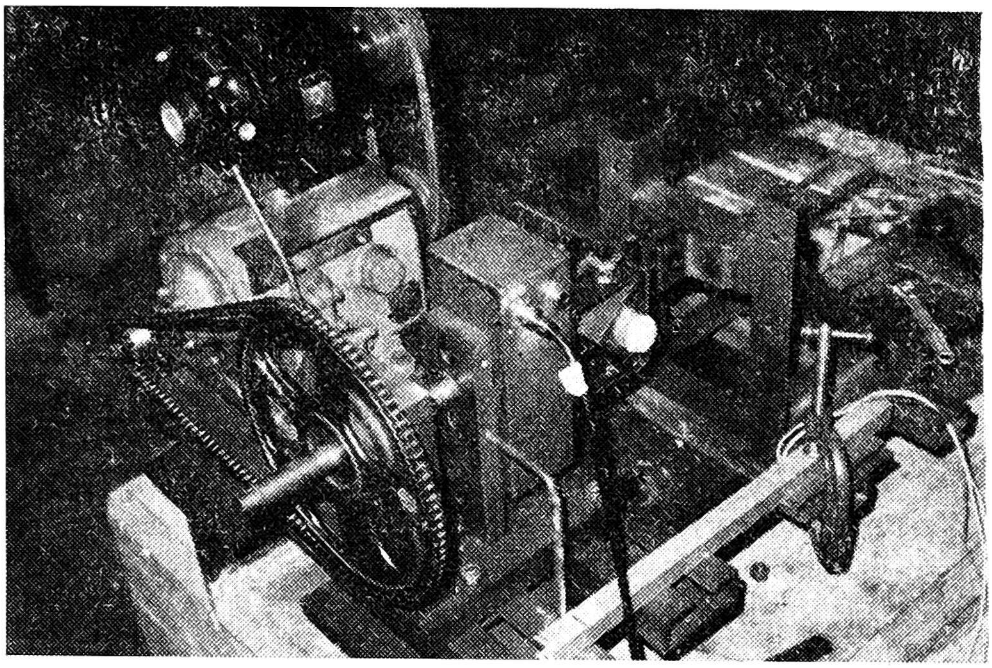

Fig. 2. Laboratory test device

all tests. The stalks of sugar cane, banana and pineapple were tested. Three fresh samples for each stalk were measured. The penetration resistance versus depth of penetration were recorded and plotted on an x—y graph. One sample result for each of the stalks is shown in Fig. 3. To simplify the analysis, the penetration resistance R shown in Fig. 1 is assumed to combine two parts.

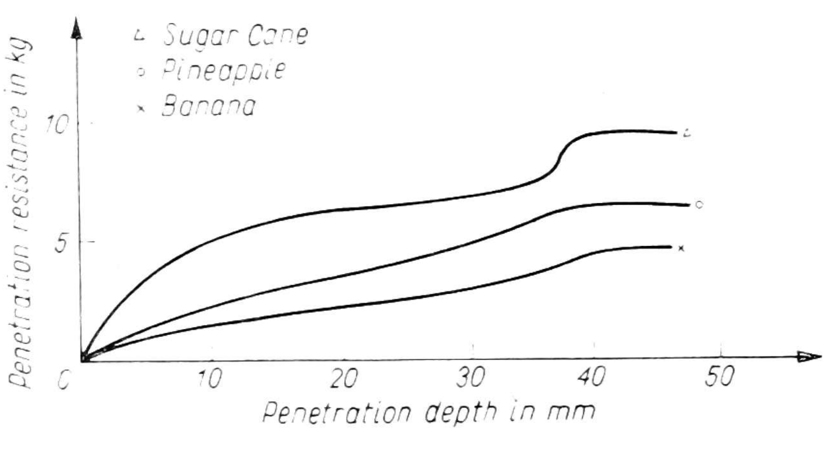

Fig. 3. Penetration resistance versus penetration depth plotted on an $x-y$ graph for cutting stalks

One is defined as projection resistance R_p caused by the enlargament of the hole size, which is taken by the projection area of the pin A_p in the penetration direction; the other is the frictional resistance R_f acting between the material and the immdiate Contact Surface A_s of the pin.

RESULT ANALYSIS

1. The penetration resistance shown in Fig. 3 increased as the penetrated depth increased but with a different increasing rate, due to the effect of skin, and the change of A_p and A_s.

2. There was a highly increased rate of R (0.811 Kg/mm) from the depth of 0 to 5 mm for sugar cane due to the skin effect but no significance of skin effect for banana, or pineapple.

