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Design and Development of Broiler Feeding System for Chicken Model Closed-House System

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Abstract*: Broiler poultry is one of the many jobs carried out by the Indonesian people. The industrial revolution changes many aspects of broiler poultry, especially technology developments that made work easier. One of them is broiler poultry using a closed-house system. This system has several advantages, including temperature and humidity that can be adjusted to the broilers. Conventional feeding systems are also a problem. Therefore, in this study, a broiler feeding system was designed for a closed-house system. The development of an automatic chicken feeding machine can be very useful to the growth of the farming industry, this automatic broiler feeding system has three main components, feed hopper which works as chicken feed storage, screw conveying screw conveyor is useful for transfer of feed material from feed and motor drive systems for drive the screw conveyor. Based on the results of analysis and testing, the automatic feeding system can function properly and can distribute the feed properly. The AC motor has a power of 0.75 HP. The V-pulley is used for power transmission with a size of 2 inches and 8 inches. And the shaft that is connected to the spiral auger has a diameter of 20 mm to support the shaft force of the conveyor screw.

Keywords: broiler, closed-house system, feeding system, screw conveyor.

I. INTRODUCTION

Indonesia is a very fertile agrarian country. The majority of populations lives from the agricultural sector and works as farmers, plantations, livestock, and fisherman. One of the farms that live in Indonesia are broiler farms. For broiler farms, better and continuous maintenance is needed to produce a broiler with good quality. The development of the broiler industry is in line with the advance in science and technology. The increasing demand for poultry meat in Indonesia urges an industrial oriented farming system to achieve more efficient and optimal poultry meat production [1]. The industrial revolution brought many changes, especially technological developments, that increasingly made work easier. One of them is a closed house system. This broiler chicken cage has several advantages, including setting the temperature and humidity in a cage that can be adjusted to the needs of chickens, the air pollution generated can be minimized, and direct human contact with chickens can be avoided so that the quality of the chicken produced is better. This certainly cannot be separated from the application of the existing technology in closed broiler cage systems.

In addition, the automatic temperature and humidity for the broiler in the closed-house system are available, while the automatic broiler feeding system is still rare. Even though this certainly makes farmers easier to provide food to their broilers. The broiler feeding system is very important because the contaminated feed will infect poultry. The automatic broiler feeding system is employed to modify the feeding method, reducing the value and increasing the dimensions of a farming. For industrial poultry farming, a feed is the most important value of the operation [2].

Further, much previous research has been carried out monitoring and control the chicken farm operation and environmental condition available [3] [4] [5] [6] [7] and research on automatic feed equipment has also been carried out [8], but there is still a lack of research design tools for the automatic broiler chicken feed with a screw conveyor mechanism. Additionally, the calculation of motor power planning, a motion transmission system and a shaft diameter used for automatic broiler chicken feed are also investigated. Finally, the analysis of the performance of the broiler chicken feed with a screw conveyor mechanism based on the calculations is performed.

II. METHOD

A. *Research Steps*

The system of automatic broiler feeding is designed for a farm. This means that the basic concept of the machine is automatically supplied feed chicken using a screw conveyor mechanism [9] [10]. The screw conveyors are often used for dosing and metering small amounts of materials, like particles of granules [11]. Next, the flow chart is useful for facilitating the understanding of the flow of the ongoing research process. In this study, the research steps are shown in Fig. 1.

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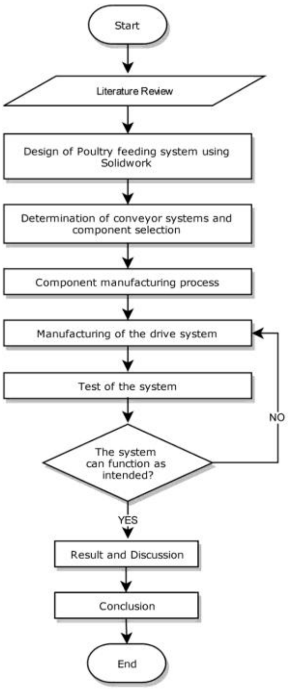

Figure 1. Flow chart of the research.

