

Competitive Research Grant  
**Sub-Project Completion Report**

on

Design and Development of Power Operated Palm Oil  
Fruit Stripper

Project Duration

August 2017 to September 2018

Submitted By

Department of Farm Power & Machinery  
Bangladesh Agricultural University, Mymensingh

Submitted to

Project Implementation Unit-BARC, NATP 2  
Bangladesh Agricultural Research Council  
Farmgate, Dhaka-1215



September 2018

Competitive Research Grant (CRG)

# Sub-Project Completion Report

on

Design and Development of Power Operated Palm Oil  
Fruit Stripper

Project Duration

August 2017 to September 2018

Submitted By

Department of Farm Power & Machinery  
Bangladesh Agricultural University, Mymensingh

Submitted to

Project Implementation Unit-BARC, NATP 2  
Bangladesh Agricultural Research Council  
Farmgate, Dhaka-1215



September 2018

Citation

**[Design and Development of Power Operated Palm Oil Fruit Stripper]**

Project Implementation Unit

National Agricultural Technology Program-Phase II Project (NATP-2)

Bangladesh Agricultural Research Council (BARC)

New Airport Road, Farmgate, Dhaka – 1215

Bangladesh

Edited and Published by:

Project Implementation Unit

National Agricultural Technology Program-Phase II Project (NATP-2)

Bangladesh Agricultural Research Council (BARC)

New Airport Road, Farmgate, Dhaka – 1215

Bangladesh

***Acknowledgement***

The execution of CRG sub-project has successfully been completed by [insert org/inst/uni] using the research grant of USAID Trust Fund and GoB through Ministry of Agriculture. We would like to thanks to the World Bank for arranging the grand fund and supervising the CRGs by BARC. It is worthwhile to mention the cooperation and quick responses of PIU-BARC, NATP 2, in respect of field implementation of the sub-project in multiple sites. Preparing the project completion report required to contact a number of persons for collection of information and processing of research data. Without the help of those persons, the preparation of this document could not be made possible. All of them, who made it possible, deserve thanks. Our thanks are due to the Director PIU-BARC, NATP 2 and his team who given their whole hearted support to prepare this document. We hope this publication would be helpful to the agricultural scientists of the country for designing their future research projects in order to technology generation as well as increasing production and productivity for sustainable food and nutrition security in Bangladesh. It would also assist the policy makers of the agricultural sub-sectors for setting their future research directions.

Published in: September 2018

Printed by: [Name of press with full address]

## Acronyms

%	Percentage
&	And
BAU	Bangladesh Agricultural University
mm	Millimeter
Kg	Kilogram
FFA	Free fatty acid
FFB	Fresh fruit Bunch
Hr	Hour
t	Ton
KW	Kilo watt
Tk	Taka

## Table of Contents

Sl. No.	Subject	Page No.
	Acknowledgement	iii
	Acronyms	iv
	Contents	v
	Executive Summary	vi
<b>A</b>	<b>Sub-project Description</b>	<b>1-21</b>
1	Title of the CRG sub-project	1
2	Implementing organization	1
3	Name and full address with phone, cell and E-mail of PI/Co-PI	1
4	Sub-project budget (Tk)	1
5	Duration of the sub-project	1
6	Justification of undertaking the sub-project	1
7	Sub-project goal	2
8	Sub-project objective (s)	2
9	Implementing location (s)	2
10	Methodology in brief	2
11	Results and discussion:	10
12	Research highlight/findings	20
<b>B</b>	<b>Implementation Position</b>	<b>21</b>
1	Procurement:	21
2	Establishment/renovation facilities	21
3	Training/study tour/ seminar/workshop/conference organized	21
C	Financial and physical progress	21
D	_Achievement of Sub-project by objectives	22
E	Materials Development/Publication made under the Sub-project	22
F	Technology/Knowledge generation/Policy Support (as applied):	23
G	Information regarding Desk and Field Monitoring	23
H	Lesson Learned/Challenges	24
I	Challenges	24

## Executive Summary

In Bangladesh, use of edible oil is not limited to cooking purpose only; it has wide use in various industries as raw material. Each year, government of Bangladesh as well as business individuals import considerable amount of edible oil from foreign countries. Dependency for edible oil on other countries are affecting negatively on our national balance of payment, because huge currency flows away to other countries. Unfortunately, this dependency is increasing day by day. However, we can decrease this problem by reducing dependency on edible oil if we produce oil in our country. This may sound a little bit difficult, but it is attainable indeed. Recently palm oil has opened a new dimension in edible oil market, especially in Bangladesh. Malaysia and Indonesia are the main productive country of palm fruit production. The production of palm fruit is also increasing in Bangladesh. The consumption rate of palm fruit was 23.29% in 2017 which was 4.29% in 2008. Recently government has given priority for oil palm plantation in order to meet up the country's emerging need for edible oil on the one hand and reduce the valuable currency on the other. However, absence of suitable palm oil processing technology (crude oil from FFB), a lot of fresh fruit bunch are wasted. Optimization of the processing technologies and/or machines will go a long way to improve palm oil extraction efficiency which makes the palm oil more popular.

The design of the palm fruit stripper had been done to use the auto-cad software. The design and parts specification had been selected based on locally available material that is low-cost, higher through put, more efficient, easy to operate and easy to maintain. Effective sterilization time and temperature were undertaken in the departmental workshop. Three different temperatures (100, 120, 140)<sup>0</sup>c were considered to this experiment. Three different times (5, 10, 15) minutes were taken for each sterilization temperature (Fig. 3.7(a)). At two minutes interval the temperature was measured (Fig. 3.7(b)). Another experiment was done at control treatment (without sterilization). The best performance was found by this experimentation. A vertical type cylinder (d=560mm, h=465mm) set up on a table type frame. Four spikes were adjusting with the shaft. Fruit had been collected from Dinajpur and BAU campus to conduct the experiment. The best performance of this machine came from the combination of sterilization temperature 120<sup>0</sup>c and sterilization time 10 minutes and performance was very low at control treatment (without sterilization). The best operating capacity and stripping efficiency of the machine had been determined to be 0.811 ton/hr and 98.5 respectively.

This machine could be preferable for both small and medium scale palm oil processors.

