Analysis of Feeding, Drinking and Automatic Fecal Cleaning in Quail Cages Based on The Internet of Things

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Abstract

This study aims to analyze and evaluate an automated system based on the Internet of Things (IoT) for feeding, cleaning feces, and providing drinking water to quail cages. Analyze the effect of the slope of the feeding valve on the consumption of quail feed to determine the optimal angle of inclination, evaluate the effect of the variation in the diameter of the timing pulley on the conveyor belt on the rotation speed and cleaning time of the cage manure to find the most effective pulley size, and study the effect of liquid viscosity on the filling time of the tank using a water pump in order to optimize the liquid filling system in the farm. An applied experimental method with a quantitative approach was used to test the influence of free variables in the form of feeding, feeding, and automatic cleaning system on quail productivity. The data collected including feed consumption, fecal cleaning time, and drinking water filling time were analyzed numerically to obtain valid and objective results. The results showed that increasing the tilt of the feeding valve from 20°, 25°, to 30° increased feed consumption from an average of 348 grams to 725 grams. The timing diameter of the pulley has an effect on the rotational speed and cleaning time, with the small pulley (25 mm) resulting in the fastest cleaning (42.93 seconds) and the largest pulley (50 mm) the slowest (1 minute 38.82 seconds). In addition, the viscosity of the liquid affects the filling time of the 10-liter tank, where ordinary water is the fastest (3 minutes 52 seconds), water with 5 vitamins is slightly longer, and the mixture of water with molasses and salt is the slowest (4 minutes 31 seconds). These automated systems are expected to improve operational efficiency, reduce manual workloads, and minimize environmental pollution, while providing significant benefits to quail farmers.

Keywords: *Quail Cages, Precision feeding, Farm efficiency*

I. INTRODUCTION

Businesses in the field of poultry farming, especially raising quails, are increasingly in demand by the Indonesian people because of their promising economic potential (Lokapirnasari, 2017; (Ferlito & Respatiadi, 2018). According to data from the Central Statistics Agency (BPS), poultry production in Indonesia accounts for around 24% of the agricultural sector with a value of USD 34 billion and absorbs 10% of the national workforce (Collins dkk., 2021; (Destia dkk., 2018). In Indonesia, quail production is divided into two main categories, namely quail that lays eggs for consumption and quail that produces seeds (Panekenan dkk., 2013).

Fluctuations in the price of quail eggs are an important factor that must be considered in the management of this business (Ananda dkk., 2023; (Ratu Reni Budiyanti dkk., 2024). Therefore, increased production through efficient cage management and proper nutritional fulfillment is indispensable (Raharjo dkk., 2018). Currently, Internet of Things (IoT) technology is beginning to be applied to overcome the problem of feed and drinking water management that is still carried out manually, which often experiences human error and irregularity (Saharman dkk., 2022). The use of this technology has been proven to increase efficiency and effectiveness in quail cultivation (Yohanna & Tri, 2018).

Nutrition fulfillment management with this system often experiences human error and is irregular due to management delays (Widayanto & Aji, 2025). Remote system technology as implemented in the Internet of Things has been widely used to overcome cultivation problems in the current Industrial Era 4.0 (Saharman dkk., 2022). One of the reasons is inefficient feeding management (Roni dkk., 2024). In addition, another problem that often arises in quail cultivation is the fulfillment of feed and water nutrition which is still done manually (Ananda dkk., 2023).

One of the drawbacks faced in quail farming is the production of quite abundant manure waste (Abdullahi dkk., 2019; (Khan dkk., 2023). The waste produced from quail farming, known as extreta, has a very distinctive and unpleasant aroma. If this waste is left without proper handling, it can cause serious problems such as odor pollution as well as wider environmental pollution. Therefore, it is very important to implement good cage management, especially when it comes to cleaning quail droppings (Rachmawati, 2000).

Unfortunately, waste handling is often done manually or using conventional systems that are less efficient. This method usually requires considerable time and labor, and can potentially cause water and soil pollution if not managed properly (Fabanyo dkk., 2024). With the increasing need for modern technology, the use of mobile phones as a means of receiving information from microcontrollers has become an innovative solution. This technology makes it easier for farmers to monitor and regulate the feeding and drinking water for their quails more effectively and efficiently (Yohanna & Tri Natasia Lumban Toruan, 2018).

