OPTIMIZATION AND PERFORMANCE EVALUATION OF CHICKEN FEATHER PLUCKING MACHINE.

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ABSTRACT: The top-table chicken feather plucking machine was optimized to top style chicken feather plucking machine and its performance was evaluated. The machine consists of metal drum, plucker finger, plucker bass, plucker rotor, feather plate, electric motor, shaft, tyre, pulley, v-belt and metallic frame. An electric motor of 1 hp provides drives to the feather plate through v-belt and pulley via 45mm diameter shaft. The rubber fingers that were fixed on the feather plate rotate against the stationary cylinder drum that was studded with rubber plucker. The machine performed the plucking as the plate rotates with the fingers against the stationary rubber plucker on the casing. The machine was evaluated using five different species of chicken at three different speeds of 400 rpm, 450 rpm and 500rpm. The results obtained showed that the machine performed highest at an average efficiency of 84.49% at the speed of 400 rpm on average time of 22.8 seconds. The analysis of variance (ANOVA) of the results obtained showed that speed and species of chicken significantly affect the efficiency of the machine.

Keywords: optimization, performance, evaluation, chicken feather, plucking.

1 INTRODUCTION

Poultry meat is popularly consumed among non-vegetarians world-wide due to low fat and calorific content. Poultry is defined as domestic fowls raised for flesh or eggs, examples of which are chicken, duck, goose, turkey, etch. The relatively increased preference for chicken over some other type of meat has generated keen interests in poultry farming and processing industry. Likewise with the growing world population, livestock consumption rate may likely be increasing correspondingly to meet the affective protein requirements of the world. In third world countries, and developing countries, poultry processing has faced challenges that are of safety and health concern, some of which include tasks that could result in cuts or lacerations, repetitive motion disorders, ships and falls exposure to cold and wet climates, dust dermatitis, chemicals and noise,[1], [6].

The level of human exposure to occupational risk and other health hazard resulting from intense manual operation is significant in scalding and de-feathering operations. This calls for effective mechanization of the process which will support quality, safe, ergonomic and economic operation. Various machines have also been developed for de-feathering process which can handle either large or few number of chickens [3].

However, their demand and acceptance are different from one country to another. Some years ago for instance, Nigeria Government place embargo on the importation of some poultry processed meat. This step placed a boost on the operation of local poultry industries and allied. There are large numbers of large scale processing plants currently located around the world but small sized of household capacity are scarcely found,[1].

Development of a poultry de-feathering machine is such an economical practice of a mechanized poultry processing plants to replace the removal of poultry feathers by hand for meat preparation, so as to increase the numbers of poultry products processed per day. On the other hand de-feathering or plucking simply means the process of removing feathers from scalded fowls. Therefore, development of a poultry de-feathering machine is planning and building of a mechanical structure that will remove feathers of poultry birds [4].

To avoid accidents and infections from poultry carcass which may occur during some of the processing operations, there is need for user-friendly, reliably and efficient poultry processing devices. [8].

The tub-style chicken plucking machine is a concept device that can really help our poultry processing industries and poultry abettors to ease their plucking process and have the carcass very clean and free from poison or being contaminated to other diseases, when using hand-plucking. This hand-plucking is very tedious, unhygienic, discouraging and time consuming [7].

2 MATERIALS AND METHODS

The de-feathering machine was developed by using the following materials which include clinch device, hack saw, tape, welding machine and electrodes, an electric filling machine and Lathe machine. A tub style vertical chicken de feathering machine, efficient and economically viable was optimized and fabricated with readily available and cheap materials (suitable engineering materials that could give optimum performance in service). Materials for fabricating the machine were chosen on the basis of their availability, suitability, economic consideration, viability in service etc.

2.1 Methods and Optimization of Chicken De feathering Machine

The shaft was designed on the basis of strength; and was subjected to axial loads in addition to combine torsion and bending loads. Consideration was given to the axial load (F) which comprises the plate that was being attached to the shaft and the weight of the chicken to be de-feathered. Figure 1 shows the distribution of loads on the shaft in attempt to calculate the diameter of the shaft. To determine the shaft diameter, we adopt the formula;

$$d^3 = \frac{16}{\pi\delta_{sy}}[(K_b M_b)^2 + (K_t M_t)^2]^{\frac{1}{2}} \quad \text{.....1}$$

Where;

d = diameter of shaft (mm)

K_b = combined shock and fatigue factor for bending moment.

