



Design of Onion Epidermis Peeling and Onion Smoothing Machine with Rubber Friction Method Application

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Abstract

Onions are the main ingredients for all types of cuisine so the level of demand is quite high. In the industrial world, a great number of processes of onion epidermis peeling are still using either manual and simple low capacity methods or high capacity machines with expensive components. Therefore, it is necessary to make a high capacity machine to peel the onion epidermis in a short time by using inexpensive and durable components that are designed with the help of Solidworks software. The onion epidermis peeling and smoothing machine uses a 0.5 HP electric motor power as a bond drive and a rubber friction method for the process of peeling the onion epidermis. Besides, this machine is also designed to be compatible with peeling by connecting the rotation of the motor that is directly connected to the electric motor so that its design is simpler and does not require a long cycle of time. This peeling process is able to peel 2 kg of onion in 3 minutes and 0.5 kg for the refinement process in 5 minutes.

Keywords: Rubber friction method, onion epidermis, peeling, smoothing.

1. Introduction

Onions are a type of plant that is widely used as a cooking spice in various countries in the world. Apart from being able to make the taste of food delicious, onion is also rich in nutritional value. Therefore, onions continue to be used and even become one of the main needs in seasonings until now.

Judging from the current needs, it is clear that the use of onions is high in the daily lives of Indonesian people. In its processing, most of the stripping of the onion epidermis is still a problem for the majority of foodstuff producers whose main ingredient is onion. In addition, peeling the epidermis makes their eyes runny. So, it is deemed necessary to have an innovation similar to an onion epidermis peeling machine using a different system from the previous design. The motor power used on the previous machine is also large so that in terms of cost it is certainly expensive and requires considerable electrical power.

From the problems, this research will make a design of onion epidermis peeling and smoothing machine that has clean green epidermis with a different design using rubber friction and is easier to maintain and replace its components by utilizing centrifugal force and friction to peel onion epidermis. Thus, it is more efficient and effective because it can minimize cycle time.

Whereas the previous machine used a mounting system on all walls in the tube so that if it was calculated in terms of cost it would cost more.

1.1 Literature Review

Lydia 2017, made a redesign of garlic peeler machine that uses a spiral-shaped rubber which in its work process uses a blender tube media which is placed in the middle of the tube and can only accommodate the capacity of 0.25 onions in each process [1].



Figure 1. Prototype Design Results

The onion peeler machine has also been made by Sahrudin et al. 2018. This machine was named "Portable Onion Peeler Machine". This machine consists of a plate that is directly in

contact with the onion so it can make the epidermis of the onion peel off with a rough surface. The epidermis of the onion will be more easily peeled off with a large enough capacity [2].

Effendi, R, et al. 2018, also made the design of a multipurpose onion chopper machine driven by an electric motor with a capacity of 55 kg/hour. This machine uses an electric motor with a speed of 1400 rpm, power of 0.25 HP, and a voltage of 220 V, and the diameter of the drive shaft used is 9.586 mm [3].



Figure 2. Peeler Machine Design

Modification of Onion Peelers is also made by Ikram et al, 2018. The specification of the machines used are frame size 600x550x3mm, stripping tubes 400x350x2 mm and electric motor 1400 rpm. The test results of the machine designed to be able to peel 1500g of 2kg capacity of onions in 300 seconds. Where stripping reaches 79% [4].



Figure 3. Design of onion peeler machine

Preliminary studies on the design of onion peeling machines have been carried out by Saputro, et al 2017. The onion peeling machine design aims to help onion sellers in markets to meet consumer needs and to help food entrepreneurs or other entrepreneurs to speed up the peeling process. The design is made of a rotating system of onions using a stirring shaft connected to a 1 HP calling motor so that friction occurs between the onion and the designed wall so that the epidermis of the onion can be peeled off without damaging the onion [5].