B. *Tool Design*

In this study, the design was made for several components, namely for a feed hopper, a spiral auger, and the motor drive configuration system. This design was made using SolidWorks 2016. The overall design of the automatic chicken feed system is shown in Fig. 2.

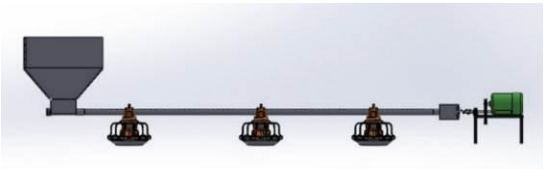

Fig. 2. Design of broiler feeding system.

III. RESULTS AND DISCUSSION

A. *Motor Selection*

The automatic broiler feeding system is already on the market, but until now the price of the equipment is expensive and still produced overseas. This causes not all broiler breeders, especially those from small to medium scale, can develop the production value of their livestock. Therefore, in this study, the selection of components that are more affordable in price, and availability is carried out but produces a similar output. In the market, the automatic broiler feeding system uses a three-phase AC motor, and it has a torque of 60 kg. Cm. The risk of using a three-phase AC motor is the need for a voltage above 220V, where the supply of PLN (State Electricity Company) is generally only 220V. If you continue to use a three-phase AC motor, you need a special electricity supply that has a voltage above 220V and requires a special request to PLN. Based on the motor specifications used in the automatic broiler feeding system that is sold in the market, researchers are looking for motors that produce similar power but are more affordable in terms of price and availability. Therefore, calculations are made to determine appropriate motor power [12]. To determine motor power, the rotational speed value is needed which can be determined using the Equation (1). Electric motors that are sold commonly on the market have a frequency of 50 Hz and have poles as much as 4P. Then, this value is used in the calculation.

$$\begin{aligned} n &= (f * 60)/P \\ &= 50(Hz) * (60/4) \\ &= 750\,rpm \end{aligned} \tag{1}$$

After obtaining the rotational speed value generated by the motor, it can be calculated the value of the electric motor power needed for the automatic chicken feed tool. Power can be calculated using the Equation (2). The known torque value is 60 kg.cm and worth 4.34 lb.ft.

$$\begin{aligned} P(HP) &= 5252 \\ &= (750(rpm) * 4{,}34(lb.ft))/5252 \\ &= 0{,}62\,HP \end{aligned} \tag{2}$$

Based on the above calculation, we obtained the power of 0.62 HP to meet the torque requirements on the broiler feeding system. Because there is no electric motor that has a power specification of 0.62 HP, the specification is taken which has the power above the calculation of results, which is chosen 0.75 HP. Then we get a single-phase motor that has the power of 0.75 HP. The use of a single-phase electric motor is intended to make it easier for farmers who will use this automatic chicken feed system. Because the input voltage is 220 V and is in accordance with the electricity from the PLN. The electric motor used in this study is shown in Fig. 3.

Figure 3. Single-phase of AC motor.

B. *Calculation and Selection of Pulley and Belt*

The calculation for the pulley ratio of the motor and the auger shaft is determined by the amount of rotational speed required on the auger shaft us the Equation (3). Based on the references of the automatic broiler system on the market, the average rotating speed on the auger is 180 rpm. Next, the rotational speed produced by an electric motor is 750 rpm. Then, the pulley ratio is calculated using the Equation (3) which is obtained based on the comparison between the rotational speed of the motor and the auger.

$$\begin{aligned} i_{pulley} &= n_1/n_2 \\ &= 750(rpm)/180(rpm) \\ &= 4{,}71(rpm) \end{aligned} \tag{3}$$

Further, because there is no pulley that has a ratio of 4.17, the pulley ratio is rounded 4. And if a small pulley diameter installed in the motor is set at 2 inches, then the diameter installed in the spiral auger shaft can be obtained using the Equation (4).

$$P_d = f_c * P \\ = 1{,}2 * 0{,}56kW \\ = 0{,}67kW \quad (4)$$

After knowing the diameter of the pulley motor and pulley spiral auger was 2 inches and 8 inches, the next step is finding the type of pulley that matches the rotational speed and the power plant. The power plant (P_d) can be calculated using the Equation 5. Because the power is 0.67 kW, and it has a rotating speed of 180 rpm, an A-type pulley is used which have one belt segment. This type of pulley is usually called type A1. The pulley used in the study is shown in the Fig. 4.

