



DEVELOPMENT

DESIGN OF AN AUTOMATED POULTRY SCALDING AND DE-FEATHERING
MACHINE

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ABSTRACT

The automated poultry bird de-feathering machine is a machine which aids feather removal from birds, it helps to reduce manual labour and time spent in de-feathering process. To ensure good functionality, the boiler, scalding as well as the de-feathering compartments, were fabricated using stainless steel materials. The machine has a reservoir capacity to accommodate about 210 liters of water, a boiler compartment with 85-liter capacity. The machine uses a belt and pulley mechanism on the de-feathering compartment and a chain and sprocket mechanism on the scalding compartment. An electric motor with 3.0hp rating with 500mm and 80mm pulley on driver and driven pulley respectively were used on the de-feathering compartment, on the scalding compartment, a motor of 0.5hp with 102 teeth and 17 teeth on driver and driven sprocket were used respectively. The machine has a water pump of 1 hp which helps circulate water to the boiler, reservoir and de-feathering sprinkler hose with the help of pipes. Poultry chickens (old layer – Isa brown specie) were used to test the performance of the machine. The automated de-feathering machine has a maximum throughput capacity of 37g/s, an efficiency of 95.30%, and a de-feathering time of 32 seconds per cycle for a 10 birds capacity drum, and the processing of approximately 110 birds per hour can be achieved.

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1.0 Introduction

One of the steps taken in bird processing before it reaches the end product for cooking is de-feathering of the bird (Adetola, et al., 2023; Dickens and Shackelford 2004). De-feathering involves removing feathers from the slaughtered birds, traditionally, in this part of the world, it is done manually by the use of hand after it has been soaked in hot water for a few minutes (Adetola, et al., 2023). This process results in low output, time consuming, tedious, and could lead to injury (Ogundipe and Sanni 2002). There is therefore a need to design and develop machines using locally sourced materials to minimize cost, avoid supply disruptions, create jobs, and simplify maintenance (Ocheri, et al., 2018; Adetola, et al., 2023). It takes an average of 5 minutes for a person to de-feather a bird while the machine processing of a bird that is lowered into hot water at 80°C – 85°C takes 40 – 50 seconds (David, 1999).

The objective of a centralized poultry processing paltry of any scale of operation is to produce hygienic, wholesome, and attractive birds of consistent quality and high standard (Buckland, 2005). De-feathering machine saves time, easy to operate and better picking is achieved (Ogundipe and Sanni 2002). Mechanical de-feathering employs various de-feather mechanism such as rubber finger, rotating plate, drum and angle bar mechanism (Adetola, et al., 2023; Dickens and Shackelford 2004). This is done after slaughtering the birds which is accompanied by bleeding period (Adetola, et al., 2023). The carcass is removed and lowered into a tank of heated water to a certain temperature and plucked (Ogundipe and Sanni 2002).

The use of de-feathering machine in processing poultry has contributed tremendously to the successful processing of dressed and Hygienic chicken for consumption (Jekayinfa, 2007; Adetola, et al., 2023). Additionally, de-feathering machine overcomes the tediousness, time consumption, messy handling, and discouragement in the process of hand de-feathering (Adetola, et al., 2023). Also, there is mass production of processed chicken in de-feathering machine than hand de-feathering (Adetola, et al., 2023; Awotunde, et al., 2018).

It is noteworthy that there are three different ways in which feathers can be removed completely from the chicken; the first is for broilers only and is by hand, the feathers are simply pulled from the carcass and placed in a feather bin (David, 1999). This method takes a lot of time; it is tedious and results in low output, (David, 1999; Mady and Obaia 2018). The second method is by holding the carcass against rubber fingers protruding from a continuously rotating horizontal drum, the drum rotates away from the operator and the feathers follow until they are thrown towards the back of the machine (David, 1999). The bird is held with a leg in each hand and laid firmly on its left breast on the rotating rubber fingers; it is agitated backwards and forwards to pluck the left breast and thigh; the bird is turned over to pluck the right breast and thigh (David, 1999). Both legs are taken in the left hand and the tail feathers gripped in the right hand before pulling them out with a twisting movement (David, 1999). The third method uses a bowl de-feather; scaled birds, to a weight specified by the manufacturer, are placed in the bowl de-feather chute which passes into the body of the machine, the machine is stopped and a door to the bottom of the machine is opened and the plucked carcasses emerge ready for further processing (David, 1999; Ogundipe and Sanni, 2002; Mady and Obaia 2018). Time taken in the de-feathering bowl will depend on the nature of the bird, its age, and processing conditions etc. (David, 1999).

