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RESEARCH ARTICLE

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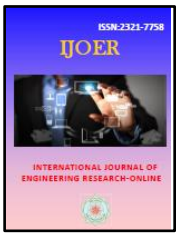
DESIGN, CONSTRUCTION AND PERFORMANCE EVALUATION OF POWER DRIVEN POTATO PEELING MACHINE

MOHAMMED TEMAM
MSc, Agricultural Engineering Research Team, Melkassa Agricultural Research Canter, Ethiopia Agricultural Research Institute, Ethiopia
Mohtemam4@gmail.com



ABSTRACT
The potato peeling machine consists of seven parts, main frame, peeling drum, hopper, collection basin, waste remover, water supplying systems, and power transmission. The machine was evaluated using different potato bulb sizes (small, medium & large). A mixed sample of different sizes was also tested. The evaluation process was conducted between1000 and 1440rpm drum rotational speeds , three different peeling residence times (10,15 and 20seconds) and two different batch loads (1 and 1.5 kg). The optimum peeling efficiency of 52.55%, 87.99% and98% was obtained at 10, 15 and 20 seconds respectively and at recommended drum speed of 1440 rpm. The average value of the mean field capacity of the potato peeler obtained from the trials for small, medium, large and mixed sizes were 0.092kg/sec, 0.093kg/sec ,0.091kg/sec and 0.093kg/sec respectively. Generally the mean field capacity of the potato peeler obtained from the trials for small, medium, large and mixed sizes were 0.092kg/sec (333.7164 kg/hr). The estimated costs of potato peeling machine including the machine costs, the raw materials, and labor cost was 3,252.65EB.

1. INTRODUCTION

Agriculture is the most important sector in the Ethiopian Economy. It is estimated that about 80% of the population's livelihood is based on this sector CSA, (2013). According the 2013 CSA report area covered by cabbage, onion, potato and tomato is estimated to be 34792, 21864, 74935 and 7238 hectares respectively, whereas the total production in tons 3709952, 21989, 863348 and 55514 in that order.

Several field vegetables crops, from tubers and roots below the surface of the soil. Those crops could be termed root crops and they may be classified according to the strategic important into major and minor root crops. The major root crops are potatoes, beets for sugar, sweet potatoes, onions and peanuts (Amin, 1990).

The potato (*Solanum tuberosum*) is a herbaceous annual that grows up to 100 cm tall and produces a tuber also called potato, so rich in starch that it ranks as the world's fourth most important food crop, after maize, wheat and rice (Bradshaw, 2010).

Potato processing includes different process like washing, peeling, slicing, chopping and soon. These processes are labor-intensive they require mechanization in order to meet up with current demand for these products. One major bottleneck in potato processing was potato peeling because of the variation of diameter and length of potato.

From the previous work, it is clear that the hand peeling process is very tedious, time consuming work and costly as well, therefore, the main aim of this study is to design, fabricate and evaluate potato peeling machine from local available raw materials to assure high quality, high peeling efficiency and losses reduction with low

cost. This machine will be used in small and medium production units, such as restaurants, hotels and small potato dryers.

2. LITERATURE REVIEW

Various types of peeling machines are manufactured for different root crops like cassava, onion and potato from small hand-operated batch-types to large automatic continuous operation models. Some are petrol, diesel or electric motor operated. In this project I have designed and evaluate the power operated potato peeling machine which is manufactured with locally available materials.

The 'Crypto peelers' abrasive drum peeler is an example of a typical commercial machine in which a rotating abrasive drum rubs the skin from the material passed through (UNIFEM, 1993).

It is most commonly used to peel potatoes. Various sizes of such machines are available fromas small as 1.3 kg/batch. They are powered by electric motors.

Mohammed (2008) reported in his thesis work about rotator potato peeler which has six stainless steel peeling blades. It can Peels1 kg potatoes in two minutes with powerful motor, safety switch, handy size regulator, transparent lid, and cord retraction. This machine comes apart easily for cleaning and it has also extra function: use the basket also supplied as a centrifuge to dry lettuce and salad.