(a) (b)

Figure 4. Pulley (a) A1 (8" type); (b) A1 (2" type).

The last thing to consider is the length of the circumference of the belt used to connect two pulleys. To calculate the circumference of the belt to be used, it takes the value of the diameter of each pulley, as well as the distance between two pulleys. From the design that has been made, the distance between the two pulleys is 10.5 inc1. For calculating the circumference of the belt, it can be determined by using the Equation (4).

$$L = 2C + \frac{\pi}{2}(d_p + D_p) + \frac{1}{4C}(D_p - d_p)^2$$
$$L = 2*10{,}5 + \frac{3{,}14}{2}(2+8) + \frac{1}{4*10{,}5}(8-2)^2$$
$$L = 21 + \frac{3{,}14}{2}(10) + \frac{1}{42}(6)^2 \quad (4)$$
$$L = 37{,}5 \approx 38inch$$
$$C = \frac{b + \sqrt{b^2 - 8(D_p - d_p)^2}}{8} \quad if \quad b = 2L - \pi(D_p - d_p)$$
$$C = \frac{44{,}6 + \sqrt{44{,}6^2 - 8(8-2)^2}}{8}$$
$$C = \frac{44{,}6 + \sqrt{1701{,}16}}{8}$$
$$C = 10{,}7inch$$

The calculation of the results obtained the value of 37.5 inches but rounded up to 38 inches because it adapts to the belt sold on the market. Therefore, it is necessary to calculate the distance between two pulleys so that the appropriate distance is obtained, and the belt can be installed properly. To calculate the value of the distance between two shafts, a similar equation is used.

C. *Calculation and Selection of Shaft*

First, the power (P) must be transmitted, and the shaft rotation n1 (rpm) given. In this case, an examination of the power is needed. If power is the nominal output power of the drive motor, then a variety of security factors can usually be taken in planning so that a first correction can be taken too small. If the correction factor is f_c, then the power plant (P_d) can be calculated using the Equation (5).

$$P_d = f_c * P \\ = 1{,}2 * 0{,}56kW \\ = 0{,}67kW \quad (5)$$

After the planned power value is found, it is continued by looking for the value of a torsional moment or commonly referred to as a planned moment with the symbol T (kg.mm). The equation of the planned moment is obtained from the plan power equation shown in the Equation (6).

$$T = 9{,}74 * 10^5 P_d / n_1$$
$$T = 9{,}74 * 10^5 0{,}67kW / 187{,}5rpm \quad (6)$$
$$T = 3490{,}8kg.mm$$

For calculating the shaft, the type of material will also affect the diameter of the shaft to be used. The mechanical characteristics used are tensile strength and correction factors of the material. In this study, a shaft with mild steel material ST41 / AISI 1018 / JIS S15C was used which had a value of tensile strength 44.9 kg / mm2. For the correction factor of the JIS SC type material, the correction factor value is 6.0 [13]. While the value of Sf2 value between 1.3-3.0 is used to value 2.0. The maximum allowable shaft shear stress is shown in the Equation (7).

$$\tau = \frac{\sigma_B}{(Sf_1 * Sf_2)}$$
$$\tau = \frac{44{,}9}{(60 * 2{,}0)} \quad (7)$$
$$\tau = 3{,}74 \, kg/mm^2$$

In the shaft planning, there are two types of loads that occurred, which are a torsional load and a bending load. To calculate the bending moment, it takes a large number of forces acting on the shaft. The free-body diagram of the axis to be used is shown in Fig. 5.

