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Development of an Automated Ammonia Concentration Monitoring System for Poultry Farm

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Abstract - Increase in ammonia concentration at poultry farms causes health hazards to chickens, which reduces the production. At many poultry farms even today the traditional method of manually raking technique is followed to reduce ammonia concentration, which is time-consuming and disturbing the routines of chicks. In the present work, a semi-autonomous ammonia monitoring system (robot) for a poultry farm is developed. The development of the system is initiated through QFD by interacting with poultry farm owners. Based on the discussion six different conceptual designs were developed. Out of which a flexible raking mechanism is selected and the hardware implementation is done. The developed ammonia monitoring system is tested at the field and the performance was found to be satisfactory. The developed system is capable of monitoring ammonia for less than 250 ppm and can operate for more than one hour. By employing the developed monitoring system, it helps to reduce the manpower required for the raking process

Index Terms - Ammonia Concentration, Raking Mechanism, Arduino, Infrared Sensor

INTRODUCTION

Poultry farming refers to the entire process of rearing domesticated birds for the goal of producing meat or eggs for human use. Among the most commonly raised birds are chickens, turkeys, ducks, pigeons, and geese. To meet the current global consumer demands, chicken production has increased dramatically during the last 50 years. In reality, poultry has dominated meat consumption across the globe [1]. It has become the world's most dynamic animal product. Furthermore, between 2000 and 2012, the global consumption of chickens climbed from 40.64 billion to 59.86 billion per year, while the average eviscerated weight per bird grew from 1.44 kg to 1.55 kg [1]. According to FAO projections, chicken meat production will rise at a rate of roughly 2.3 % per year until 2024, reaching 133 million tonnes, making it the largest meat sector from 2020 onwards as indicated in Figure 1 the growth rate of egg production and poultry meat in India.

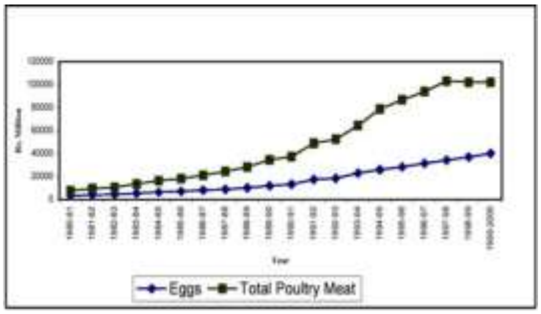

Figure 1 Growth rate of egg production and poultry meat in India

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India is one of the world's largest producers of eggs and broiler meat. The poultry industry in India has undergone a major shift in structure and operation during the last two decades transforming from a mere backyard activity into a major industry with the presence of a large number of integrated players. This transformation has involved a sizeable investment in breeding, hatching, rearing and processing activities. Only a few large poultry integrators have controlled-environment housing with automatic feeding and drinking systems, while the majority of poultry farms are having basic open sheds. In India, the controlled environment chicken barn model is not widely adopted due to high capital costs and unpredictable power supplies. Many poultry farmers, particularly those in small-scale farming, carry out a variety of tasks manually. As a result, the farmers are unable to reap the greatest benefits, as evidenced by economic feasibility.

Methods and Methodology

LITERATURE REVIEW

Up to 40% of a farmer's performance in the poultry business is determined by the design of the poultry housing system. In the case of egg production, the hen house should be long, wide, and high, with captive-reared layers. Farmstead structures should be erected at a specific angle, taking into account the sunrise and sunset times as well as the direction of the prevailing winds. Food safety and quality, efficient and sustainable animal farming, healthy animals, guaranteed animal welfare, and the acceptable environmental effect of livestock production have all become more important in modern civilization [2].