El-Ghobashy et al. (2016) designed, fabricated and tested onion peeling machine with the optimum peeling efficiency of 74.9, 65.24, 80.08 and 85.45% were obtained at 24kg batch load (0.36 ton/h.)

Adetoro (2012) reported that the abrasion method has been used to peel tubers such as potatoes and ginger and sometimes on yam also. Jessica et al. (2006) developed a cassava peeling machine, which was designed using brush as peeler; the machine was widely used on oval shaped fruits and vegetables. The machine consumes about 4kW of power.

According to the report of Jackson (2003), waste from peeling, slicing and washing contain starch which has commercial value. This, together with small potatoes may be used as animal feed.

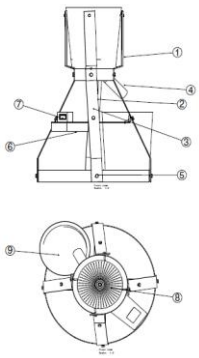
3. METHODOLOGY

***3.1.The Experimental Site*:** The Fabrication of prototype and laboratory experiments were conducted at Melkassa Agricultural Research Center(MARC), 17 km South of Adama, or it is located 117 km South East of Addis Ababa, Ethiopia. Melkassa has a highly variable rainfall that ranges between 500 and 800 mm annually. The agro-ecology is termed as Kolla (Warm, semi-arid lowlands). Any adjustment or maintenance of the proto type was conducted in AIRIC workshop, which is found in the center.

***3.2. Materials used for Experiments*:** The materials and tools used for this project include, the mechanical engineer drawing instrument, flat iron, sheet metal, stainless steel, brass, ball bearings, electric motor, two plastic baldies, drilling machine, grinding machine, lath machine and milling machine were used during the construction of the prototype.

3.3.Physical properties of the Potatoes used for Experiments: The tuber were cleaned manually to remove all foreign matter such as dust, dirt and stones before determine the mean size of the tuber, Five verities (Jalene, Belete, Gudene, Gemechu and Gera) were selected at Holeta Agricultural Research Center and by taking 9 samples from each verity, totally 36 potato tubers were taken randomly and divided into 9 samples and randomly and statistically analyzed to get the mean values (Av.) by measuring major, intermediate and minor diameter of the potato using digital caliper of 0.01mm accuracy.

***3.4. Description of the Potato Peeling Machine**:* The Potato peeling machine consists of seven main parts, included: Main frame, Peeling plate (abrasive plate), Hoper, Waste collection basin, Waste remover, Water supply systems and Power transmission.



No.	part name
1	Hopper
2	Shaft
3	Frame
4	Wast remover
5	Nut and Bolt
6	Motor
7	Dimer switch
8	Abrasive plate
9	Waste collection basin

Fig.1Main parts of potato peeler

3.5. Power Transmission System: The Peeling drum is driven by a 0.8 KW, electric motor. The motor is directly connected to the vertical shaft and this vertical shaft transfers the rotary motion to the abrasive plate. I have used dimmer switch was used to vary speed (rpm) of motor by varying the voltage to the electric motor.

3.6. Water Supply Systems: Water supply from supply hose is used to wash the peeled potato and to remove the peel and unnecessary materials such as soil and to get pure potato.

