COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH- FOOD RESEARCH INSTITUTE (CSIR-FRI), ACCRA, GHANA

REPORT ON THE OPERATION COST ESTIMATION OF THE EXTRUSION PLANT

Prepared by:

Nancy Nelly Idun-Acquah

Desmond Mensah

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1.0 INTRODUCTION

1.1 Extrusion

Extrusion is regarded as one of the most versatile and energy-efficient processes in food and feed production (Guz *et al.*, 2011, *Ayadi et al., 2012*, Samuelsen *et al.*, 2013, Guz *et al.*, 2014, Oniszczuk *et al.*, 2017). Extrusion cooking is defined as a high-temperature-short-time (HTST) cooking process, which involves the cooking of ingredients in the extruder barrel, by a combination of high pressure, heat and friction (De Cruz *et al.*, 2015). Materials exit through a small die which is designed to produce highly expanded, low-density products with unique physical and chemical characteristics (Pansawat *et al.*, 2008, Tiwari and Jha, 2017; Masatcioglu *et al.*, 2014; Moscicki and van Zuilichem, 2011). The extrusion process combines several unit operations including mixing, cooking, kneading, shearing, shaping and forming (Stojceska *et al.*, 2009). Extrusion cooking is environmentally friendly and can be operated continuously with high throughput (Guy, 2011). The extrusion process can also improve the final product in terms of durability, digestibility, and palatability (Ayadi *et al.*, 2011; Rosentrater *et al.*, 2009b). Besides the economic benefits, chemical and structural (physical) transformations occur during extrusion cooking, such as gelatinization and expansion of the starches, formation of lipid complexes, enzyme inactivation, denaturation of anti-nutritional factors, and degradation reactions of pigments (Ding *et al.*, 2005), all of which have both physical and nutritional benefits (Cheng *et al.*, 2003). It is assumed that the short residence time reduces the side reactions such as degradation of bioactive compounds (Hirth *et al.*, 2014). Extruded foods are composed mainly of cereals, starches, and/or vegetable proteins. Numerous reports show that starch-based materials are ideal for extrusion processing (Moad, 2011; Yu *et al.*, 2012), because the major role of these ingredients is to form the structure, texture, mouth feel and many other characteristics desired for specific finished products (Anton *et al.*, 2009; Li *et al.*, 2014). In extrusion cooking, the quality of the final product depends mainly on the extruder type, die geometry, screw speed and configuration, feed moisture and composition, feed particle size, feed rate, and temperature profile in the barrel (Ding *et al.*, 2005; Pansawat *et al.*, 2008)

1.2 Types of Extruders

Generally, extrusion is categorized according to screw types; single screw and twin-screw extruders.

Single screw extruders

They are an attractive option for many applications due to low capital investment, low manufacturing cost, low maintenance, simplicity in design and straight forward operation (Kim and Kwon, 1996). A typical single screw extruder comprise**s** three main zones: feed, metering and compression, with a die for shaping. It relies on drag flow to move the material down the barrel and develops pressure at the die (Kelly *et al.,* 2006). Material enters from the feeder and moves in a channel toward the die when a screw rotates inside the barrel (Kim and Kwon, 1996).

Twin-screw extruders

They are classified according to the direction of screw rotation as either counter-rotating or co-rotating (Ayadi *et al.,* 2011). Advantages of the twin-screw extruders over the conventional single-screw extruders include better control of residence time and more uniform distribution of shear within the material (Kim and Kwon, 1996). Twin-screw extruders can process materials with different moisture contents and different viscosities. In addition, twin-screw feed rates are independent of screw speed and not influenced by pressure flow caused by restriction at the die. Also, twin-screw extruders can have larger heat transfer areas, larger outputs, more positive conveying, shorter residence times, better mixing, less wear and tear compared to single-screw extruders (Ayadi *et al.,* 2011).

2.0 METHODOLOGY

2.1 Components of the Twin Screw Extrusion Plant

The Twin Screw Extrusion Plant consists of the following line of equipment: Electric Cabinet Dryer, Miller, Mixer, Screw Conveyor, Twin Screw Extruder, Pneumatic Conveyor, Roasting Oven, Conveyor, Flavouring line and Packaging machine.

Electric cabinet dryer

The electric cabinet dryer has a batch drying capacity of 100 kg/h. It has two alternative sources of power supply for its operation: steam and electric power. If it is running on steam, it requires 18 kg of steam per hour. If it is running on electricity, it requires 27 kW per hour. The electric cabinet dryer has a heat exchange area of 20 m^2 with temperature difference at the top and bottom being ± 2. The electric cabinet dryer has 48 baking or drying trays and two drying or baking trolleys.

