Kinematics Analysis of End Effector for Carrier Robot of Feeding Broiler Chicken System

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Abstract. The demand for commodities, especially Broiler chicken farms are increasing, the volume of feed requirements Broiler chickens increased with age up to the age of 30-57 days required feed 3,829 grams /day/head, so if the chicken population is 3,000 needed transporting feed 11,487 kg/day. This research aims to produce a robot capable of transporting feed in the top of the cage by using a control system so as to make efficient use of manpower. Design robot performed using software design three-dimensional Solidworks2010, process of making the robot is started with the design manufacture three (3) units of mechanical systems (mechanical system for holder feed, mechanical systems for lifter feed and mechanical systems for transporting feed), then do the design process framework as a component buffer so that the mechanical system will work properly and safely when the robot operates. Furthermore, the manufacture of electronic circuits and control are using Arduino Mega microcontroller. After assembling all components mechanical systems and installation of electronic systems and control, then experiments to evaluate the performance of the robot have been made. The results of experiments showed that all components work well according to plan, in particular the speed and acceleration of end effector motion so it can hold and release the feed well. This strongly supports the robots perform tasks in accordance with the intent, i.e., holding, lifting and moving feed.

Keywords: End effector, Mechanical System for Broilers System Arduino, control design

1. Introduction

Demand for livestock commodities tends to increase along with increasing income, population, and public awareness to improve nutrition. Livestock commodities containing high protein nutrients in 1993 were set to be consumed 10 grams per day, 4 grams of livestock origin and 6 grams of fish origin. Nevertheless, the survey results show that the new Indonesian population can consume as much as 7.60 grams.

The Broiler is a fast-growing race chicken that can produce meat in a relatively short time (5-7 weeks). Broiler has an important role as a source of animal protein from livestock. To maintain the health of cattle is needed vaccine at a certain age. Vaccination is an effective way to prevent humans and animals from some infectious diseases [1].

Body weight of broiler chickens is determined at 7 to 28 days and feeding is recorded periodically to calculate the ratio of feed conversion (FCR) (Liu et al., 2016). Feed quantity is classified into four age groups are: week 5 (age 30-36 days) 111 grams /day /cage, week 6 (age 37-43 days) 129 grams /day/ cage, week 7 (age 44-50 days) 146 grams / day /chicken and week 8 (age 51-57
days) 161 grams /day/ chicken. So the total amount of feed per tail at age 30-57 days is 3.829 gram /days/chicken [2].

Ammonia concentrations of ambient air ambient lows are achieved in enclosures mixed with husk, shell charcoal, zeolite, and soil. In the cage, this place looks drier and not damp base. Probably the ability of litter to absorb dirt, liquids, and ammonia is better than other treatments. In addition to the presence of soil, it is thought that some ammonia has been converted to nitrates by nitrifying bacteria, as seen in the following reaction [3].

Observational data of the study found that the chicken population capacity of each cage ranged from 3,000 to 5,000 heads. For a population of 3,000 chickens at the age of 30-57 days requires the transportation of feed above the cage 11487 kg. The amount of feed that must be transported above the cage during the cultivation process is still done manually by using human power. Then, the process of transporting this feed will be very helpful when using a mechanical system and automatic control.

2. Research Method

Our research begins with a design process that is divided into two main parts, namely the design of mechanical systems which then proceed with the process of designing the frame as a place of support when the mechanical system works.

2.1. Mechanical System Design

The manipulator as part of a mechanical system is a parallel platform, and the end effector is connected with several linear mechanisms [4]. Robot manipulators are designed for home services, such as for handling multiple household objects or serving dishes with mobile platforms [5]. Acceleration of manipulator arises from four sources 1. motion link, 2. Grounding motion, 3. Wheel rotation and 4. Rotation of flexible robotic manipulator rotor [6]. The design of mechanical system that we made in the manufacture of robot consists of 3 (three) units, namely: mechanical feed holder system, mechanical lifting system and feed mechanical transfer system. The manufacturing process of each can be seen as follows:

The design of an End Effector Mechanical System:

We cannot generally assure that a fixed connection unit will produce the desired end-effector velocity as desired [7]. The feed holder is a series of connecting rods that will move at relative speeds of each other whose magnitude can be determined through a kinematic speed or differential polygon system. The kinematic differential is the study of joint and stems velocity, especially the speed of the effector end. The connecting rod will form a new configuration of the manipulator according to the minimal spacing configuration between the end effector [8]. The design of the feeding mechanical system is based on the form of feed media which will be held by the robot. The feed that will be held by the robot to move is the feed still in the sack, so the design of the feed holder mechanism that is able to hold the feed in the form of a sack with dimension approach 25 cm x 55 cm x 75 cm. So as to enable to hold the feed properly it is made to design the feeding mechanism by using four (4) fingers as in figure 1 (a, b).
The feed lifting process will be done by lifting the feed in a sack weighing 50 kg with vertical lift upward with a lift height of 25 cm. Based on the type of lifting process to be carried out and the amount of load to be lifted, the design of the feed lifting mechanism using bolts and nuts is selected. The position of the lifter gear is mounted horizontally so that the gear axle where mounting screw lift becomes vertical which form angle 90° to side gear lift as in picture 2c.