3.7. Design Analysis

3.7.1 Estimation of Power Required by the Machine: According to Eugene and Theodore (1996), the force Frequired crushing out the potato peel by the drum of mass m having a tangential acceleration ais given by:

$$F = ma \quad \text{.....} \quad (3.1)$$

Where

F=Force

m=mass

a=acceleration

Therefore, equation (3.1) becomes:

$$F = \frac{m \times 2\pi rN}{60t}$$

For one seconds, the force becomes:

$$F = \frac{m \times 2\pi rN}{60} \quad \text{.....} \quad (3.2)$$

$m = m_p + m_{ap}$

But m_p = 2kg and m_{ap} =0.2533

m=2 + 0.2533

m=2.2533kg

Recommended rpm according to IJEIT (2017), N=1440rpm

$$F = \frac{2.25 \times 2\pi \times 0.102 \times 1440}{60}$$

F =34.6N

This is the load per second on the abrasive plate as the peeling is in progress. The torque, T due to this load is given by:

$$T = Fr \quad \text{.....} \quad (3.3)$$

Where

T=torque

F=force

r=radial distance

Substituting equation (3.2) to equation (3.3)

$$T = \frac{m \times 2\pi r^2 N}{60} \quad \text{.....} \quad (3.4)$$

But m=2.25kg

N=1440rpm

r=0.102

$$T = \frac{2.25 \times 2\pi \times 0.102^2 \times 1440}{60}$$

T = 3.53Nm

$$P = T\omega \quad \text{.....} \quad (3.5)$$

Where

ω =the angular speed, which is given by:

$\omega = \frac{2\pi N}{60}$ Therefore, equation (3.4) becomes:

$$P = T\frac{2\pi N}{60} \quad \text{.....} \quad (3.5)$$

Substituting equation (3.4) into (3.5), gives

$$P = mr^2\left(\frac{2\pi N}{60}\right)^2 \quad \text{.....} \quad (3.6)$$

Recommended rpm for potato peeler is N = 1440 rpm

$$P = 2.25 \times 0.102^2\left(\frac{2\pi \times 1440}{60}\right)^2$$

P = 532 W

=0.532Kw

$P = \frac{0.532}{0.764}$ =0.6 hp

According to Oluwole (2013) having a factor of safety of 2 gives 1.2hp. A 1hp motor would be used.

3.7.2. Shaft Design: The vertical shaft of the machine that receives power from an electric motor then transfer to the peeling drum.

3.7.2.1. Torque on the Shaft

$$T = \frac{60P}{2\pi N} \quad \text{.....} \quad (3.7)$$

Where

T=torque

P= the power delivered by the motor, and

N= the speed of the rotation

But P=532w and

N=1440rpm

$$T = \frac{60 \times 532}{2\pi \times 1440}$$

T =3.52Nm

3.7.2.2. Loads on the Shaft

The vertical load, W on the shaft is the torsion load and is given by,

$$W = mg \quad \text{.....} \quad (3.8)$$

By using equation (3.6)

$W_t = \rho \times \pi r^2 t_p g + W_p$

=0.2533×9.81 +2× 9.81

=2.48N + 19.62

=22.1N

The driving loadF_d, in terms of the torque, is given by,

$$Fd = \frac{T}{D/2}$$

$$Fd = \frac{2T}{D} \quad \text{.....} \quad (3.9)$$

T = 3.52Nm

D = 30mm =0.03m

$$Fd = \frac{2 \times 3.52}{0.03}$$

Fd = 234.7N

The frictional load between abrasive plate and the potato is given by,

$$f = \mu N \quad \text{.....} \quad (3.10)$$

Where

f= frictional force

N=normal force

μ= coefficient of friction

Hence N = mg

Where

m_p=mass of potato=2kg

g= gravitational acceleration

N =2×9.81

=19.62N

μ= 0.09 (Khurmi and Gupta, 2005)

$f = \mu N$

=0.09×19.62

=1.76N

To find the unknown forces

Assume Fx = 0

$\sum F_v = 0$

But F_v =W=22.1N

$F_v - F_y = 0$

$F_y = F_v$

=22.1N

$\sum F_z = 0$

$F_z \times r - T_1 + T_2 = 0$

But r= 15mm=0.15m

T_1=3.52N

T_2=5×r

$F_z = \frac{3.52}{0.015} - 1.76 \times 0.1025$

F_z=234.7- 0.18

F_z =234.52N

3.8. Performance Test and Evaluation

Calculations used in the trial runs are as follows; Based on the collected data the peeling thickness, capacity and efficiency of the machine were calculated as follow:-

***3.8.1. Peel Thickness*:** Peel thickness were 1.5mm because the abrasive plate punched 1.5mm it peels only 1.5mm thickness this was measured by using caliper.

