DESIGN AND PERFORMANCE TESTS OF A SIMPLE THRESHER FOR PEPPER

(*DISAIN DAN UJI UNJUK KERJA MESIN PERONTOK LADA SEDERHANA*)

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ABSTRACT

Threshing of pepper (*Piper nigrum L*) to separate the berries from their stalk is one of the steps in the white pepper processing mechanically. This step is done prior to the shelling step. The aim of this research is to develop simple thresher for pepper. The threshing components consist basically of a tooth cylinder, a single curved plate sieve and a cap. The design has eliminated or simplified some components of the former thresher designed by Hidayat, but still keeping the high performance of threshing. The operation principle of the thresher resembles that of the paddy thresher. For this design it is basically to create pulling forces in tangential direction and pushing forces in axial direction due to rotation of the cylinder clockwise at 200 – 300 rpm. Due to those forces the berries and the stalk may separate and the stalk and pepper which has not been threshed yet will be guided to move forward in between the threshing teeth in spiral paths. During its motion the pepper will be threshed again. The berries pass through the sieve, fall down and leave the thresher through the berry outlet while the stalk leaves the thresher through the stalk outlet. Equipped with 35 rubber teeth and layered by rubber sheet around its surface the cylinder size is 30 cm in diameter and 80 cm in length, while the sieve size is 64 x 22 cm. The thresher is driven by a 6½ HP – 1500 rpm gasoline engine. In the performance tests with the feed levels of 10, 15, and 20 kg pepper, it was found that the thresher was quite effective to thresh pepper and stable in performance at the three feed levels indicated by relatively constant and high percentages of berries (85 - 86%), and low percentages of inseparable pepper (2.5%) and stalk in berries (3.5 – 4.0%). During the tests it was almost no berries in stalk and no berries damage found. If counted in berries mass, the threshing efficiency was 97.7%. The threshing capacity was 5.70 kg pepper per minute. Compared with productivity and cost for separating of berries from the stalk by manual method which are 0.50 kg pepper per minute per person and Rp. 159,- per kg pepper respectively, the productivity of the simple thresher in this research is 2.85 kg pepper per minute per operator while its threshing cost is Rp. 105,- per kg pepper.

Keywords: Pepper thresher, performance, productivity, threshing cost.

ABSTRAK

Perontokan lada (Piper nigrum L) untuk memisahkan bulir dari tangkainya adalah salah satu tahap pada pengolahan lada putih secara mekanis. Tahap ini dilakukan sebelum tahap pengupasan kulit bulir lada. Penelitian ini bertujuan untuk mendisain sebuah mesin perontok lada yang lebih sederhana dari pada disain sebelumnya yang dibuat oleh Hidayat. Komponen perontok pada prinsipnya terdiri atas silinder perontok, saringan bulir lada dan penutup ruang perontokan. Prinsip kerja mesin perontok ini didisain seperti pada prinsip kerja mesin *perontok padi. Dengan disain ini akan dihasilkan gaya tarik pada arah tangensial dan gaya dorong pada arah aksial akibat putaran silinder perontok pada putaran 200 – 300 rpm. Karena efek kedua gaya tersebut, bulir lada akan terpisah dari tangkainya selanjutnya tangkai dan lada yang belum sempat rontok akan diarahkan bergerak kedepan melalui celah-celah diantara gigi-gigi perontok. Lada yang belum rontok akan mengalami proses perontokan berikutnya. Bulir lada yang terpisah dari tangkai melalui saringan, jatuh kebawah dan keluar melalui lubang pengeluaran bulir, sedangkan tangkai yang terpisah keluar melalui lubang pengeluaran tangkai. Silinder perontok dilengkapi dengan 35 buah gigi perontok. Diameter silinder 30 cm sedangkan panjangnya 80 cm. Ukuran saringan 64 x 22 cm. Mesin perontok digerakkan oleh sebuah motor bensin 6½ HP – 1500 rpm. Pada uji unjuk kerja mesin perontok masing-masing dengan 10, 15 dan 20 kg lada diperoleh bahwa mesin cukup efektif merontokkan lada dan cukup stabil unjuk kerjanya, yang ditunjukkan oleh prosentase bulir yang terpisah relatif tinggi dan konstan nilainya (85 - 86%), sedangkan prosentase lada yang tidak sempat rontok dan sisa tangkai terikut bulir relatif kecil dan konstan dengan nilai masing-masing 2,5% dan 3,5 – 4,0%. Bila perhitungan didasarkan atas massa bulir lada, maka efisiensi perontokannya adalah 97,7% dan kapasitas perontokan 5,70 kg lada per menit. Dibandingkan dengan produktivitas dan biaya pemisahan bulir dari tangkai secara manual masing-masing 0,50 kg lada per menit per orang dan Rp. 159,- per kg lada, peroduktivitas perontokan mesin perontok pada penelitian ini 2.85 kg lada per menit per operator sedangkan biaya perontokannya Rp. 103,- per kg lada.*