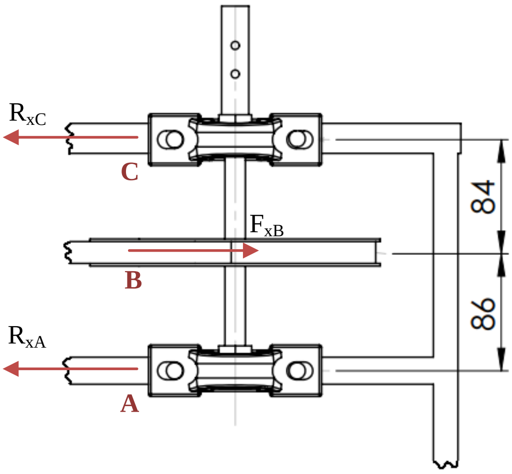

Figure 5. Free-body diagram

The effective force is transmitted through the pulleys found in the shaft. It can be calculated using the shaft torque value and the pulley diameter. The diameter of the pulley mounted on the auger shaft has a diameter of 8 inches which is worth 203.2 mm, then the effective force can be calculated as following the Equation (8).

$$F_N = \frac{T}{\frac{D_v}{2}} \qquad F_N = \frac{3490{,}8}{\frac{202{,}2}{2}} \qquad F_N = 34{,}35kg \tag{8}$$

Then determine the arching force of the pulley against the shaft calculated using the effective force value (FN) which can be calculated using the following Equation (9).

$$F_B = 1{,}5 * F_n \qquad F_B = 1{,}5 * 34{,}35 \qquad F_B = 51{,}53kg \tag{9}$$

The arching force on the pulley is the resultant force obtained from the force on the X-axis and the force on the Y-axis. Therefore, it takes a large force on each axis. The installation of pulleys and shafts is carried out without any specific slope angle, therefore the angle of θ used is 90^o using the Equation (10).

$$F_{xB} = F_B * \cos 90 \qquad F_{xB} = 51{,}53 * 1 \qquad F_{xB} = 51{,}53kg \qquad F_{yB} = F_B * \sin 90 \qquad F_{yB} = 51{,}53 * 0 \qquad F_{yB} = 0kg \tag{10}$$

It takes a force value that works on bearings A and C on the X-axis. The values of R_{xa} and R_{xc} are obtained using the Equation (11).

$$R_{xa} = \frac{F_{xb} * L_2}{L_1 + L_2} \qquad R_{xa} = \frac{51{,}53 * 84}{170} = 25{,}5kg \qquad R_{xc} = \frac{F_{xb} * L_1}{L_1 + L_2} \qquad R_{xc} = \frac{51{,}53 * 86}{170} = 26kg \tag{11}$$

Calculating the bending moment in the pulley (point B) is done, it is following the direction of the X-axis. The bending moment is obtained by taking into account a force on R_{xa} and R_{xb} and the shaft length between the pulley and bearing can use Equation (12).

$$M_B = R_{xc} * L_2 - R_{xa} * L_1 \qquad M_B = (26 * 84) - (25{,}5 * 86) \qquad M_B = 9kg \tag{12}$$

Furthermore, when the value of a torsional moment and bending moment along with the maximum shear stress on the shaft are known, the size of the shaft diameter can be calculated. The value of the diameter of this shaft is the minimum diameter so that there is no failure of the shaft. Therefore, it is required to use a shaft with a diameter above the calculation value. In a diameter calculation equation, there are K_m and K_t values. The K_m and K_t values are taken for a rotating shaft with the load slowly being charged. K_m = 1.5 and K_t = 1.0. The calculation of the shaft diameter can use the Equation (13).

$$d_s = \left[\frac{5*1}{\tau}\sqrt{(K_m M_{lentur})^2 + (K_t M_{puntir})^2}\right]^{1/3} \qquad d_s = \left[\frac{5*1}{3{,}74}\sqrt{(1{,}5*9)^2 + (1{,}0*3490{,}8)^2}\right]^{1/3} \qquad d_s = [4758{,}12]^{1/3} \qquad d_s = 16{,}36mm \approx 20mm \tag{13}$$

IV. CONCLUTION

In this study, the conclusions for the design and development of a broiler feeding system can be drawn as follows: the design of an automatic broiler feeding system was obtained with several main components, namely a feed hopper, a spiral auger, and the drive system configuration; For the drive system configuration, the AC motor uses 0.75 HP, in which it uses two V-pulleys with a diameter of 2" and 8" as motion transmissions towards a spiral auger shaft. The diameter of the auger shaft is 20 mm; the Automatic broiler feeding system with screw conveyor mechanism is a practical chicken feed tool, easy to use, and has an affordable cost. And it can improve the quality of broiler chickens produced because a number of foods will be more evenly distributed in the closed-house system.

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