Then a further study was carried out namely modification of the Shallot Peeler Machine by Ikram, et al 2018. The electric motor used has a power of 0.5 HP with a maximum rotation of 1400 rpm. This machine is also supported by the

existence of a peeling plate which is designed to peel the shallots by rotating at a certain speed and utilizing the rubbing of the rubber found on the part around the tube. It also has a container with a large enough capacity in order to keep the test material (onion) from being thrown out while the peeling process is in progress. In the testing process, there are two stages carried out. The first testing phase, the device is tested using a mass of red onions of 1 kg with a motor speed of 1400 rpm whose power is passed on to the peeling disk rotation through a belt and pulleys and using water inserted in a stripping tube. In this first test, the peeling process is carried out 3 times using the same mass of onion that is 1 kg for 5 minutes. The tool is able to produce an average of 767 grams of peeled onions. In this first test, the percentage of success of the tool was 79.8%. Furthermore, in the second test phase, the length of time and the rotational speed of the tool is still the same as in the first test phase which is still using a working time of 5 minutes and a rotational speed of 1400 rpm. However, the mass of onions added to the paring machine was added to 2 kg. So, an average yield of 1533 grams of chopped onions was obtained. With this result, the second experiment achieved a success rate of 79% [4,6].

1.2 Research Objectives

This research aims to create an innovative machine design that is different from existing designs and mobile. This system is made simple and easily understood by users by using all materials that are safe for food (food grade) with stainless steel and non-rubber materials and using hollow metal S403 as a construction that is not in direct contact with food ingredients

It also designs transmissions such as the use of small motor power, appropriate shaft and pivot dimensions, pulleys that can operate at the same time two functions, namely reducing the rotation of the peeling hopper and onion smoothing blender and have mechanical vibration attenuation below the safety and noise threshold and have a value depreciation of the machine so that it still has a sale value when it is used in the next few years.

2. Research Methods

The method used in this research is to design machine construction using Solidworks, where the frame dimensions are planned for length x width x height, 110 cm high, 60 cm long and 40 cm wide.



Figure 4. Design Results

The tube volume is for 17.6 liters or equivalent to 2 kg of onions while for the onion refiners after peeling are 2.2 liters or 0.5 kg equivalent.

The assembly process is the final stage of the process of designing and manufacturing the machine. In this process, each part or machine is put together to form a mechanical assembly that is ready for use in accordance with the planned function. Of course, before these parts are assembled, each section has gone through the measurement and calculation stages of the planning so that no part of the wrong size is found again.

The steps for assembling Onion Peeling and Smoothing Machines with a capacity of 2 kg is as follows. It begins with the installation of a 2-inch pulley to an electric motor and then the installation of a belt to the motor pulley (so that the frame is not later pinched) and the mounting of the motor against the frame. After that, the installation of the onion smoothing rotator, tube, and cap smoothing. The installation of pillow bearings to the upper frame is also carried out when mounting the stirring shaft to the pillow bearings. Then, the installation of 10-inch pulleys to the stirrer shaft followed by the installation of belts on both pulleys, Pillow bearings 2 on the lower frame and ending with the installation of a peeler tube, onion stirrer and the lid of the tube. After the components have been combined or assembled, the machine can be used in accordance with its function.

3. Results and Discussion

3.1 Material for Making Peelers and Smoothing Onions

The materials needed in the design or manufacture of onion peeler and smoothing machines can be seen in the table 1:

Table 1. List of Machinery Manufacturing Materials

No	Material	Amount	Information	Specification
1	Hollow Iron	1 bar	as a framework	4x4 cm x 6 m
2	Galvanized Plate	1 sheet	as a tube holder on the frame	4x150 cm
3	Stainless Steel Plate	1 Pcs	as making peeler tubes	0,5x1 meter
4	Blender Tubes	1 Pcs	as a container for smoothing onions	2 Liter
5	Blender Knife	1 Pcs	as an onion smoothing knife	4x4 cm
6	Electric Motor	1 Pcs	as a mover	0,5HP
7	Pulley	2 Pcs	for motor pulleys and stirrer shafts to continue the motor rotation to the stirrer shaft to turn the onion peeler plate	2-inch & 10-inch
8	V-Belt	1 Pcs		Tipe-A 135 cm
9	Iron Shaft	1 Pcs		D=25 mm
10	Pillow Bearing	2 Pcs	as a peeler shaft bearing	D=25,4 mm
11	Peeling Rubber	8 Pcs	as a friction media on onions to connect between components on the frame as an anti-rust coating on the frame and adds artistic value	2x8 cm
12	Bolts and Nuts	10 Pcs		bolts 12 bolts 10
13	Paint	3 Pcs		Pylox Light Green

