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Semi-automatic rambutan boring machine

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Abstract Semi-automatic rambutan boring machine were developed with dimensions of the machine 80 x 170 x 100 cm. The semi-automatic rambutan boring machine was powered by Motor Ac 220 Volt 0.25 kW and transmitted power to a 1:60 reduction gear, driving a chain with 20 sets of rambutan transport with a diameter of 40 mm to transport the rambutan to the seed drill set, size 18 mm. The drilling system was a 4 bar air pressure pneumatic, and the Geneva sprocket controlled the drilling range. The average rambutan boring capacity was 3,185 fruits h^{-1}, and variability of rambutan seed boring speed, rambutan diameter, rambutan height, rambutan weight, rambutan seed diameter, rambutan seed height, rambutan seed weight, rambutan peel, and rambutan seed boring ability were 1.13±0.54, 44.04±2.78, 60.60±3.83, 21.39±1.35, 8.60±0.54, 17.01±1.07, 5.41±0.34, 2.62±0.16 and 69.44±4.39, respectively. The efficiency of the semi-automatic rambutan boring machine was 95.75%, with a machine payback period of 140 days and a break-even point of 288.2 h $year^{-1}$.

Keywords: Rambutan, Semi-automatic machine, Boring machine

Introduction

Rambutan is a very popular fruit both in Thailand and foreign countries. Moreover, there are many in the southern and eastern provinces of Thailand. In 2020-2021, Thailand could produce 270,053 tons and earn an income for the country of 598,978,044 baht (Office of Agricultural Economics, 2021). It was divided into 49% fresh rambutan, and 51% processed rambutan. The rambutan was processed into many products, such as rambutan in syrup and rambutan jam. These products have a high price, resulting in a rambutan processing business continuously adding more value for responding to consumer needs in Thailand and foreign countries. At present, entrepreneurs are facing problems in the production process. Because it requires much labor in processing, such as rambutan peeling and rambutan seed boring. It causes time and labor wastage and a lost business opportunity to high industry competition. Therefore, the

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production sector needs to find machines for help in production to keep up with the opportunity. Currently, many agencies create machines to help produce processed rambutans (Pramart *et al*., 2019). In particular, the development of a rambutan seed boring machine based on the same principles and methods of boring as a manual boring with a knife, capable of boring 7 kg of rambutans per hour (Tidtaram *et al*., 2020). A semi-automatic rambutan peeling and boring machine were developed. The system was equipped with a vertical reamer and a horizontal slitting knife, compressed air as a Power Engine system, and a pneumatic air cylinder to drive the prototype machine's various components. PLC was used as the control device of the system with a working rate of 17.51 kg per hour. However, the system of both machines was still working intermittently. As a result, it may waste time in the production process. Therefore, the researcher has an idea to create a rambutan seed boring machine that can work continuously to help speed up the processing of rambutan products to keep up with the season. In addition, it reduces the number of operators, eliminates the need for skilled labor, and makes it safe to operate.

Materials and methods

Study of physical and mechanical properties of rambutan The physical properties of rambutans were studied using ripe rambutans to be harvested between 130-160 days after flowering (Technology Chaoban, 2018). The rambutan was divided into 3 parts: (1) Peel, (2) Flesh, and (3) Seed (Figure 1). (Charoenphun *et al*., 2020). 250 rambutan fruits were taken. Diameter, height of rambutan, and rambutan seed size were measured by Vernier caliper digital (Figure 1). Using a 5 mm flat indenter, constant pressing speed of 100 mm min^{-1}, it was found that the mean pressure capable of penetrating rambutan peel was 1.29 kg cm^{-2} (Terdwongworakul *et al*., 2009). (Figure 2).