In Nigeria, fast food business is fast growing so also is the population of people eating chicken during festivals and other ceremonies (Ogundipe and Sanni, 2002). Therefore, there arises the need to design and develop a de-feathering machine that will be low cost, rugged, simple, with locally sourced materials (Adetola, et al., 2023).

2. Materials and Methods

The de-feathering machine operates on the principle of a belt-driven pulley and abrasion where rubbers fingers in rotary motion hit the birds and pluck their feathers (Tanimola, et al., 2014). The scalding compartment (a hot water bath where stunned birds are immersed to loosen their feathers), operates on the principle of chain and sprocket drive which tilts at an angle of 110 degrees and returns to position. The test operation was carried out with two, five and ten birds respectively, and their weights recorded. The boiler heats up the water to a temperature of 75°C, which is emptied into the scalding bucket to soak the birds for 45 seconds before it was emptied into the de-feathering compartment. The scalding bucket waits for 4 seconds there returning to its original position. The de-feathering machine rotated for 30 seconds and then stops. All operations were automated according to the control sequence.

2.1 Mechanical Design Theory

1. Pulley Design

The relationship is given by Equation (1):

$$\text{Speed Ratio} = \frac{N_1}{N_2} = \frac{d_2}{d_1} \quad 1$$

where; d_1 = small pulley diameter, d_2 = large pulley diameter, N_1 = small pulley speed and N_2 = large pulley speed, Khurmi and Gupta (2005).

2. Electric Motor Selection

The relationship is given by Equation (2):

$$P_{out} = T * \omega \quad 2$$

where T = Torque, ω = angular speed, and P_{out} = power output

$$\text{The angular velocity } (\omega) = \frac{2\pi N}{60} \quad 3$$

where; N= number of speed

3. Centrifugal force

The relationship is given by Equation (4):

$$F_C = m\omega^2 r \quad 4$$

where m = mass of birds, r = radius of compartment

4. Belt Selection

The belt length is given by Equation (5) as:

$$L = \pi \left[\frac{(D + d)}{2} + 2x + \frac{(D - d)}{4x} \right] \quad 5$$

where L = total length of belt, x = distance between the centres of two pulley,

D = large diameter, d = small diameter (Khurmi and Gupta, 2005).

5. Power transmitted by the belt

The power transmitted by a given belt drive is represented in Equation (6) as:

$$P = (T_1 - T_2)v \quad 6$$

where P = power, T₁ = Tension of tight side of the belt, T₂ = Tension of slack side of the belt and v = velocity (Khurmi and Gupta, 2005). The belt tensions are given by Equation (7):

$$\frac{T_1}{T_2} = e^{\mu\theta} \quad 7$$

6. Shaft design

Equation (8) is the used to determine the diameters of a shaft

$$\frac{T}{J} = \frac{G\theta}{L} = \frac{\tau}{r} \quad 8$$

where T = twisting moment (or torque) acting upon the shaft, J = polar moment of inertia r = radius, G = modulus of rigidity, θ = angle of twist, L=Length of shaft, τ = *Torsional shear stress* (Khurmi and Gupta, 2005).

7. Rate of heat flow

The heat loss in the Scalding compartment is given by Equation (9):

$$Q = \frac{\lambda A}{X} (T_1 - T_2) \quad 9$$

where λ = Thermal conduction of material, A = Area of the cylinder, T₁ = temperature of water, T₂ = Temperature on boiler cylinder wall, x = Thickness of material

8. Chain drive

The velocity ratio of a chain drive given in Equation (10) as:

$$V.R = \frac{T_1}{T_2} = \frac{N_1}{N_2} \quad 10$$

where T₁=Number of teeth on the smaller sprocket, T₂= number of teeth on the bigger sprocket, N₁ =speed of rotation of smaller sprocket in r.p.m, and N₂ =Speed of rotation of bigger sprocket in r.p.m (Khurmi and Gupta, 2005).

9. Torque for scalding controller

The Equation (11) gives the relationship to determine the torque:

$$\text{Torque } T = Fr$$

11

where F = force (weight on the compartment), r = radius of scalding compartment

10. Pump selection

The selection criteria for the pump are given in Equations (12) and (13):

Hydraulic power of the pump

$$P_h = \frac{Q\rho gh}{3.68 \times 10^6}$$

12

where Q = flowrate, ρ = density, g = acceleration due to gravity, h= total head

Discharge and velocity (Nakayama and Boucher, 2000).

$$Q = AV$$

13

where, A = Area of flow, V = Velocity of flow

2.2 Mechanical Design Specifications

Table I gives a detailed specification and mechanical design values of the de-feathering machine.