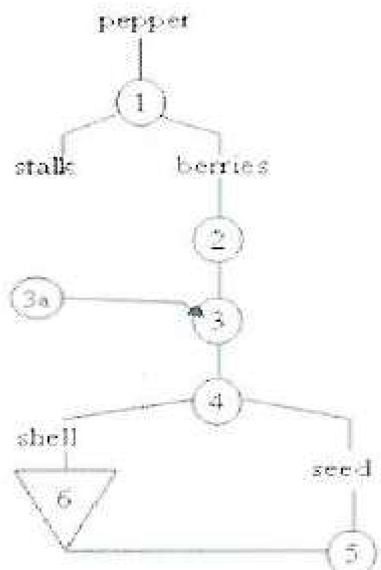
Kata Kunci: *Mesin perontok lada, unjuk kerja, produktivitas, biaya perontokan*

INTRODUCTION

Pepper (*Piper nigrum L*), both black and white is one of the important non-oil export commodities of Indonesia. With production more than 25,000 ton per annum, 90% of the production is exported to Europe, America and other Asian countries and the rest is for the domestic markets. The world demand for pepper is projected to increase in the future indicated by the increase of the pepper consumption from 55 to 75 grams per capita per annum during the last years (Rukmana, 2003). In Indonesia pepper is cultivated widely in Lampung, Bangka, Belitung, West dan East Kalimantan and South Sulawesi.

One of the steps in the white peppers processing mechanically is threshing of pepper to separate the berries from their stalk. The step is done prior to the shelling step (Risfaheri et al. 1992 and Yunus et al. 2001).

The separation of berries from their stalk is a time consuming process if the step is done manually especially when the quantity of the pepper to be processed is quite large. As a comparison, one person requires around two hours to separate the berries from the stalk of 30 kg pepper by hands or 0.25 kg pepper per minute per person. This capacity does not take into account the human fatique factor. The use of machine for separating the berries may shorten the process, thus increase productivity of the separation.



1. Threshing of pepper
2. Immersion in water
3. shelling
3a. Watering
4. Washing and shell separation
5. Drying
6. Packing and storage

Figure 1. Flowchart for white pepper processing mechanically

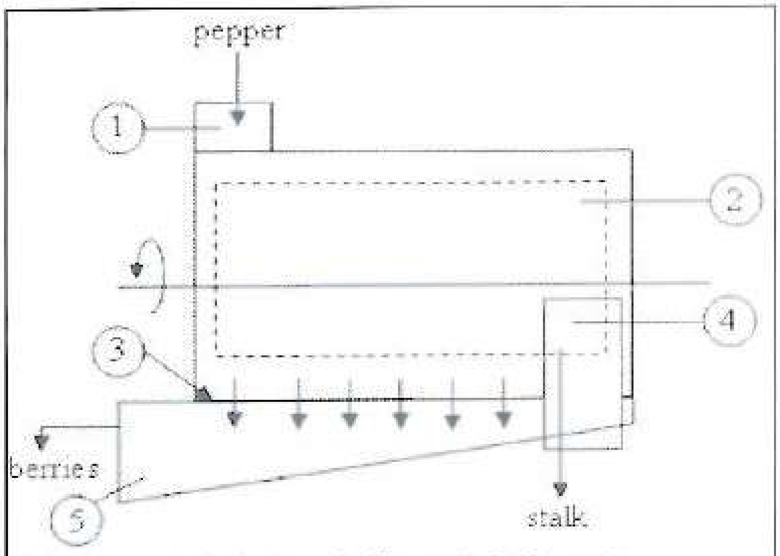
In the earlier work, Hidayat et al (2001) has designed and tested an axial type thresher for pepper. The threshing components include a tooth cylinder with 32 cm in diameter, a concave as the first stage sieve of berries with 15 x 15 mm holes, and a cap. To guide the pepper and the stalk moving along cylinder surface, three spiral fins are fixed on the inner surface of the cap. Five blades fixed on the shaft end has function to throw the stalk to leave the thresher. A separation sieve with 9 x 9 mm holes placed below the concave and equipped with vibrating springs and pendulum acts as the second stage sieve. The thresher performance was measured based on the berry or stalk mass. The optimum condition for threshing process was 300 rpm cylinder rotation with threshing efficiency 98.55%, berries in stalk 5.20% and berries damage 6.30%. The threshing capacity was 260.56 kg pepper per hour or 4.35 kg pepper per minute. In operation the thresher is served by two operators.