## CRG Sub-Project Completion Report (PCR)

### A. Sub-project Description

1. Title of the CRG sub-project: **Design and Development of Power Operated Palm Oil Fruit Stripper**
2. Implementing organization: Bangladesh Agricultural University, Mymensingh-2202
3. Name and full address with phone, cell and E-mail of PI/Co-PI (s):

**Dr. Md. Abdul Awal**

Professor

Department of Farm Power and Machinery

Bangladesh Agricultural University, Mymensingh-2202

Email: [awalbau@gmail.com](mailto:awalbau@gmail.com);

Phone: 01710987258

4. **Sub-project budget (Tk):**

4.1 Total: **20,00,000.00** (Twenty Lacs Only)

4.2 Revised (if any): **20,00,000.00** (Twenty Lacs Only)

5. **Duration of the sub-project:** One year and two months

5.1 Start date (based on LoA signed): **August, 2017**

5.2 End date: **30 September, 2018**

6. **Justification of undertaking the sub-project:**

Traditionally, the harvested palm fruit bunches is heaped and allowed to ferment to facilitate easy stripping of the fruits. The picked fruits are then collected and digested into a mash, after which it is mixed with water and agitated in a pit to separate the crude oil from the mixture. After adequate mixing, the oil that floats at the tip is scooped off for clarification. Apart from the drudgery, time wasting and high labour requirement in this method, it gives poor quality oil as the period of fermentation increases the free fatty acid (FFA) content of the oil. According to Badmus (1991), processing the fruit without delay or fermentation yielded the highest oil extraction of 87 percent and best quality oil with free fatty acid (FFA) of 2.31 percent. Hence, it is important that fresh fruit bunches be processed as soon as possible so as to prevent a rapid rise in free fatty acid which normally affect the quality of crude palm oil. In the processing part a palm oil stripper is an important part which separates the fruit from the brunch, which is time consuming, laborious and health hazard. There are various types of stripper which are functionally nearly same but different

in shape and structure (vertical, horizontal or inclined). The stripper minimizes the stripping time, cost and human drudgery.

**7. Sub-project goal:** Development of new machine for separation of palm fruit from the bunch easily and rapidly with less drudgery.

**8. Sub-project objective (s):**

- To determine effective treatments (temperature, sterilization time etc) for efficient fruit separation.
- To design and develop different parts of an oil palm stripper machine.
- To evaluate the working performance of the machine in the Laboratory.

**9. Implementing location (s):** Department of farm power and machinery, BAU, Mymensingh

**10. Methodology in brief:**

Experiment was conducted at the laboratory of farm power & machinery department, BAU to design and development of a palm oil stripper. The full design of this machine was done by using Auto-Cad software. Design considerations and design analysis was considered to design and fabrication of this machine.

**Design Considerations**

Some of the factors which were taken into account while designing the palm fruit stripper are as described:

**Reliability and performance of the various components**

Factors such as rigidity, deflection, wear, corrosion, vibration and stability were considered in the selection of appropriate material, sizing and shaping of the various machine components. Also, in order to take into account a number of uncertainties such as variation in material properties, effect of environment in which the machine is expected to operate, and the overall concern for human safety, provisions were made through the use of factor of safety stipulated by standard and experience.

**Availability of materials**

The machine was constructed of locally available materials so as to enhance the possibility of replacing damaged parts with less expensive but equivalently satisfactory parts that are locally available.

**Simplicity**

The ease of design and fabrication of machine for productivity were considered, bearing in mind the need of dismantling to carry out routine cleaning and maintenance of the machine when necessary so as to maintain higher level of performance and also for the possibility of conveying the machine from one point of use to the other whenever the need arises.

### **Effectiveness**

Meeting the farmers general requirements with minimum loss of oil that may arise from oil being absorbed and carried off by the stalks of the stripped bunches or loss due to unstripped fruits still attached to the bunches. And also the need to have a fruit discharge outlet that is different from the stripped bunch discharge outlet for optimum separation.

### **Cost**

The reduction of cost was taken into account through critical value analysis on the phases of design, material selection, production and maintenance of the machine which at the end make it affordable by farmers and other intending users.

### **Design Analysis**

In the design of this machine, relevant physical and mechanical properties of oil palm fruits were considered as a basic design input for the determination of the mesh size for the drum sieves and power requirement. Other factors considered include availability of materials, cost of materials, durability, and the ease of feeding and discharging of palm fruit bunches, and the condition of palm fruit bunches before stripping.

#### **Stripping Chamber:**

The stripping chamber was cylindrical in shape with diameter of 0.560 m (fig. 1)

$$D = \text{diameter of the cylinder} = 0.56 \text{ m}$$

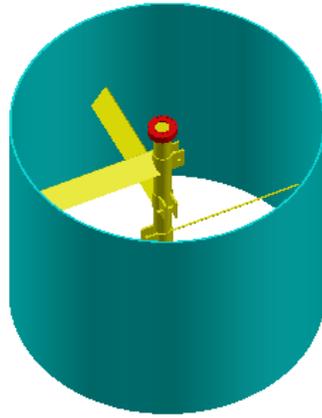
#### **Volume of the stripping unit (cv):**

The mathematical expression given by balogun et al (2009) was adopted to determine the volume of the stripping unit.

$$Cv = \pi r^2 h$$

Where h = height of the stripping unit (m)

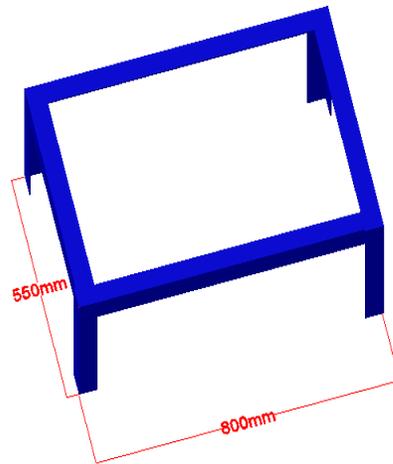
r = radius of the stripping unit (m)



**Fig. 1:** Design of stripping chamber

**Supporting frame:**

A supporting frame was necessary to set up the cylinder. The size of the supporting frame was proper to set up the cylinder. Fig 2 shows the design of the supporting frame.