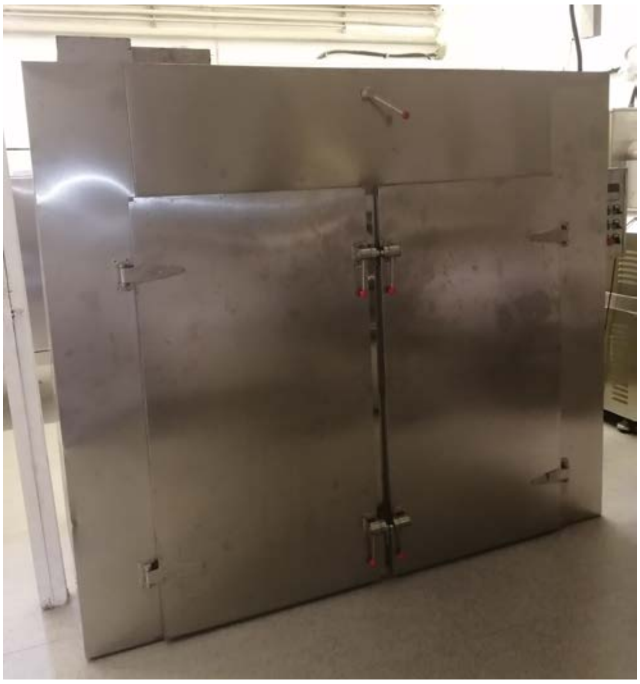

Figure 1 Electric Cabinet Dryer

Miller

The miller has capacity ranging from 150kg/h to 300 kg/h with a rotary speed of 3000 rev/min. It has a main motor, dust extraction motor and discharge motor which require 7.5 kW, 4 kW and 0.75 kW of electric power, respectively, to operate.

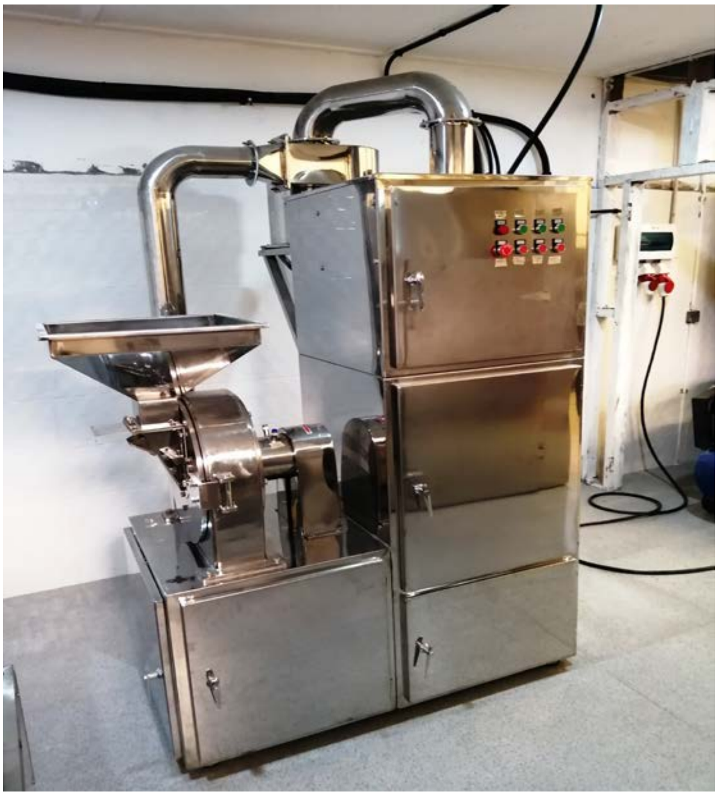

Figure 2 Miller

Mixer

The mixer consists of a mixing tank with a stirring wing inside. It is run by an electric motor which requires 4 kW of electric power to operate.

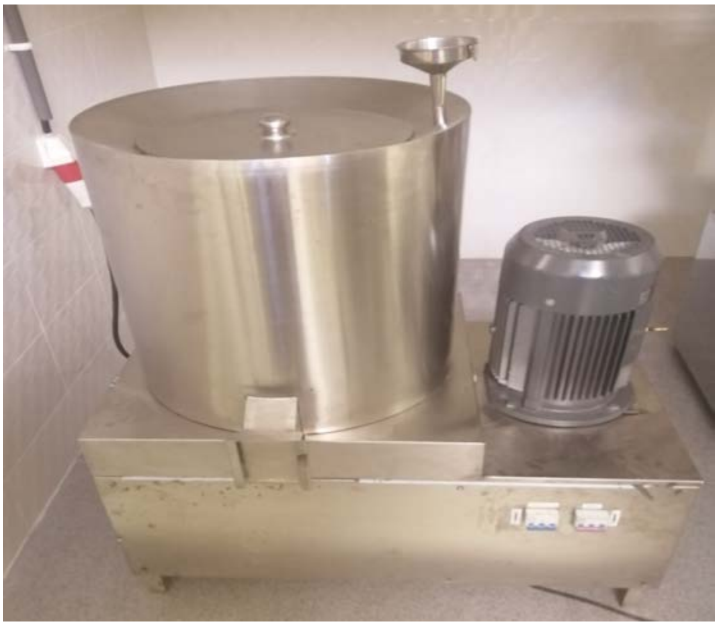

Figure 3 Mixer

Screw conveyor

The screw conveyor consists of a screw connected to a trough for receiving mixed product from the mixer and transporting the product to the extruder feeder. It requires 0.75 kW to run the screw motor.

Figure 4 Screw conveyor

Twin Screw Extruder

The twin screw extruder consists of three main systems: the feeding, the extruding and the cutting system. The feeding system consists of the raw material within which lies the screw mixer and driver. The extruding system consists of the two screws within a barrel which run along three heating zones in the extruder. The cutting system consists of a motor, knife and belt. The entire extruder set up requires 45.92 kW of electricity to run the various components of the twin screw extruder.