***3.8.2. Capacity*:** Machine peeling capacity (t/h) was defined as the batch load of the potatoes divided by the total peeling time (loading time+ peeling residence time+ unloading time) in an hour, and could be calculated using (El-Ghobashy et al.,2016) equation

$$Cp = \frac{Lb}{T1+Tr+Tu} \times 60/1000 \quad \text{.....} \quad (3.11)$$

Where

C_p= machine peeling capacity (ton/h)

L_b =batch load (kg)

T_l = loading time (min)

T_r = peeling residence time (min)

T_u = unloading time (min)

3.8.3. Peel Weight Proportion

The peeling weight proportion as given by Balami*et al.*, (2012)

$$P_w = \frac{(M_{pc}) \times 100}{M_s} \quad \text{.....} \quad (3.12)$$

Where:

Mpc= weight of peel collected (kg)

Ms= weight of the sample (kg)

***3.8.4. Peeling Efficiency**:* Peeling efficiency is the ratio of the throughput capacity to the theoretical capacity expressed as a percentage. The peeling efficiency of the machine was determined by an expression as given by (Agrawal, 1987) in Equation (3.43);

$$\eta p = \frac{MpO \times 100}{Twp} \quad \text{.....} \quad (3.13)$$

Where:

ηp = peeling efficiency (%).

M*po*= weight of peel collected through the peel outlet of the machine (kg)

Twp=total weight of peel collected by manual peeling (kg)

3.9. Economic Evaluation: According to the report of Lowa State University (2015) Farm machinery costs can be divided into two categories: annual ownershipcosts, which occur regardless of machine use, and operatingcosts, which vary directly with the amount of machine use.

The cost of operation for the machine was worked out by calculating the fabrication, fixed andVariable costs as presented in Appendix G. Estimation of annual and hourly operational costs ofthe power driven potato peeler were based on capital cost of the peeler, interest on capital, cost of repairs and spare parts, labor cost, and depreciation.

4. RESULTS AND DISCUSSIONS

4.1. Laboratory Test Results

4.1.1. Physical Properties of the Potato Tuber

In order to get some of the physical properties of the tuber, 36 sample potatoes were randomly taken and their major, intermediate and minor diameters were measured. So, table 4.1 contains geometric mean, volume, aspect ratio and sphericity of five potato tuber varieties (Jalene, Belete, Gudene, Gemechu and Gera). Belete and Gudene varieties had longer diameters than the other three varieties of potatoes. The geometric mean can be used to determine the average diameter of potato. This was useful in designing the diameter of abrasive plate and volume of the hopper; in addition to this, sphericity of potato also used to decide the shape of abrasive plate, thickness of the teeth on the abrasive plate. Surface contact of the potato with the abrasive plate is also affected by the sphericity of the potato, which means more round potato, is easier to peel than irregular shaped potato using potato peeling machine.

Table 4.1 the mean values of the physical properties of the tuber

Description	Tuber Dimension (mm)						
	a(mm)	b(mm)	c(mm)	V(mm3)	D_p(mm)	S_p(%)	R_a (%)
Samples size	36	36	36	_	_	_	_
Mean	61.38	47.79	41.51	63337.3	49.37	80.43	77.86
SD	7.68	5.103	3.91	79.8458	5.34	69.57	66.42
Minimum	49.17	40.8	36.35	37923.8	41.62	84.64	82.97
Maximum	71.95	55.87	47.63	99560.4	57.40	79.78	77.66
Volume(mm^3)	50225.37						
Geometric Diameter(mm)	38.43754						
Sphericity (%)	78.60888						
Aspect ratio	76.22716						

4.1.2. Capacity of Peeling Potato using Traditional Peeling Tool (Knife): As shown in Table 4.2 the mean manual peeling capacity of using Knife obtained from the trials were 0.1175kg/min (7.05kg/hr.). Noticed from the table that when we classified in gender manual peeling capacity of male is lower than the manual peeling capacity of female. The average peeling capacity of manual peeling was 0.09kg/min for male and 0.145kg/min for female. This result indicated that females are faster than male.

