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Mangosteen Sizing Machine

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ABSTRACT

Mangosteen sizing machine is made of diverging belt installed on 4m.-long, angle steel frame. The belts are 25° inclined to horizontal plane and driven by 1-hp. electric motor.

Experimental results show that by sizing mangosteen into 3 grades (EXTRA-fruit weight > 100 gm., EXTRA-fruit weight 75 to 100 gm, B-fruit weight < 75 gm.) the machine can size 1,100 kilogram of fruits per hour with 80% sizing efficiency. The sizing machine requires an operator and 0.2 kilowatt-hour of electrical energy.

INTRODUCTION

Fruit is a kind of agricultural produce which is graded according to its physical and chemical properties. Popular fruit of good price has to have appropriate size, shape, color and taste suitable for consumer.

Quality of mangosteen is graded according to its color and size (Kosiyachinda, 1987). Color of good mangosteen suitable for distant market is red or changing. When mangosteen turns red it is ready to be eaten. Popular mangosteen size ranges from moderate to small.

In Thailand mangosteen sizing is done by hand. Training a man or woman to be a good sizer would take a long time. Besides, human power is so limited that sizing a lot in a day is terribly hard-working and inaccurate. In other words, quality or uniformity of sizing varies decreasingly with time that man works.

When demand of mangosteen in the world market increases and requirement to supply produce to the market is also rising, introduction of the sizing machine becomes necessary.

Sizing method by machine can be done by using sizing sieve, weight, diverging belt (Nhorkoae, 1984).

Fruit of spherical body can be sized by shaking sizing sieve (conventionnally made of metal chemically inactive (to fruits). Small fruits will pass through the perforations leaving bigger fruits on the sieve. However, mangosteen having calyx and not completely spherical may not be operable with such a sieve. Mechanism of sizing by weight is moment and lever. Fruits being placed on trough or automatic conveyor will be sensed by spring inside the systems. The spring will be so displaced that the trough or conveyor turns and fruits are graded out of the system. This sizing method is rather complicated and expensive (Peleg, 1985). Diverging belt consists of 2 forward-drive belts the clearance between which increases with the distance the belts travel. Fruits will be brought into the diverging belt at the smallest clearance. Sizing will cause small fruit dropping down first at the beginning of the belts. The bigger fruit will be sized out at further distance.

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At present, there is no development of mangosteen sizing machine for commercial use. Since mangosteen is one of the economic fruit crops of Thailand, therefore it is appropriate to study on the design and construction of a machine for grading this fruit.

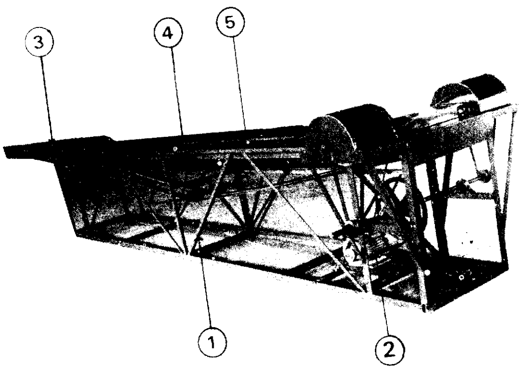
OBJECTIVES

To design, construct and test the machine for sizing mangosteen.

DESIGN AND EXPERIMENTATION

Specifications for design of mangosteen sizing machine are (i) simple, strong and cheap structure and (ii) capable of sizing mangosteen which is not spherical.

Design configuration of the mangosteen sizing machine is decided to be diverging belt consisting of 5 components (Figure 1.)



1. Steel structure (โครงสร้างเหล็ก)
2. 1 HP. Electrical Motor (มอเตอร์ไฟฟ้า ขนาด 1 แรงม้า)
3. Feeding Tray (ถาดรับมังคุดก่อนคัดขนาด)
4. Diverging Belt (สายพานคัดขนาด)
5. Receiving Tray (ถาดรับมังคุดหลังคัดขนาด)

Figure 1 Mangosteen Sizing Machine

(a) steel structure of 400 cm. long, 80 cm. high and 60 cm. wide,

(b) power generated by 3 kw. variable speed electric motor (speed range 0-1400 rpm.),

(c) feeding tray holding 10-kilogram mangosteen at a time,

(d) diverging belt (3-inch wide) the slope of which is 25 degree,

(e) receiving tray featured by 3 partitions for 3 different grades (EXTRA : more than 100 gm./fruit, EXTRA : 75 to 100 gm./fruit, B : less than 75 gm./fruit). The tray is lined with 1 cm. thick sponge which is 10 cm. below the diverging belt. The clearance is to secure a fruit from mechanical damage (Tongdee, 1987).