According to current EU recommendations on broiler welfare, birds should be kept at a stocking density of roughly 33 kg/m2 live weight. The farming process is tied to environmental conditions. The standard values for each parameter are specified, and the typical interval of operations is depicted so that the difficulty of controlling a set of variable and dependent parameters is understood. These variables are affected by the weather, season, time, external climate and building insulation. Environmental influences on egg production feed consumption and feed conversion ratio [3]. The majority of farmers are still using traditional farming methods. It was observed that by using traditional farming methods, the yield of poultry is low and sustainability is very less and scientific ways of analyzing problems results in good yield in poultry farms. Sensors and machines also support these analyses very accurately. Automation of the whole farm by the combination of sensors and controllers supports to achieve healthier and higher yield. Automation of poultry farms can be adapted using a combination of sensors and controllers which helps to reduce the manpower. (Literature about sensors and robots to be added)

An autonomous and semiautonomous robots plays a vital role in most of the activities in agricultural, industrial and poultry farms [1-8]. Controling these robots is an another cruisial task. Arduino is most the commonly used microcontroller to control the various tasks in robots [4,6].

FIELD SURVEY

From the literature review conducted through the work of the various scientist, it was observed that no critical work was found on the technological support for the minimization of the impact of ammonia concentration on chicks in the poultry farms Based on the field visit and the feedback from farmers, QFD was developed. Figure.2 indicates the results of the QFD develop

The outputs of the QFD review and the results projected are based on the priorities:

Roller design gets the highest priority

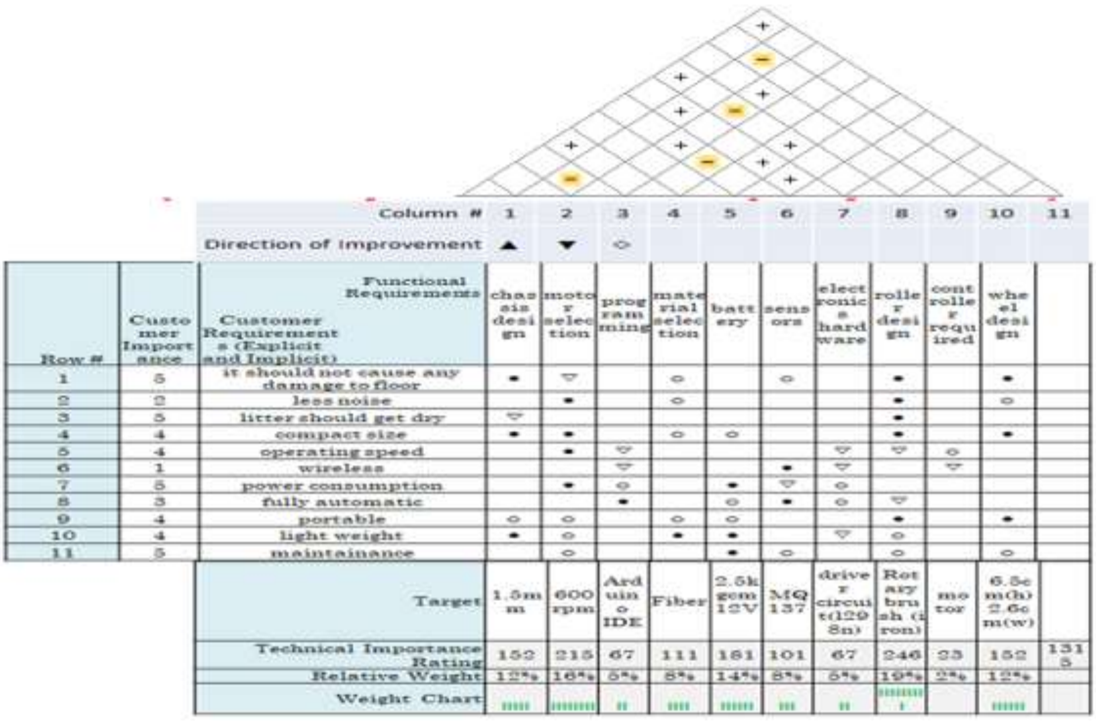
The motor selection gets the next priority, for the design of robot and DC gear motors was selected

The tiller mechanism uses a dual shaft motor and the battery selection is done based on the weight of the load that the robot should drive

Based on the type of terrain and ground clearance the wheels are selected

Selection of sensors and materials to build the robot gets the next priority and an ammonia(NH3) detection sensor is selected for the purpose