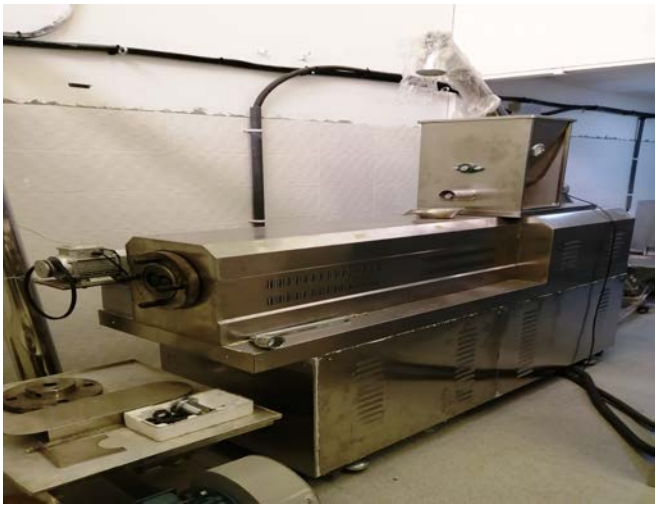

Figure 5 Twin Screw Extruder

Pneumatic conveyor

The pneumatic conveyor transfers extruded products from the extruder to the roasting oven. It requires 1.1 kW to operate.

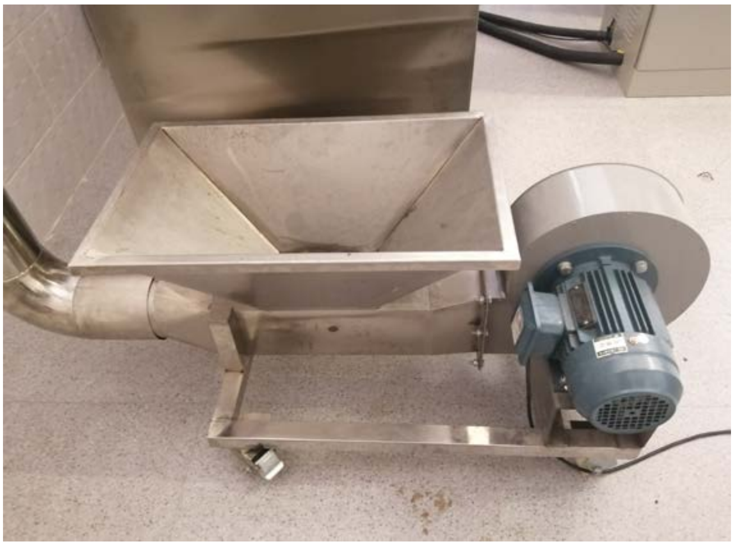

Figure 6 Pneumatic conveyor

Roasting oven

It consists of a heating chamber which contains five moving/rotating mesh belts on which extruded products from the extruder through the pneumatic conveyor go through thorough drying. It requires 46.1 kW to operate.

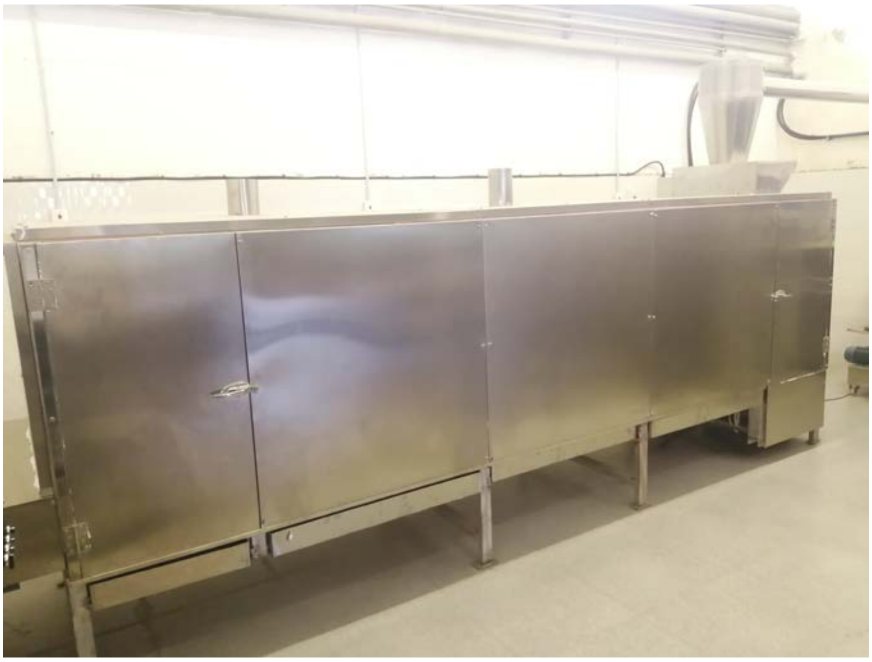

Figure 7 Roasting oven

Flavouring line

The flavouring line consists of the conveyor/hoister (transports dried extruded products from the exit of the roasting oven into the roller or rotating drum), the seasoning tank (holds and distributes seasoning powder on the products in the roller while the roller drum is rotating), the sprayer and the roller drum. The seasoning tank and the hoister require 1.12 kW to operate. The sprayer and roller drum require 2.37 kW and 0.75 kW, respectively, to operate.