II. THEORY

A. Motor Steper

A stepper motor is a motor whose rotation is based on steps. Stepper motors are widely used in industrial applications such as CNC, robotic arms, scanners, and 3D printers, due to their reliability and open loop control capabilities (Ricci & Meacci, 2018).

This pulse calculation system works automatically and is able to show how many laps have been made without requiring feedback from the system. The precision in controlling the movement of the stepper motor is greatly influenced by the number of steps required to complete a revolution; The more the number of steps specified, the more accurate the movement produced by the motor. To achieve a higher level of precision, some stepper motor drivers are equipped with the ability to divide normal steps into half steps or even micro steps, thereby improving the resolution and precision of motor movement.

To choose the right stepper motor, it is necessary to calculate the torque needed so that the motor can move the load properly. The total torque of the MM motor is the sum of several torque components, namely the acceleration torque Ma, the friction torque Mf, and the load torque Mt in equation 1, 2, and 3.

$$M = Ma + Mf + Mt \quad (1)$$

Where:

$$Ma = (Jm = Jt)\ X\ \frac{n}{t}\ X\ 1.02\ X10\text{-}2(\text{Nm}) \quad (2)$$

a. Jm and Jt are motor inertia and load (kg·cm²).
b. n = is the speed of the motor to be achieved (rpm).
c. T = is the acceleration time of the motor (seconds).

$$Mf = \frac{\mu W}{2\pi}\ X10^{-2}\ (Nm) \quad (2)$$

a. u = is the coefficient of friction.
b. Ws = is the frictional force.
c. η = is the efficiency of transmission.
d. i = is the gear reduction ratio.

Mt is the load torque generated by the cutting force or mechanical load. An example of calculating the torque of a stepper motor based on load and distance (radius) can be done with the formula:

$$T = F\ X\ r \quad (3)$$

Where:

a. F = m × g (force weight of load).
b. r is the distance from the center of rotation to the load point (meters).
c. m is the mass of the load (kg).
d. g is the acceleration of gravity (9.8 m/s²).

B. Pulley

Pulley is a part or component of an engine that functions to transmit or transmit power from one shaft to another by using a belt. Pulley is also a tool used to make it easier for the belt to run a power. It works by transmitting rotational motion and is often used to change the direction of a given force. This component has become part of the working system of a machine, both in industrial engines and motor vehicle engines, Pulley also provides mechanical advantages if it is in a vehicle (Saputra, 2022).

The things that must still be considered in the installation of pulley belts are that the two shafts must be completely aligned, so that the tightness of the belt can be evenly distributed, the distance between the two pulleys should not be too close, so that the contact angle on the pulley is small as much as possible. The distance between the two pulleys should also not be too far, because it can cause the belt to overload the shaft, belts that are too long tend to swing from side to side which will cause the belt to wear out faster and the tight side of the belt must be below, so that if the belt goes down on the loose side it will increase the angle of contact on the pulley.

C. Motor Servo

Servo motors are devices that are able to move up to 360º, but do not rotate continuously. This is due to the use of a closed feedback system, which allows the motor to return to its starting position by rotating in the opposite direction.

This process is carried out by providing information to the control series contained in the servo motor system. A servo motor is made up of several components, including a gear and a potentiometer. The potentiometer serves as a determiner of the rotation limit of the servo motor, while the control circuit regulates the movement of the motor. The axis angle of a servo motor is determined by the width of the pulse transmitted through the signal from the motor wire. The wider the pulse off, the greater the movement of the servo motor clockwise

D. Motor Wiper

A wiper motor is an electric motor designed to convert electrical energy into mechanical energy, generally used to drive the wiper blades on car glass. These motors typically use permanent magnet or electromagnetic winding technology, and are equipped with a reduction gear mechanism to produce stable and controlled movement.

In this study, the wiper motor was used as the main driver of the automatic quail droppings cleaning system. This motor is connected to a v-belt transmission system and a belt conveyor, which functions to transport quail droppings from the cage to the shelter. The selection of wiper motors is based on its ability to generate large torque at low speeds, making it suitable for cleaning applications that require stable and sustained movement. With this system, the cleaning process can be carried out automatically without manual intervention, improving the efficiency of cage maintenance and maintaining the health of quails by reducing ammonia levels in the cage.