**Fig. 2:** Design of supporting frame

**Shaft Diameter:**

Mild steel was used to shaft design and shaft diameter was obtained from the following expression given by Khurmi and Gupta (2005)

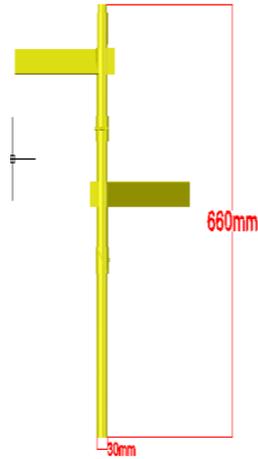
$$d^3 = \frac{32m_c}{\pi\sigma_b}$$

Where d = Shaft diameter (mm)

$m_c$  = Equivalent bending moment

$\sigma_b$  = maximum permissible working stress

The shaft and the arrangement of the beaters are shown in figure 3.



**Fig. 3:** Design of shaft and beaters

#### **Selection of Pulley Speed:**

Pulley speed was selected by using the equation as stated by Onifade (2016) Stephen and Emmanuel (2009)

$$N_1D_1 = N_2D_2$$

Where, N1 =speed of the driving pulley (rpm)

D1 = diameter of driving pulley (mm)

N2 speed of the driven pulley (rpm)

D2 = diameter of the driven pulley (mm)

#### **Belt length and Centre Distance:**

The center distance between the two adjacent pulleys and belt length were calculated using equation as stated by Khurmi and Gupta (2005), Akande and Onifade (2015)

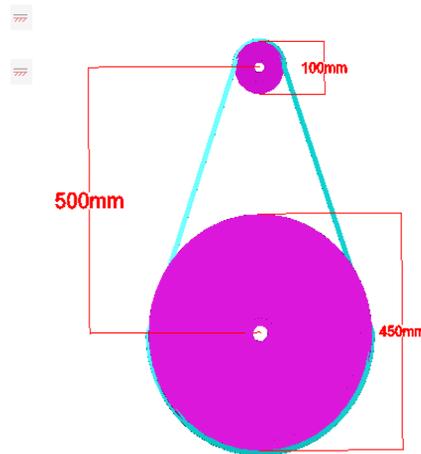
$$C = \frac{D_1 + D_2}{2} + D_1$$

For belt length

$$L = \frac{\pi}{2} (D_1 + D_2) + 2C + (D_1 - D_2)/4C$$

Where, C = center distance

The design of the belt-pulley arrangement is shown in figure 4. B-type V-belt made from rubber and nylon was used to transmit the power from the motor to the shaft.



**Fig. 4:** Design of belt and pulley

### Power Requirement

A change in speed of any fan in operation will predictably change the pressure rise and power necessary to operate under predictable sets of laws concerning its speed, power and pressure (Ojomo, et al, 2010), the law can be applied to agricultural equipment that uses shaft as a power take off, one of the equations from these laws is given as

$$\frac{K_{w1}}{K_{w2}} = \left(\frac{N_1}{N_2}\right)^2$$

Where  $K_{w1}$  = power from the motor KW

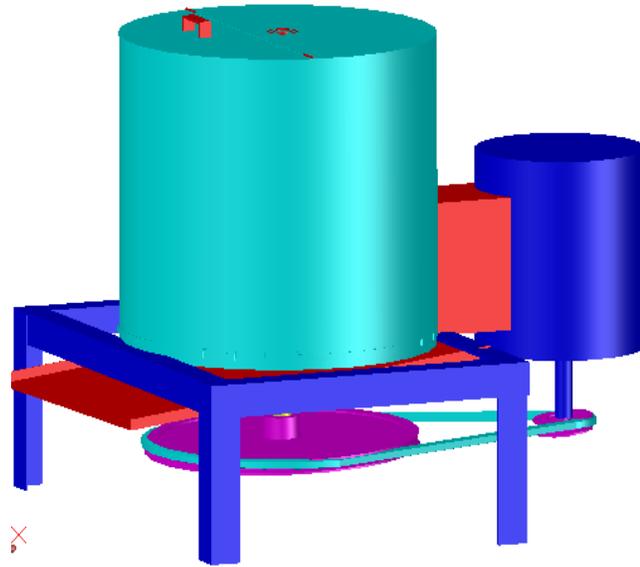
$K_{w2}$  = power required by the Gear shaft, KW

$N_1$  = speed of the gear shaft rpm

$N_2$  = speed of the motor rpm

### Design of the stripper:

The design of the machine is shown in figure 5. The power was transmitted from the motor to the shaft by using belt-pulley. The motor rpm was 1800 which was converted in 450 rpm by using the belt-pulley.



**Fig. 5:** Complete design of stripper

### **Fruit collection**

Fruits had been collected from Dinajpur and BAU campus, Mymensingh for experimentation. Fig 6(a) shows the collection of fruits from the field. The collected fruits were mature properly. The collected fruits were gathered in the workshop which shown in figure 6(b).



**Fig. 6(a):** collecting fruits



**Fig. 6(b):** Gathering collected fruits

### **Determine effective treatment**

Effective sterilization time and temperature were undertaken in the departmental workshop. Three different temperatures (100-110, 110-120 and 120-140)<sup>0</sup>C were considered to this experiment. Three different times (5, 10, 15) minutes were taken for each sterilization temperature (Fig. 7). At two minutes interval the temperature was measured. Temperature was measured at the time of steaming of the palm fruits by industrial thermometer. Another experiment was done at control treatment (without sterilization). The best performance was found by this experimentation.



**Fig. 7:** Measuring temperature at two minutes interval

### **Performance test of the stripper**

The bunch was placed at the stripping chamber after sterilization. When the motor was started the fruits was started to separate from the bunch as the result of hitting of beaters. The separated fruits were collected by the outlet tray (Fig 8). The fruits were counted as separated fruits, injured fruits and attached fruits.



**Fig. 8:** Machine operation

## **Cost Estimation**

### **Annual worth method**

In annual worth (AW) method, annual worth analysis is defined as the equivalent uniform annual worth of all estimated receipts (income) and disbursements (costs) during the life cycle of a project.

In annual worth method, annual worth of a farm is calculated as,

$$AW = AR - AC \text{ (Obukoeroro, 2011)}$$

Where,

AW = Annual worth (Tk.)

AR = Annual revenue (TK.) and

AC= Annual cost (Tk.)