K_t = combined shock and fatigue factor for torsional moment.

M_b = Resultant bending moment (Nm)

M_t = Resultant torsional moment (Nm)

δ_{sy} = Allowable shear stress (MN/m^2)

π = constant, 3.142

The optimization of the already existing machine which is table-top plucker into tub-style plucker is to have an easy mechanical assistance that will enhance poultry meat processing at reduced energy and time. The optimization include reducing the boredom to the operator, time wasted, energy and increasing neatness of the carcass, and as well to free your hands into the job unlike the table-top plucker. The table-top plucker is very risky to tub-style plucker because in table-top plucker, you have to up-hold the chicken and gradually dropping the chicken to the spinning fingers and manually move it around the machine but for tub-style plucker you just put in your chicken in the tub and allow the machine to do the whole job.

2.2 Principle of Operation of the Machine

The Scalded chicken was conveyed manually to the de-feathering machine. The machine consists of an electric motor transmitting torque to the sheave by belt and pulley which will be transmitted to the shaft supported by two bearing assembly. The shaft drives the feather plate studded with rubber fingers that is rotating against a stationary cylindrical drum consisting of studded rubber pluckers too. While rotating, the rubber pluckers grips on the feathers, thus de-feathering the bird within a period of about 20seconds, the carcass then became barely naked and clean, and ready for worktable. There is a space between the cylindrical drum and the feather plate which is about 3cm, where the feathers flies off due to the gravity and centrifugal force. The size of driven pulley determines the speed of which the feather plate spins.

2.3 Evaluation of the tub style De feathering machine

The machine was tested with different species of chicken at difference machine speed. The effect of these different species on machine parameters such as plucking efficiency, duration of plucking, neatness of chicken after plucking and mechanical damage were determined. During plucking, weight of chicken before plucking (dry and wet), weight of chicken after plucking, total weight of feather on the chicken and weight of feather plucked were taken. The performance test was conducted for each species of chicken at different speed using those parameters for both the old and new machine. The results obtained were analyzed using analysis of variance (ANOVA).

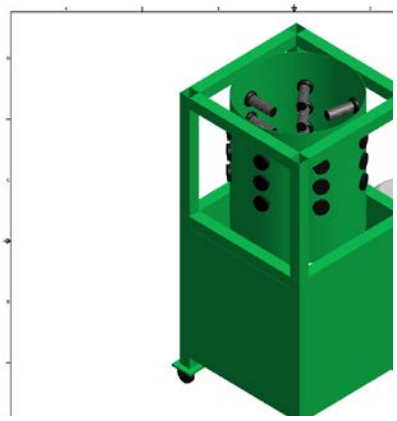

Fig1: Isometric View of Tub-Style Chicken De feather

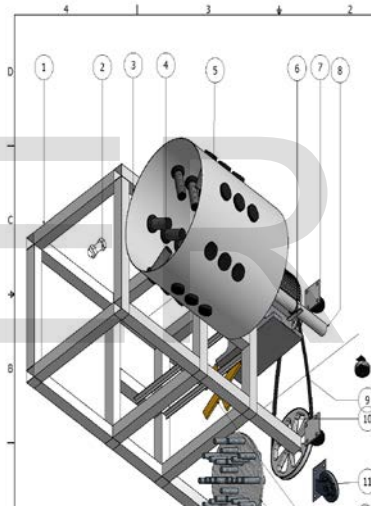

Fig 2: Exploded View of Tub-Style Chicken De Feather.

3 RESULTS AND DISCUSSION

The performance of the chicken feather plucking machine was determined using three different speeds and five different species of chicken. The efficiency of the machine was obtained by de feathering different species of chicken at three varying speeds of 400 rpm, 450 rpm and 500 rpm. It was observed in table 1 that the average

efficiency of the machine was 84.49% on average time of 22.8 seconds at 400 rpm speed. The maximum efficiency was 96.21 % which was obtained at the same speed on the second species of chicken plucked on the time of 22 seconds.