(a) (b) (c)

Figure 1. a) Layers of the Rambutan fruit, b) Dimension of Rambutan fruit and c) Dimension of Rambutan Seed fruit

Figure 2. Quasi-static compression test by Force Gauge

Construction of semi-automatic rambutan boring machine The structure was made of square steel, size 50 x 50 mm, thickness of 2.5 mm, plated galvanized, width 40 cm, length 170 cm, and height 110 cm. Rambutan feeder set made by forming hard plastic and punching set size 18 mm, it made of stainless steel (Figure 3).

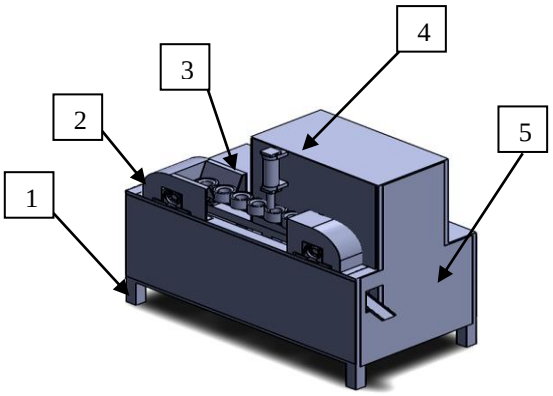


Figure 3. The components of prototype machine

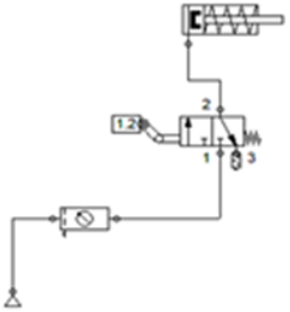


Figure 4. Diagram Directional Control Valve 3/2

Table 1. Specification of the semi-automatic rambutan boring machine.

Specification	Dimension
Width	80 cm
Length	170 cm
Height	100 cm
Stroke cylinder	30 cm
Diameter Drilling	18 mm
Weight	40 kg

From the design and construction of a semi-automatic rambutan seed boring machine (Table 1).

Components and working principle

Semi-automatic rambutan seed boring machine, there were important working components which were the power transmission system (Figure 3); (1) receives the power from Motor Ac 220 Volt 0.25 Kw and drives a 1:60 reduction gear (Figure 3); (2) to a 90 mm spur gear to drive chain No. 428 with 20 sets of rambutan transport, diameter 40 mm (Figure 3); (3) Transport rambutans to 18 mm seed drill bits with a stroke size of 100 mm (Figure 3); (4) The drilling system was pneumatic with air pressure in the 4 bar system. The Geneva sprockets controlled the drilling range. Power was sent to a 3/2 valve, roller type, controlling a 250 mm pneumatic cylinder to up and down in a straight line used to drill rambutan seeds and send the rambutan drilled to the exit channel (Figure 3).

Cross-sectional area of pneumatic cylinders

$$A=\frac{D^2 \times \pi}{4} \quad (1)$$

by

A = piston cross-section area (cm^2)
D = piston dimension (cm)

Piston speed

$$V=\frac{Q}{A} \quad (2)$$

by

V = piston speed ($m\ min^{-1}$)
Q = flow rate of air flowing into piston ($l\ min^{-1}$)

Examples of rambutans used for testing

Rongrien Nasan Rambutan were tested. Harvest ages range between 130-160 days after the flowers bloom. The rambutans were selected in testing from rambutans of the height of 30-70 mm in the amount of 250 rambutans, boring with a continuous assortment method, tested, and recorded by a prototype builder.