The next priority is for the selection of hardware components and programming them to build the robot. Arduino is used for interfacing and programming thesensor and motors to build the robot



Row #	Customer Importance	Customer Requirements (Explicit and Implicit) / Functional Requirements	chassis design	motor selection	programming	material selection	battery	sensors	electronics hardware	roller design	controller required	wheel design	
		Column #	1	2	3	4	5	6	7	8	9	10	11
		Direction of improvement	▲	▼	◇								
1	5	it should not cause any damage to floor	●	▽		○		○		●		●	
2	2	less noise		●		○				●		○	
3	5	litter should get dry	▽							●			
4	4	compact size	●	●		○	○			●		●	
5	4	operating speed		●	▽				▽	▽	○		
6	1	wireless			▽			●	▽		▽		
7	5	power consumption		●	○		●	▽	○				
8	3	fully automatic			●		○	●	○	▽			
9	4	portable	○	○		○	○			●		●	
10	4	light weight	●	○		●	●		▽	○			
11	5	maintainance		○			●	○		○		○	
		Target	1.5mm	600 rpm	Arduino IDE	Fiber	2.5kgcm 12V	MQ 137	driver circuit(1298n)	Rotary brush (iron)	motor	6.5cm(h) 2.6cm(w)	
		Technical Importance Rating	152	215	67	111	181	101	67	246	23	152	1315
		Relative Weight	12%	16%	5%	8%	14%	8%	5%	19%	2%	12%	

Figure2 Results of Quality Functional Deployment (QFD)

Based on the literature review and field visit, it was decided to focus the research work on the development of a mechanism to monitor and control the concentration of ammonia. Concept development To develop the raking system according to the requirement, six concepts were developed. The concepts were developed in stages, from a vague idea to a specific message with accompanying images and materials. Before developing the actual system, developed concepts were compared and the best among them were selected for further design. Ideally, this method will help to solve the design challenge, communicates successfully on several levels. The developed model is programmed to achieve the requirement.

Figure 3 shows the block diagram of the ammonia concentration monitoring system. It consists of a DC motor that helps the robot to move forward, backward, and sideward. To provide required voltage level for DC motors L298N (H bridge) motors drivers circuit is used. MQ 135 senor is used for detecting ammonia concentration. IR sensor is used to make the robot run on specified platform in poultry farm and turn automatically as per the requirement. Arduino is used for interfacing the motors and sensor with the robot and to make it run automatically. |