Experimentation is divided into three parts.—

(a) Determination of partitioning point: 40 Newly-harvested mangosteens of three different grades were selected at random. Each fruit is placed at the belt, the corresponding motor speed of which is 600 rpm. Record the fruit falling point from the belt. Try six replications for each fruit. Plot a graph relating frequency of fruit falling to falling position. Of the graph, temporary partioning point between grade EXTRA and A, and grade A and B will be chosen (Figure 2 region M and N).

Further experimentation is obtained by feeding the mangosteens of all grades. Record the fruit correctly falling to its relative grade and the associated partitioning points.

(b) Determination of maximum sizing efficiency versus belt speed. Feed the mangosteen fruits of all grades onto the diverging belt running at different speeds (600, 800, 1000 and 1200 rpm.). Record the fruits correctly and incorrectly falling to their relative grades. For each testing speed, a Digital AC Power Meter YEW Type 2503 was connected to the driving motor to show electrical power consumption of the machine.

Sizing efficiency can be calculated from the following expression.

$$EW = \sum \left[\frac{Pgi\ Wi\ Gi}{Pi\ Q} \right]$$

Where
$Pgi = Ngi/Nti$
$Nti = Ngi + Nij$
$Wi = KiPi/ [Ki\ Pi]$
$Pi = Ni/\sum Ni$
$Gi = Wi/t$
$Q = Wt/t$
EW = Sizing efficiency
Gi = Outflow rate of mangosteen grade i (kilogram/min.)
Ki = Fraction of price of mangosteen among grades
Ni = Number of mangosteen fruits of grade i fed to the sizing machine
$\sum_{i=1}^{n} Ni$ = Total number of mangosteen n grades
Nij = Mangosteen of grade J falling into grade i partition
Ngi = Mangosteen of grade i falling correctly into grade i partition
Nti = Total mangosteen falling into grade i partition
Pi = Fraction of mangosteen grade i before sizing
Pgi = Fraction of mangosteen grade i in grade i partition
Q = Outflow rate of mangosteen (kilogram/minute)
t = Total sizing time (minute)
Wi = Weighting function
Wi = Total weight of mangosteen fruits falling into grade i
Wt = Total weight of mangosteen fruits

RESULTS AND DISCUSSION

Figure 2 shows distribution of mangosteen fruit falling along the length of diverging belt. X, Y and Z are the regions that fruits of the grades B, A, E mainly fall. M and N are the regions that fruits of the grades B and A, and A and E commonly fall where such common area fruits of related grades fall decreasingly. M and N are assumed to become temporary partitioning points.

Figure 3 exhibits distribution of fraction of mangosteen falling into grade i for varying partitioning points. After four trials it was found that the partitioning point for A and E, and A and B are at 212 and 255 cm., respectively (from the bigger clearance end). This was selected because fractions AE, EA, BA and AB are small and relatively slightly different.

Figure 4 illustrates variation of sizing efficiency Ew against that of motor speed. High Ew (81%) is obtained at belt speed 12.8 m./min. (corresponding to motor speed 600 rpm.). Increase in belt speed gave rise to decrease in Ew. This is probably because higher belt speed caused greater resultant force exerting on a mangosteen.

Besides, its direction tends to push the fruit more forward. Therefore, opportunity of incorrect fall is increased.