Annual revenue can be calculated as,

Annual revenue= Capacity of plant (kg of separated fruits/day)\*working days/year\*selling price per kg of separated fruits \* machine efficiency

The machine is economically attractive if  $AW \geq 0$

### **Benefit Cost Ratio (BCR) Method**

The BCR is the ratio of discounted benefits to the discounted cost with reference to the same point in time. Data were analyzed using descriptive statistics, gross margin and profitability analysis. The value added was examined using the net profit approach while viability was testing using the Benefit-Cost Ratio (BCR). The gross margin is given as;

$$GM = TR - TVC \quad (\text{Alufohai et al, 2012})$$

Where,

GM = Gross Margin, TR = Total revenue

TVC = Total variable cost

Net profit was determined using the expression:

$$N = GM - TFC \quad (\text{Alufohai et al, 2012})$$

Where,

N = Net profit

TFC = Total fixed cost (depreciation, using straight line method)

Benefit-Cost ratio (BCR) = Present value of total benefit / Present value of total cost.

However, the data in the study were just cross-sectional and as such were not discounted. A  $BCR \geq 1$  indicates a viable project.

## 11. Results and Discussion

### 1. Fabrication of different parts

Based on the design consideration and analysis the design of different parts had been done by using Auto-Cad software. Fabrication had been done according to the design sequentially. The measurements of different parts were followed strictly.

#### 1.1. Supporting frame

The supporting frame was fabricated by using MS angle bar (50\*50mm). The length of frame was 800mm and wide was 550mm. Fabrication of supporting frame is shown in fig 9.



**Fig. 9:** Fabrication of supporting frame

#### 1.2. Cylinder

The cylinder was fabricated by using MS plan sheet. The cylinder put on the supporting frame. The diameter of the cylinder was 560mm, height was 465 mm and the thickness was 5 mm. The fabrication of cylinder is shown in fig 10.



**Fig. 10:** Fabrication of cylinder

### 1.3. Shaft and beaters

The diameter of the shaft was 30 mm (Appendix 1). 4 beaters had been adjusted with the shaft. The wide of the beater was 50mm and length was 250mm (Fig. 11). All the parts were fabricated according to the design.



**Fig. 11:** Fabrication of Shaft and beaters

### 1.4 Power transmission system

Belt-pulley arrangement was used in the power transmission system. The diameter of drive pulley was 450mm and the diameter of driven pulley was 100mm which convert the motor rpm from 1800 to the shaft rpm 450. The centre to centre distance of the pulley was 500 mm (fig. 12).



**Fig. 12:** Fabrication of pulley

### 1.5. Assembling of machine

After fabrication the fabricated parts had been assembled (fig. 13). The stripper consisted of four basic units- feeding unit, stripping chamber, drive mechanism, discharge outlet. A handle had been set with the feeding unit. An outlet tray had been set at the lower part of the cylinder by 12<sup>0</sup> angles. After complication the separation of fruits from the bunch the fruits were discharged by outlet tray.



**Fig. 13:** Assembling of Machine

### 2. Performance of stripper

The result of performance test is presented in the table 1 to table 10. These tables showed the weight of the bunch, percent of injured fruits, machine capacity and efficiency. Fig 14 shows the interaction result of injured fruits and fig 15 shows the interaction result of efficiency and capacity at different condition.

The result showed that the maximum injured fruits percentage was 2.63 and minimum injured fruits percentage was 2 (average 2.4), maximum stripping efficiency was 0.93 and minimum stripping efficiency was 0.91 (average 0.92) and maximum capacity was 0.49 t/hr and minimum capacity was 0.40 t/hr (average 0.44) at 100-110<sup>0</sup>c and 5 minutes sterilization (Table 1).

**Table 1:** Performance test at temperature 100-110<sup>0</sup>c and 5 minutes sterilization

Sl. No.	Weight of bunch (Kg)	No. of Separated fresh fruits	No. of injured fruits	No. of attached fruits	Total number of fruits	% of injured fruits	Stripping time (min)	Stripping efficiency	Capacity (t/hr)
1	5.32	428	12	26	466	2.57	0.8	0.91	0.40
2	5.76	416	12	28	456	2.63	0.8	0.91	0.43
3	8.25	657	14	32	703	2	1	0.93	0.49
Avg.						2.4		0.92	0.44

The result found that the maximum injured fruits percentage was 2.21 and minimum injured fruits percentage was 1.79 (average 1.96), maximum stripping efficiency was 0.95 and minimum stripping efficiency was 0.92 (average 0.93) and maximum capacity was 0.56 t/hr and minimum capacity was 0.39 t/hr (average 0.48) at 100-110<sup>0</sup>c and 10 minutes sterilization (Table 2).

**Table 2:** Performance test at temperature 100-110<sup>0</sup>c and 10 minutes sterilization

Sl. No.	Weight of bunch (Kg)	No. of Separated fresh fruits	No. of injured fruits	No. of attached fruits	Total number of fruits	% of injured fruits	Stripping time (min)	Stripping Efficiency	Capacity (t/hr)
1	5.56	418	10	24	452	2.21	0.85	0.92	0.39
2	7.2	576	11	30	617	1.79	0.9	0.93	0.48
3	8.37	605	12	30	647	1.89	0.9	0.95	0.56
Avg.						1.96		0.93	0.48

The maximum injured fruits percentage was 1.28 and minimum injured fruits percentage was 0.86 (average 1.07), stripping efficiency was 0.96 and maximum capacity was 0.72 t/hr and minimum capacity was 0.55 t/hr (average 0.60) at 100-110<sup>0</sup>c and 15 minutes sterilization (Table 3).

**Table 3:** Performance test at temperature 100-110<sup>0</sup>c and 15 minutes sterilization

Sl. No.	Weight of bunch (Kg)	No. of Separated fresh fruits	No. of injured fruits	No. of attached fruits	Total number of fruits	% of injured fruits	Stripping time (min)	Stripping Efficiency	Capacity (t/hr)
1	7.35	558	5	14	577	0.86	0.8	0.96	0.55
2	4.63	375	5	9	389	1.28	0.5	0.96	0.55
3	8.44	632	7	13	652	1.07	0.72	0.96	0.72
Avg.						1.07		0.96	0.60

The result showed that the maximum injured fruits percentage was 0.59 and minimum injured fruits percentage was 0.28 (average 0.43), maximum stripping efficiency was 0.98 and minimum stripping efficiency was 0.96 (average 0.97) and maximum capacity was 0.81 t/hr and minimum capacity was 0.46 t/hr (average 0.67) at 110-120<sup>0</sup>c and 5 minutes sterilization (Table 4).