Table I: Specification of the De-feathering Machine

Description of Items	Machine parts/Specification
Mechanism	Pulley, Belt and chain, sprocket drive
Target costumer	Farmers and small scale industry and home use.
Prime mover	Electric Motor
Mode of operation	Automatic
Motor specification for de-feathering machine.	3HP motor
Major pulley diameter on de-feathering machine	500mm diameter
Minor pulley for electric motor	80mm diameter
Major sprocket on scalding section	102 teeth
Minor sprocket on scalding section	17 teeth
live stocks	Birds, goose and duck
Machine dimension	163cm × 127cm × 117cm
Manufacturing	Machining, Assembling and Welding
Cylinder diameter and height for boiler	380mm×310cm
Cylinder diameter and height for scalding	590mm×310cm
Cylinder diameter and height for de-feathering	610m×460cm
Reservoir specification	152cm×40cm×42cm
Water pump specification	1 HP
Motor specification for scalding machine	0.5 HP
Heat loss	3.0 watts

The pictorial design of the poultry bird de-feathering machine is shown in Plate I



Plate I: Poultry Birds De-feathering Machine

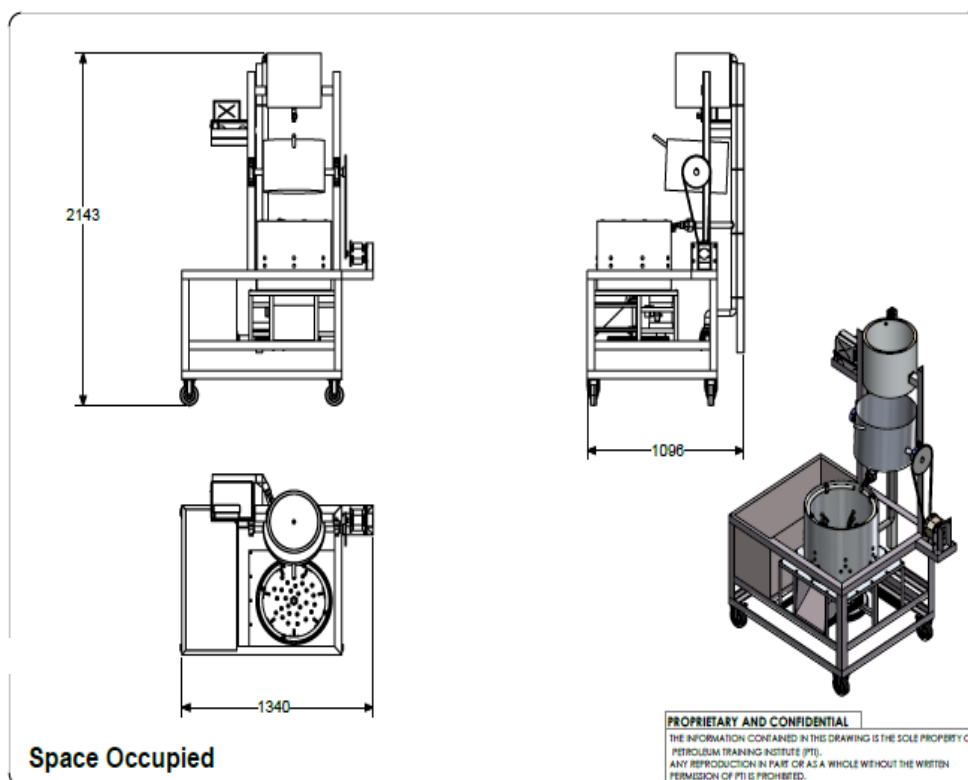


Figure I: Orthographic View

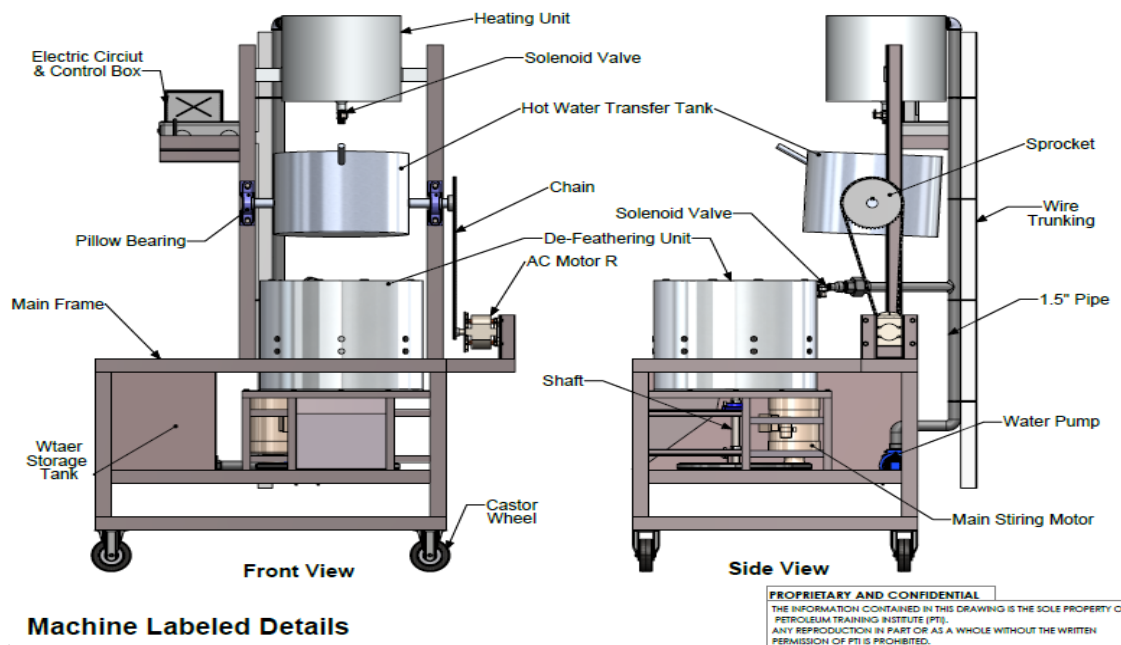


Figure 2: Labeled Details of De-feathering Machine

2.3 Electrical Design Theory

1. Peak inverse voltage

The peak inverse voltage is given in Equation (14) as:

$$\text{Peak inverse voltage } P_{iv} = \sqrt{2} \times V_{rms} \quad 14$$

where V_{rms} = Transformer output voltage (Theraja and Theraja 2007).

2. Selection of the filter capacitor (C1)