Table.4.2. the Performance of using Manual Peeling tool (knife)

Traditional peeling tool					Capacity (Kg/min)	Gender	Average Capacity(Kg/ min)
Test	W_t (kg)	W_p (kg)	L_t (kg)	T (min)			
1	2	1.6	0.3	20	0.1	M	0.117
2	2	1.7	0.3	24	0.08	M	
Average	2	1.7	0.3	22	0.09		
1	2	1.4	0.6	12	0.16	F	
2	2	1.6	0.4	15	0.13	F	
Average	2	1.5	0.5	13	0.14		

***4.1.3. Capacity Test*:** The average value of the mean field capacity of the power operated potato peeler obtained from the trials was 0.092699kg/sec (333.7164 kg/hr).

The productivity of the potato peeling machine was mainly affected by the batch load and the peeling residence time. Figs. 2, 3 and 4 show the peeling machine capacity at different batch loads, size and peeling residence time. It can be noticed that the increasing of the peeling residence time from 10 to 20 sec, tends to decrease the capacity of the potato peeler from 0.13kg/sec (468kg/h) to 0.06kg/sec (216 kg/ h) (fig.2).As shown from fig. 3 the average capacity of small, medium, large and mixed size were 0.092kg/sec (331.2kg/h), 0.093 kg/sec (334.8kg/h), 0.091kg/sec (327.6kg/h) and 0.093 kg/sec (334.8kg/h)respectively. From fig. 4 can be noticed that increase of the batch load from 1 to 1.5 kg, tends to increase the capacity of

the potato peeler from 0.1kg/sec (360kg/h) to 0.15kg/sec(540 kg/h) at 10second residence time, from 0.07kg/sec (248.4kg/h) to 0.1kg/sec(360 kg/h) at 15sec and from 0.05kg/sec(180kg/h) to 0.07kg/se(288 kg/h) at 20second peeling residence time.

Generally this indicate that when the residence time increase peeled potato per unit time is decreased because of the eventual weight of the peeled potato is substantially reduced is indicate low capacity. This prototype has five time more capacity than the capacity of Khan (2013) Potato peeler