**Table 4:** Performance test at temperature 110-120<sup>0</sup>c and 5 minutes sterilization

Sl. No.	Weight of bunch (Kg)	No. of Separated fresh fruits	No. of injured fruits	No. of attached fruits	Total number of fruits	% of injured fruits	Stripping time (min)	Stripping efficiency	Capacity (t/hr)
1	8.76	705	3	14	722	0.42	.7	0.97	0.75
2	13.5	1388	4	20	1412	0.28	1	0.98	0.81
3	6.1	650	4	18	672	0.59	0.8	0.96	0.46
Avg.						0.43		0.97	0.67

The result showed that the maximum injured fruits percentage was 0.22 and minimum injured fruits percentage was 0.15 (average 0.18), stripping efficiency was 0.98 and maximum capacity was 0.83 t/hr and minimum capacity was 0.79 t/hr (average 0.81 t/hr) at 110-120<sup>0</sup>c and 10 minutes sterilization (Table 5).

**Table 5:** Performance test at temperature 110-120<sup>0</sup>c and 10 minutes sterilization

Sl. No.	Weight of bunch (Kg)	No. of Separated fresh fruits	No. of injured fruits	No. of attached fruits	Total number of fruits	% of injured fruits	Stripping time (min)	Stripping efficiency	Capacity (t/hr)
1	11.54	1254	2	14	1270	0.15	0.9	0.98	0.83
2	5.3	443	1	8	452	0.22	0.4	0.98	0.79
3	6.82	589	1	6	596	0.16	0.51	0.98	0.80
Avg.						0.18		0.98	0.81

The result found that the maximum injured fruits percentage was 0.24 and minimum injured fruits percentage was 0.11 (average 0.17), maximum stripping efficiency was 0.99 and minimum stripping efficiency was 0.98 (average 0.98) and maximum capacity was 0.91 t/hr and minimum capacity was 0.74 t/hr (average 0.83 t/hr) at 110-120<sup>0</sup>c and 15 minutes sterilization (Table 6).

**Table 6:** Performance test at temperature 110-120<sup>0</sup>c and 15 minutes sterilization

Sl. No.	Weight of bunch (Kg)	No. of Separated fresh fruits	No. of injured fruits	No. of attached fruits	Total number of fruits	% of injured fruits	Stripping time (min)	Stripping efficiency	Capacity (t/hr)
1	6.86	540	1	6	547	0.18	0.45	0.99	0.91
2	4.95	404	1	6	411	0.24	0.4	0.98	0.74
3	10.5	908	1	14	923	0.11	0.75	0.98	0.84
Avg.						0.17		0.98	0.83

The result found that the maximum injured fruits percentage was 0.68 and minimum injured fruits percentage was 0.39 (average 0.51), stripping efficiency was 0.97 at all bunches and maximum capacity was 0.7 t/hr and minimum capacity was 0.64 t/hr (average 0.68 t/hr) at 120-140<sup>0</sup>c and 5 minutes sterilization (Table 7).

**Table 7:** Performance test at temperature 120-140<sup>0</sup>c and 5 minutes sterilization

Sl. No.	Weight of bunch (Kg)	No. of Separated fresh fruits	No. of injured fruits	No. of attached fruits	Total number of fruits	% of injured fruits	Stripping time (min)	Stripping efficiency	Capacity (t/hr)
1	8.23	745	3	14	762	0.39	0.70	0.97	0.70
2	7.98	706	5	16	727	0.68	0.75	0.97	0.64
3	5.89	597	3	17	617	0.48	0.50	0.97	0.70
Avg.						0.51		0.97	0.68

The injured fruits percentage was near about zero (average 0.11), maximum stripping efficiency was 0.99 and minimum stripping efficiency was 0.98 (average 0.98) and maximum capacity was 0.86 t/hr and minimum capacity was 0.76 t/hr (average 0.81 t/hr) at 140<sup>0</sup>c and 10 minutes sterilization (Table 8)

**Table 8:** Performance test at temperature 120-140<sup>0</sup>c and 10 minutes sterilization

Sl. No.	Weight of bunch (Kg)	No. of Separated fresh fruits	No. of injured fruits	No. of attached fruits	Total number of fruits	% of injured fruits	Stripping time (min)	Stripping efficiency	Capacity (t/hr)
1	6.87	702	1	8	711	0.14	0.54	0.98	0.76
2	11.5	1145	2	9	1155	0.17	0.80	0.99	0.86
3	8.34	764	0	12	776	00	0.62	0.98	0.80
Avg.						0.11		0.98	0.81

The result showed that injured fruits percentage was near about zero (average 0.07), maximum stripping efficiency was 0.99 and minimum stripping efficiency was 0.98 (average 0.98) and maximum capacity was 0.83 t/hr and minimum capacity was 0.77 t/hr (average 0.81 t/hr) at 120-140<sup>0</sup>c and 15 minutes sterilization (Table 9).

**Table 9:** Performance test at temperature 120-140<sup>0</sup>c and 15 minutes sterilization

Sl. No.	Weight of bunch (Kg)	No. of Separated fresh fruits	No. of injured fruits	No. of attached fruits	Total number of fruits	% of injured fruits	Stripping time (min)	Stripping efficiency	Capacity (t/hr)
1	6.97	687	1	8	696	0.14	0.50	0.98	0.83
2	6.72	702	0	7	707	00	0.52	0.99	0.77
3	9.60	1098	1	12	1110	0.09	0.70	0.99	0.82
Avg.						0.07		0.98	0.81

At control temperature a large amount of fruits were damaged & average efficiency and capacity was very low and injured fruits percentage was very high. At the control treatment the capacity and efficiency of the machine were 0.14 and 0.19 respectively. The injured fruits percentage was 34.33 (Table 10).

**Table 10:** Performance test at Control treatment (without sterilization)

Sl. No.	Weight of bunch (Kg)	No. of Separated fresh fruits	No. of injured fruits	No. of attached fruits	Total number of fruits	% of injured fruits	Stripping time (min)	Stripping efficiency	Capacity (t/hr)
1	5.82	75	179	255	509	35	2	0.14	0.17
2	7.08	89	165	280	534	30.8	2	.016	0.21
3	6.97	72	205	273	550	37.2	2	0.13	0.20
Avg.						34.33		0.14	0.19

Fig. 14 showed the injured fruits at different conditions. From this figure at control temperature, the percent of injured fruits was high and at 110-120<sup>0</sup>c sterilization temperature and 10 minutes sterilization time the percent of injured fruits goes to near about zero. A very little bit effect or no effect was shown to increase the sterilization temperature with time.