The filter capacitor is selected using Equation (15):

$$V_{peak} - V_d - V_c = 0 \quad 15$$

where V_{peak} = Bridge rectifier output, V_d = Voltage drop across rectifier diode V_c = Capacitor terminal voltage

3. Capacitor capacitance SELECTION

The capacitance of the capacitor is selected using Equation (16):

$$C = \frac{Q}{\Delta V} \quad 16$$

where Q = charged stored

ΔV = difference between maximum peak voltage and the minimum peak voltage

4. Selection of the switching transistor

This selection of the switching transistor is based on Equations (17) and (18):

$$\text{Relay Coil Current} = \frac{\text{Relay Coil Voltage}}{\text{Relay Coil Resistance}} \quad 17$$

$$\text{Electric Power, } P = IV \quad 18$$

where I = Current, V = voltage (Theraja and Theraja, 2007).

The Table 2 provides detailed specification and electrical/electronic design values of the de-feathering machine. Corresponding author's email address: atadiouds@pti.edu.ng 955

Table 2: Specification for Electrical/Electronic Components

Description of Items	Machine parts/Specification
Voltage Regulator	7812 IC Rating: VMax=12V, VMin=11.8V 7805 IC Rating: VMax=5.2V, VMin=4.8V
Transformer	75VA 220/15v center tapped
Rectifying Circuit	IN4007 Diodes
Filter Capacitor	40V
Capacitor Capacitance	100nF
Switching Transistor	ULN2003
Controller Unit	ATmega328P-PU Microcontroller

2.3.1 Power supply unit

This unit converts the 220V AC to 5V DC required by the circuit; the design of the circuit diagram of the power supply unit is shown in Figure 3 (Idim and Iyere, 2020).