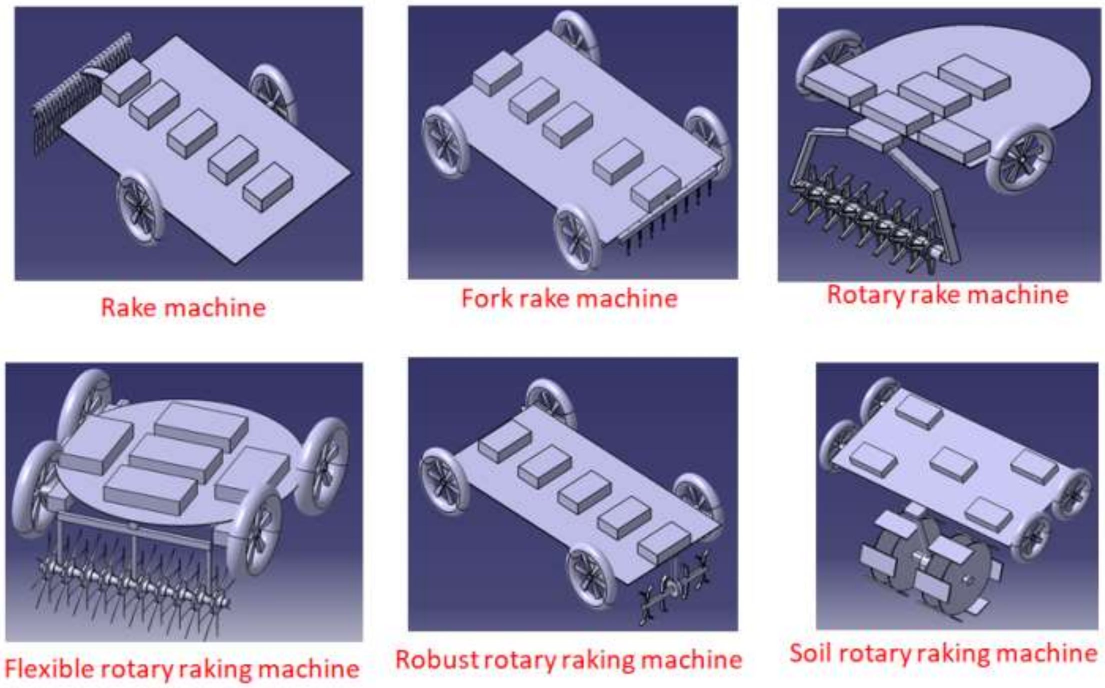


Figure 3 Block diagram of ammonia concentration monitoring system

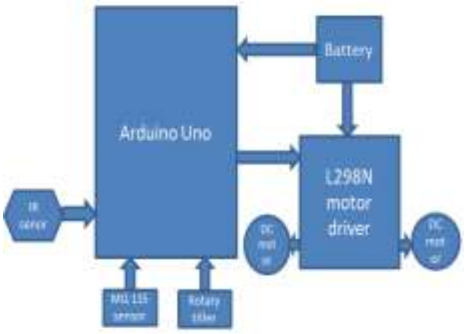


Figure 4 Comparison of developed concepts

To achieve the desired output, six concepts shown in Figure 4 were developed, compared and the results are discussed. Concept-01- The rake machine is made up of two wheels and a fixed raking system is attached. It is found to be not very efficient, since, it requires more power for raking and the movement of the vehicle and balancing of the system is very difficult It requires more turning radius and power loss is more due to fixed raking system and raking coverage area is less.

Concept02- Fork rake machine: made up of four wheels and with a fixed raking system, the power required is more because it has a big body with a fixed tiller and the balancing of the system is fairly easy it can run comfortably. The turning radius required is more It needs more area to turn around because of the rigid body design and power loss is more due to the fixed raking system and the raking coverage is less.

Concept 03- Rotary rake machine: consists of two wheels and a flexible raking system, the power requirement is less for raking because the system has the option to lift the

tiller while moving idle and the balancing of the system is a bit difficult because it has only two wheels. The turning radius area requirement is less due to its design and power loss is low due to the flexible raking system and it covers more raking area and raking quality is efficient because of the flexible design of the tiller and the tiller will have self-rotating power and raking coverage is

Concept 04-Flexible rotating raking machine: made up of four wheels and with a flexible raking system, the power requirement is low for this four-wheel robot because it has a flexible tiller so the robot can lift the tiller when raking is not required and balancing of the system is easier due to four-wheel. The turning radius requirement is less and the power loss is low due to the flexible tiller design system and raking coverage is more.

Concept 05-Robust rotating raking machine: made up of four wheels and with a flexible raking system, the power requirement is low for this four-wheel robot because it has a flexible tiller so the robot can lift the tiller when raking is not required and balancing of the system is fairly easy it can run comfortably, and turning radius required is more due to rigid body design and the power loss is low because it has flexible tiller system, raking coverage is less. Concept 06-Self rotating raking machine: made up of four wheels and with a flexible raking system, the power requirement is low because it has a flexible tiller so the robot can lift the tiller when raking is not required, the balancing of the system is easier due to its four-wheeler design and turning radius area requirement is less because of the robot design, the Power loss is low due to the flexible tiller design system and the raking coverage is more.

Based on the analysis, advantages and disadvantages of all the six concepts are discussed and analysed. Concept 04- flexible rotating raking machine is selected for hardware implementation and it’s found to be more flexible and the power consumed is less to achieve the target.

Virtual software implimentation

The raking system helps to monitor and control the ammonia concentration in the poultry farms. Using TINKER CAD tool the sensors and motors are connected to Aurdiuno to cross check its functionality, which helps in reducing the risk of hardware failure.