E. Huper

A hupper or temporary feed container is a container that functions to accommodate a certain amount of feed before it is automatically distributed to livestock feeders. The main function of the hupper is to ensure that the feed supply is always available and can be distributed evenly without having to refill it frequently manually. This system helps reduce human error in feeding, improve efficiency, and maintain nutritional stability for quails or other livestock.

This variation of inclination allows flexible feed setting, for example at 20°, 25° and 30° angles, which can be adjusted via a microcontroller-based or IoT-based control system. The system can also be integrated with ultrasonic sensors or other sensors to ensure the amount of feed that comes out according to the needs of the quail, thereby improving feeding efficiency and reducing wastage.

III. METHOD

The appropriate type of research is Applied Experimental Research with a Quantitative Approach. This study aims to determine the causal relationship between the manipulated variables, namely feeding, drinking, and automatic cleaning system, and the dependent variable in the form of quail productivity. Using experimental designs, researchers can control specific conditions to observe the effects of the treatment given, thus allowing for more valid conclusions to be drawn regarding the influence of feed management and hygiene on quail health and productivity.

This study uses a quantitative approach that focuses on collecting and analysing data in the form of numbers to explain the observed phenomena, especially data related to egg productivity, feed consumption, and drinking water. Thus, this research not only provides an understanding of best practices in quail rearing, but also plays a role in the development of more effective and efficient management models in the field of livestock.

IV. RESULTS AND DISCUSSION

A. General Description

The analysis was carried out based on test results on several main parameters, namely the effectiveness of feeding, the efficiency of dirt cleaning time, and the reliability of the automatic drinking water filling system.

Each parameter is tested with several variations of the system settings to determine the best configuration. The system quality assessment refers to the operational efficiency standards of poultry farms and the success parameters of the automation system that have been set in this study. The results of the analysis are expected to provide a comprehensive overview of the advantages and disadvantages of the developed system, as well as provide recommendations for further development.

B. Feeding Analysis

To analyse the feed needs in IoT-based automated feeding cages with a capacity of 40 heads, the feed requirement of quail per head per day is 26 grams. With a cage capacity of 40 quails and a frequency of feeding three times a day, the feed needs per time of feeding can be formulated as follows:

Known:

a. Feed requirement per head in one day = 26 Grams
b. Drum capacity = 40 pcs
c. Frequency of feeding = 3 times in one day

Feeding needs multiplied by giving

$$\frac{26\ Gram\ X\ 40\ Pcs}{3} \quad (4)$$

Calculation Results:

Formula for feed needs multiplied by feeding

$$\frac{(Berat\ Pemberian\ Pakan\ 40\ Pcs)}{(Number\ of\ Feedings\ in\ One\ Day)} \quad (5)$$

Example:

Feed needs in one feeding

$$\frac{1040\ Gram}{3} = 346{,}67\ Gram$$

Conclusion:

The need for quail feed in the automatic feeding system for cages with a capacity of 40 is 346.67 grams per feeding, with a frequency of feeding three times a day.

In TABLE 1, the test results showed a significant difference in feed consumption at each slope:

a. At a 20-degree inclination, the average feed consumption was around 348 grams in three experiments.
b. At a 25-degree inclination, the average feed consumption increased to about 523 grams in three experiments.
c. At a 30-degree inclination, the average feed consumption reached about 725 grams in three experiments.

TABLE 1.
Data on the Measurement of Quail Feed Portion Measurements

No.	Slope of Output Hupper used	Total Weight of Feed Released (Grams)	Average Amount of Feed Released (Grams)
1	20th	345,50	348,69
		350,80	
		349,77	
2	25th	520,50	523,82
		525,90	
		525,06	
3	30th	722,10	725,58
		728,50	
		726,14	

These results suggest that an increase in the angle of feed slope can affect the amount of feed consumed by quails, which has implications for feeding efficiency and the potential for improving the bird's production performance. Determining the right feed portions is very important in quail rearing management to optimize feed consumption while supporting productivity such as egg production and body weight growth.

C. Dirt Cleaning Analysis

In this study, three variations of the diameter of the belt conveyor shaft pulley were used, namely 25 mm, 37 mm, and 50 mm. The automatic manure cleaning system in quail cages uses a belt conveyor as a medium for transporting manure. The belt conveyor is driven by a wiper motor and transmitted through a timing pulley with a fixed wiper motor pulley diameter of 20 mm.