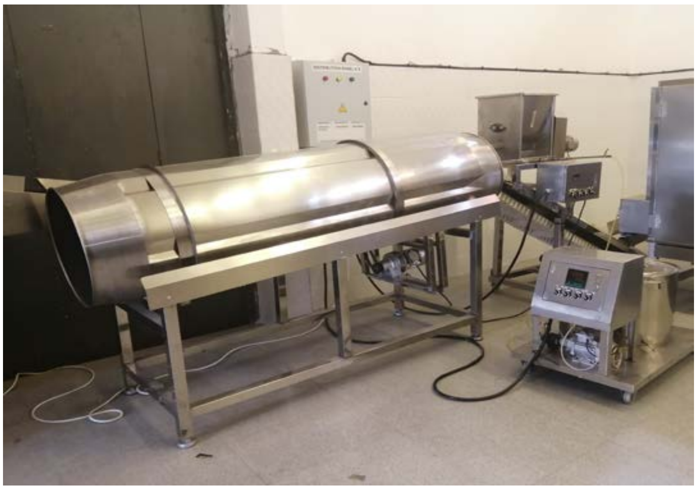

Figure 8 Flavouring line

Semi-automatic Packing machine

It consists of product feeding point, product bagging point, bagged product sealing point and bagged product cutting point. It has packing speed of 30-60 bags per minute. It requires 2 kW to operate.

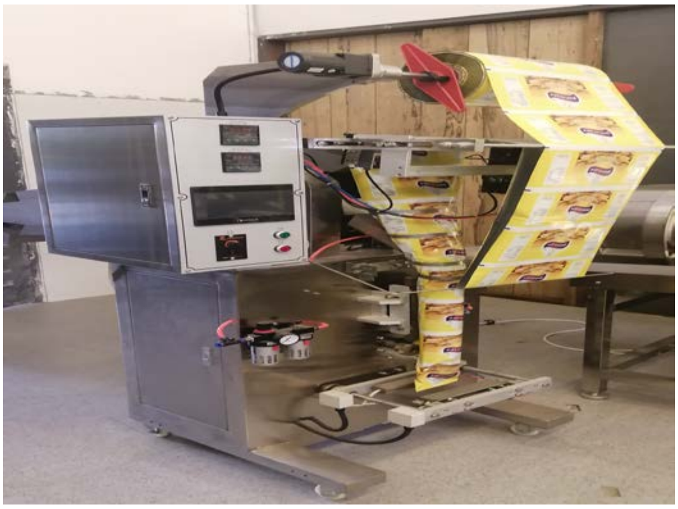

Figure 9 Semi-automatic packing machine

3.0 RESULTS

3.1 Extrusion plant operation cost components

The cost of operating the extrusion plant for one hour in extruding products can be estimated using the following input parameters assuming they are all in use during production:

- Cost of total power consumed per hour (P_t)
- Cost of water used during the extrusion process
- Depreciation of the extrusion plant
- Cost of Labour
- Profit margin

3.2. Cost of total power consumed per hour

It is determined by summing all power consuming components at an hour duration operation of the extrusion plant**:**

a. Electric Cabinet dryer (P_E) = 27 kW

b. Miller (P_M) = 12.25 kW

c. Mixer (P_X) = 4 kW

d. Screw conveyor (P_{SC}) = 0.75 kW

e. Twin screw extruder (P_{TSC}) = 45.92 kW

f. Pneumatic conveyor (P_{PC}) = 1.1 kW

g. Roasting oven (P_{RO}) = 46.1kW

h. Flavouring system (P_{FS}) =1.12 kW

i. Semi-automatic packing machine (P_{SPM}) = 2 kW

j. Roller drum (P_{RD}) = 0.75 kW

k. Sprayer (P_S) = 2.37 kW

l. Extraction fans (P_{EF}) = 0.68 kW

m. Light (P_L) = 0.144 kW

3.2.1 Category A: Total power (P_A) consumed when all components are in use.

Assuming all the components of the extrusion line are used during production, the total power consumed per hour is the sum of individual cost of power consumed by each power consuming element along the production line and during production.

Thus, $P_A = (P_E + P_M + P_X + P_{SC} + P_{TSC} + P_{PC} + P_{RO} + P_{FS} + P_{SPM} + P_{RD} + P_S + P_{EF} + P_L)$ kW

$P_A = (27 + 12.25 + 4 + 0.75 + 45.92 + 1.1 + 46.1 + 1.12 + 2 + 0.75 + 2.37 + 0.68 + 0.144)$ kW

$\boldsymbol{P_A = 144.184}$ **kW**

3.2.2 Category B: Total power (P_B) consumed when all components **except** Electric cabinet dryer are in use.

Assuming only the Electric cabinet dryer is not used during the extrusion process but all other components are used, then the total power consumed per hour is the sum of the power consumed by all other components during production **except** that of the electric cabinet dryer.