Analysis of physical characteristics of rambutan and functional capacity of semi-automatic rambutan boring machine

250 Rongrien Nasan Rambutans were used to test and analyzed by equation (3) (4) (5).

$$\text{Mean } (\bar{X}) = \frac{\sum_{i=1}^{n} xi}{n} \quad (3)$$

$$\text{Standard Deviation (S.D.)} = \sqrt{\frac{(x-\bar{x})^2}{n-1}} \quad (4)$$

$$\text{Coefficient of Variation (C.V.)} = \frac{\text{S.D.}}{\bar{x}} \text{x100} \quad (5)$$

by

$\sum_{i=1}^{n} xi$ = sum of data from rambutan measurements (Diameter, Height)

n = number of rambutan (250 fruits)

Performance evaluations of prototype semi-automatic rambutan boring machine

With equations (6)-(10) (Qinpaisan, 2014).

$$\text{Availability Rate (A)} = \frac{L}{T} \text{x100} \quad (6)$$

$$\text{Performance Efficiency (P)} = \frac{N}{T} \text{x100} \quad (7)$$

$$\text{Quality Rate (Q)} = \frac{O}{q} \text{x100} \quad (8)$$

$$\text{OEE} = \frac{A}{100} \text{x} \frac{P}{100} \text{ x } \frac{Q}{100} \text{x100} \quad (9)$$

$$\text{Capacity (C)} = \frac{c}{t} \quad (10)$$

by

T = time when the machine digs rambutan seed (h)

L = run time of rambutan seed boring machine (h)

N = Net operating time (h) = (idle time - L)

O = number of rambutans that can be cut according to the requirements (fruits)

q = number of rambutans that have all seeds extracted (fruits)

OEE = Overall Equipment Effectiveness (%)

c = number of rambutans (fruits)

t = time for boring rambutan seeds (h)

Engineering economic analysis

Analysis of the use of the semi-automatic rambutan boring machine as in equation (11) and (12) (Lungkapin, 2020).

Pay-back period of the semi-automatic rambutan boring machine

$$PBP = \frac{L}{T} \quad (11)$$

by

PBP = Time to payback (year)
P = Machine Price (Baht)
R = Net profit per year (Baht year^{-1})

Break-even point

$$BEP = \frac{Fc}{B\text{-}Vc} \quad (12)$$

by

BEP = Break-even point (h year^{-1})
Fc = Fixed expenses (Baht)
B = rate of hire (Baht h^{-1})
Vc = cost of work (Baht h^{-1})

Results

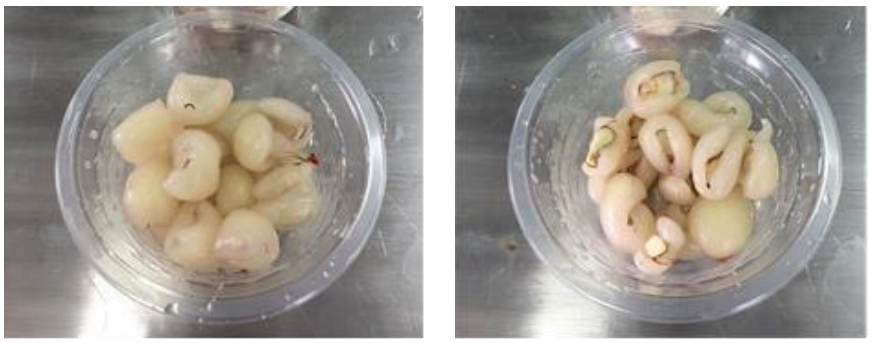
Semi-automatic rambutan seed boring machine

The important functional components of the semi-automatic rambutan seed boring machine were the transmission system by receiving power from Motor AC 220 Volt 0.25 kW to drive a 1:60 reduction gear to a spur gear size 90 mm to drive a chain No. 428 with 20 sets of rambutan transport with a diameter of 40 mm (Figure 4b). Next, it transported the rambutan to the 18 mm seed drill bit with a stroke size of 100 mm. The drilling system was pneumatic, with 4 bar air pressure, controlled drilling range by Geneva sprocket (Figure 4a). The Power was sent to a 3/2 roller valve, controlling a 25.4 mm pneumatic cylinder to up and down in a straight line used to drill rambutan seeds and send the rambutan drilled into the exit channel (Figure 4c). Finally, rambutans that had been bored were taken for analysis of the fruit integrity.