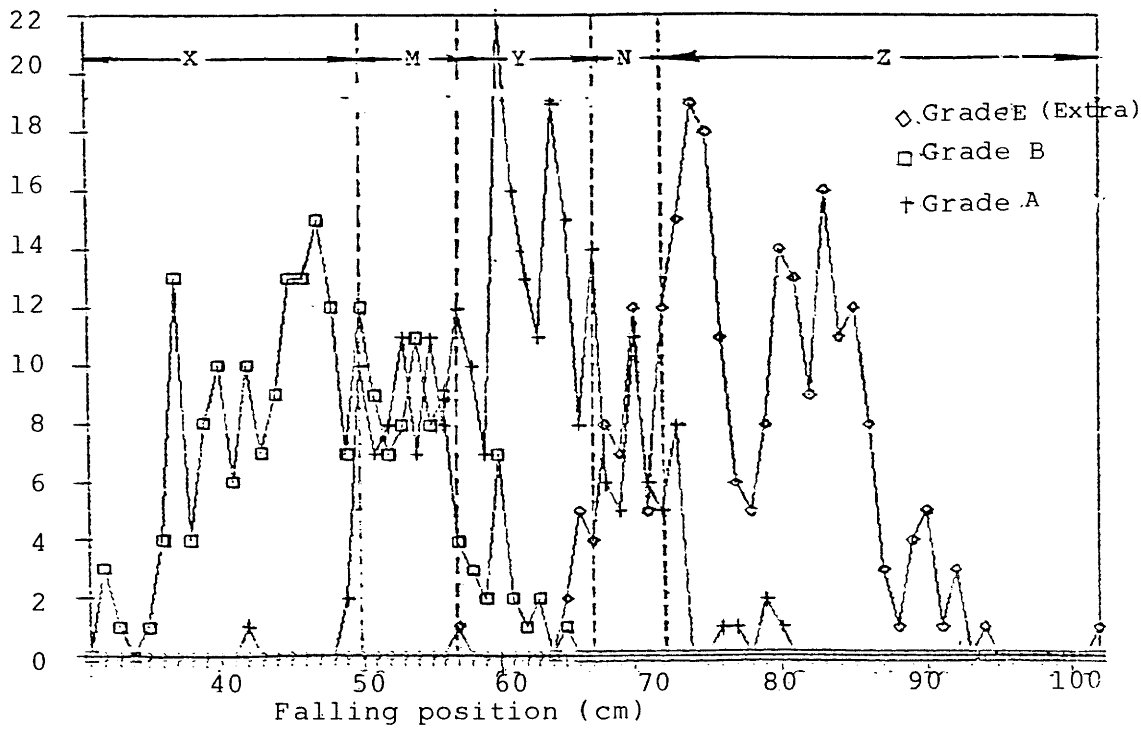


Figure 2 Distribution of position of mangosteen falling versus diverging belt length