Thus, $P_B = (P_M + P_X + P_{SC} + P_{TSC} + P_{PC} + P_{RO} + P_{FS} + P_{SPM} + P_{RD} + P_S + P_{EF} + P_L)$ kW

$P_B = (12.25 + 4 + 0.75 + 45.92 + 1.1 + 46.1 + 1.12 + 2 + 0.75 + 2.37 + 0.68 + 0.144)$ kW

$\boldsymbol{P_B = 117.184}$ **kW**

3.2.3 Category C: Total power (P_C) consumed when all components **except** Electric cabinet dryer and Miller are in use.

Assuming the Electric cabinet dryer and Miller are not used during the extrusion process but all other components are used, then the total power consumed per hour is the sum of the power consumed by all other components during production **except** that of the Electric cabinet dryer and the Miller.

Thus, $P_C = (P_X + P_{SC} + P_{TSC} + P_{PC} + P_{RO} + P_{FS} + P_{SPM} + P_{RD} + P_S + P_{EF} + P_L)$ kW

$P_C = (4 + 0.75 + 45.92 + 1.1 + 46.1 + 1.12 + 2 + 0.75 + 2.37 + 0.68 + 0.144)$ kW

$\boldsymbol{P_C = 104.934}$ **kW**

3.2.4 Category D: Total power (P_D) consumed when all components **except** Electric cabinet dryer, Miller and Semi-automatic packing machine are in use.

Assuming the Electric cabinet dryer, the Miller and the Semi-automatic packing machine are not used during the extrusion process but all other components are used, then the total power consumed per hour is the sum of the power consumed by all other components during production **except** that of the Electric cabinet dryer, the Miller and Semi-automatic packing machine.

Thus, $P_D = (P_X + P_{SC} + P_{TSC} + P_{PC} + P_{RO} + P_{FS} + P_{RD} + P_S + P_{EF} + P_L)$ kW

$P_D = (4 + 0.75 + 45.92 + 1.1 + 46.1 + 1.12 + 0.75 + 2.37 + 0.68 + 0.144)$ kW

$\boldsymbol{P_D = 102.934}$ **kW**

3.2.5 Category E: Total power (P_E) consumed when all components **except** Electric cabinet dryer, Miller, Flavouring system and Semi-automatic packing machine are in use.

Assuming the Electric cabinet dryer, the Miller, the Flavouring system and the Semi-automatic packing machine are not used during the extrusion process but all other components are used, then the total power consumed per hour is the sum of the power consumed by all other components during production **except** that of the Electric cabinet dryer, the Miller, the Flavouring system and the Semi-automatic packing machine.

Thus, $P_E = (P_X + P_{SC} + P_{TSC} + P_{PC} + P_{RO} + P_{RD} + P_S + P_{EF} + P_L)$ kW

$P_E = (4 + 0.75 + 45.92 + 1.1 + 46.1 + 0.75 + 2.37 + 0.68 + 0.144)$ kW

$\boldsymbol{P_E = 101.814}$ **kW**

3.2.6 Category F: Total power (P_F) consumed when all components **except** Electric cabinet dryer, Miller, Flavouring system, Sprayer and Semi-automatic packing machine are in use.

Assuming the Electric cabinet dryer, the Miller, the Flavouring system, the Sprayer and the Semi-automatic packing machine are not used during the extrusion process but all other components are used, then the total power consumed per hour is the sum of the power consumed by all other components during production **except** that of the **Electric cabinet dryer, Miller, Flavouring system,** the **Sprayer** and the **Semi-automatic packing machine.**

Thus, $P_F = (P_X + P_{SC} + P_{TSC} + P_{PC} + P_{RO} + P_{RD} + P_{EF} + P_L)$ kW

$P_F = (4 + 0.75 + 45.92 + 1.1 + 46.1 + 0.75 + 0.68 + 0.144)$ kW

$\boldsymbol{P_F = 99.444}$ **kW**

Per the new Electricity Tarrifs, Fourth Schedule, Non-Residential, Tarrif Category (EUT) approved by the Public Utilities Regulatory Commission, effective 1st July, 2019, the estimated cost of power consumed by the equipment are given in Table 1.

Table 1 Summary of Category of equipment used during the extrusion process and their corresponding total power consumption and cost of power consumed**.**

No	Category	Power consumed (kWh)	Amount (GHp)	Amount (GH₵)
1.	A	$P_A = 144.184$	10860.083	108.6008
2.	B	$P_B = 117.184$	8826.416	88.26416
3.	C	$P_C = 104.934$	7903.734	79.03734
4.	D	$P_D = 102.934$	7753.092	77.53092
5.	E	$P_E = 101.814$	7668.732	76.68732
6.	F	$P_F = 99.444$	7490.222	74.9022

Note: 1 kWh is equivalent to GHp 75.3210

3.3. Cost of water used during the extrusion process

The cost of water used in the extrusion process is in two parts:

i. **Cost of water used by the extruder during extrusion**: It is borne by the client since the client would be required to supply their own bottled water for the extrusion of products.

ii. **Cost of water used for cooling the bearing components of the miller when milling of raw products exceeds 30 minutes**. Currently, there is no cooling system in place for the miller yet. Thus, the cost of water consumption is on hold.