### 2.1.1. Design of Mechanic System of Feeder Transportation

To maintain the load balance during feed transfer process, the mechanical desiccant system of feed transfer uses 4 (four) wheels, each of the two wheels on the left side and two wheels on the right side. Each wheel is driven by a gear (4th gear) each of which has 40 teeth per gear. The pair of gears on each side (left and right) are driven by a moving gear (Gear 3) through a chain. The 3-valve gear mechanism of this mechanism is 2 (two) pieces driven by a driving gear (tooth 2) through a shaft. Teeth 2 is driven by a driving gear (tooth 1) through a chain. For more details can be seen in Figure 2d.

### 2.1.2. Frame Design

To support the mechanical system capable of moving the power optimally at the time of operation, then made a frame design for each mechanism. The basic consideration of the framework design is done based on the type of loading that will be handled and the shape of the mechanical system to be sustained.

The design of the frames we make is, of course suitable to handle loads of the three mechanical systems used. For more details can be seen in Figure 3.

### 2.2. Control System Design

The movement of robotic components occurs due to the process of transmitting power from the motor to a mechanical system in the form of a finite kinematic circuit. The process of power transmission that occurs causes the relative movement with a certain speed on the kinematic stem circuit that aims to give movement to the robot in accordance with its function through the control system. The variable to be controlled is the angular velocity of the component end while the control system considers the
link speed angle of the manipulator. In order for the reference command in the form of point velocity to be changed to the angular velocity parameter, it must use intercellular kinematic interfaces [10].

2.3. Experimental Works
Robotic mechanical system testing procedure is divided into two groups, namely testing on each unit of a mechanical system, and testing when all mechanical systems are installed in their respective positions on the robot.

2.3.1. Testing of each mechanical system
This testing process is carried out separately to determine the performance of mechanical systems that have been made, the purpose is to find the possible deficiencies in the mechanism so that the deficiencies can be resolved wherever possible before the assembly robot intact. The testing of each mechanical system are:

In the feeding system, test the end effector capability of opening and closing at the time the motor is operating so that it can hold the feed well.

In the feed lifting system, testing the ability of whether to lift the weight of the feed or not, in this case the minimum feed mass to be lifted is 50 kg. The task of this mechanism is the most severe compared to other system mechanisms because it is tasked to change the position of feed vertically.

In the feeding transfer system, the ability of the system is going well. It is able to move to the target well. In this experiment there are several things that must be considered include the process of transmitting the force from the teeth 1 to the 2nd and 3rd gear to the 4th gear using the chain, whether the chain rotates well and not caught when the motor is operated, so does the wheel axle position does not shift At the time the driving force is run.

2.3.2. Testing complete mechanical system on a robot.
This test is performed when the entire system of mechanisms is mounted in position, including the wheels already installed on the tracks that have been provided. The mechanical system testing is done in the robot working order during the load removal process. That is the first is to test the feed holder system to do the job well is to process the clamping (holding) the load in the sack that has been provided, after the process of holding the feed done then continued the process of feeding appointment, this process to test the mechanical system lifter installed on the robot Can lift the target load well. After the feed is lifted, then the next testing process exists.

3. Results of Experiments
From the results of the research, the design of robot feed robot Broiler chicken capable of holding, lifting and transporting feed from one place to another place that has been determined.

3.1. Direction of Motion Point on End Effector
The end effector is one part of the feeding robot that is supported by a driving mechanism. End effector in performing its function is driven a DC motor that is connected directly with screw shaft feed holder. When the motor is operating, the base end of the end effector moves up and down following the direction of motor rotation. The movement resulted in other parts of the end effector also moving in a certain direction.

![Figure 2](image1.png)

Figure 2. (a, b) Frame End Effector b) Lifting frame and feed carrier. (Source: RuslanBauna, Thesis Robot Feeder Broiler Chickens, 2016)

Figure 2 (a, b) shows the starting position as the motor rotates causing the lift nest (A1) to move upwards relative to the right position of the pin point 1, this causes the point to the left of pin 1 (B1, C1 and D1) to move Form a counter clockwise pattern with the center point of point 1, while the point centered at pin 2 (B2, C2 and D2) moves in a clockwise direction, consequently the points are on the outside of the end effector (B1-B2, C1-C2, And D1-D2) move closer together so that both ends of the end effector move clamped, this movement is used as a feeding process as shown in figure 24, there is only one wheel in contact with the ground, and the other wheels rotate on the wheel axis In contact with the runway due to rotation

