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DESIGN AND CONSTRUCTION OF FISH WASHING MACHINE

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ABSTRACT

This study aimed to design and construct a fish washing machine, detailing its operational principles and maintenance requirements. The primary objective was to develop, build, and evaluate a prototype that integrates mechanical safety features. The project centers on an electrically powered fish washing machine, which operates by converting electrical energy into rotary motion to facilitate the washing process. Fish washing is a critical component of fish processing; however, many processors find it to be an undesirable and labor-intensive task. The advent of fish washing machines has significantly reduced the time required for this process, thereby minimizing the need for manual labor. Despite the advantages, the existing machines on the market are predominantly imported and costly, creating a barrier for fish processors in our country, where over 50% of the population lives in extreme poverty. These processors often lack the financial means to purchase imported machines and the expertise required for their operation. The machine developed in this project has a capacity of 50 kg/hr, compared to the 20 kg/hr achievable through manual washing. It can wash 10 kg of fish under 10 minutes, with a shaft diameter of 0.0795 mm and an outer cylinder failure stress of 0.985 mm. This project emphasizes the local design and fabrication of an electric motor-powered fish washing machine.

Keyword: Design, Washing Machine, Fish, Shaft, Bearing

INTRODUCTION

A fish washing machine serves the purpose of cleaning fish species such as catfish, tilapia, and hake. The manual fish washing step takes long to wash the fish clean. Due to prolonged periods of discomfort, the manual washing method also causes physical problems for its operators, such as backaches and muscle ach. This designation typically pertains to machines that employ water for the cleaning of fish during processing activities. The innovation of fish washing technology was introduced to lessen the amount of manual labor required, incorporating either an open basin or a sealed container with paddles or fingers that automatically agitate the fish. Initially, these machines were hand-operated and crafted from wood, but later iterations transitioned to metal construction (Rhoades, 2012).

The washing machine is a specialized apparatus designed to cleanse dirty items, significantly aiding in the demanding task of washing fish during processing activities. The tradition of hand washing fish has been practiced for centuries, long before the invention of washing machines. Fish processors would typically wash their catch in local streams or rivers to prepare it for smoking. This manual method was both arduous and time-consuming, prompting the creation of machines now widely known as washing machines (FAO, 2022a). With the emergence of electric washing machines, the process of cleaning fish has become remarkably efficient, requiring only a simple button press and eliminating the need for human effort. However, while such technology is commonplace in developed countries, fish processors in Africa often struggle to afford these machines due to their prohibitive costs or the lack of access to electricity needed for their operation (FAO, 2015).

The resurgence of traditional fish processing techniques is becoming increasingly prominent in large-scale commercial settings, primarily due to the lack of effective technological interventions to support fish farming operations. Many of these traditional practices, especially in the area of fish washing, have not adequately addressed the significant challenges faced by end-users (Oktaviana *et al.,* 2021). Existing fish washing machines often struggle to thoroughly remove dirt, scales, and impurities, particularly from fish with complex shapes or residual substances. This washing process is not only time-consuming but also limits throughput, thereby affecting productivity in large-scale fish processing. Manual washing requires considerable water usage, and the inefficiency of current washing machines can lead to increased operational costs and environmental issues. Furthermore, inadequately designed or operated fish washing machines can cause physical damage to the fish, such as bruising or breaking bones, which negatively impacts the quality and value of the fish. The accumulation of residual dirt, scales, and organic matter within the machines can also create a risk of contamination (Zhang *et al.,* 2021).

In the drum of a fish washing machine, a rotating shaft with attached washing paddles circulates the fish in water. Once the washing is completed, the used water is drained from an outlet at the bottom of the drum. A rubber seal is utilized to prevent any leakage through the door. This research project resulted in the local fabrication of an affordable, electrically powered fish washing machine, which is intended for use in rural areas as an alternative to traditional hand washing methods (Kaletnik and Lutkovska, 2020).

MATERIALS AND METHODS

Design Considerations

i. Availability of the materials: Materials used for the design and fabrication of a fish washing machine were selected based on their availability.
ii. Cost of materials: Materials with relatively lower prices were selected without compromising other engineering properties.
iii. Strength and rigidity: Materials with high strength and rigidity were selected for the design and fabrication of a fish washing machine, so that the fish washing machine can withstand weight of the fish to be washed.
iv. Ease of operation: The design and fabrication of a fish washing machine should be easy to operate by Antisana fish processors with little training.

Conception of a Fish Washing Machine

The fish washing machine is made up of three main parts: the washing chamber, power chamber and the exit chamber. The function of washing chamber is to wash the fish while power chamber generate the rotatory motion needed to power the washing shaft inside the washing drum and exit chamber make way for passage of used water after operation.