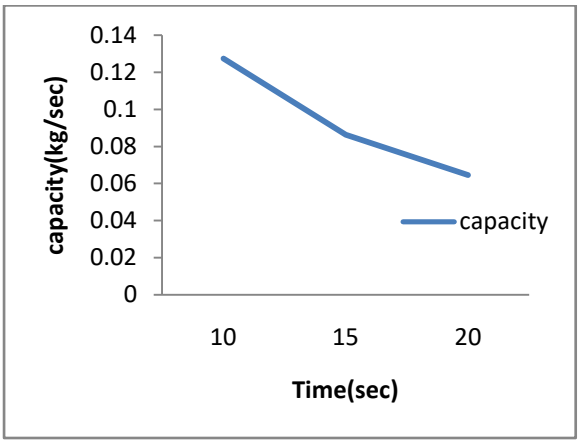


Fig. 2.Residence Time versus capacity graph

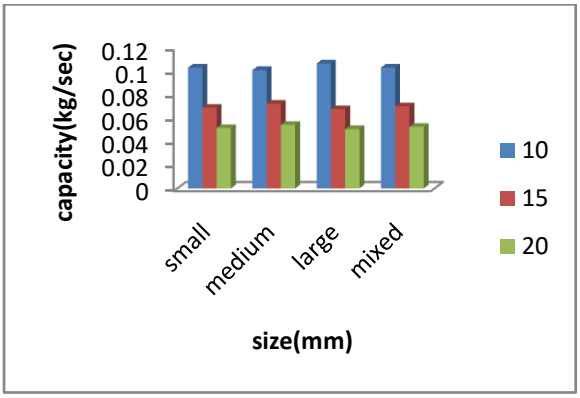


Fig.3. Size versus capacity graph

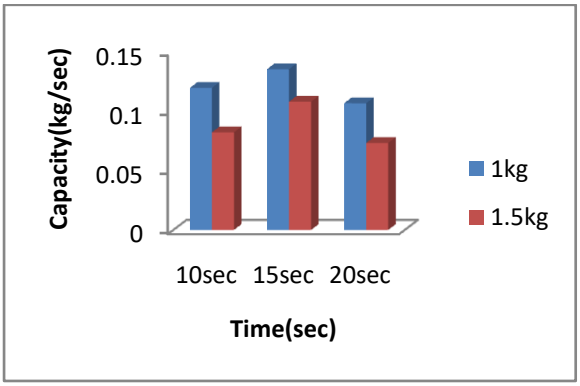


Fig. 4.Time versus capacity graph

4.1.4. Peel Weight Proportion: The average peeling weight proportion of the prototype at 10,15and 20 sec retention time were 10.275%, 19.634% and 32.445%

The peeling weight proportion of the potato peeling machine was mainly affected by the batch load and the peeling residence time. Figs. 5 and 6 show the peel weight proportion at different batch loads, size and peeling residence time.

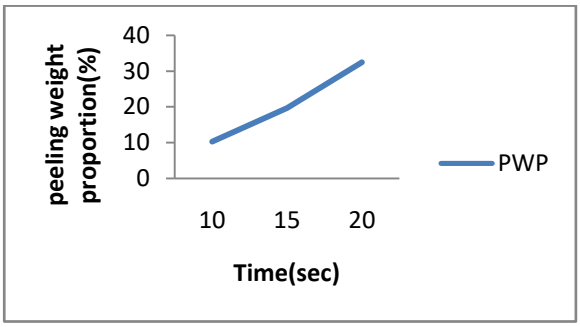


Fig. 5.Time versus peel weight proportion

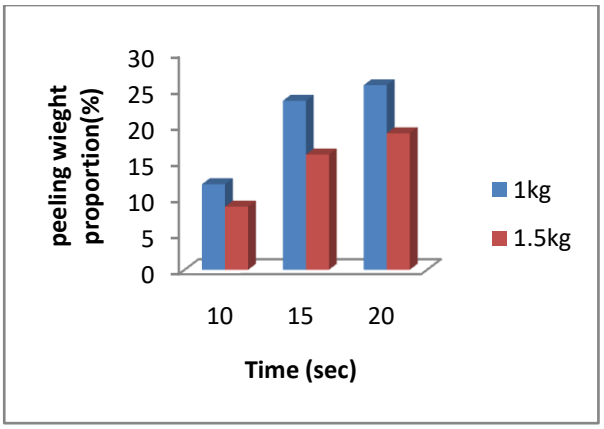


Fig. 6.The effect of Time on peel weight proportion

As shown from fig. 5 as the retention time increase from 10 to 20 sec the peeling weight proportion decrease from 10.275% to 32.445%.It can be noticed from figures that the increase of thebatch load from 1 to 1.5 kg, tends to decrease the peel weight proportion of the potato peeler from 11.825% to 8.72% at 10second residence time, from 23.35% to 15.9% at 15sec and from 25.5% to 18.87% at 20second peeling residence time (fig. 6). Compared with Oluwole (2013) of peeler the mean peeling weight proportion of this proto type was increased by 4 percent.

4.1.5. Peeling Efficiency Test: The average value of the mean efficiency of the prototype peeler obtained from the trials at 10,15 and 20 seconds were 52.55%,87.99% and98% respectively.