3.4. Depreciation of the extrusion plant

Depreciation is the method of calculating the cost of an asset over its lifespan.

Depreciation using the Straight Line Method

Purchase price of Extrusion plant, P_t = \$44,500.00

Assumptions

Salvage or scrap value, S = 15% of Total purchase price of Extrusion plant

Salvage or scrap value, S = \$6,675

Life span of Extrusion plant, N = 10 years

Number of working months in a year, N_m = 12

Number of working days in a month, N_d =27

Number of working hours in a day, N_h

Depreciation per annum = D_a

Depreciation per month = D_m

Depreciation per day = D_d

Depreciation per hour = D_h

Depreciation per annum, $D_a = \frac{P_t - S}{N}$

$$D_a = \frac{\$44{,}500 - \$6{,}675}{10}$$

$D_a = \$3{,}782.5$

Therefore the depreciation cost per annum of Extrusion plant is \$3,782.5.

Depreciation per month, $D_m = \frac{D_a}{N_m}$

$$D_m = \frac{\$3,782.5}{12}$$

$D_m = \$\,315.208$

Therefore the depreciation cost per month of Extrusion plant is $\$\,315.208$.

Depreciation per day, $D_d = \frac{D_m}{N_d}$

$$D_d = \frac{\$315.208}{27}$$

$D_d = \$\,11.674$

Therefore the depreciation cost per day of Extrusion plant is $\$\,11.674$.

Depreciation per hour, $D_h = \frac{D_d}{N_h}$

$$D_h = \frac{\$11.674}{8}$$

$D_h = \$\,1.46$

Thus, depreciation cost per hour of Extrusion plant is $\$\,1.46$ (ie. GH₵8.03 per current dollar rate).

3.5. Cost of Labour

The cost of labour factors in the number of persons required to operate the Extrusion plant and the amount of money each person charges per hour during drying operation according to their ranks. The number of persons needed in operating the Extrusion plant during processing is seven: Plant Manager, Plant Engineer, Assistant Plant Engineer, Production Manager, Assistant Production Manager, Electrical Engineer and Quality Manager.

Amount charged by Plant Manager per hour:

Monthly salary of Plant Manager = PM_m= GH₵4849.67

Number of working days in a month = N_d =27

Number of working hours in a day = N_h =8

Amount charged per day or daily wage by Plant Manager = W_{dPM}

$$W_{dPM} = \frac{PM_m}{N_d}$$

$$W_{dPM} = \frac{GH₵4{,}849.67}{27}$$

$$W_{dPM} = GH₵\ 179.62$$

Amount charged per hour by Plant Manager = W_{hPM}

$$W_{hPM} = \frac{W_{dPM}}{N_h}$$

$$W_{hPM} = \frac{GH₵179.62}{8}$$

$$W_{hPM} = GH₵\ 22.45$$

Therefore, the amount charged by **Plant Manager** per hour is GH₵22.45.

Amount charged by Plant Engineer per hour:

Monthly salary of Plant Engineer = PE_m = GH₵ 4,149.67

Number of working days in a month = N_d =27

Number of working hours in a day = N_h =8

Amount charged per day or daily wage by Plant Engineer = W_{dPE}

$$W_{dPE} = \frac{PE_m}{N_d}$$

$$W_{dPE} = \frac{GH₵\ 4{,}149.67}{27}$$

$$W_{dPE} = GH₵\ 153.69$$

Amount charged per hour by Plant Engineer = W_{hPE}

$$W_{hPE} = \frac{W_{dPE}}{N_h}$$

$$W_{hPE} = \frac{GH₵\ 153.69}{8}$$

$W_{hPE} = GH₵\ 19.21$

Therefore, the amount charged by Plant Engineer per hour is $GH₵$ 19.21

Amount charged by Assistant Plant Engineer per hour:

Monthly salary of Assistant Plant Engineer = APE_m = GH₵ 6,290.31

Number of working days in a month = N_d =27

Number of working hours in a day = N_h =8

Amount charged per day or daily wage by Assistant Plant Engineer = W_{dAPE}

$$W_{dAPE} = \frac{APE_m}{N_d}$$

$$W_{dAPE} = \frac{\text{GH₵ 6,290.31}}{27}$$

$$W_{dAPE} = GH₵\ 232.974$$

Amount charged per hour by Assistant Plant Engineer = W_{hAPE}

$$W_{hAPE} = \frac{W_{dAPE}}{N_h}$$

$$W_{hAPE} = \frac{GH₵\ 232.974}{8}$$

$$W_{hAPE} = GH₵\ 29.12$$

Therefore, the amount charged by Assistant Plant Engineer per hour is GH₵ 29.12.