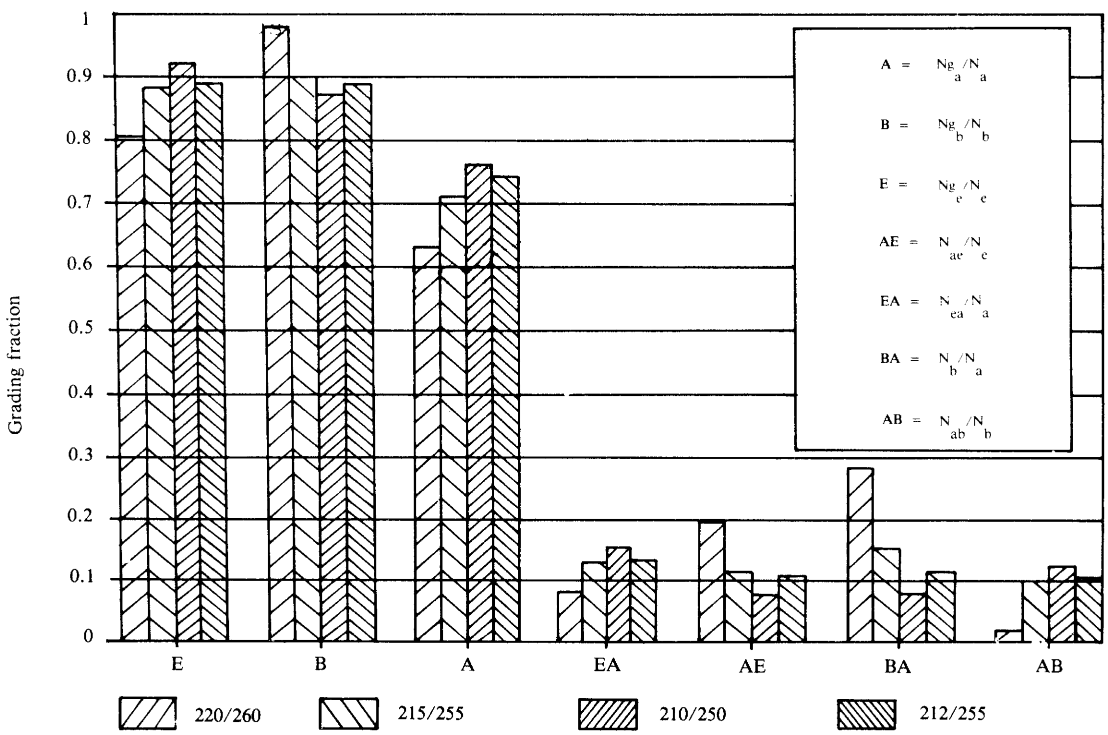


Figure 3 Distribution of mangosteen grading at varying partitioning position

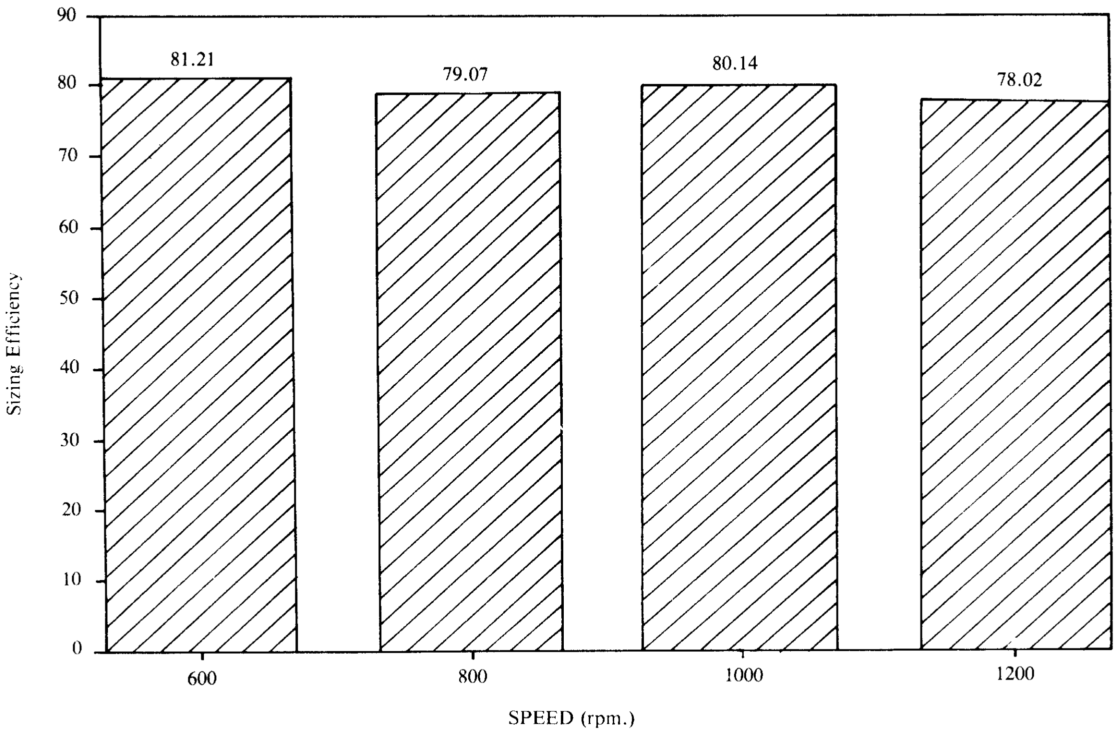


Figure 4 Sizing efficiency versus motor speed

However, the prototype machine, recommended for commercial use, runs at belt speed 21 m./min. (corresponding to motor speed 100, rpm.) giving Ew averagely 80% It is worth obtaining higher capacity while losing little Ew (NAMC, 1987).

Table 1 shows electrical power consumed by the sizing machine at selected speed. The faster motor speed is, the greater power becomes. This complies with theory that horse power depends upon torque and speed of motor (Surbrook, 1985).

Table 1 Electrical power consumption of the mangosteen sizing machine.

Motor speed (rpm.)	Power used (Kilowatt)
600	0.09
800	0.14
1000	0.17
1200	0.19

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