The analysis was focused on determining the effect of variation in the diameter of the timing pulley on the effectiveness of cleaning and the time required in the dirt cleaning process. The test was carried out by comparing the performance of the three pulley sizes in driving the belt conveyor, so that accurate data was obtained regarding the relationship between pulley diameter and dirt cleaning efficiency.

The wiper motor is used with a constant rotation of 35 rpm. The diameter of the wiper motor pulley (Dm) is fixed at 20 mm, while the pulley diameter on the belt conveyor shaft (Dc) is varied to 25 mm, 37 mm, and 50 mm.

Known:

a. Wiper motor speed Nm = 35 rpm
b. Diameter pulley motor wiper, Dm = 20 mm
c. Conveor shaft pulley diameter, D=25mm, 37mm, and 50mm (variation)

Belt conveyor shaft pulley speed formula:

$$Nc = Nm\ X\ \frac{Dm}{Dc}$$

a. For 25 mm belt conveyor shaft pulley diameter:

$$Nc = 35\ X\ \frac{20}{25} = 35\ X\ 0{,}8 = 28{,}00\ rpm$$

b. For 37 mm belt conveyor shaft pulley diameter:

$$Nc = 35\ X\ \frac{20}{27} = 35\ X\ 0{,}5405 = 18{,}92\ rpm$$

c. For 50 mm belt conveyor shaft pulley diameter:

$$Nc = 35\ X\ \frac{20}{50} = 35\ X\ 0{,}4 = 14{,}00\ rpm$$

Conclusion:

a. With a belt conveyor shaft pulley diameter of 25 mm, the rotational speed of the belt conveyor is about 28.00 rpm.
b. With a belt conveyor shaft pulley diameter of 37 mm, the rotational speed of the belt conveyor is about 18.92 rpm.
c. With a belt conveyor shaft pulley diameter of 50 mm, the rotational speed of the belt conveyor is about 14.00 rpm.

The variation in pulley diameter on the belt conveyor shaft has a significant influence on the rotational speed of the belt conveyor itself. This change in rotation speed further has a direct impact on the effectiveness and duration of the automatic dirt cleaning process in the quail cage.

This test is also measured using a tachometer to obtain more accurate data. Measurements were taken three times. By repeating the test, a more representative average score is obtained so that the results obtained can be trusted and valid for further analysis.

TABLE 2.
Data on Dirt Cleaning Analysis Results

No	Diameter puli digerakan (mm)	Waktu yang terpakai (menit : detik)	Waktu rata-rata pembersihan kotoran (menit : detik)	Putaran Conveor (Rpm)
1	25 mm	00 : 40,61	00 : 42,93	100,1
		00 : 41,89		
		00 : 46,29		
2	37 mm	01 : 15,19	01 : 15,83	54,4
		01 : 14,50		
		01 : 17,80		
3	50 mm	01 : 36,53	01 : 38,82	32,2
		01 : 39,47		
		01 : 40,46		

In TABLE 2, The results of this study show that the variation in the diameter of the timing pulley on the belt conveyor shaft affects the rotation speed of the belt conveyor, which in turn affects the effectiveness and duration of the dirt cleaning process in quail cage. Choosing the right pulley size is an important aspect of cage hygiene management to ensure the cleaning process runs optimally and supports the health and comfort of quails. The 25 mm pulley timming diameter requires a cleaning time of 42.93 seconds at a speed of 100.1 rpm, while a 37 mm pulley timming diameter requires a cleaning time of 1 minute 15.83 seconds at a speed of 54.4 rpm, and a 50 mm pulley timming diameter requires a cleaning time of 1 minute 38.82 seconds at a speed of 32.2 rpm.

D. Viscosity Value Analysis

Giving to quails is very important and there are recommended doses such as, vitamins A, B12, and C with doses of 500 1000 IU, 0.1-0.2 mg, and 100-200 mg per liter of drinking water one to two times a week, as well as molasses of 5-10 ml and salt of 0.5-1 grams per liter once a week, important for improving health, appetite, and the growth of quails. By testing the viscosity of the liquid to find out the filling time of the water in the drinking water container.