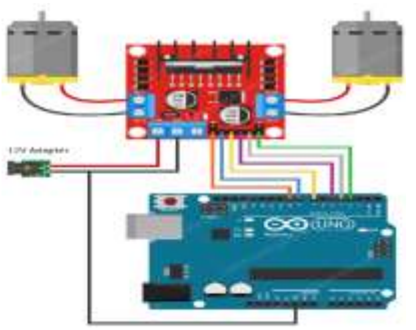


Figure 5 Arduino UNO with DC motor and driver

A flexible rotating raking machine is configured through Arduino UNO with L298N which helps the motor to on or off, The positions of the pins are set to regulate the motor's direction. The details of the connection are indicated in Figure 5

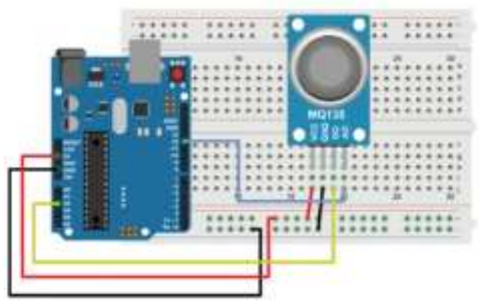


Figure 6 Arduino UNO with MQ135 sensor

The circuit connection of MQ135 air quality detection sensor, which can be predominantly used for ammonia detection with Arduino is indicated in the Figure 6. The MQ 135 gives the digital output as 1 and the analog output as 1023, if the ammonia concentration more than 250 ppm. The digital result is 0 and the analog output is less than 1023, if the ammonia concentration is less than 250 ppm.

Figure 7 Arduino UNO with servo motor

|The servo motor synchronized with the Aurdunio Uno indicated in the figure 7 is used to rotate the rotary tiller to 180 degrees to pulverize the rice bed if the ammonia concentration more than 250 ppm.

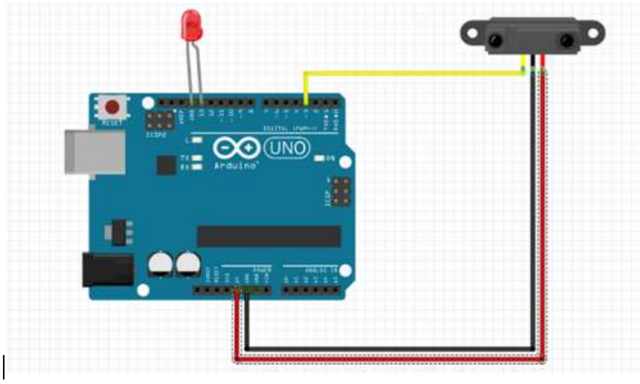


Figure 8 LED and IR sensor with Arduino UNO

| LED and IR sensors with Arduino Uno is as shown in Fig 8. The LED cathodes are linked to a 220-ohm resistor that is connected to the ground. The IR sensors supports for manovering of the system.

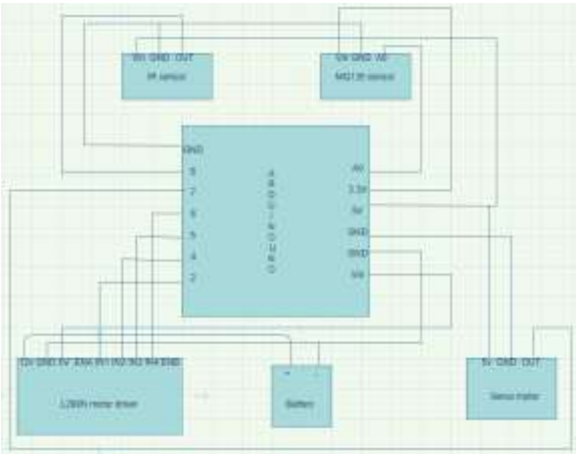


Figure 9 Connection diagram Automated Ammonia Monitoring System

Automated Ammonia Monitoring System Consists of MQ 135, IR Sensor, battery, servo motor, DC motor, motor driver are connected to Arduino Uno board. The connections along with the pin numbers are shown in the Figure 9.