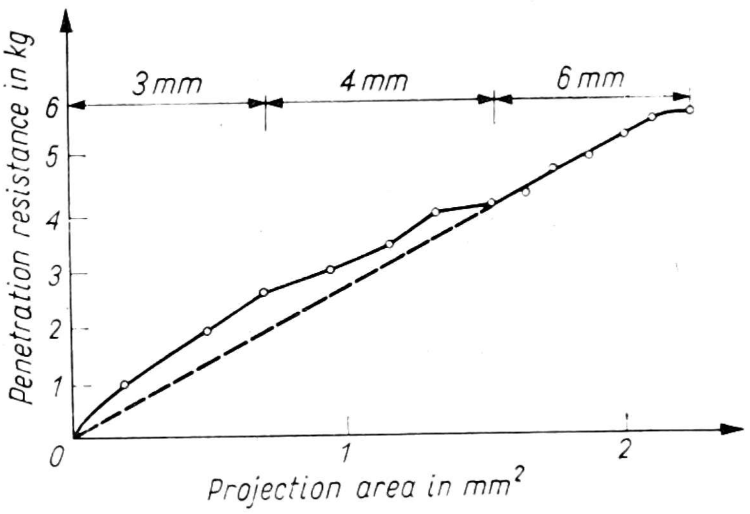

Fig. 4. Relationship between penetration resistance and projection area for sugar cane

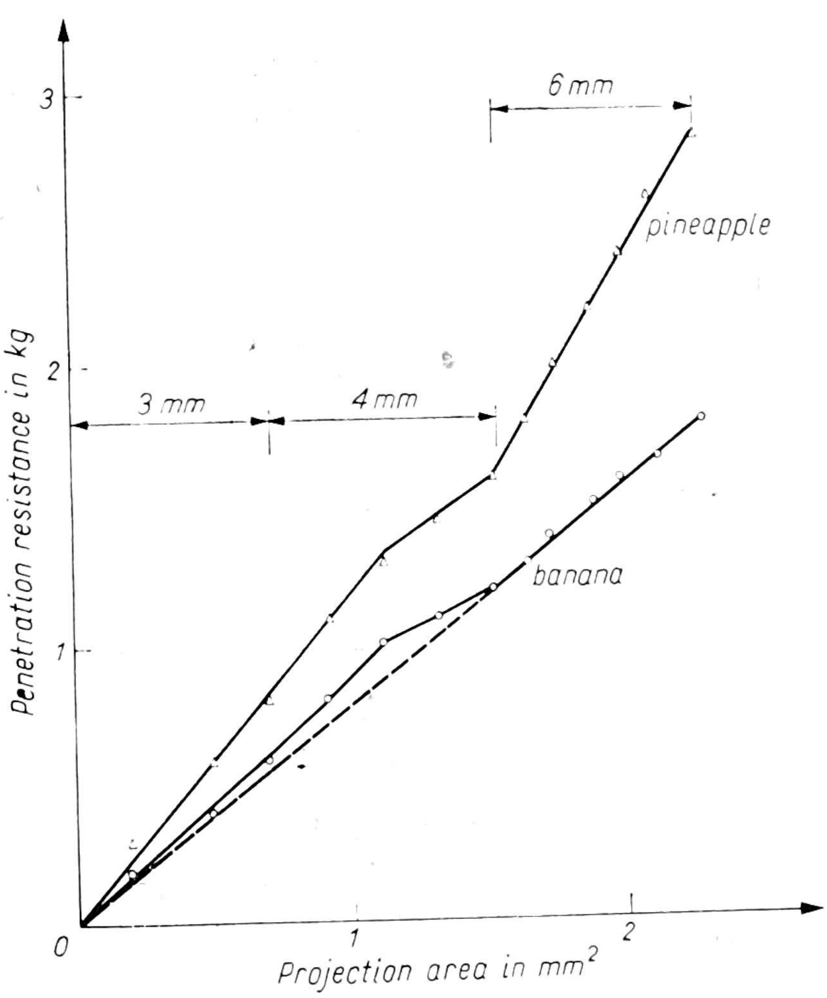

Fig. 5. Relationship between penetration resistance and projection area for pineapple and banana

3. From the depth of 0 to 13 mm (the length of tip head), the increased resistance was contributed by R_p and R_f due to the increase of A_p and A_s of the penetrated hole.

4. After 13 mm of depth, the increased R was only contributed by R_f since A_p beyond 13 mm was constant. In this portion the increasing rate was linear. The R_f at any depth of x beyond 13 mm is $R_{fx} = R_x - R_{13}$; where R_x is the R measured at the depth of x; R_{13} is the R measured at the depth of 13 mm (tip head length). The results showed that the R_f is very small for sugar cane and banana in comparison with total R.

5. The penetration resistance plotted against the corresponding cross section area is shown in Fig. 4 and 5. The area was taken from each mm length of the pin from 0 to 13 mm and as su me that the R_f is negligibly small. The results indicate that there exists two linear portions one with a higher gradient in skin layer and a lower slope corresponding to the soft core portion for sugar cane and banana, but the core of the pineapple is harder than its skin. For a linear relationship neglecting the effect of R_f, there exists a constant R_p/A_p.