Material Selection

The materials utilized in the production of the electrical powered fish washing machine include:

i. Galvanized steel
ii. Cast iron frame
iii. Aluminum
iv. Electrical motor

Experimental Site

The fish kiln was constructed at farm mechanization unit of agriculture technology department, federal college of freshwater fisheries technology (FCFFT) new Bussa Niger state, Nigeria. Borgu local government area is located on latitude 90N and 11N and longitude 2 E. the climate is generally characterize by two extreme temperatures; hot and cold season, relative at the southern guinea savannah, highest temperature during the raining season is experienced on the month of July and August. The mean annual temperature is 33C. Raining period which fails between September and October is characterized by very warm temperature and dust laden winds often accompanied by thick fog of high intensity occasionally. The mean annual rainfall is between1150-1250mm; the soil is light brown, interface with block rocky and clay marshy soil at the river or lake valley. The inhabitants are mainly farmers, fisherman, traders or civil servant, fishing and fish farmers are the major professional of those living around the lake (Ogundana *et al.,* 2021).

Design Calculation

Failure Stress of the outer cylinder

To ascertain the maximum shear stress that galvanized steel can sustain. The Cascadia Metals Grade Data Sheet indicates that this is 33 ksi.$1ksi$ = 6.895 Mpa

$33ksi = 33 * 6.859 = 227.535 Mpa = 227.535 * 10^{3}$Pa

The force carried, Fc = force of the water carried + force of the clothes carried = F (water) + F (fish)

For the design, only fifth of the cylinder will be fill

$thus, volume\ of\ water = \frac{Volume\ of\ cylinder}{5}$

Volume of water = $\frac{\pi r^2 h}{5}$

For the Cylinder

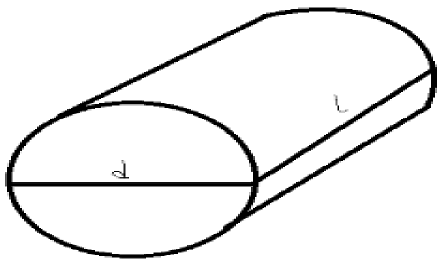

Figure 1: Fish Washing Cylinder

$r = \frac{d}{2}$

h = l

d = 45.72cm = 0.4572 m

l = 50 cm = 0.5 m

Mass of water carried = volume x density (water)

Weight = 9.81 x mass

Weight = 9.81 x $\frac{1}{5}$ x π x $(\frac{0.4572}{2})^2$ x 0.5 x 1000 = 161.05 N

Average mass of one fish = 500g

Assuming 7 fishes, weight = 0.5 x 9.81 x 7 = 34.335 N

$thus, F_c$ = 161.05 + 34,335 = 5,529.651 N

$\frac{F}{A} = \frac{\tau}{n}$ $where\ n\ is\ our\ preferred\ factor\ of\ safety$ = 2.4

$Area = 2(dt\ x\ lt)$

$thus, t\ \frac{5,529.651\ x\ 2.4}{2\ x\ 0.9572\ x\ 222.535\ x\ 10^3}$

$t = 0.985mm$

The Shaft Diameter

The Calculation of Shaft Diameter to determine the shaft diameter, it is essential to calculate the tensions at the shaft pulley using the formula: Tension, T = P/N where P represents the power transmitted through the shaft, and N denotes the rotational speed in radians. Consequently, the equation can be expressed as T = P / (n x π/30), where n indicates the rotational speed in revolutions per minute (rpm). Thus, the relationship can be simplified to T = 9.549P/120, resulting in T = 0.0795.

The Belt Drive
$d_1 = diameter\ of driver = 29cm$
$d_2 = diameter\ of follower = 5.5cm$
$v_1 = velocity\ of\ driver\ in\ rpm = N = 120rpm$
$v_2 = velocity\ of\ follower\ in\ rpm$?
Thus, $\frac{v_1}{v_2} = \frac{d_1}{d_2}$
$v_2 = \frac{v_{1d_2}}{d_1} = 120 \text{ x } \frac{29}{5.5} = 632.7$ rpm
$T = \frac{9.549P}{n}$
$average\ power\ transmitted\ by$ electric motor = $200w$
$thus, T = 3Nm$
Let T1 and T2 = Tensions in the tight side and slack side of the belt on pulley A
ince the torque on the pulley is same as that of shaft (i.e. 3Nm), therefore
(T1– T2) RA = 3 or T1 – T2 = 3 / 0.055 = 54.54N ...(i)
Using 2.3log $(\frac{T_1}{T_2}) = \mu.\theta$
Thus, $\frac{T_1}{T_2} = \ = e^{u \text{ x } \theta} = e^{0.25 \text{ x } \theta}$
$here, \theta = (180 - 2\alpha) * \frac{\pi}{180}$
$sin\alpha = \frac{r^1 - r^2}{x}$
$where\ r_1\ and\ r_2 = radius\ of\ driving\ and\ driven\ pulleys\ respectively,$
x = Distance between the centers of the two pulleys = 0.46 m
Thus, $\alpha = 30.72° = 0.536rad$
$\theta = 2.07rad$
$\frac{T_1}{T_2} = 1.67$
$T_1 = 135.94N,$
$T2 = 81.4N$