3.2. Speed of Motion Point on End Effector
DC motor data and end effector used:
Torque (Tm) = 100 kg.cm
Round (n) = 500 rpm
Pic thread (p) = 1.6 mm
A large change in the velocity of the base end effector in the path (Δω)= -2°.
Distance point 1-A = 138.3 mm
Distance point 1-B = 208.1 mm
Distance point 1-C = 132 mm
Distance point 1-D = 205.3 mm
Linear velocity point A (VA) :
VA = n . p (1.6 mm)
VA = 500x1.6
VA = 800 mm/menit
From the VA value, then another point velocity value can be obtained by using the speed polygon as in figure 5c.
Corner rod speed (ω₁):
1 rpm = 0.10467 radian/sec

\[ V_A = 1A \times 6.28 \times \omega_1 \]
\[ 6.28 \times \omega_1 = V_A / 1A \]
\[ \omega_1 = 800 / (138.3 \times 6.28) = 0.92 \text{ rpm} \approx 1 \text{ rpm} \]

Stem angle acceleration (α₁)
The length of the end of the end effector (s) = 111.8 mm, the end effect effect (t) = 0.14 minutes = 8.4 seconds, then

\[ \alpha_1 = \frac{\Delta \theta_1}{\Delta t} = \frac{-2}{0.4 \times 6.24} = -0.04 \text{ rpm (angular deceleration)} \]

Acceleration of point A (Aₐₐₐ):
\[ A_A = A_A^n + \rightarrow A_A^t \]
\[ A_A = (1 - A) \times \omega_1^2 + \rightarrow (1 - A) \times \alpha_1 \]
\[ A_A = 138.3 \times 1^2 \rightarrow 138.3 \times (-0.04) \]
\[ A_A = 138.3 + \rightarrow (-5.532) \]
\[ A_A = 138.32 \text{ mm/min}^2 \]

Transient acceleration (AAT) is very small compared to normal acceleration (AAN). From the results of normal acceleration calculation (AAN) and tangential acceleration (AAT) can be obtained acceleration polygon as in figure 5d.

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Figure 3. a) Position end effector release, b) Position end effector holding, c) Polygon speed, d) Polygon acceleration. (Source: RuslanBauna, Thesis Robot Feeder Broiler Chickens, 2016)
4. Discussion and Conclusion

From the results of the end-effector motion testing it is found that, although point 1, point A, point B, point C, point D is located on the same rod, but from polygon image perception seen no difference in velocity value. This occurs because the points have different distances to the momentary center of the stem during a movement. The farther the point from the center of the moment will result in greater speed. While the angular velocity of point 1, point A, point B, point C, and point D are the same, this occurs because all of those points lie on a rigid stem with a momentary center point (point 1).

The propeller end shaft drive source used is a DC motor with a spin (n) of 500 rpm, this means that the shaft rotation of the end-effector shaft is constant. The screw rotation of the end effector will be converted into translational motion by the nut end effector with a constant velocity, this is what causes point An on the end effector moving up and down which produces the holding motion and release the feed on the end effector pair (end effector 1 and 2). But constant point A motion is not constant with constant angular velocity (ω), where from the test results it is seen that when point A moves upwards it will cause a smaller angular velocity, and vice versa when point A moves down the angular velocity will increase at a constant linear velocity of point A. This happens because when point An end effector move upwards will cause point A to grow away from the center of momentary point 1 so that radius (r) rotation is bigger. Because the linear velocity of point A remains while the radius of rotation is greater, so to keep up with constant velocity at the time of the increase of radius than the effect of turning angle decreases. Similarly vice versa when point A moves down, the radius of rotation is smaller so that the time required for one spin will be shorter so that the effect of angular velocity is greater.

Because at the point An end effector moves upward there is a decrease in angular velocity (ω) due to the increase of rotary radius, meaning that at that moment angular acceleration (α) is negative (slowing). While at point An on the end effector moves downward the increment of angular velocity (ω), in this case the angular acceleration (α) is positive (accelerated).

From the above acceleration polygon image shows that the tangential acceleration at each point on the end effector is very small compared to the normal acceleration. This happens because the angular acceleration (α) that occurs at the very small end of the effector end which causes the tangential acceleration also becomes very small compared to the tangential acceleration.

4.1. Conclusions and Recommendations

From the results of the above analysis and discussion can be drawn some conclusions include:

Rotational motion of the motor can be transformed into linear motion by the end-effector mechanism system. Motion from point An end effector causes rotating motion at point B, C and D which is still part of the end effector with non-constant angular velocity. Instantaneous revolving motion alternately point B, C and D on the end effector is used as the motion of holding and removing the feed by the feeding robot.

To achieve more optimal results, it is advisable in planning to choose the type of frame material more suited to the type of loading task experienced, allowing the construction of robots to become lighter and stronger. For operational toughness, it is possible to select a stronger DC motor with a smaller current but still be able to operate the robot properly. This final task can still be developed again in subsequent studies.

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