It was shown in table 2 that the machine performed highest (84.43%) at the second species and lowest (79.78%) at the third species of chicken plucked. The average efficiency of the machine at the speed of 450 rpm was 81.74%, and was obtained on average time of 20.40 seconds.

The results obtained at the speed of 500 rpm were shown in table 3. The results showed that the machine performed highest (84.10%) at fifth species and lowest (78.99%) at second species of chicken plucked. The average efficiency of the machine was 80.98% on average time of 19.8seconds.

Figure 4 is the graph of the machine plucking efficiency on three different machine speeds and five species of chicken. The maximum efficiency of the machine was 96.21% at 400 rpm and the minimum was 78.90% at 500 rpm as shown by the graph.

The summary of the results obtained on the optimized machine showed that the highest average efficiency of the three speeds used was 84.49% at the speed of 400 rpm, which implies that the machine performed highest at that point. It was also showed the lowest average efficiency of 80.98% at the speed of 500 rpm, which shows that the higher the speed the lower the efficiency of the machine.

Table 4 showed the analysis of variance (ANOVA) of the results obtained which signified that speed of the machine and species of chicken are considered important parameters that affect the efficiency of the chicken feather plucking machine.

4 CONCLUSIONS AND RECOMMENDATION

The chicken feather plucking machine was optimized and its performance evaluated. The results obtained showed that the highest average machine performance was 84.49% at the speed of 400 rpm on 22.8seconds average time. The lowest average performance of the machine was 80.98% at the speed of 500 rpm on average time of 19.8 seconds. The results deduced that the higher the speed the lower the efficiency of the machine. However, holding the chicken with bare hand while plucking the feather, as for top-table, causes unwanted scare, uneven plucking and also time consuming. The optimized machine works without holding the chicken with bare hand, as against top-table plucking machine that could cause an injury to an operator. If the machine will be made available to the local and other poultry farmers, processing of poultry meat will be faster and as well reduced the drudgery involved on manual way of plucking chicken feather. The machine is recommended to the poultry meat processors because of its time limitation, ease of operation and hygienic processing of poultry meat.

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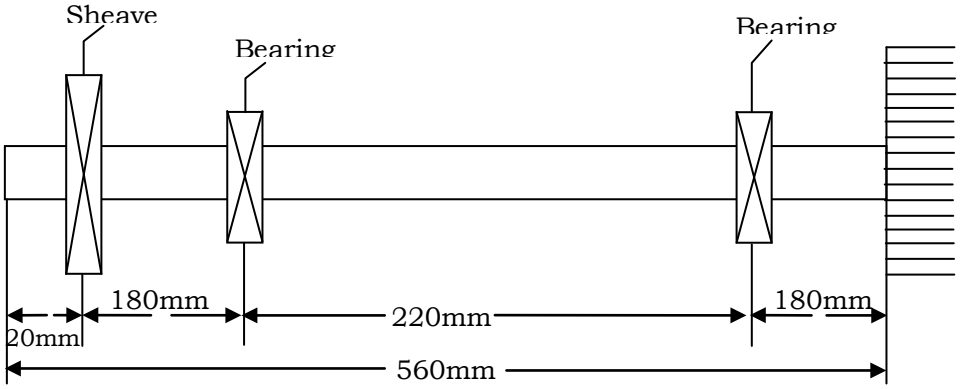

Fig 2: Axial, torsion and bending loads on the shaft

Table1: Machine performance at the speed of 400 rpm on five different species of chicken.

species	chicken weight before plucking (kg) (dry)	(wet)	Chicken weight after plucking(kg)	Total weight of feather on the chicken(kg)	Weight of feather plucked(kg)	Plucking time (seconds)	Efficiency of the machine (%)
1	1.665	1.875	1.537	0.157	0.128	25	81.53
2	1.682	1.896	1.326	0.370	0.356	22	96.21
3	1.838	2.043.	1.589	0.301	0.249	20	82.72
4	1.763	2.010	1.628	0.164	0.135	23	81.40
5	1.802	2.014	1.598	0.253	0.204	24	80.60
Average						22.8	84.49

Table2: Machine performance at the speed of 450 rpm on five different species of chicken.