PROPOSED PENETROMETER INDEX

Based on the analysis above, and the informations of interest to detect the cutting ability the following indexes may be useful.

1. Resistance of the pin tip head RH:

$$RH = R_{13} \text{ (} R \text{ taken from the depth of 13 mm) in kg.}$$

2. Resistance of sliding friction (RF)

$$RF = R_{20} - R_{13} \text{ in kg}$$

3. Unit penetration resistances for skin (URS)

$$URS = \frac{R_5}{A_{p5}} = \frac{R_5}{1.13} \text{ in Kg/mm}^2$$

where R_5 and A_{p5} are the R and A_p taken from 5 mm of depth.

4. Unit penetration resistance for core. (URC)

$$URC = \frac{R_{13}}{A_{p13}} = \frac{R_{13}}{2.26} \text{ in Kg/mm}^2$$

5. Unit resistance of sliding friction (URF)

$$URF = \frac{RF}{7\pi\Phi} = \frac{\text{RF}}{37.3}$$

(the depth is taking from 13 to 20 mm) in Kg/mm^2.

The indexes for sugar cane, banana and pineapple are shown in Table 1.

Table 1

Indexes

	RF Kg	*RH* Kg	*URS* Kg/mm^2	*URC* Kg/mm^2	*URF* Kg/m^2m
Sugar cane	5.8	0.6	3.0	2.56	0.016
Banana	1.6	0.5	0.85	1.15	0.013
Pineapple	2.8	0.9	1.15	1.23	0.024

CONCLUSION

The pin penetrometer indexes give a good comparable value for cutting stalks. It provides a useful information for design of harvesting cutters, but further study for the standardization of the pin is needed.

REFERENCE

1. Mohsenin, Nuvi N. "Physical properties of Agricultural products". Volume I. Dept. of Agricultural Engineering, Pennsylvania State University, March 1968.
2. Billy J. Sochran, Gene Baker „Engineering Properties of Sugar Cane and Their Relationship to Mechanical Harvesting". ASAE Paper 70—359, July 1970.

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WSKAŹNIK PENETROMETRYCZNY MATERIAŁÓW ROŚLINNYCH

Streszczenie

Materiał roślinny jest materiałem o właściwościach lepko-sprężystych, którego wytrzymałość zdeterminowana jest przede wszystkim wpływem czasu, wilgotności i jego budowy anatomicznej. Ustalenie standardowych właściwości mechanicznych jest zagadnieniem złożonym i trudnym, gdyż wymaga zachowania jednolitych warunków przy oznaczaniu cech mechanicznych, jak np. odporność na ścinanie w okresie zbioru.

Praca stanowi próbę zastosowania wskaźnikowego penetrometru trzpieniowego (PPI) do oceny zachowania się materiału roślinnego podczas przebijania trzpieniem o standardowych wymiarach poprzez określenie wskaźnika odporności na przebicie. W badaniach użyto trzpienia ze stali nierdzewnej o średnicy 1,75 mm i kącie stożka 20°.

W laboratorium przeprowadzono wstępne badania dla trzciny cukrowej, palmy oliwkowej, ananasa i banana.

Wstępne wyniki wskazują że:

— przeciętna wartość wskaźnika odporności dla trzciny cukrowej, palmy oliwkowej, ananasa i banana w stanie świeżym wynosi odpowiednio: 53 (5,83 kG), 110 (12,1 kG), 36 (3,95 kG), 24 (2,64 kG).

— odporność na cięcie wzrasta wraz ze wzrostem wskaźnika, co zostało stwierdzone za pomocą różnych zespołów tnących.

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ПОКАЗАТЕЛЬ СТРЕЖНЕВОГО ПЕНЕТРОМЕРА РАСТИТЕЛЬНЫХ МАТЕРИАЛОВ

Резюме

Растительный материал является материалом с липко-упругими свойствами, прочность которого предопределяется прежде всего воздействием времени, влажности и его анатомической структуры. Установление стандартных механических свойств является сложной и трудной проблемой, так как нуждается в сохранении одинаковых условий при определении механических свойств, как нпр сопротивления срезу во время сбора.

Работа является попыткой применения индикаторного стержневого пенетрометра (PPI) для оценки поведения растительного материала при прокалывании стержнем стандартных размеров путем определения показателя сопротивления проколу. В исследованиях был применен стержень из нержавеющей стали диаметром 1,75 мм и с углом конуса 20°.

В лаборатории были проведены предварительные исследования для сахарного тростника, масличной пальмы, ананаса и банана.

Они показывают, что:

1) средняя величина показателя сопротивления сахарного тростника, масличной пальмы, ананаса и банана составляет соответственно: 53(5,83 кГ), 110 (12,1 кГ), 36(3,95 кГ) и 24(2,64 кГ) в свежем состоянии,

2) сопротивление срезу возрастает с ростом показателя, что было установлено при помощи различных режущих систем (агрегатов).

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