As shown from the figures 7 and 8 the efficiency of power operated potato peeling machine was mainly affected by the peeling residence time and the batch load of the tuber on peeling machine.

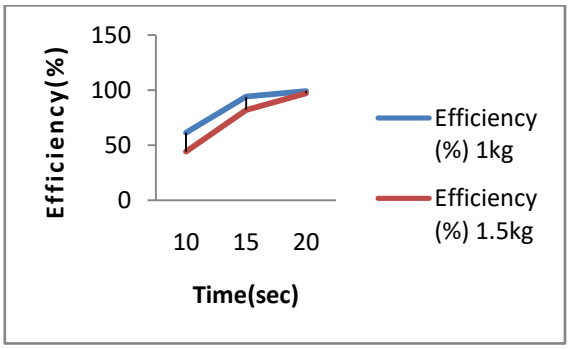


Fig .7.Residence Time versus peeling efficiency graph at 1kg and1.5kg batch load

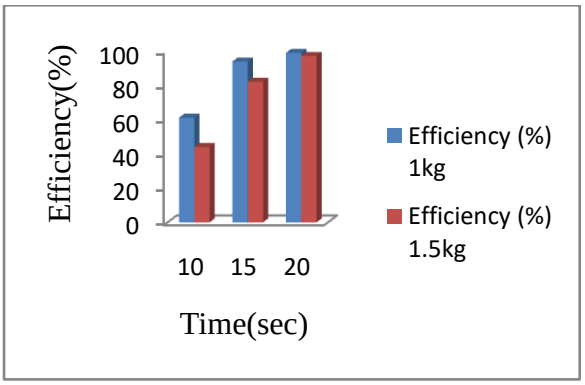


Fig. 8.Residence Time versus peeling efficiency graph at 1kg and1.5kg batch load

The optimum peeling efficiency of 61.1, 93.9 and 98.9 % were obtained at 1kg batch load, at 10, 15 and 20 seconds retention time respectively. The optimum peeling efficiency of 43.9, 82.05 and 97.09 % were obtained at 1.5kg batch load, at 10, 15 and 20 seconds retention time respectively (fig. 7). It can be noticed from figures that the increase of the batch load from 1 to 1.5 kg, tends to decrease the optimum peeling efficiency of the potato peeler from 61.1% to 43.9% at 10second residence time, from 93.9% to 82.05% at 15sec and from 98.9% to 97.09% at 20second peeling residence time (fig. 8). Generally we can see from this result that increasing of the residence time up to 20 sec increases the efficiency of the machine but if we increase the residence time above 20 sec it will damage the flesh of part of the tuber. According to El-Ghobashy et al. (2016) the closer the value of ηp% to 100, the higher the peeling efficiency, ηp% less than 100 refers to an incomplete peeling potatoes, while ηp% greater than 100 denotes some loss of useful potato flesh for the sized samples.

4.2. *Cost of Potato Peeling Machine:* The initial price of the potato peeling machine including the machine costs, the raw materials, and labor cost was 3,252.65EB. Meanwhile, the machine is simple, maintainable and can be operated using small power (about 0.8 kW) and consumes limited amount of water and constructed of standard locally manufactured components. Compared with Olukunle (2012) peeler which is 5481EB the cost of this prototype is lower by 2229EB.