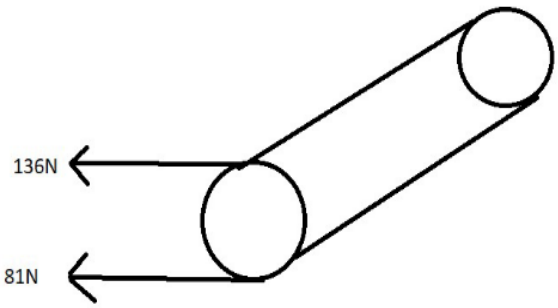

Figure 2: Fish Washing Machine Pulley System

For the stresses along the x-y axis
Weight of inner cylinder = volume x density x 9.81
$= \pi \text{ x } (R^2 - r^1)\ h \text{ x } 7870 \text{ x } 9.81$
$= \pi \text{ x } (0.372^2 - 0.371^1) \text{ x } 0.382 \text{ x } 7870 \text{ x } 9.81 = 68.8N$
$plus\ the\ previous\ weight\ of\ the\ water\ and$ fish, $the\ total\ weight = 174.784 + 68.8$
$= 243.584N$ $this\ load\ acts\ at\ the\ centre\ of\ the\ small\ cylinder$

Fish Washing Machine Performance Evaluation
The design principle of the fish washing machine. Through the inlet funnel, the fish are introduced one at a time. Once the fish is inside the washing cylinder, the electric motor-powered washing shaft is inserted inside the cylinder and rotated at the desired speed. After the fish have been cleaned, they are taken out of the cylinder one at a time via the outlet, and the used water is drained through the control valve located at the bottom of the cylinder. The washing cylinder is filled with water and a small amount of salt. The machine's performance was examined in relation to the weight of the fish samples that were used.


Plate 1: Fish Washing Machine

RESULTS AND DISCUSSION
Result
The fish washer design is practical, time-saving, and cost-effective, with an estimated production cost of ₦70,000. In contrast to the traditional methods, which involve processors manually washing the fish in a large bowl, the fish washing machine's inlet and outlet funnels take anthropometric data into account to ensure that the operator

can easily enter and remove fish. The flexible, spiral-shaped stirrer blade, which can force the fish out, offers a number of benefits over the prior model. The fish is kept clean and undamaged throughout the washing process by the flexible stirring blade. Furthermore, the fish being cleaned is assisted by the spiral-shaped mixing blade in gradually pushing out of the instrument and toward the outlet funnel. Compared to thorough manual washing, which takes 20 kg per hour, the washing machine can wash 50 kg per hour. In less than ten minutes, the machine washed ten kilograms, evaluation result is shown in Table below.

Table 1: Evaluation Results Obtained from the Washing Machine

No	Samples Catfish in Kg	Duration of washing	Results
1	2 Kg of Catfish	1 minute	Slim removed
2	5 Kg of Catfish	2 minutes	Slim removed
3	7 Kg of Catfish	4 minutes	Slim removed
4	9 Kg of Catfish	6 minutes	Slim removed
5	10 Kg of Catfish	8 minutes	Slim removed
6	12 Kg of Catfish	10 minutes	Slim removed
7	15 Kg of Catfish	12 minutes	Slim removed

Discussion

The study highlights the importance of technology in fish processing and its impact on local economic development in communities that raise fish. To encourage sustainable living, it also emphasizes how important it is to utilize a nation's potential resources to their fullest. The design of a home fish washer is covered in this study. Fish processing, which happens right after harvesting to stop spoiling and increase the fish's shelf life, produces the well-known smoke-dried fish. Immediately after harvesting, the fish must be manually cleaned by rubbing and rinsing each individual piece. This is one of the most crucial steps in the production process. Due to an uncomfortable working position, the extended manual process may cause physical issues for the operators, such as backaches and muscular aches. Even though they are sold commercially, motor-powered fish washers are too expensive for small businesses. This research develops a low-cost fish washer that maintains the quality of the fish-washed product while being ergonomic and practical. The study is noteworthy because it provides a solution to the problems faced by fish processors and entrepreneurs, specifically with regard to the process of washing fish. A useful and affordable choice, the fish washer design can improve both the quality of the fish-washed product and the fish processing operation.

CONCLUSION

This study created a practical and affordable fish washing machine for home business owners. Although there are usually several steps in the fish processing process, the manual fish washing step takes the longest. Due to prolonged periods of discomfort, the manual washing method also causes physical problems for its operators, such as backaches and muscle aches. For home business owners, a fish washing with a motor must be within their budget. This study's outcome was a useful and reasonably priced fish washer. The outcome of the study is a fish washer design that can streamline operations and save time during the washing process. At an estimated N70,000 to N70,000k for production, it is incredibly inexpensive. The following findings were observed during the testing of the fish washing machine: the sample fish (catfish) was thoroughly cleaned, and table salt was successfully used to remove all slim and dirt. Effective operation of the operating system was made possible by the electrical power motor. There was less water in the washing cylinder as a result of water escaping from the machine's feeding point.

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