3.2 Calculation of Onion Peeler and Smoothing Tube

❖ Onion Peeler Tubes

Based on the size of the onion which has an average diameter of 2 cm and it is planned to meet 2 kg of onions in one peeling process, we need to calculate the required tube dimensions and volume, which in this design uses a tube shape with a diameter of 30 cm and a height of 25 cm. To calculate the capacity of the tube the following volume formula is used [3,9]:

$$\begin{aligned}
 V_t &= \pi r^2 \cdot t & (1) \\
 &= 3,14 \times (15\text{cm})^2 \times 25\text{cm} \\
 &= 17.662,5 \text{ cm}^3 = 17,6 \text{ dm} = 17,6 \text{ Liter}
 \end{aligned}$$

With a 17.6 liter result, it can be said to be ideal for loading 2 kg of onions which in the process requires more space so that the onion does not come out of the container during the process.

❖ **Onion Smoothing Tube**

In this design, the onion smoothing tube is planned to hold 0.5 kg, so the tube for onion refiners uses a blender jar that is already on the market that has a dimension of 20 cm high and 12 cm in diameter, then it can be calculated:

$$V_t = 3,14 \times (6\text{cm})^2 \times 20\text{cm}$$

$$V_t = 2260,8 \text{ cm}^3 = 2,2\text{dm} = 2,2 \text{ Liter}$$

With 2.2 liter results, it is certain to hold 0.5 kg of onion per process.

Table 2. Results of Tube Volume Calculations

Component	Capacity
Peeler Tube	10,8 Kg
Smoothing Tube	1,4 Kg

3.3 Motor Calculations

It is known that the motor power is 0.5 HP = 0.37 kW and the correction factor is 1.3. Taken based on the use of machines 8-10 hours per day [8].

❖ **Motor synchronous speed (rpm)**

$$n_s = \frac{120 \times F}{p} \tag{2}$$

$$= \frac{120 \times 50}{4,5}, n_s = 1330\text{rpm}$$

❖ **Calculating slip-on Motor**

$$\% \text{Slip} = \frac{n_s - n}{n_s} \times 100 \tag{3}$$

$$= \frac{1330 - 1330}{1330} \times 100 = 0$$

❖ **Power Plans**

$$P_d = f_c \cdot P \tag{4}$$

$$= 1,3 \times 0,37\text{kW} = 0,481 \text{ kW}$$

❖ **Calculate the torque produced**

$$T = \frac{5252 \times P}{N} \tag{5}$$

$$= \frac{5252 \times 0,5}{1330}, T = 1,97 \text{ Nm}$$

❖ **Calculate motor rotation per second**

$$v = \frac{\text{Rpm}}{\text{Detik}} \tag{6}$$

$$= \frac{1330}{60} = 22,1 \text{ Rps}$$

❖ **Calculate mechanical power**

$$P_m = 9,8 \times \mu \times w \times v \times 10^{-3} \times \frac{100}{\eta} \tag{7}$$

$$P_m = 9,8 \times 0,06 \times 0,5 \times 22,1 \times 10^{-3} \times \frac{100}{65}$$

$$P_m = 0,26 \text{ watt} = 260 \text{ Kw}$$

3.4 Onion Peeler Shaft Round Planning

The planned rotation of the onion peeler shaft is 250 rpm where the motor used has 1330 rpm. The type of pulleys used are type-A pulleys where the motor pulleys have a diameter of 2 inch and a diameter of peeling pulleys of 10 inch. So, to find out the resulting rpm, it can be calculated by using the following formula [7,9,10]:

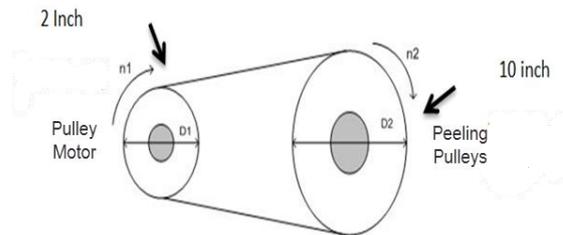


Figure 5. Pulley Dimensions

$$\frac{n_2}{n_1} = \frac{D_1}{D_2} \tag{8}$$

$$\frac{n_2}{1330\text{rpm}} = \frac{50,8\text{mm}}{254\text{mm}}, n_2 = 266 \text{ rpm}$$

With the result $n_2 = 266 \text{ rpm}$, it can be said to be ideal if you look at the planned rpm before 250 because the pulley ratio is the closest to the planned rpm when compared to other pulley size comparisons [8,9].