The aim of this research is to develop another simple thresher for pepper. Some components of the Hidayat et al thresher have been eliminated or simplified but still keeping the high performance of the thresher. As known, the thresher is one of the machines required in the processing line to produce white pepper mechanically. Other machines and facilities in the processing line include shelling machines, washing facilities, dryers, sun-drying floor, packing equipment etc.

METODOLOGY

The methodology of this research comprises of design, construction and testing of the simple thresher for pepper. Moreover, productivity of the thresher in relation with its processing time and labor input as well as its threshing cost were also calculated. The thresher is designed on the basis of functional design including the design calculation of some parts of the thresher.

The principle of operation of the thresher resembles that of the threshers for paddy. For this design it is basically to create pulling forces in tangential direction and pushing force in axial direction on the pepper due to rotation of a tooth cylinder anticlockwise. Due to those



1. Hopper; 2. Cylinder ; 3. Sieve; 4. Stalk outlet ; 5. Berry outlet

Figure 2. Mass flow in process

forces the berries and the stalk may separate and stalk and pepper which has not been threshed yet will be guided to move forward in between the threshing teeth in spiral paths. During its motion the pepper will be threshed again.

The threshing process is expected to occur mainly along the first section of the cylinder length (left side in Figure 2). It is also expected that before reaching the stalk outlet, the pepper has been threshed all. The berries pass through the sieve, fall down and leave the thresher through the berry outlet, while the stalk leave the thresher through the stalk outlet. The thresher is operated by two operators.

To do the performance tests pepper from Bulukumba and Sinjai regencies of South Sulawesi were used. The pepper is ripe enough indicated by yellowish shell color of the berries mixed with red color shell berries. The diameter of the berries mostly varied from 5 to 7 mm.

The feeds were varied at the levels of 10, 15, and 20 kg fresh pepper with two replications each. During threshing process, the cylinder was adjusted to rotate between 200 and 300 rpm.

The parameters to measure the performance of the thresher includes threshing capacity and percentages of separation i.e. the percentages of berries, stalk, stalk in berries, inseparable pepper and pepper loss in processing. The inseparable pepper is defined as the pepper which have not been threshed or completely threshed yet in the previous processing. Stalk in berries is the stalk mixing with the berries leaving out from the berry outlet while berries in stalk is the barriers mixing the stalk on the stalk outlet. Berries and stalk are the separable berries and the separable stalk respectively.

The threshing capacity is calculated from the equation:

$$C = \frac{\text{pepper feed}}{\text{processng time}} \quad \text{.............................} \quad (1)$$

If the feed mass is denoted as F, the percentages of berries (B), stalk in berries (SB) and inseparable pepper (IP) from the berry outlet, and the percentages of stalk (S) and berries in stalk (BS) from the stalk outlet, can be calculated in wet mass basis as follow:

$$P = \frac{B, SB, IP, BS \text{ or } S}{F} \quad \text{...........................} \quad (2)$$

The percentages of pepper loss in processing is then calculated from the equation:

$$P = \frac{F - (B + SB + IP + BS + S)}{F} \quad \text{................} \quad (3)$$

RESULTS AND DISCUSSION

A. Design and Construction

The threshing components of the simple thresher for pepper consists basically of the cylinder equipped with 35 rubber teeth, the single sieve for berries and the cap. The design has eliminated the second stage sieve for berries including its vibrating springs and pendulum, the blades, and the spiral fins as in the Hidayat et al. thresher (2001). The hopper and the stalk outlet are also designed oblique for easy pepper feeds and let the stalk fall down freely from the stalk outlet.

The cylinder has dimension 30 cm in diameter and 80 cm in length, while the sieve has dimension 64 x 22 cm with 30 x 10 mm holes. The shaft with 38 mm in diameter and 100 cm in length is made from carbon steel S-45 C with tensile strength 80 (kg/mm^2). Material for the keys is chosen carbon steel S-35C with tensile strength 70 (kg/mm^2). A rubber sheet with 10 mm in thickness is layered and fixed on surface of cylinder by strong glue. The rubber teeth with 100 x 15 x 10 mm in dimension are fixed on the outer cylinder surface in seven rows each with five teeth also by strong glue.

Two deep groove type ball bearings are fixed to the shaft to support the shaft and the cylindrical device. The outer diameter of the bearing is 80 mm, while the width is 23 mm.

The power and rotation of the 6½ HP – 1500 rpm gasoline engine is transmitted to the cylinder through a double V-belt drive with two pulleys. The pulleys are made from CI with diameter 80 and 340 mm respectively. In operation the rotation of the cylinder is set in the range of 200 to 300 rpm by adjusting or reducing the speed of the gasoline engine. For gasoline engine as the speed is reduced its power output generally is also reduced from its maximum power.