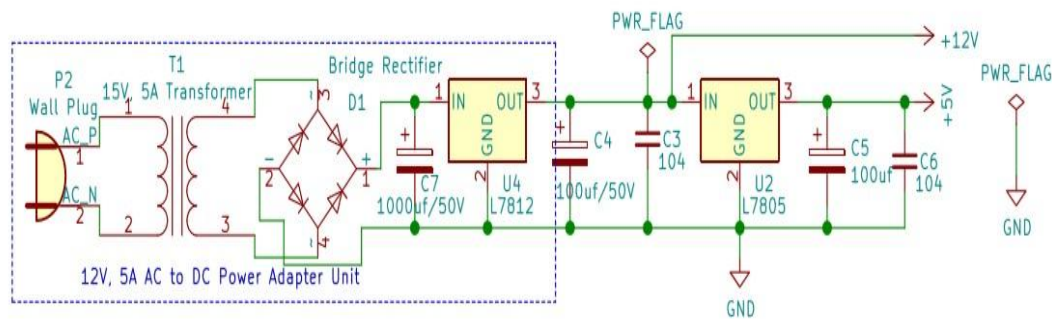


Figure 3: Power Supply Unit

2.3.2 The display unit

This unit provides a visual display of the water level inside the reservoir; the unit, in-conjunction with the HMI unit also creates a platform that enables the user to input the SET Point (Mbonu and Ikpo, 2022). Figure 4 shows the display unit Interface with the controller unit.

Selection of the display unit

A 20 × 4 liquid - crystal display (20 characters per Row, 4 Rows) was selected; the display unit gets its DATA from the Controller Unit that is connected to The PC4 and PC5 PINS of the Atmega328P-PU Microcontroller (Mbonu and Ikpo, 2022).

2.3.3 The FCE and FCE control unit

The Final Control Element (FCE) was implemented with a 220V_{AC} 1/2hp Water pump; the FCE Control unit is a switching circuit that assists the Controller unit to switch the Pump ON and OFF (Ebegba, 2019). Figure 5 shows the FCE control unit:

2.3.4 The controller unit

This unit is the heart of the entire system; it performs the entire logic of the system (Idim and Iyere, 2020). The ATmega328P-PU Microcontroller was selected and was biased with a 16MHz Crystal oscillator and two (2) 22pF Capacitors; this is shown in Figure 6.