The falling ball method is one of the simple and effective viscosity measurement techniques. The basic principle of this method is to drop a ball of a certain diameter and mass into a tube filled with the liquid to be tested. As the ball moves down through the liquid, the forces acting on the ball are:

a. The force of gravity (weight of the ball) that pulls the ball down.
b. The buoyancy force that pushes the ball upwards due to the difference in density between the ball and the liquid.
c. A viscous friction force (drag force) that counteracts the movement of the ball and depends on the viscosity of the liquid.

In this study, the first sample tested was plain water mixed with a weekly vitamin specifically for quails. The addition of the vitamin is thought to affect the viscosity of the water due to the presence of solutes that increase the concentration of particles in the liquid. An increase in the concentration of these solutes has the potential to increase the viscosity of the liquid, thus affecting the viscosity value measured. Thus, the viscosity analysis of this sample can provide an overview of the effect of vitamin addition on the nature of the fluid flow used in providing nutrition to quails.

The second sample consisted of a mixture of water with molasses (molasses) and salt. Both solutes play a role in increasing the concentration of the solution, so its viscosity is estimated to be higher than ordinary water. Molasses, which has viscous and concentrated properties, as well as salts that are easily soluble in water, can increase the interaction between molecules in the solution. This increase in frictional force between molecules causes the dropped ball to move more slowly, resulting in a longer ball drop time. Thus, a mixture of molasses and salts has the potential to provide significant changes to the flow properties of liquids measured through viscosity.

The measurement procedure is carried out by dropping a ball made of boron silica glass into a tube containing each liquid sample, then measuring the travel time the ball falls from the upper limit to the lower limit using a stopwatch or video tracker to improve accuracy. This fall time is then entered into the viscosity formula based on the falling ball method to obtain the value of the viscosity coefficient of the liquid.

The results of these viscosity measurements can be used to compare the viscosity of the two samples. Usually, solutions with molasses and salts have a higher viscosity than vitamin solutions in ordinary water due to the denser and thicker content of solutes. Dynamic viscosity can be calculated using the formula n (in mPa.s) calculated using the following equation 6 and TABLE 3:

TABLE 3.
Ball Constant Table

No. Urut	No. Bola	Terbuat dari	Densitas g/cm^3	Diameter bola (mm)	Konstanta K (kira-kira) $mPa.s - cm^3/g.s$	Rekomendasi jarak pengukuran $mPa.s$
800-0002	1	Gelas boron silika	2.2	1581 ±0.01	0.007	0.6-10
800-0003	2	Gelas boron silika	2.2	15.6 ±0.05	0.09	7-130
800-0004	3	Paduan nikel besi	8.1	15.6 ±0.05	0.09	30-700
800-0005	4	Paduan nikel besi	8.1	15.2 ±0.1	0.7	200-4800
800-0006	5	W.-No.4034	7.7-8.1	14.0 ±0.5	4.5	800-10000
800-0006	6	W.-No.4034	7.7-8.1	11.0	33	6000-75000

Palace Viscosite Dynamism:

$$\acute{\eta} = K\,(\rho 1 - \rho 2).\,t \qquad (6)$$

Known:

K = Deep ball constant $(mPa.\frac{scm^3}{g}.s$

ρ= Inner ball density (g/cm3)

ρ= Fluid density measured when deep temperature measurement (g/cm3)

t= Time the ball falls (seconds)

TABLE 4.
Viscosity Calculation

Perhitungan Viskositas					
Waktu jatuh bola (s)					
konstanta bola 1 (mPa.scm3/g.s)	0.007		Waktu Sampel 1	Waktu Sampel 2	Waktu Sampel 2
densitas bola rho 1(g/cm3)	2.2		9.74	11.31	24.05
Densitas Cairan rho 2 (g/cm3)			9.45	11.01	24.05
massa piknometer kosong	15.1675		9.45	11.32	23.97
massa pikno + sampel 1	25.1359	0.99684	9.546666667	11.21333333	24.02333333
massa pikno + sampel 2	25.8343	1.06668			
massa pikno + sampel 3	27.099	1.19315	Viskositas (mPa.s)		
volume piknometer (ml)	10		Sampel 1	0.080403172	
			Sampel 2	0.088958065	
			Sampel 3	0.169315252	

In TABLE 4, the results of viscosity measurements, the mixture of water with weekly vitamins showed a viscosity value of 0.0804 mPa.s, while the mixture of water with sugarcane drops and salt produced a higher viscosity, which was 0.1693 mPa.s. This indicates that the addition of molasses and salt significantly improves the viscosity of the solution compared to the weekly addition of vitamins to plain water.