All parts of the thresher in contact with the pepper are made from stainless steel except for the teeth and the cylinder layer which are made from hard rubber material. The frame of the machine is constructed from 35 x 35 mm L iron beams.

The shaft chosen should be checked for shear stress and torsional deflection. For this purpose, the torsion working on the shaft was determined first by the following equation (Sularso and Suga, 2001):

$$T = 9.74 \times 10^5 \frac{Pd}{n} \quad \text{..............................} \quad (4)$$

where T is the torsion (kg.mm), Pd is the design power (kw), and n is the rotation of the cylindrical device (rpm).

The design power itself is calculated from the equation below (Sularso and Suga, 2001):

$$Pd = fc.P \quad \text{.......................................} \quad (5)$$

where Pd is the design power, fc is the correction factor, and P is the nominal output of the gasoline engine (kw). For normal power fc = 1.0 – 1.5. By taking fc = 1,0 and since P = 6½ HP (1 HP = 0.735 kw) we find out from Eq. 2, Pd = 5.73 kw.

By taking n = 200 rpm, from Eq. 4 it was calculated that the torsion T = 27905 (kg.mm).

The shear stress working on the shaft is given in Eq. 6 (Sularso and Suga, 2001):

$$\tau_a = \frac{5.1 \times k.Cb.T}{d_s^3} \quad \text{.............................} \quad (6)$$

where τ_a is the shear stress (kg/mm^2), k is the correction factor recommended by ASME, Cb is the bending stress factor, and d_s is the shaft diameter (mm).

For the shaft received light shock in operation k = 1.0 – 1.5. The bending stress factor Cb = 1.2 – 2.3 (Sularso and Suga, 2001). Since the shaft may work in light shock condition during threshing of pepper and receive bending force due to the weight of the cylindrical device and pulling force of the belt, we take k = 1,2 and Cb = 2.0. Because of ds = 38 mm, it was found out from Eq. 6 that the shear stress $\tau a = 6.22$ (kg/mm^2).

Calculation of the allowable stress of the shaft should take into account the fatique limit of the shaft material and the shear concentration due to the slot of the key. The limit factor for torsional fatique $Sf_1 = 6.0$, while the key slot factor $Sf_2 = 1.3 - 3.0$ (Sularso and Suga, 2001). By taking $Sf_2 = 1.5$, it was found out that the allowable stress $(\tau a) = \sigma b/(Sf_1 x Sf_2) = 80/(6.0x1.5) = 8.89$ (kg/mm).

Because of $\tau a < (\tau a)$, it was found out that the shaft is quite strong toward shear stress working on it.

Deformation of the shaft in terms of torsional deflection is determined from the following equation (Sularso and Suga, 2001):

$$\theta = 584 x \frac{T.L}{G.d_s^{\ 4}} \quad \text{.................................} (7)$$

where θ is the torsional deflection of the shaft (degree), L is the effective length of the shaft between two bearings (mm), and G is the shear modulus of the shaft.

For steel $G = 8.3 \times 10^3$ (kg/mm^2). For L = 860 mm, we find out from Eq. 7 the torsional deflection θ = 0.63 (degree). According to Sharma and Anggarwal (1997) it is a common practice to limit the torsional deflection of the shaft to one degree in a length equivalent to 20 times the shaft diameter. Since ds = 38 mm the length equivalent in the shaft design is 20 x 38 = 760 mm which is closed to the effective length L = 860 mm. Because the torsional deflection from the calculation is lower than its allowable limit 0.63 < 1.00 (degree) the shaft of the thresher is safe enough toward the torsional deflection.

The dimension of the pulleys is designed based on the outer diameter dk. For the nominal diameter of the driving pulley $D_{P1} = 80$ mm, dk = Dp + 2 k, where k = 4.5 mm, while the pulley width B = e + 2f, where e = 15 mm and f = 10 mm (Sularso and Suga, 2001). Therefore the dimension of the driving and the driven pulleys $dk_1 = 89$ mm, $dk_2 = 349$ mm, and B = 35 mm..

For the belt we choose V-belt No. A-62 with length L = 1575 mm, width t = 12.5 mm, and groove angle β = 40°. To check whether the V-belt drive design is already correct for its contact angle we take calculation of the angle from the equation below (Sularso and Suga, 2001):

$$\theta = 180^o - \frac{57(D_{p2} - D_{p1})}{C} \quad \text{......................} (8)$$

where θ is the contact angle of the driving pulley (degree), and C is the distance between the two pulleys (mm).