(a) (b) (c)

Figure 4. Operation of prototype a) Control drilling range with Geneva sprocket b) transport rambutan c) Rambutan drilling

Physical characteristics of rambutan and working ability of semi-automatic rambutan boring machine from tested 250 fruits with an average pressure of 1.29 kg cm^{-2}, the results were shown in Table 2.



(a) (b)

Figure 5. Comparison of characteristics of drilled rambutan. a) Complete rambutan b) Incomplete rambutan

Table 2 Prototype capacity and dimension of rambutan

	Min	Max	$\bar{x}$	%C.V.
Diameter Fruit (mm)	34.58±2.18	51.35±3.24	44.04±2.78	7.01±0.01
Height Fruit (mm)	36.52±2.30	69.00±4.36	60.60±3.83	6.47±0.006
Weight Fruit (g)	17.00±1.07	26.00±1.64	21.39±1.35	8.15±0.02
Speed (Sec)	0.78±0.54	1.69±0.63	1.13±0.54	15.87±0.01
Shell weight (g)	1.30±0.08	4.00±0.25	2.62±0.16	22.22±0.53
Diameter Seed (mm)	8.58±0.54	10.11±0.63	8.60±0.54	2.06±0.01
Height Seed (mm)	16.97±1.07	21.34±1.34	17.01±1.07	2.10±0.007
Weight Seed (g)	3.00±0.18	9.00±0.56	5.41±0.34	23.16±0.27
Capacity	41.96±2.65	96.92±6.12	69.44±4.39	16.21±0.01

Performance measurement

The performance of the semi-automatic rambutan seed boring machine as in Table 3.

Table 3. Overall Machine Effectiveness (OEE)

Availability Rate (%)	Performance Efficiency (%)	Quality Rate (%)	OEE (%)
98.78	98.87	96.00	95.75

Table 4. Details and price to build a prototype

Component	Price (Baht)
Structure	35,500
Motor AC 220 V 0.25 Kw	14,000
Control Valve	9,500
Cylinder 1 way	7,000
Gear box	9,000
Chain Drive	1,000
Plastic Block 20 Unit	10,000
Air pump	25,000
Control box	7,000
Total	**118,000**

The semi-automatic rambutan seed boring machine was developed. The cost was fixed at 118,000 baht, and the average rambutan boring capacity was 3,185 fruits h^{-1}, Rambutan diameter, rambutan height, rambutan weight, rambutan seed diameter, rambutan seed height, rambutan seed weight, rambutan rind, and rambutan seed boring ability were 1.13±0.54, 44.04±2.78, 60.60±3.83, 21.39±1.35, 21.39±1.35, 8.60±0.54, 17.01±1.07, 5.41±0.34, 2.62±0.16, and 69.44±4.39, respectively. The performance of the semi-automatic rambutan boring machine was 95.75% with a payback period of 140 days and a break-even point of 288.2 h $year^{-1}$.

Discussion

From the design and construction of a semi-automatic rambutan boring machine with a fixed cost of 118,000 baht and compensation when hired for boring rambutan seeds at 17.72 baht kg^{-1} (Tidtaram *et al*., 2020). It was found that there was a payback period for the machine of 140 days and a break-even point of 288.2 h $year^{-1}$. The various boring methods in use today, e.g., manual boring, an average of 1,000-1,100 fruits per day per person (Sayasoonthorn and Kaewrueng, 2019). but boring by machine roller blades and seed aisles capable of peeling 10,800 fruits h^{-1} (Pramart *et al*., 2019). and boring using principles and methods of boring same manual boring of knives with a boring capacity of 180 fruits h^{-1}. Compared to the semi-automatic machine that can make bored 3,185 rambutan seeds h^{-1}, three times more than a manual boring. The researcher expected that if the semi-automatic rambutan seed boring machine were used in industries would be able to help manufacturers to produce products according to the needs and seasons of the rambutan.

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