E. Analysis of Drinking Water Supply

Data collection in this study focused on measuring the time it takes for a water pump to fill a tank to a full capacity of 10 liters, using three different types of drinking water mixtures.

The first mixture is plain water without any additives, the second mixture is water mixed with weekly vitamins, and the third mixture is water mixed with molasses (molasses) and salt.

The results of this test are expected to provide an overview of the effect of drinking water viscosity on the efficiency of filling tanks using water pumps.

TABLE 5.
Data on the Results of Analysis of Drinking Water Supply

No	Kandungan Air Minum	Nilai Viskositas cairan (mPa.s)	Waktu yang terpakai (menit : detik)	Waktu rata-rata pengisihan tandon air minum (menit : detik)
1	Air	0,01 mPa.s	03 : 51,50	03 : 52,58
			03 : 53,40	
			03 : 52,84	
2	Air dan vitamin mingguan	0,0804031723 mPa.s	03 : 53,20	03 : 54,54
			03 : 55,80	
			03 : 54,62	
3	Air, tetes tebu dan garam	0,169315252 mPa.s	04 : 32,85	04 : 31,47
			04 : 30,12	
			04 : 31,44	

In TABLE 5, based on the results of the analysis, the filling time of a 10-liter tank using a water pump showed significant differences depending on the type of drinking water mixture used. Regular water takes the fastest time, which is about 3 minutes 52.58 seconds, followed by water mixed with weekly vitamins with a filling time of 3 minutes 54.54 seconds. Meanwhile, the mixture of water with the addition of molasses and salt takes the longest, which is 4 minutes 31.47 seconds. This time difference shows that the increased viscosity of the water mixture, especially in water with molasses and salts, affects the flow efficiency and filling speed of the tank.

V. CONCLUSION

The following is a development of the conclusions of the research regarding the automatic system of feeding, drinking, and cleaning feces in quail cages based on the Internet of Things (IoT):

a. The tilt of the feeding valve has been shown to have a significant influence on the consumption of quail feed. Based on the results of the study, the larger the angle of tilt of the valve, namely from 20°, 25°, to 30°, the feed consumption by quails has increased quite noticeably, from an average of 348 grams to 725 grams. This increase shows that the angle of the valve slope plays an important role in making it easier for quails to access feed, so that birds can eat more freely and efficiently. Therefore, the adjustment of the valve tilt angle on the feed holder needs to be considered optimally so that feeding becomes more effective and efficient. Thus, breeders can increase quail productivity while minimizing feed waste, so that livestock businesses become more profitable.

b. The variation in the timing diameter of the pulley on the conveyor belt has a direct effect on the rotation speed and the efficiency of the quarry manure cleaning time. The test results showed that the use of a small diameter pulley, which is 25 mm, was able to produce the fastest cleaning process with an average time of 42.93 seconds and a rotation speed of 100.1 rpm. On the other hand, the use of a large diameter pulley, which is 50 mm, actually produces the slowest cleaning process, which takes up to 1 minute 38.82 seconds with a rotation speed of only 32.2 rpm. These findings confirm that the selection of the right pulley diameter is critical to optimizing the performance of the belt conveyor in cleaning the cage. By choosing a small diameter pulley, the cleaning process can be carried out faster and more efficiently, so that it can save time and effort in the management of quail cages. In addition, this efficiency also has the potential to increase cage productivity and cleanliness, which ultimately has a positive impact on the health and comfort of quails.

c. The filling time of a 10-liter tank using a water pump is greatly influenced by the viscosity level of the liquid used. From the test results, ordinary water is able to fill the tank with the fastest time, which is 3 minutes 52 seconds. Meanwhile, when water is mixed with vitamins, the filling time becomes slightly longer, signaling an increase in viscosity that begins to inhibit the flow rate. Mixing water with molasses and salt results in the longest charging time, which is 4 minutes and 31 seconds. This shows that the higher the viscosity of a liquid, the slower the flow speed that the pump can achieve. These findings are important to note, especially in applications that require time efficiency and accurate liquid filling, such as in automated feeding or drinking systems on farms. Therefore, the selection of the type of liquid and the understanding of its viscosity characteristics are factors in optimizing the performance of equipment and operational processes.

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