The distance between the two pulleys is expressed as (Sharma and Anggarwal, 1997):

$$C = \frac{1}{8}(p + \sqrt{p^2 - q}) \quad \text{.............................} (9)$$

in which,

$p = 2L - \pi (Dp_1 + Dp_2)$

$q = (D_{P2} - D_{p1})^2$

Using Eq. 9 and after rounding its result then C = 450 mm. From Eq. 8 it was found that the angle of the driving pulley θ = 147 degree or θ = 2.66 radian. According to Sharma and Anggarwal (1997), for the V-belt transmission with θ ≥ 2.10 radian is considered good.

The dimension of the key standard for the shaft diameter ds = 22 – 30 (mm) is as follows (Sularso and Suga, 2001):

- cross section = 8 x 7 mm (b x h)
- depth of the key slot on the shaft $t_1 = 4$ mm
- depth of the key slot on the pulley $t_2 =$ 3.3 mm

The tangential force working on the key is determined from the equation below:

$$F = \frac{2T}{d_s} \quad \text{....................................} (10)$$

where F is the tangential force on the key (kg). Since ds = 38 mm, from Eq.10 it can be calculated that F = 1468 kg. According to Sularso and Suga (2001) the key length is designed as l = (0.75 – 1.75) ds, in which l = ds = 38 mm.

The key length considering the shear stress working on the key should follow the equation below (Sularso and Suga, 2001):

$$l \geq \frac{F}{b.\tau_k} \quad \text{.......................................(11)}$$

where l is the key length (mm), b is the key width (mm) and τ_k is the shear stress (kg/mm^2) of the key material.

The allowable shear stress (τ_k) = $\sigma B/(Sf_1 x\ Sf_2)$, where the safety factors $Sf_1 = 6$ and $Sf_2 = 1.5 - 3$ for light shock operation. By taking $Sf_2 = 2.0$ it was found out that (τ_k) = 70/(6x2.0) = 5.8 (kg/mm^2).

Since b = 8 mm, then from Eq. 11 it can be calculated that the key length l ≥ 31.6 mm.

The key length considering the surface stress working on the key should follow the equation below (Sularso and Suga, 2001):

$$l \geq \frac{F}{Pe \times (t_1 or\ t_2)} \quad \text{............................ (12)}$$

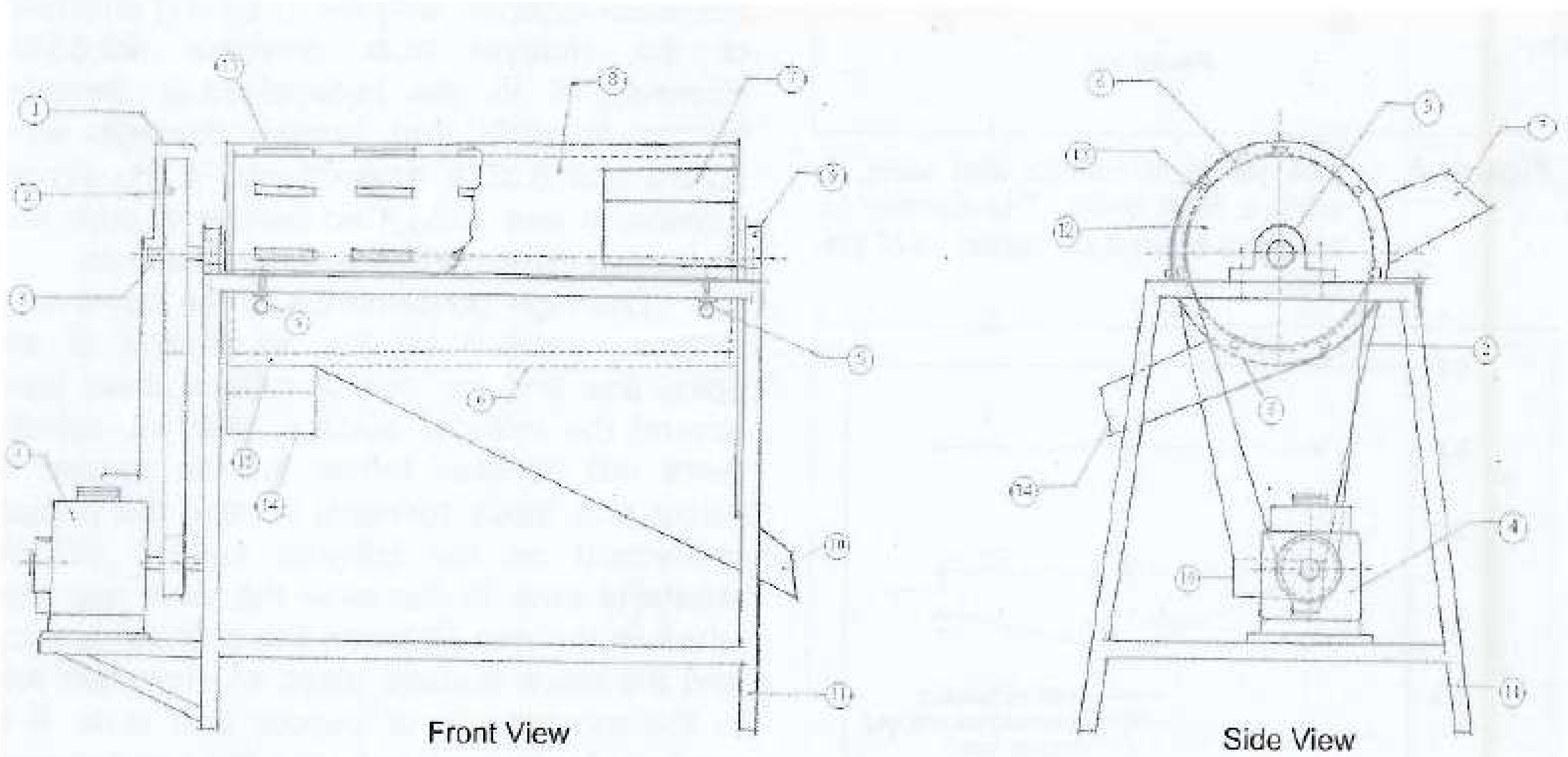
where Pe is the allowable surface pressure (kg/mm^2) and t is the depth of the key slot (mm). For the shaft with small diameter Pe = 8 (kg/mm^2) (Sularso and Suga, 2001). Since t_2 = 3.3 mm (the smaller depth), we have from Eq. 12 the key length l ≥ 22.9 mm. Therefore, the key length in the design l = 38 mm is quite strong toward shear stress and the surface pressure based on the calculation of Eqs. 11 and 12.