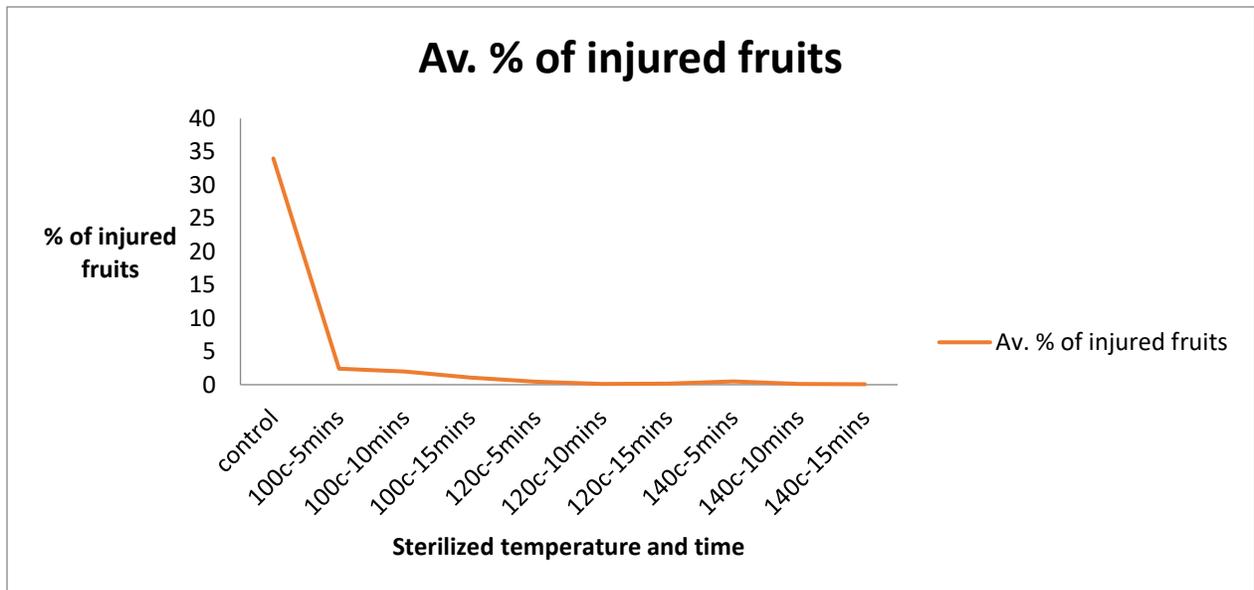


Fig 14: % of injured fruits at different conditions

The interaction result of efficiency and capacity showed in fig. 15. At control treatment the efficiency and capacity were very low. Sterilizing the fruits had increased the machine capacity and efficiency. Performance was good at sterilization temperature 110- 120<sup>0</sup>c with at sterilization time 10 minutes. The Performance was a little bit change or no change to increase the sterilization temperature with time.

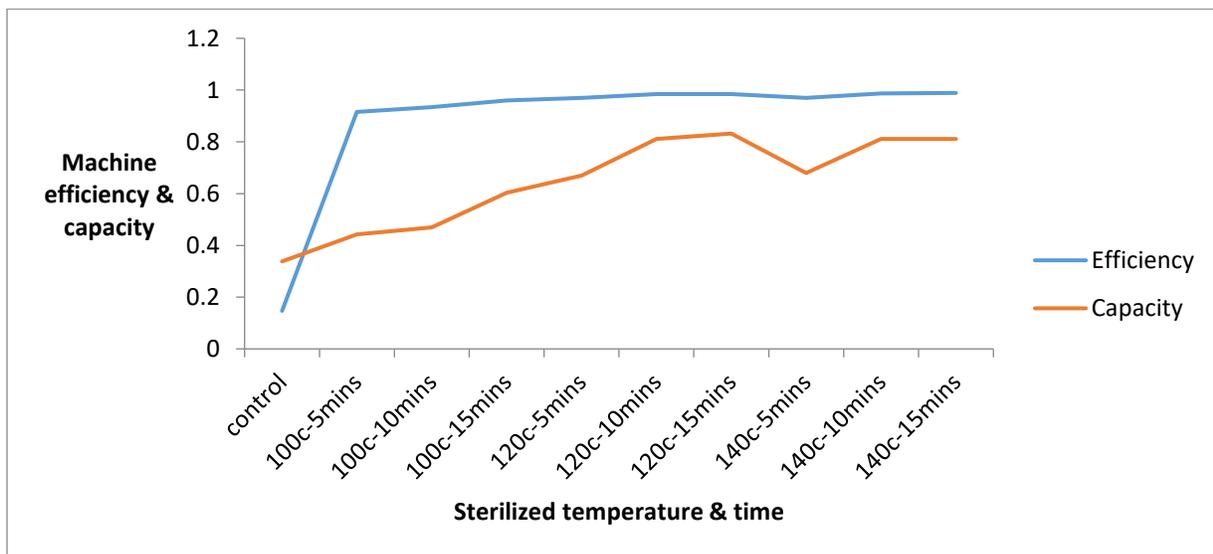


Fig 15: Interaction result of machine capacity and efficiency at different condition

### 3. Cost analysis of palm fruit stripping

Cost calculation of palm oil fruit stripper

The operating cost of the machine was calculated based on the following

Yearly working hours =  $150 \times 8 = 1200$

Efficiency = 75%

Labour cost = 50 Tk/hr, One labour is required

Economic life = 8 yrs

Salvage value = 10% of P

Rate of interest I = 8%

Calculation

Purchase price = Tk. 25000

Salvage price = Tk. 2500

Fixed cost

$$D = \frac{(P-S)}{L} = \frac{25000-2500}{8} = 2812.5$$

$$I = \left(\frac{P+S}{2}\right) * i = \frac{25000+2500}{2} * .08 = 1100$$

T = 2% of purchase price = 500

$$\text{Total fixed cost} = D + I + T = (2812.5 + 1100 + 500) = 4412.5$$

Variable cost

Labour cost = 50tk/hr

R & M cost = 0.003 % P = .00003\*25000 = .75 tk/hr

$$\text{Electricity energy cost} = \frac{\sqrt{3}VICos\mu}{1000} = \left(\frac{\sqrt{3} * 403 * 15 * 0.8}{1000}\right) * (1 * 4.5) = 37.71 \text{ tk/hr}$$