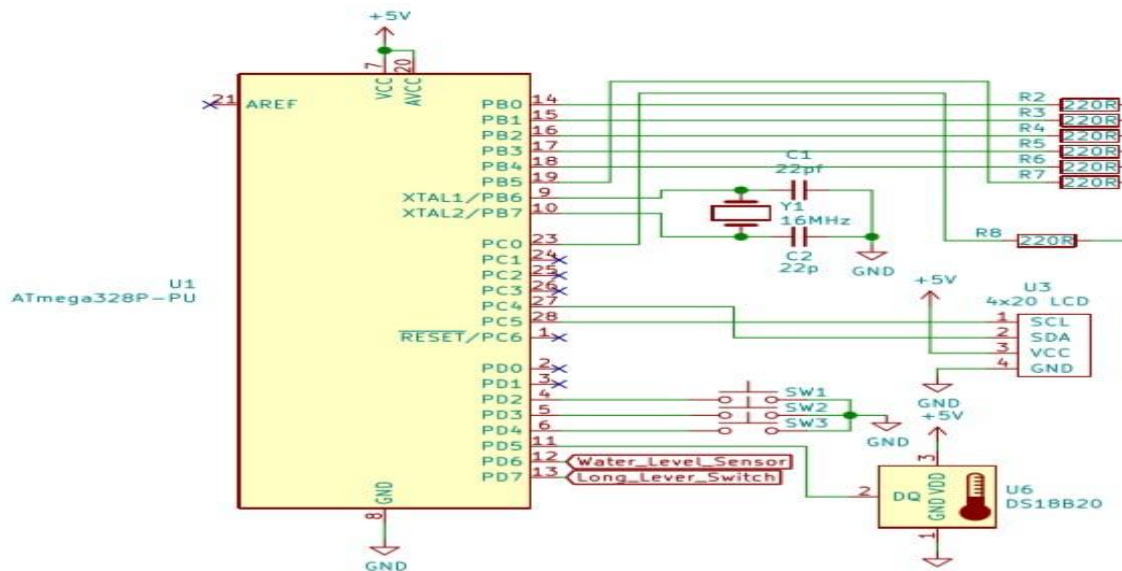


Figure 4: Display Unit Interface with the Controller unit

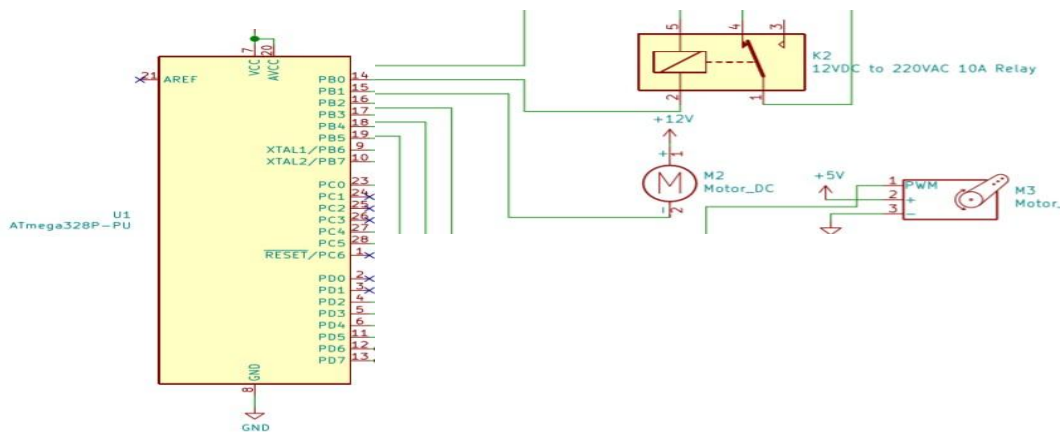


Figure 5: FCE Control Unit

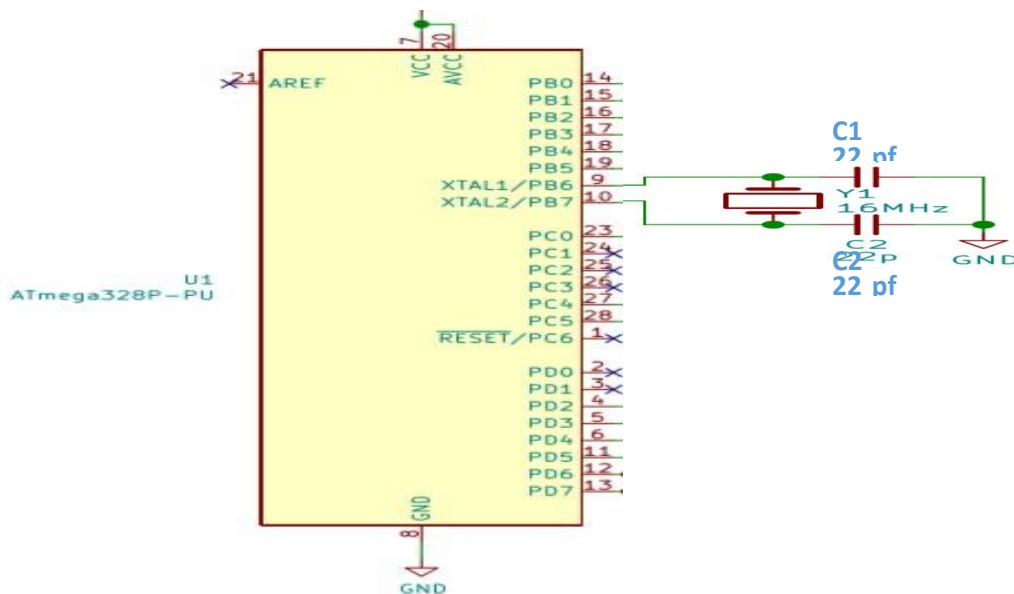


Figure 6: The Controller Unit

2.4 Software Design

The software design is divided into three stages; these are algorithm generation, flow chat representation and coding (Nwukor, 2020).

2.4.1 Algorithm Generation

An algorithm is a statement of the procedure adopted in solving a problem; the sequence of the system operation is stated below (Nwukor, 2020).

1. Initialize the system at startup.
2. Initialize the displays with “0-100 Level Rig”
3. Get Process Level from the pressure transmitter.
4. Update the display unit based on the sensor reading.
5. Update the Pump control unit.
6. End process.

2.4.2 Flow Chart

The flow chart gives a graphical representation of the sequence of program execution; the flow chart for the system is given in Figure 7 (Idim and Iyere, 2020).