Amount charged by Electrical Engineer per hour:

Monthly salary of Electrical Engineer = EE_m = GH₵ 4,149.67

Number of working days in a month = N_d =27

Number of working hours in a day = N_h =8

Amount charged per day or daily wage by Electrical Engineer = W_{dEE}

$$W_{dEE} = \frac{EE_m}{N_d}$$

$$W_{dEE} = \frac{\text{GH₵ 4,149.67}}{27}$$

$W_{dEE} = GH₵\ 153.69$

Amount charged per hour by Electrical Engineer = W_{hEE}

$$W_{hEE} = \frac{W_{dEE}}{N_h}$$

$$W_{hEE} = \frac{GH₵\ 153.69}{8}$$

$W_{hEE} = GH₵\ 19.21$

Therefore, the amount charged by Electrical Engineer per hour is $GH₵\ 19.21$

Amount charged by Production Manager per hour:

Monthly salary of Production Manager = PRM_m = GH₵ 4,258.43

Number of working days in a month = N_d =27

Number of working hours in a day = N_h =8

Amount charged per day or daily wage by Production Manager = W_{dPRM}

$$W_{dPRM} = \frac{PRM_m}{N_d}$$

$$W_{dPRM} = \frac{GH₵\ 4{,}258.43}{27}$$

$W_{dPRM} = GH₵\ 157.720$

Amount charged per hour by Production Manager = W_{hPRM}

$$W_{hPRM} = \frac{W_{dPRM}}{N_h}$$

$$W_{hPRM} = \frac{GH₵\ 157.720}{8}$$

$W_{hPRM} = GH₵\ 19.715$

Therefore, the amount charged by Production Manager per hour is GH₵ 19.715.

Amount charged by Assistant Production Manager per hour:

Monthly salary of Assistant Production Manager = $APRM_m$ = GH₵ 4,326.88

Number of working days in a month = N_d =27

Number of working hours in a day = N_h =8

Amount charged per day or daily wage by Assistant Production Manager = W_{dAPRM}

$$W_{dAPRM} = \frac{APRM_m}{N_d}$$

$$W_{dAPRM} = \frac{\text{GH₵ } 4{,}326.88}{27}$$

$$W_{dAPRM} = GH₵\ 160.25$$

Amount charged per hour by Assistant Production Manager = W_{hAPRM}

$$W_{hAPRM} = \frac{W_{dAPRM}}{N_h}$$

$$W_{hAPRM} = \frac{GH₵\ 160.25}{8}$$

$$W_{hAPRM} = GH₵\ 20.03$$

Therefore, the amount charged by Assistant Production Manager per hour is GH₵ 20.03.

Amount charged by Quality Manager per hour:

Monthly salary of Quality Manager = QM_m = GH₵ 4,849.67

Number of working days in a month = N_d =27

Number of working hours in a day = N_h =8

Amount charged per day or daily wage by Quality Manager = W_{dQM}

$$W_{dQM} = \frac{QM_m}{N_d}$$

$$W_{dQM} = \frac{\text{GH₵ } 4{,}849.67}{27}$$

$$W_{dQM} = GH₵\ 179.62$$

Amount charged per hour by Quality Manager = W_{hQM}

$$W_{hQM} = \frac{W_{dQM}}{N_h}$$

$$W_{hQM} = \frac{GH₵\,179.62}{8}$$

$$W_{hQM} = GH₵\,22.45$$

Therefore, the amount charged by Quality Manager per hour is GH₵ 22.45.

The **total amount of money charged** by the Plant Manager, Plant Engineer, Assistant Plant Engineer, Production Manager, Assistant Production Manager, Electrical Engineer and Quality Manager per hour in running the Extrusion Plant is the sum of the individual charges per hour for each person.

Thus, cost of labour in per hour in running the Extrusion Plant is GH₵ 152.19.

3.6. Profit margin

The amount of money to charge as profit is at the discretion of management or administration.

3.7 Total Operation Cost of the Extrusion Plant

The total cost of operating the Extrusion Plant per hour depending is summarised in Table 2. The categories refer to the various components of the Extrusion Plant used during its operation as explained under the cost of power consumption.

Table 2 Total cost of operating the Extrusion Plant per hour.

	CATEGORY					
COST COMPONENT (GH₵)	**A**	**B**	**C**	**D**	**E**	**F**
Power	108.60	88.26	79.04	77.53	76.69	74.90
Water	N/A	N/A	N/A	N/A	N/A	N/A
Extrusion Plant Depreciation	8.03	8.03	8.03	8.03	8.03	8.03
Labour	152.19	152.19	152.19	152.19	152.19	152.19
Profit Margin	-	-	-	-	-	-
TOTAL	**268.82**	**248.48**	**239.26**	**237.75**	**236.91**	**235.12**

CONCLUSION

The total cost of operating the Extrusion Plant per hour is estimated at **GH₵ 268.82**, **GH₵ 248.48, GH₵ 239.26, GH₵ 237.75, GH₵ 236.91** and **GH₵ 235.12** for **CATEGORY A**, **B**, **C**, **D**, **E** and **F**, respectively, excluding profit margin which is assigned at the discretion of the institute). The total cost of drying per hour for each category is also subject to change in the event of changes in utility tariffs (water and electricity) and cost of labour.

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APPENDICE

Appendix 1 Electricity Tariff

PUBLIC UTILITIES REGULATORY COMMISSION (PURC)
PUBLICATION OF ELECTRICITY TARIFFS

In accordance With the statutory duty imposed on the Public Utilities Regulatory Commission ('the Commission') under Section 19 of the Public Utilities Regulatory Commission Act, 1997 (Act 538), ('the Act') this publication is made this 20 June 2019.