Raw material cost = Kg of separated fruits/day\*Working days/year\* Price of per kg of branch\*

Estimated capacity utilization (Capacity Utilization is the ratio of actual output to the potential output)

$$= \text{Tk. } (.8118 * 8 * 1000 * 150 * 8 * .75)$$

$$= \text{Tk. } 5839200$$

$$\text{Total cost} = 4412.5 + (50+37.71+.75)*1200 + 5839200 = \text{Tk. } 5949764.5$$

Annual revenue

Annual revenue = Capacity of plant ( Kg of separated fruits/day ) \* Working days/year \* Price of per kg

of separated fruits \* Estimated capacity utilization

$$= .811 * 8 * 1000 * 150 * 15 * .75 = 10948500$$

$$\begin{aligned}\text{Annual worth} &= \text{Annual revenue} - \text{Annual cost} \\ &= \text{Tk. } (10948500 - 5949764.5) \\ &= \text{Tk. } 4998735.5\end{aligned}$$

$$\begin{aligned}\text{Gross margin, Gm} &= \text{Total revenue} - \text{Total variable cost} \\ &= 10948500 - (106152 + 5839200) \\ &= 5003148\end{aligned}$$

Net profit per year

$$\begin{aligned}\text{Net profit} &= \text{Gross margin} - \text{total fixed cost} \\ &= \text{Tk.}(5003148 - 4412.5) \\ &= \text{Tk. } 4998735.5\end{aligned}$$

### **Benefit-cost ratio**

$$\begin{aligned}\text{Benefit-cost ratio} &= \frac{\text{Present value of total revenue}}{\text{Present value of total cost}} \\ &= \frac{109848500}{5949764.5} \\ &= 1.846\end{aligned}$$

Palm oil stripper would be viable in our country when annual revenue overcomes annual cost with a great difference. From this result it was seen that there was a great difference between the annual revenue and annual cost. Considering market price the annual revenue was approximately Tk. 10948500. The machine price was low. The main cost in the annual cost was the raw material cost. The gross margin of the machine was approximately Tk. 5003148 and the net profit was Tk. 4998735.5. The benefit cost ratio was approximately 1.846.

## **12. Research highlight/findings (Bullet point – max 10 nos.)**

- ❖ **Design of the machine:** The design of Palm fruit stripper has been completed by using Auto-cad software.
- ❖ **Fabrication and assembling of machine:** Fabrication and assembling of the machine have been done to follow the design.
- ❖ **Determine effective treatment:** Effective sterilization time and temperature was undertaken in departmental workshop. Three different temperature was taken (100, 120,140)<sup>0</sup>c with three different time (5, 10, 15)mins. Another experiment was done at control treatment (without sterilization) The best performance comes from the sterilization time 10 minutes when the sterilization temperature was 120<sup>0</sup>c and performance is very low when experiment was done at control treatment (without sterilization)

- ❖ **Performance evaluation:** The efficiency of the machine is 98.89 and capacity is 0.81 ton/hr when the sterilization time 10 at 120<sup>0</sup>c. On the other hand the efficiency of the machine is 93.97 and the capacity is 0.626 ton/hr when the sterilization time is 5 minutes at 100<sup>0</sup>c.. The result of this experiment is very poor (efficiency is 12.12 and capacity is 0.087ton/hr ) when the experiment was done without any sterilization.

## **B. Implementation Position**

### **1. Procurement:**

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	100	100	100	99.92	
(b) Lab &field equipment	100	100	100	99.99	
(c) Other capital items	100	100	100	99.89	

### **2. Establishment/renovation facilities: N/A**

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

### **3. Training/study tour/ seminar/workshop/conference organized:**

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					
(b) Workshop	36	11	47	one day	

## **C. Financial and physical progress**

**Fig in Tk**

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	380700	380700	380700	00	100	
B. Field research/lab expenses and supplies	559300	559300	558900	400	100	
C. Operating expenses	250000	183827	150725	33102	90	
D. Vehicle hire and fuel, oil & maintenance	240000	160000	88500	71500	90	
E. Training/workshop/seminar etc.	50000	50000	50000	00	100	
F. Publications and printing	100000	100000	49900	50100	100	
G. Miscellaneous	60000	60000	26835	33165	100	
H. Capital expenses	360000	360000	359850	150	100	

### **D. Achievement of Sub-project by objectives: (Tangible form)**

<b>Specific objectives of the sub-project</b>	<b>Major technical activities performed in respect of the set objectives</b>	<b>Output(i.e. product obtained, visible, measurable)</b>	<b>Outcome(short term effect of the research)</b>
To determine effective treatments (temperature, sterilization time etc) for efficient fruit separation.	Effective sterilization time and temperature were undertaken in the departmental workshop. Three different temperatures (100-110, 110-120,120-140) <sup>o</sup> C were considered to this experiment. Three different times (5, 10, 15) minutes were taken for each sterilization temperature.	The best performance of this machine came from the combination of sterilization temperature 120 <sup>o</sup> c and sterilization time 10 minutes	The best sterilization time and temperature were found by this experimentation
To design and develop different parts of an oil palm stripper machine.	Different parts of the oil palm stripper machine were fabricated. The stripper consisted of four basic units- feeding unit, stripping chamber, drive mechanism, discharge outlet. A handle had been set with the feeding unit. The stripping chamber was cylindrical in shape. Belt-pulley arrangement was used in the power transmission system. An outlet tray had been set at the lower part of the cylinder by 12 <sup>o</sup> angles.	The fabricated parts were assembled.	A oil palm stripper had been developed
To evaluate the working performance of the machine in the Departmental Laboratory.	The performance of the machine had been evaluated. The bunch was placed at the stripping chamber after sterilization. When the motor was started the fruits were started to separate from the bunch as the result of hitting of beaters.	The best stripping efficiency and operating capacity of the machine was determined which were 98.5 and 0.811 ton/hr	This machine could be preferable for both small and medium-scale farmers.

### **E. Materials Development/Publication made under the Sub-project:**

<b>Publication</b>	<b>Number of publication</b>		<b>Remarks (e.g. paper title, name of journal, conference name, etc.)</b>
	<b>Under preparation</b>	<b>Completed and published</b>	
Technology bulletin/ booklet/leaflet/flyer etc.		<b>Leaflet</b>	
Journal publication	Journal paper		
Information development			
Other publications, if any		<b>MS Thesis</b>	

## **F. Technology/Knowledge generation/Policy Support (as applied):**

### **i. Generation of technology (Commodity & Non-commodity)**

A palm oil fruit stripper has been developed to separate fruit-let from Fresh Fruit Bunch (FFB), which is an important part of the processing of palm oil from the bunches. The stripping efficiency of the machine was 98.5 and capacity of the machine was 0.811t/hr.