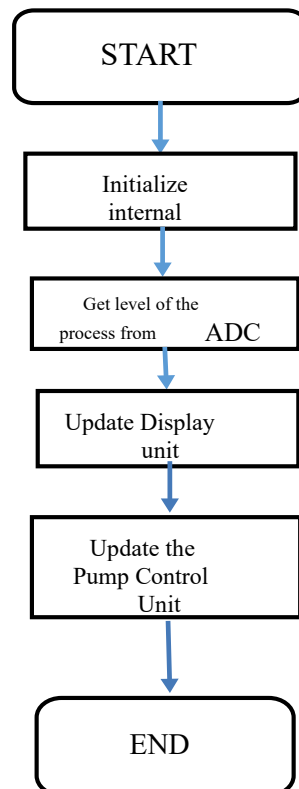


Figure 7: Flow Chart

2.4.3 Coding

The code was written in C language (Idim and Iyere, 2020). The code contains the instruction of program to direct the affairs of the water level controller (Idim and Iyere, 2020; Nwukor, 2020). There are five subroutines in the complete code; each subroutine performs specific function as group of instructions (Idim and Iyere, 2020; Nwukor, 2020). The subroutine and functions are stated as follows;

1. **Initialization** – This subroutine initializes the microcontroller including preloading the counters and reference values for the system,
2. **Read Level** – This subroutine makes the controller to get the process level the ADC output and store the value into its data memory,
3. **Conversion** – This subroutine converts the value read to the equivalent level,
4. **Update Display** – The subroutine enables the controller to display value on the LCD display, and
5. **Update Control** – This subroutine enables the microcontroller to control the switching circuit (Idim and Iyere, 2020; Nwukor, 2020).

3. Results and Discussion

The result of the test carried out shows that the heating process took a total of 45 minutes to heat the water up to 75°C and the scalding time was 45 seconds. The scalding bucket was programmed to delay for 4 seconds before returning to its initial position. De-feathering bucket then operates for 30 seconds and stops after the birds were completely processed. Furthermore, the total time taken from start to finish was 46 minutes 19 seconds to de-feather the birds. The average time taken for de-feathering during a repeat cycle (scalding and de-feathering) takes a total of 76.33 seconds. The de-feathering bucket was designed to accommodate 10 – 15 birds depending on their sizes. However, the results for de-feathering two, five and ten birds are shown in Tables 3, 4 and 5 respectively.

Table 3: De-feathering Data for Two (2) Birds

Weight of Chicken before plucking (kg)	Weight of Chicken after plucking (kg)	Weight of feather (kg)	Plucking time (sec)	Scalding time (sec)
2.6	2.5	0.1	30	45
2.54	2.4	0.14		
5.14	4.9	0.24	30	45

$$\text{Average weight of feather per second (throughput capacity)} = \frac{0.24}{30} = 0.008 \text{ kg/s or } 8.00 \text{ g/s}$$

$$\text{Average feathering efficiency} = \frac{4.90}{5.14} \times 100\% = 95.33\%$$

Table 4: De-feathering Data Five (5) Birds

Weight of Chicken before plucking (kg)	Weight of Chicken after plucking (kg)	Weight of feather (kg)	Plucking time (sec)	Scalding time (sec)
2.54	2.43	0.11	31	45
2.57	2.44	0.13		
2.53	2.4	0.13		
2.6	2.49	0.11		
2.58	2.46	0.12		
12.82	12.22	0.6	31	45

$$\text{Average weight of feather per second (throughput capacity)} = \frac{0.60}{31} = 0.0194 \text{ kg/s or } 19.36 \text{ g/s}$$

$$\text{Average feathering efficiency} = \frac{12.22}{12.82} \times 100\% = 95.32\%$$

Table 5: De-feathering Data Ten (10) Birds

Weight of Chicken before plucking (kg)	Weight of Chicken after plucking (kg)	Weight of feather (kg)	Plucking time (sec)	Scalding time (sec)
2.56	2.43	0.13	33	45
2.51	2.4	0.11		
2.54	2.42	0.12		
2.62	2.49	0.13		
2.58	2.44	0.14		
2.61	2.48	0.13		
2.58	2.46	0.12		
2.55	2.42	0.13		
2.51	2.4	0.11		
2.53	2.43	0.1		
25.59	24.37	1.22	33	45

$$\begin{aligned} \text{Average weight of feather removed per second (throughput capacity)} &= \frac{0.60}{31} = 0.0194 \text{ kg/s or } 19.36 \text{ g/s} \\ \text{Average defeathering efficiency} &= \frac{24.37}{25.59} \times 100\% = 95.23\% \end{aligned}$$

The results obtained from Table 3 shows that the defeathering efficiency is 95.33% while the throughput capacity is 8.00 g/s, whereas the results from Table 4 indicates an increase in the throughput capacity of the machine at 19.36 g/s with five birds being processed, however, its efficiency of 95.32 % remain the same when compared with the result from Table 2. Again, when the processed birds were increased to ten, the result obtained from Table 5 shows a further increase in throughput capacity of 37.00 g/s and an efficiency of 95.23 %. These results indicates that, the throughput capacity of the machine increases as the number of birds in the de-feathering drum is increased to its design capacity, without affecting the overall efficiency of the machine.