5. CONCLUSION

A prototype of power driven potato peeling machine was designed, manufactured and evaluated successfully for different bulb sizes and different operational parameters such as rotational speed, feeding rate and peeling residence time. The most important results could be summarized as follows:

- The machine capacity increased from 0.10335 to 0.151275 kg/sec, with increasing of batch load from 1 to 1.5 kg at 10sec retention time, increased from 0.0696 to 0.102867 kg/sec, with increasing of batch load from 1 to 1.5 kg at 15sec retention time, increased from 0.0522 to 0.0769 kg/sec, with increasing of batch load from 1 to 1.5 kg at 20sec retention time
- The machine capacity decreased from 0.12731to 0.06455 kg /sec with increasing the peeling residence time from 10 to 20sec.
- The machine capacity increased from 0.103to 0.1065 kg /sec with increasing the size of the potato from small to large at 10sec retention time, decreased from 0.06873to 0.0675 kg /sec with increasing the size of the potato from small to large at 15sec retention time and decreased from 0.05155to 0.0506 kg /sec with increasing the size of the potato from small to large at 20sec retention time.
- Relative to manual peeling the capacity of power operated potato peeler increase by 326kg/h., therefore by using this machine we can decrease the drudgery and safe to operate.
- The average value of the mean efficiency of the prototype peeler obtained from the trials at 10,15 and 20 seconds were 52.55%,87.99% and98% respectively. From this we can conclude that as the retention time increases to

20 sec the efficiency of the machine increase but if the retention time increase above 20 sec it damages the flesh part of the tuber.

- The initial price of the potato peeling machine including the machine costs, the raw materials, and labor cost was 3,252.65EB.This cost is relative to the purpose of the machine it is not much because if we use manual although the cost is low but it need more time and dangerous to our hand.

6. RECOMMENDATION

A prototype of power driven potato peeling machine was manufactured with locally available materials and it is simple for use. It can decrease the drudgery of women in home; it can also useful for potato processing industries and hotels. It is also recommended to use it for peeling of onion and similar tubers in addition to potato.

The waste materials from the power driven potato peeler that means the washed peel and foreign materials can be used as a fertilizer for plantation and it can also use as animal feed.

For the future it will be designed and manufactured more simple, low cost, movable and attractive power driven potato peeling machine that is suitable for any shape and condition of potatoes. It would result into good efficiency with less peel loss.

REFERENCE

[1]. Adetoro, K. A. 2012. Mechanical Engineering unit, Faculty of Engineering. Development of yam peeling machine.Osun state, Nigeria.

[2]. Agrawal, Y. C. 1987. Ginger peeling machine parameters. Agricultural Mechanization in Asia. Africa and Latin America 18(2): 59-62.

[3]. Amin, E.1990.Mechanization for potato production on small farms Ph.D. Theses, Agric. Eng.dept Fac. of Agric., Mansoura University.

[4]. Balami, A. A., Mohammed, I. A., Adebayo, S. E., Adgidzi, D. andAdelemi, A. A. 2012. The relevance of some engineering properties of cocoyam (Colocasia esculenta) in the design of post- harvest processing machinery. Academic Research International 2(3): 53- 59.

[5]. El-Ghobashy, H; Adel H. Bahnasawy; Samir A. Ali; M. T.Afify; Z. Emara.2016. Development and evaluation of an onion peeling machine. International Journal of Engineering and Innovative Technology (IJEIT). 2017. Volume 6, Issue 9.

[6]. Jackson N Kabira and Berga Lemaga.2003, potato processing,Quality evaluation procedures for research and food industry applications in East and Central Africa,Nairobi.

[7]. J.E. Bradshaw. 2010. Root and Tuber Crops Scottish Crop Research Institute InvergowrieDundeeDD25DA United Kingdom

[8]. Lowa State University.2015.Estimating farm machinery costs.

[9]. Mohammed Syahmi, B. Shahrom. 2008. Development of potato peeling machine, Faculty of Mechanical Engineering, university Malaysia Pahang.

[10]. Oluwole, O. O., Adio M. A.2013.Design and Construction of a Batch Cassava Peeling Machine.

[11]. R.S Khurmi,J.K. and Gupta.2005.Text book of machine design, Ram Nagar,Delhi.

[12]. United Nations Development Fund for Women (UNIFEM).1993. Food Cycle Technology Source Book:Root Crop Processing. Intermediate Technology Publications Limited, Southampton, Row, London.