### **ii. Generation of new knowledge that help in developing more technology in future**

Sterilization is an essential step of oil palm processing from FFB. The best sterilization temperature and time was determined by this study. Three different temperatures (100-110<sup>0</sup>, 110-120<sup>0</sup>, 120-140<sup>0</sup>c) were considered for this study. Three different times (5, 10, 15 minutes) were taken for each sterilization temperature. The best performance of this machine came from the combination of sterilization temperature 110-120<sup>0</sup>c and sterilization time 10 minutes.

### **iii. Technology transferred that help increased agricultural productivity and farmers' income**

The machine would be highly profitable for the smallholder farmers. One labour can separate only 0.12 ton of fruits per day where as the machine can separate 6.48 ton which means the machine is equivalent to 54 labours. The machine operating cost also very low.

### **iv. Policy Support**

The machine was constructed of locally available materials with low cost so as to enhance the possibility of replacing damaged parts with less expensive but equivalently satisfactory parts that are locally available.

## **G. Information regarding Desk and Field Monitoring**

### **i) Desk Monitoring [description & output of consultation meeting, monitoring workshops/seminars etc.):**

Progress monitoring by BAURES team 27/2/2018  
Progress workshop 18/03/2018

### **ii) Field Monitoring (time& No. of visit, Team visit and output):**

Monitoring by BARC team 08/03/2018

**H. Lesson Learned/Challenges (if any)**

- i) Sterilization temperature controlled by manually was a hard task.
- ii) The best performance of the machine found at 10 minutes sterilize with 110-120° C.
- iii) The developed machine could be useful foe small and medium scale oil palm grower.

**I. Challenges (if any)**

Design and development of the machine was challenges within the project timeframe

Signature of the Principal Investigator  
Date .....  
Seal

Counter signature of the Head of the  
organization/authorized representative  
Date .....  
Seal

### Advantage of the machine

- The machine is portable
- The machine is environmental friendly
- It's easy to operate and no expert is needed to operate it
- One labor can separate only 0.12 ton fruits per day where as the machine can separate 6.48 ton. That means the machine is equivalent to 54 labors.
- The machine BCR is 1.846.
- The machine operation is risk free.
- Injured fruits percentage is only 0.14 at the time of machine operation
- Its reduce the cost and time to separate the fruits which will make the palm oil production more profitable.
- Separate the fruits by hand are very laborious and causes health hazard. Hence most of the labors are not interested to do it. This machine is the solve of this problem.

### Maintenance:

- The maintenance of the machine is simple.
- After using, the cylinder and the outlet tray should be properly clean
- The machine should set up under a shade which can increase the machine life
- The motor should be properly covered so that rain water cannot enter in to the motor.

### Caution:

- The machine should be put on a flat place. Otherwise vibration may be occurred which can hamper the work.

### Contact Dr. Md. Abdul Awal

Professor  
Department of Farm Power and Machinery  
Bangladesh Agricultural University  
Mymensingh-2202  
Email: awalbau@gmail.com  
Phone: 01710987258

## Power Operated Oil Palm Fruit Stripper



### Authors

Dr. Md. Abdul Awal  
Professor  
Hafijur Rahaman  
MS student



Department of Farm Power & Machinery  
Bangladesh Agricultural University, Mymensingh-2200



Funded by  
BARC, NATP-2, CRG Sub Project (Project ID 576)  
Farmgate, Dhaka.

### Background.

Oil palm tree produces one of the most popular edible oils in the world. It is versatile oil with super nutritional value. The main palm fruit production countries are Malaysia and Indonesia. Government has given to priority for oil palm plantation in order to meet up the country's emerging need for edible oil on the one hand and reduce the valuable currency on the other. In 2008 the domestic consumption of palm oil was 850,000 MT which comes at 1,620,000 in 2017. The However, absence of suitable palm oil processing technology (crude oil from fresh fruit bunch (FFB), a lot of fresh fruit bunch are wasted. Separation of palm fruits from the bunch is an important, laborious and time consuming task in palm oil processing technology. Traditionally, the harvested palm fruit bunches is heaped and allowed to ferment to facilitate easy stripping of the fruits which gives poor quality oil as the period of fermentation increases the free fatty acid (FFA) content of the oil. Hence, it is important that mechanical separation of fresh fruit bunches be processed as soon as possible to prevent a rapid rise in free fatty acid which normally affect the quality of crude palm oil. Therefore, oil palm stripper is an important machine which could be used mechanical separation of the fruit from the bunch easily and rapidly.

### Description of machine

Fabrication of this machine is easy with locally available materials. The stripper consists of four basic units- feeding unit, stripping chamber, drive mechanism, discharge outlet (Fig 4). The cylinder diameter is 580 mm and the height is 460 mm which is suitable for both small and medium scale palm oil processing mill. The cylinder is setup on a support frame. Four bitters are attaching with the shaft according to design (Fig. 1). The adjustment of the cylinder with shaft and bitters are shown in Fig 2. A 4.5 Hp motor is used to supply the power. Belt and pulley is used to convert the motor rpm to the shaft rpm (Fig. 3).

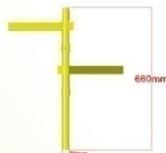


Fig. 1: Shaft with bitters

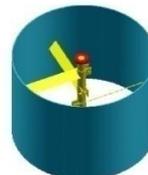


Fig. 2: Adjustment of shaft and bitters with cylinder

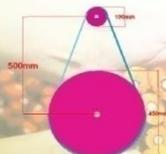


Fig. 3: Power transmission system



Fig. 4: Assembling of palm fruit stripper

### Machine capacity, stripping efficiency and cost estimation

The market price of the machine is tk. 25000 to tk. 30000 based on the cylinder and motor size. The capacity of the machine is 0.81 ton/hr and the stripping efficiency is 98.79%. Operation cost of the machine is 37 to 40 tk. per hour.



Fig. 5: Machine operation



Fig. 6: Fresh Fruit Bunch



Fig. 7: Stripping Fruits