Hardware Results

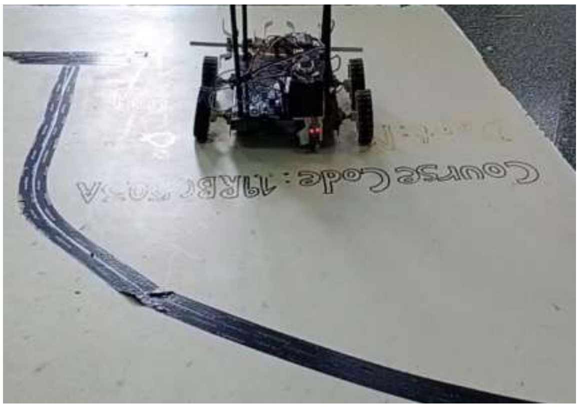
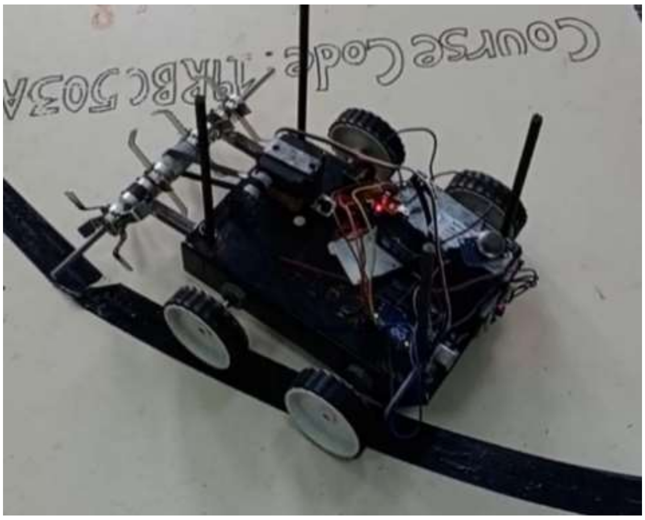


Figure 10 Forward movement of Robot

The developed flexible rotating raking system is programmed and tested. The forward movement of the system which governed with DC motor is indicated in Figure 10. The system starts working from the start point of the farm and proceed forward until it detects the ammonia more than 250 ppm and the raking mechanism is activated. To verify the functionality of the developed system, actual liquid ammonia is sprayed on the platform is indicated in the Figure 12.



| **Figure 11 system turning at the working boundary**

When the ammonia concentration achieved below 250 ppm, the raking mechanism stops working and the system proceed forward until to the defined boundary. When it approaches the boundary the IR sensor indicates the Arduino to enable the system to trun according to the need.

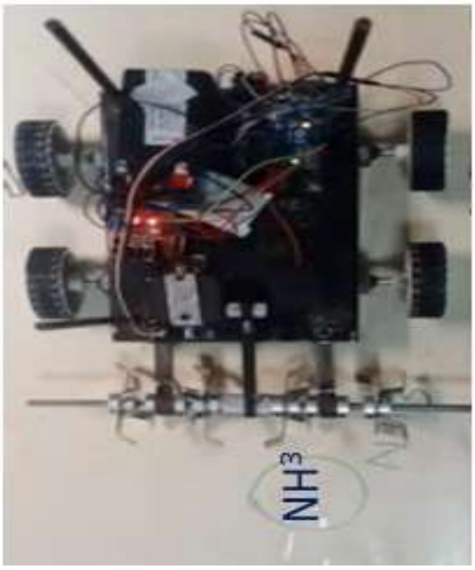


Figure 12 Robot Detection of ammonia

The developed system is verified for its functionality in the actual field and observed that it requires 90 minutes to complete the raking process.

CONCLUSIONS

Based on the literature review and field survey, the QFD was developed. Six concepts were developed based on the specifications and the best concept flexible raking machine was selected for further study. The components (battery, platform, wheels and Arduino Uno) were selected for the design of the flexible raking system. Arduino Uno is used as a microcontroller and programmed for forward, backward and tilling mechanism. A field trial of the developed ammonia monitoring system was conducted and was observed that the system can complete the raking process in 90 minutes and helps to save 3 to 4 hours of man power.

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