1. The Bulk Generation Charge provided in the First Schedule is the weighted average rate at which electricity distribution companies (DISCos), namely Power Distribution Services Limited (PDS)I, Northern Electricity Distribution Company Limited (NEDCo) and Enclave Power Company Limited (EPCL) shall procure electricity from generation sources in respect of their operations in the regulated market, from I July 2019.
2. The Transmission Service Charges (TSC) provided in the Second Schedule are the rates applicable to the transmission of electricity by the Ghana Grid Company Limited (GRIDCo), from 1 July 2019 as follows:
    a. TSC is the rate for GRIDCo to recover the cost of transmission network operations.
    b. TSC 2 is the rate for GRIDCo to recover transmission losses.
3. A DISCO or Bulk Customer which procures electricity from an electricity generator and pays the full cost Of the total electricity purchased to the electricity generator shall pay TSC I only, to GRIDCo.
4. A DISCo or Bulk Customer which procures electricity from an electricity generator and pays the cost Of the electricity purchased excluding transmission losses, shall pay both TSC 1 and TSC 2 to GRIDCo,
5. The Distribution Service Charges (DSC) provided in the Third Schedule are the rates applicable to the distribution of electricity by DISCos, from 1 July 2019 as follows:
    a. DSC 1 is the rate for DISCos to recover the cost Of distribution network operations.
    b. DSC 2 is the rate for DISCos to recover distribution losses.
    c. DWC comprises DSC 1 and DSC 2 and is the rate payable to DISCos for the use of their networks by embedded Bulk Customers.
6. A Bulk Customer embedded in the distribution network which procures electricity directly from an electricity generator and pays the total cost of the electricity purchased including TSC 1 and TSC 2 shall pay DSC 1 only to the DISCo.
7. A Bulk Customer embedded in the distribution network which procures electricity through a DISCo shall pay to the affected DISCo, the cost Of the electricity delivered at the customer's premises in addition to TSC 1 TSC 2 and the DWC.
8. The End-User Tariffs provided in the Fourth Schedule are the rates payable by consumers in the specified categories, from 1 July 2019.
9. The tariffs are denominated in Ghana Pesewas (GHp).
10. The tariffs shall remain in force until they are reviewed by the Commission.

1 1 . Until the next major tariff review, electricity tariffs shall be adjusted by the Commission in accordance with the Automatic Adjustment (Indexation) Formula published in Gazette No. 15 of 25th February 2011.

12. The rates approved by the Commission and published in Gazette No. 139 of 29th October 2018 are revoked and replaced with the rates contained in this publication.

ACRONYMS

BGC	Bulk Generation Charge
DISCO	Electricity Distribution Company
DSC	Distribution Service Charge
	Distribution Wheeling Charge
EUT	End User Tariff
GHp	Ghana Pesewa
Ipp	Independent Power Producer
kVA	Kilovolt Ampere
kWh	Kilowatt-Hour
SLT-LV	Special Load Tariff — Low Voltage
SLT-MV	Special Load Tariff — Medium Voltage
SLT-HV	Special Load Tariff — High Voltage
TSC	Transmission Service Charge
VRA	Volta River Authority

With effect from 1 March 2019 Distribution and Sale Operations of the Electricity Company of Ghana are performed by Power Distribution Services Ltd. (PDS)

FIRST SCHEDULE

Tariff Cate o		Effective 1 Jul 2019
BCC VRA	GH 'kWh	29.0370
com osite BCC VRA and IPPs	GH /kWh	45.2493

SECOND SCHEDULE

Tariff Category		Effective 1 July 2019
TSC 1*	GH /kWh	5.5172
TSC 2	GH /kWh	1.9340

THIRD SCHEDULE

Tariff Cate o		Effective 1 Jul 2019
DSC 1	GH /kWh	16.0346
DSC 2	GH /kWh	14.8920

DWC	GH /kWh	30.9266

FOURTH SCHEDULE

Tariff Cate o EUT		Effective 1 Jul 2019
Residential	(GHp/kWh)	30.7780
0-50	(GHp/kWh)	61.7488
51-300	(GHp/kWh)	80.1380
301 -600 601+	(GHp/kWh)	89.0422
Service Charge:		
Lifeline Consumers	(GHp/month)	213.0000
Other Residential Consumers	(GHp/month)	703.8906
Non-Residential 0-		
100	(GHp/kWh)	75.3210
101-300	(GHp/kWh)	75.3210
301 - 600	(GHp/kWh)	80.1496
601+	(GHp/kWh)	126.4657
Service Charge	(GHp/month)	1173.1511
SLT-LV		
Energy Charge	(GHp/kWh)	98.8591
Service Charge	(GHp/month)	4692.6045
SLT-MV		
Energy Charge	(GHp/kWh)	75.0589
Service Charge	(GHp/month)	6569.6464
SLT-HV		
Energy Charge	(GHp/kWh)	78.7776
Service Charge	GHp/month)	6569.6464
SLT-HV MINES		
Energy Charge	(GHp/kWh)	249.1721
Service Charge	(GHp/month)	9.64

•Includes Regulatory Levy

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Chairman

Public Utilities Regulatory Commission

MR. MICHAEL OPAM

COMMISSIONER

COMMISSIONER

MRS. MAMI DUFIE OFORI COMMISSIONER

COMMISSIONER

MRS. DORA OPPONG

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