4. Conclusion

The automated scalding and de-feathering machine was fabricated from locally sourced materials. It has the potential to de-feather 10 chickens in a single repeat cycle. The performance evaluation of the machine gave a throughput capacity of 37g/s, with an efficiency of 95.30%, for a 10 birds capacity drum. A de-feathering time of 32 seconds per cycle was achieved, this shows that the machine can process an average of 110 birds per hour. However, several constraints were encountered, which limited certain functionalities that could have been included in the project. These constraints include enabling the system to recycle the scalding water to help conserve energy and reduce the heating up time; increasing the boiler size to ensure multiple operations with a single batch of heating. Therefore, there are opportunities for the system to be upgraded to incorporation (IoT) technology for improved performance and control, and deployed for use in industrial for bird de-feathering.

References

- Adetola, OA., Oliwajana, AS., and Akpan, VD. 2023. Modification and Testing of a Poultry Bird Defeathering Machine. Proceedings of the 2023 School of Engineering and Engineering Technology (SEET) Annual Conference, FUTA, 7th – 9th November, 2023, 86 – 91.
- Awotunde, OW., Adeyeye, K., Ponle, EA., and Fatukasi, SO. 2018. Development of a Defeathering Machine from Locally Sourced Materials. International Journal of Scientific and Engineering Research, 9(5): 1-7.
- Buckland, C. 2005. Small Scale Poultry Processing, FAO Animal Production and Health Paper 98, <https://www.openknowledgefao.org>, accessed 21 November, 2024.
- David, RA. 1999. “You can build your mechanical plucker. (Whizbang)” <https://www.FAO.org>, 21st Nov 2024
- Dickens, JA and Shackelford, AD. 2004. Feather Releasing Force Related to Stunning, Scalding Time and Scalding Temperature. Poultry Science Journal vol. 67, 1069 – 1074.
- Ebegba, D. 2019. Design and Implementation of Liquid Level Detector using Ultrasonic Sensor. International Journal of Innovative Science and Research Technology, 4(9): 499 – 504
- Idim, A., Iyere, SF. 2020. Design and Implementation of GSM Enabled Remote Sensor for Monitoring Power Transformer Operation. American Journal of Electrical and Computer Engineering, 4(2): 62-71. doi: 10.11648/j.ajece.20200402.15
- Jekayinfa, SO. 2007. Energetic Analysis of Poultry Processing Operations. Leonado Journal of Science, 10: 77-92.
- Khurmi, RS., and Gupta, JK. 2005. A Textbook of Machine Design. 14th Edition; Eurasia Publishing house India.
- Mady, MAA. and Obaia, AR. 2018. Manufacture and Performance Valuation of Poultry Plucker Suitable For Small Farms. Misr J. Ag. Eng., 35 (2): 407 – 422

Mbonu, WE. and Ikpo, KUW. 2022. Design and Implementation of a Level Control System with Real Time Data Acquisition and Logging via Internet of Things. *International Journal of Scientific Research and Engineering Development*. 5(4): 945 – 950.

Nakayama, Y., and Boucher, RF. 2000. *Introduction to Fluid Mechanics*. Butterworth - Heinemann, Great Britain.

Nwukor, FN 2020. Implementation of Car Tracking System using GSM/GPS. *International Journal of Scientific and Research Publications*, 10(3): 399 – 403

Ocheri, C., Aigbodion, VS., Agboola, JB., Mbah, CN., Mbah, AC. 2018. Design and Construction of Rock Crushing Machine from Locally Sourced Materials for Indigenous Use. *Aspects Min Miner Sci*. 2(2): 197 – 207

Ogundipe, SO. and Sanni, SA. 2002. *Economics of Poultry Production in Nigeria a Training Workshop Manual*. National Animal Production Research Institute, ABU, Shika, Zaria Nigeria. Pp. 27-45.

Tanimola, OA., Diabana, PD. and Bankole, YO. 2014. Design and Development of a De-Feathering Machine. *International Journal of Scientific and Engineering Research*, 5(6): 208-214
Theraja, BL. and Theraja, AK 2007. *Electrical Technology*, S.C and Company. New Delhi, India, 23rd Edition.