B. Performance Tests

The yields of berries and stalk with the feed levels of 10, 15, and 25 kg pepper are presented in Figure 4, while Figure 5 shows the percentages of stalk in berries, inseparable pepper and pepper loss in processing. The numbers in brackets in Fig. 4 are the percenltages of berries and stalk respectively. The processing times required for threshing pepper at the three feed levels were recorded in the performance tests as 1´50", 2´40" and 3´30" respectively.

As shown in Fig. 4, the yields of berries and stalk respectively increase as more feeds were put. However, their percentages are fairly constant i.e. 85 to 86% (85.6% on average) and 6% respectively. It means that of the three feed levels of 10, 15 and 25 kg pepper, the percentages of berries and stalk are not influenced by the feeds.

The identical patterns of the percentages of inseparable pepper, stalk in berries, and pepper loss in processing also show relatively constant trend and not



1. Safety cap
2. V. Belt drive
3. Shaft
4. Gasoline engine
5. Sieve gap adjuster
6. Sieve
7. Hopper
8. Cap
9. Bearing
10. Berry outlet
11. Frame
12. Cylinder
13. Threshing Teeth
14. Stalk outlet
15. Space for stalk

Figure 3. Sketch of the Simple Pepper Thresher

influenced by the feed levels of 10, 15 and 25 kg pepper (Figure 5). Moreover it was also found during the performance tests that there was almost no berries in stalk leaving from the stalk outlet and no berries damage leaving from the berry outlet.

The constant values of those percentages indicate that the thresher is relatively stable in performance even at different feed levels.

Because of those relatively constant percentages, the threshing capacity can be based on any of the three feed levels. Taking the feed level 20 kg pepper, the threshing capacity C = 20/3½ = 5.70 kg pepper per minute.