3.5 V-Belt Calculation

The distance between pulley centers is known to be 250 mm, so the required V-belt length can be calculated by using the following formula [9-12]:

❖ **Calculating the V-Belt Length**

$$L = 2C + 1,57 \times (d_1 + d_2) + \frac{(d_1 - d_2)^2}{4C} \tag{9}$$

$$\frac{(50,8\text{mm} - 254\text{mm})^2}{4 \times 250\text{mm}} = 1340 \text{ mm} = 134 \text{ cm}$$

So, if counted through the outside diameter of the belt, a belt length of 134 cm is needed. Because the pulleys used are type-A pulleys, the V-belt used also uses type-A V-belts.

❖ **Calculating plan moments (T_1, T_2)**

$$T_1 = 9,74 \times 10^5 \times \left(\frac{P_d}{n_1} \right) \text{ (Kg.mm)} \tag{10}$$

$$= 9,74 \times 10^5 \times \left(\frac{0,481}{1330} \right) = 352,25 \text{ (kg.mm)}$$

$$T_2 = 9,74 \times 10^5 \times \left(\frac{0,481}{266} \right) = 1761,25(\text{kg}\cdot\text{mm})$$

❖ Calculating belt speed

$$v = \frac{d_p n_1}{60 \times 1000} \quad (11)$$

$$= \frac{50,8 \text{ mm} \times 1330}{60 \times 1000} = 1,12 \text{ (m/s)}$$

3.5 Shaft Calculations

❖ Twisted Moment

$$T = 9,74 \times 10^5 \frac{(Pd)}{n_1} \quad (12)$$

$$= 9,74 \times 10^5 \frac{0,481}{1330} = 352,25 \text{ (kg}\cdot\text{mm)}$$

Using S45C-D material (Cold Defined Steel Bar), Tensile Strength, $\sigma_B = 60 \text{ (kg/mm}^2\text{)}$, and Safety Factor $Sf_1 = 6,0$, $Sf_2 = 2,0$

❖ Shear Stress

$$\tau_a = \sigma_B / (Sf_1 \times Sf_2) \quad (13)$$

$$= \frac{60}{6,0 \times 2,0} = 5 \text{ (kg}\cdot\text{mm}^2\text{)}$$

❖ Moment correction factor (K_t) and cleural factor (C_b)

$$d_s = \left[\frac{5,1}{\tau_a} K_t C_b T \right] \quad (14)$$

$$= \left(\frac{5,1}{5} \times 1,2 \times 1,5 \times 352,25 \right)^{1/3} = 13 \text{ (mm)}$$

From the results, which is 13 mm to find the safety factor of this machine design using a 25 mm diameter shaft.

3.6 Calculation of Mechanical Vibrations

❖ To find the vibration value (ωn), we first look for the k value as follows [11-12]:

$$K = \frac{3EI}{b^3} = \frac{3a^3}{4b^3} \quad (15)$$

$$= \frac{2,0 \times 10^{11} \times 0,15 \text{ m} (0,002 \text{ m})^3}{4 (0,6)^3}, = 27,77 \text{ N/m}$$

❖ It deals with parameters of personal frequency or natural frequency in one radians/sec and this frequency is obtained from the following equation:

$$\omega_n = \sqrt{\frac{k}{m}} = \quad (16)$$

$$= \sqrt{\frac{27,77}{5}}, = 2,35 \text{ rad/det}$$

❖ The natural frequency in units according to the expert given the honor, namely Hz becomes:

$$fn = \frac{1}{2\pi} \sqrt{\frac{k}{m}} \quad (17)$$

$$= \frac{1}{2\pi} 2,35 = 0,37 \text{ Hz}$$

3.7 Tool Frame Calculation

In the construction of the framework, it is necessary to calculate the load analysis that will be used for the construction to be made so that it can determine the feasibility of the frame construction that will be used. The type of iron used in making the frame is 4x4 cm galvanized hollow iron. The strength of the support experienced by the frame can be calculated as follows:

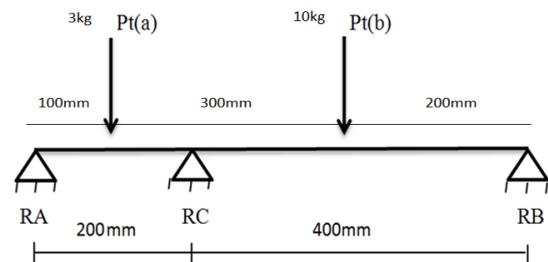


Figure 6. Load Analysis on Frame A-B

Loads that rely on cross-sections in the form of shafts, pulleys, tubes and others. It has been measured and can be loaded $Pt(a) = 3\text{kg} \times 9,8 \text{ m/s}^2 = 29,4 \text{ N}$, and load $Pt(b) = 10\text{kg} \times 9,8 \text{ m/s}^2 = 98 \text{ N}$. Thus, based on available data, it can be calculated:

❖ Calculating Force from Pt (a)

$$\sum MA = 0 \text{ (point A is on the support)}$$

$$W = \frac{1}{2} L - RC \cdot L = 0 \quad (18)$$

$$RC = \frac{W \cdot \frac{1}{2} L}{L}$$

$$RC = \frac{29,4 \text{ N} \times \frac{1}{2} 100 \text{ mm}}{100 \text{ mm}} = 14,7 \text{ N}$$

$$RA = \frac{29,4 \text{ N} \times \frac{1}{2} 100 \text{ mm}}{100 \text{ mm}} = 14,7 \text{ N}$$

❖ Calculating Force from Pt (b)

$$\sum MC = 0$$

$$RB = \frac{W \cdot \frac{1}{2} L}{L}$$

$$RB = \frac{98 \text{ N} \times \frac{1}{2} 200 \text{ mm}}{200 \text{ mm}} = 49 \text{ N}$$

$$RC = \frac{98 \text{ N} \times \frac{1}{2} 200 \text{ mm}}{200 \text{ mm}} = 49 \text{ N}$$

Then, the overall burden can be added to $RA + RB = 14,7 \text{ N} + 49 \text{ N} = 76 \text{ N}$. After the load of the total

results has been known then To find out the actual RA and RB values can be calculated:

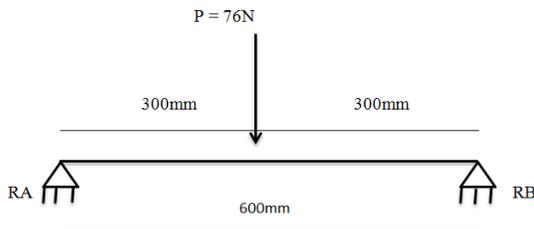


Figure 7. Continued Load Analysis

$$\sum MA = 0$$

$$RB = \frac{W \cdot \frac{1}{2} L}{L}$$

$$RB = \frac{76N \times \frac{1}{2} \times 300mm}{300mm} = 38 \text{ N}$$

$$RA = \frac{76N \times \frac{1}{2} \times 300mm}{300mm} = 38 \text{ N}$$

3.8 Bearing Calculation

The bearings used are UCP 205 type rolling bearings.

❖ Radial Load (F_r)

$$F_r = \frac{m \cdot g}{n} \quad (19)$$

$$F_r = \frac{1.9,8}{2} = 4,9 \text{ N}$$

❖ Dynamic Equivalent Load (P_r)

The value $V = 1$ for the ring in spin, and the value of factor $X = 0.56$ based on the specified value.

$$P_r = X \cdot V \cdot F_r \quad (20)$$

$$P_r = 0,56 \times 1 \times 4,9 = 2,7kg$$

❖ Static Equivalent Load (F_n)

The factor value $X_o = 0.6$ based on the predetermined value

$$P_o = X_o \cdot F_r \quad (21)$$

$$P_o = 0,6 \times 4,9 = 2,9 \text{ kg}$$

❖ Determine the Speed Factor (f_n)

The shaft rotation speed is $n = 266 \text{ rpm}$

$$f_n = \left(\frac{33,3}{n} \right)^{1/3} \quad (22)$$

$$f_n = \left(\frac{33,3}{266} \right)^{1/3} = 0,5$$

❖ Determine Age Factors (f_h)

Known C (Basic Load System) = 2002,68 and P (Constants for ball bearings) = 3

$$f_h = f_n \cdot \frac{C}{P} \quad (23)$$

$$f_h = 0,5 \cdot \frac{2002,68}{3} = 33,78$$

❖ Determine Nominal Age (L_h)

For both bearings $f_h = f_n \cdot \frac{C}{P}$

$$L_h = 500 \cdot f_h^3 \quad (24)$$

$$L_h = 500 \cdot (33,78)^3 = 17968 \text{ hours}$$

If the use of this machine is carried out continuously without stopping then the bearing life reaches 17968 hours = 750 days, planned use of the machine is 8 hours per day, so that the life of the machine can reach 2250 days or 6 years.