species	chicken weight before plucking (kg) (dry)	(wet)	Chicken weight after plucking(kg)	Total weight of feather on the chicken(kg)	Weight of feather plucked(kg)	Plucking time (seconds)	Efficiency of the machine (%)
1	1.693	1.901	1.423	0.332	0.270	20	81.30
2	1.820	1.984	1.641	0.212	0.179	22	84.43
3	1.730	2.010.	1.396	0.419	0.334	19	79.78
4	1.819	2.100	1.520	0.370	0.299	21	80.80
5	1.789	1.968	1.397	0.476	0.392	20	82.40
Average						20.4	81.70

Table3: Machine performance at the speed of 500 rpm on five different species of chicken.

species	chicken weight before plucking (kg) (dry)	(wet)	Chicken weight after plucking(kg)	Total weight of feather on the chicken(kg)	Weight of feather plucked(kg)	Plucking time (seconds)	Efficiency of the machine (%)
1	1.802	2.003	1.662	0.177	0.140	19	79.40
2	1.730	1.963	1.328	0.510	0.402	21	78.90
3	1.828	2.140.	1.442	0.469	0.386	18	82.30
4	1.982	2.210	1.520	0.576	0.462	21	80.20
5	1.742	1.997	1.432	0.369	0.310	20	84.10
Average						19.8	80.98

Table 4: ANOVA for the effect of speed of the machine and species of chicken on Performance of the machine

Source of variation	Sum of squares	Degree of freedom	Mean square	Computed F
A (speed)	58.519	2	29.260	0.141*
B(species)	296.783	4	74.196	0.357*
AB	47.050	4	11.763	0.057
Error	831.262	4	207.816	
Total	1233.614	14		

Significant at 5% probability level

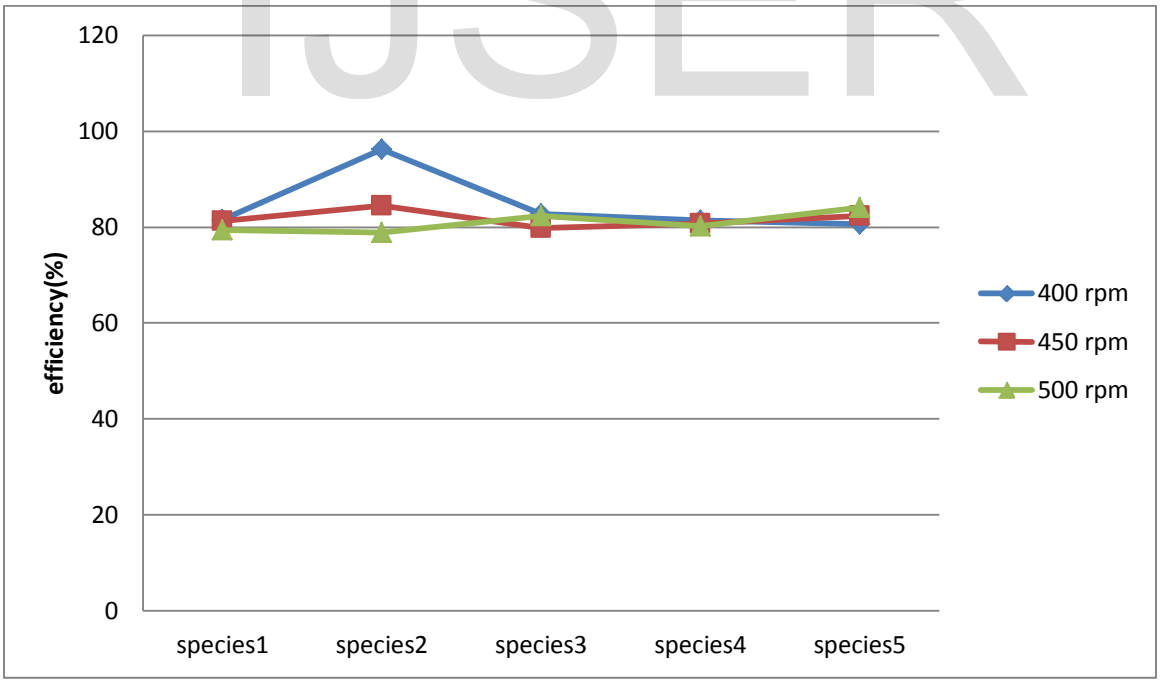

Fig 3: The machine plucking efficiency on three different machine speeds and five species of chicken