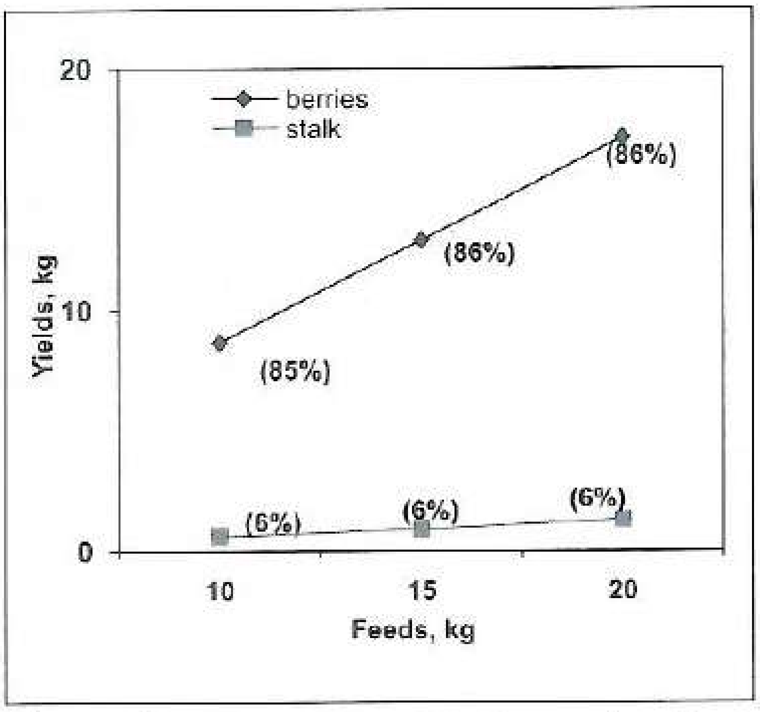


Figure 4. The yields of berries and stalk at various feed levels. The number in brackets are the percentages of the yields.

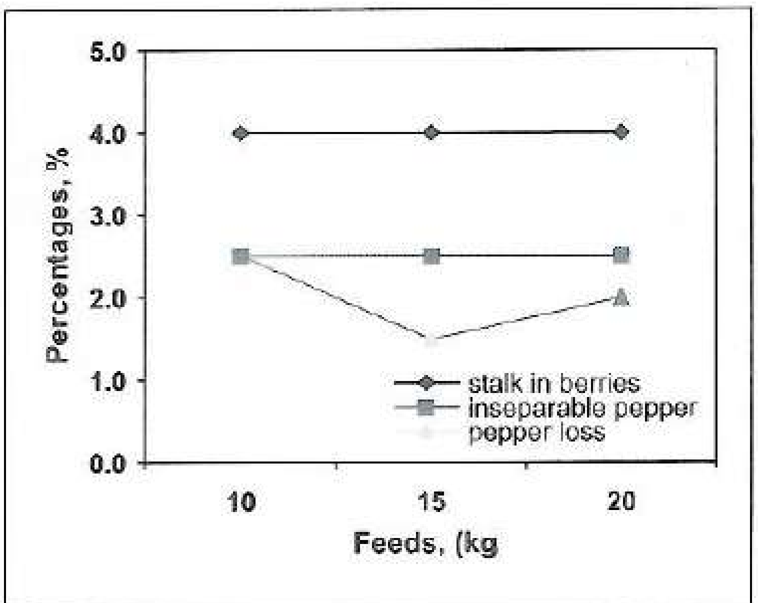


Figure 5. The percentages of stalk in berries, inseparable pepper and pepper loss in processing at various feed levels

Further, the percentages of inseparable pepper 2.5% on average and stalk in berries 3.8% on average are relatively small. This indicates that the tooth cylinder, the sieve and the cap as the threshing components have worked quite effective to thresh pepper at the power of 6½ hp and the rotation of 200 – 300 rpm. In addition, the inseparable pepper and stalk in berries leaving from the berry outlet can be sorted out manually from the berries. The inseparable pepper is then put to the thresher to be processed again.

Besides a relatively small quantity of pepper might be left in the thresher, the pepper loss in processing was probably water content of the pepper. Some berries especially the immature ones might be broken during processing releasing their water content indicated by wet condition of the cylinder surface after the processing of pepper.

If the percentages are based on the berry mass and by the assumption 85% of the inseparable pepper mass as berries mass, then it can be calculated that the percentage or efficiency of threshing = $\frac{85.5}{85.5+(0.85x2.5)}$ = 97.7% not much different with the threshing efficiency of the Hidayat et.al. thresher (98.55%). However, if in the Hidayat et.al. thresher berries in stalk and berries damage were 5.20% and 6.30% respectively, in the simple thresher it was almost no berries in stalk and no berries damage found during the tests.

The high performance of the thresher is probably caused by the elimination of the spiral fins and the use of rubber sheet layer around the cylinder surface. With no spirals, there will be less forces for the pepper to rotate and move forward, so that the pepper movement on the cylinder surface will be relatively slow. In this case the sieve gap size which is the gap between the cylinder surface and the sieve surface plays an important role in the movements of pepper and stalk. It is similarly for the cap gap size the gap between the cylinder surface and the cap surface.

Further, the rubber sheet layer is probably also contributes toward the relatively slow pepper movement which is caused by the frictional effect of the layer. As a result, the threshing process may occur mainly in the first section of the cylinder length. The stalk which can not pass through the sieve for its longer size will rotate and move forward in spiral paths in between the threshing teeth to the space for stalk (Figsure 2 and 3). Note that the sieve gap size in the first section of the cylinder length is designed a little bit wider than that in the other sections by the incline of the sieve. Eventually it may maximize the amount of berries on the berry outlet and stalk on the stalk outlet but minimize the amount of berries in stalk and berries damage.