3.9 Calculation of Machine Depreciation

To find the price of engine depreciation based on bearing life that has been calculated which is 6 years, it is needed to know the overall cost of making the machine and also the life of the machine. The following table details the costs required in making a onion peeler and smoothing machine:

Table 3. Breakdown of Manufacturing Costs

Process	Amount	Cost
Making the Peeler Tube	1 Pcs	Rp.2500.000
Blender Tubes	1 Pcs	Rp.100.000
Making the Frame	1Pcs	Rp.1.500.000
Electric Motor 1/2HP	1 Pcs	Rp.670.000
Pulley	2 Pcs	Rp.150.000
Pillow Block (bantalan)	2 Pcs	Rp.70.000
V-Belt	1 Pcs	Rp.18.000
Iron Shaft	1 Pcs	Rp.55.000
Peeling Rubber	8 Pcs	Rp.70.000
Bolts and Nuts	20 Pcs	Rp.20.000
Spray Paint	3 Pcs	Rp.93.000
Additional Costs	-	Rp.300.000
TOTAL		Rp.5.546.000.

Based on the details of the machine making funds above and the existing data, the depreciation value can be calculated as follows:

❖ Method Number of Years

Table 4. Method Total Number of Years

Year	Year Number (Reverse Order)	Depreciation Factor
1	6	6/21
2	5	5/21
3	4	4/21
4	3	3/21
5	2	2/21
6	1	1/21
Jumlah	21	

Table 5. Calculation of Depreciation Value

Year	Annual Depreciation	Accumulation BV
	DDB rate BV	Depreciation
0	5.546.000	5.546.000
1	$6/21 \times 5.546.000 = 1.584.570$	3.961.429
2	$5/21 \times 3.961.429 = 943.197$	3.018.232
3	$4/21 \times 3.018.232 = 574.901$	2.443.422
4	$3/21 \times 3.018.232 = 431.176$	2.012.246
5	$2/21 \times 2.012.246 = 191.642$	1.820.784
6	$1/21 \times 1.820.784 = 86.704$	1.734.080

Based on the table above, the residual value of the life of the machine used for 6 years is Rp. 1,734,080.

3.10 Test Results

The final stage of the Calculation and Design of Onion Epidermis Peeling and Smoothing Machine is to do a test to find out whether the machine runs with its function. This test has performed a total of 6 times, 3 times stripping test and 3 times onion crushing test. While the stripping test was carried out 3 times with a capacity of 2 kg of onion for 3 minutes, 5 minutes and 8 minutes. The onion smoothing test was also carried out with a capacity of 0.5 kg in 3 minutes, 5 minutes and 7 minutes. Where will be known the effective time needed for the maximum percentage of success of this machine.

❖ Onion Stripping Process

Table 6. Results of the Onion Stripping Process

No	Onions Capacity	Time	Percentage (%)
1	2 kg	3 minutes	70%
2	2 kg	5 minutes	85%
3	2 kg	7 minutes	95%

Based on the percentage of the results of the stripping process in table 6, it can be said to have a high effectiveness compared to stripping the onion epidermis manually, and the machine design can be said to be successful.

❖ Onion Smoothing Process

Table 7. Results of the Onion Smoothing Process

No	Onions Capacity	Time	Percentage (%)
1	0.5 kg	3 minutes	85%
2	0.5 kg	4 minutes	96%
3	0.5 kg	5 minutes	100%

From the results obtained, it takes 5 minutes only to smooth the onions to achieve maximum results.

4. Conclusions

Based on the results of the tests conducted, it can be concluded that the results of onion epidermis peeling have increased significantly compared to the previous design of the tool. The time required for the previous tool is 5 minutes with 79% results, while the results of this latest machine is 5 minutes with a result of 85%. So, there is a difference in yield of 6% increase, while the results of refinement itself reached 100% in the five minutes.

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