Since the thresher has showed relatively high performance in threshing of pepper then it is not necessary to equip the thresher with the second stage sieve as in the Hidayat et.al. thresher (2001). Similarly, the stalk which has reached the front section of the cylinder length (right side in Fig.2) will enter the space for stalk freely before leaving the stalk outlet. Therefore, the blades to throw the stalk to leave the thresher as in the Hidayat et.al. thresher are not required more.

The strongness and rigidity of the shaft measured in its shear stress and torsional deflection from Eqs. 6 and 7 may have contribution to the relatively constant performance of the thresher when operating at different feed levels. In fact, as given in the shaft calculation the allowable shear stress of the shaft is higher than its shear stress working on it. Similarly, the allowable limit of the torsional deflection is higher than its torsional deflection working on the shaft. As stated by Sularso and Suga (2001), besides the strongness, the stiffness is also an important factor in shaft design. Shafts which are easily bent or changed in shape even in a very small value might disturb the threshing process of pepper and cause noises.

Moreover, in transmitting power and rotation from the prime mover to the shaft, the contact angle of the driving pulley should be considered in the V-belt drive design. As in the calculation before, this contact angle exceeds the minimum limit for the good V-belt drive design. A relatively small contact angle might cause the belt just slip on the surface of the pulley groove which potentially disturb the operation of the thresher.

Since the thresher is operated by two operators, then the productivity of threshing of pepper in relation to the processing time and labor inputs becomes 5.70/2 or 2.85 kg pepper per minute per operator. As a comparison as mentioned before, by manual method one person in one minute could separate berries from the stalk of 0.25 kg pepper.

C. Threshing Cost

The threshing cost of pepper consists of capital cost which is related to the initial price of the thresher and interest rates, maintenance cost, depreciation, cost for labors and cost for fuel.

We assumed that the life-span of the thresher in this research is 10 years, and the yearly processing time is four months according to the harvest season of pepper during a year. The interest rate is 15%.

Considering the time required for starting up and stopping the thresher and for adjusting the thresher if there is light trouble in processing etc, it is assumed that the effective processing time is only 60% as a safety factor for cost calculation. Therefore, the real threshing capacity per day = 5.70 (kg/minute) x 60 minute x 7 hours x 0.60 = 1436.4 kg pepper. The threshing capacity for one year is 1436.4 kg x 4 months x 30 days or around 172.350 kg pepper.

Operating hours for one year = 4 months x 30 days x 7 hours = 840 hours.

a. Capital cost = 15% x Rp. 16.000.000
= Rp. 2.400.000,-

b. Maintenance cost =
5% x Rp. 16,000,000 = Rp. 800,000,-

c. Depreciation (10 years)
10% x Rp. 16,000,000 = Rp. 1,600,000,-

d. Labor cost =
2 persons x 4 months x Rp 800,000/month
= Rp. 6,400,000,-

e. Fuel Cost:
6½ hp x 0.20 (kg/hp-hr) x 840 hours x
Rp. 6.000/kg = Rp. 6,552,000,-

Total threshing cost (a + b + ... +e)
= Rp. **17,747,000,-**

It is usually advisable to determine the cost analysis on a unit of product or raw material input basis. Therefore, the threshing cost per kg pepper = Rp. 17,747,000/172,350 kg or around Rp. 103,-

If it is assumed that the labor cost for separating berries of pepper manually is

Rp. 500.000/month, then the processing cost by manual method becomes:

$$Rp500.000x\left(\frac{1}{30days}\right)x\left(\frac{2hours}{7hours}\right)x\left(\frac{1}{30kg}\right)=158,75$$

or around Rp. 159,-

Note:

- The estimated prices and costs are based on the prices and costs in 2006
- The specific fuel consumption of gasoline engines = 0.20 – 0.22 (kg/hp-hr) (Arismunandar, 1980).
- Approximate expected life of agricultural machinery and equipment = 10 years (Handerson and Perry, 1976)

CONCLUSION

Although the thresher for pepper in this research is simple in mechanism, it still shows high performance even if compared with the performance of the Hidayat et.al. thresher (2001) as indicated in its percentages of berries, stalk, berries in stalk, stalk in berries and berries damage as well as in its capacity. Simplification of the mechanism, of course, may have advantages to reduce the sheller price, maintenance cost and probability of trouble in operation.

If compared to the manual method for separating of berries from stalk, the thresher in this research also has higher productivity but lower processing cost than those of the manual method.

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