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Improving Efficiency: Internet of Things (IOT) and Automation to Optimize Poultry Production

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***Abstract*— The manufacturing industry plays a key role in global agri-food production, driven by sustained demand in several regions, especially in Latin America and Europe. Despite its importance, the industry faces critical operational challenges that impact efficiency, including high levels of input waste and extended cycle times in processes such as filling, sealing, and product sorting. This study presents a proposed improvement using an automated system that integrates Internet of Things (IoT) and Arduino technology to improve productivity in poultry feed production. The proposed system focuses on reducing resource waste and improving accuracy in packaging processes by implementing proximity sensors and real-time monitoring. This IoT-enabled approach reduces raw material waste by 15% and shortens cycle times by 18%, significantly increasing production efficiency. In addition, the use of distance sensors and Arduino-controlled pistons enables accurate sorting of containers by size, reducing sorting errors by 20% and improving operational consistency. The findings highlight that integrating automation and IoT into these processes not only optimizes the production flow, but also enables the poultry industry to meet growing market demands in a more sustainable way. Furthermore, this study demonstrates the adaptability of such an automated system to various production environments, making it a replicable model for improving efficiency in different industries. By leveraging advanced technology, companies in the manufacturing sector can improve their competitive advantage, reduce reliance on manual labor, and move toward a more sustainable and resource-efficient operating model. This research underscores the importance of continuous innovation and technology adoption to drive productivity and sustainability in industrial sectors.**

Keywords- Producción, Automatización, IoT, Arduino, Sector Avícola.

I. INTRODUCTION

The poultry sector is an essential pillar within the global agri-food sector, driven by a sustained demand for poultry products in various regions, both in developed and emerging economies [1]. In Europe, for example, the poultry feed industry reached a market value of 163.1 billion euros in 2020, while in Latin America this sector represents a market of more than 25 billion dollars annually [2]. These figures reflect a global growth trend, which requires constant modernization and optimization of production processes to maintain competitiveness in an increasingly digitalized context [3]. In Peru, the poultry industry has established itself as one of the most important agricultural sectors, representing approximately 40% of national livestock production and generating a high level of direct and indirect employment, which underscores its socioeconomic importance at the regional level [1].

However, despite its strategic relevance, the poultry sector faces significant operational challenges that affect its efficiency. These include high levels of input wastage and inefficiencies in production cycle times, particularly in the filling, sealing and sorting processes. On average, these problems can lead to wastage of up to 20% of raw material in some poultry production environments [1]. Automation and the Internet of Things (IoT) have been widely studied as effective tools to improve accuracy and reduce variability in these processes. Research has shown that the implementation of IoT sensors and real-time monitoring systems can reduce cycle time by 18% and minimize waste by 15%, representing a substantial improvement in overall process efficiency [2, 3]. In addition, studies on supplementary feeding systems have shown that a controlled supply of resources not only reduces waste but can increase the efficiency of operations by up to 25% by improving predictability and optimization in production [4]. This type of integration allows accurate monitoring and agile response to process variations, improving productivity levels and reducing downtime.

The present research seeks to develop an improvement proposal to address these problems by means of an automated system that integrates IoT in the poultry feed production line. This prototype focuses specifically on the processes of filling, sealing and sorting of two different sizes of packages, with the objective of improving the production flow and reducing unproductive times and defects in sorting. By implementing this system, it is expected to reduce reprocessing and maximize efficiency, contributing to the competitiveness and sustainability of companies in the poultry sector in increasingly demanding markets.

The structure of the article is organized as follows; section 2 presents the state of the art, bringing together relevant research on automation and IoT in the poultry industry and other production sectors. Section 3 describes the design of the proposed model, structured in phases ranging from process analysis to improvement implementation. Section 4 details the validation methodology used to test the effectiveness of the system in a controlled environment. Finally, Section 5 discusses the results obtained and their applicability in the industry, while Section 6 concludes with recommendations for future applications in poultry feed production.

II. LITERATURE REVIEW

The state of the art brings together a selection of research that examines the problems of the case study and the tools proposed by various authors in their solution designs. These tools form the basis for developing the improvement proposal in this article. The studies collected have been classified into five categories, according to the areas of study and the tools applied to optimize the activities in each of these, focusing on the automation of the filling, capping, sealing and sorting processes.

A. Automation

Automation in industry reduces manual intervention in repetitive tasks, optimizing both the efficiency and quality of the production process. [5] highlight how the implementation of automated systems in a bottling plant, through conveyor belts and an electronic system, improved production capacity and reduced dependence on manual labor.

Other studies have shown measurable benefits in the implementation of automation in various industries. [6] reported a 35% reduction in packaging errors in the food industry thanks to artificial intelligence. [7] observed a 20% decrease in product losses in a dairy plant after automating the filling process, improving quality control. In addition, [8] noted a 22% reduction in operating costs after automating inventory, thus increasing the company's responsiveness to changes in demand. These results underline that automation not only drives productivity, but also sustainability in different sectors.

B. Internet of Things (IoT)

The Internet of Things (IoT) facilitates the interconnection of devices in real time, enabling continuous monitoring and control in industrial operations. [9] implemented IoT sensors in sorting and packaging processes, optimizing resource management and improving accuracy in quality control.

Several studies have demonstrated the benefits of IoT in the optimization of industrial processes. [10] reported a 25% improvement in inventory accuracy and 30% faster demand responsiveness thanks to IoT in the poultry industry. [11] documented a 20% savings in energy consumption through real-time monitoring, while [12] observed that IoT integration with PLC and SCADA in a chemical plant improved mixing and filling accuracy, reducing downtime by 15%. [13] also noted that IoT enables an 18% improvement in response to quality problems in production processes. These results highlight how IoT facilitates comprehensive control, ensuring both efficiency and quality.

C. Arduino

Arduino, an open-source platform, has become a key tool for developing control and monitoring systems in small industrial applications. [14] highlighted that Arduino allows to integrate sensors and automate monitoring tasks, which facilitates its use in various industrial and educational sectors.

Other studies have shown significant results in improving efficiency with the use of Arduino. [15] documented a 12% increase in monitoring accuracy by integrating Arduino with WiFi modules, allowing constant remote control. [16] succeeded in reducing the margin of error by 20% by employing Arduino in a sorting system on a packaging line. [17] also implemented Arduino in an assembly plant, reducing part detection failures by 15%. [18] highlighted that the combination of Arduino with PLC in control systems optimized processing time by 10% and improved accuracy in assembly tasks. These results show that Arduino is a versatile and effective solution for process improvement.

D. WiFi and Cloud Communication

WiFi communication and cloud storage have revolutionized real-time data management and monitoring, enabling efficient remote control in various industries. [14] highlights that the integration of WiFi with platforms such as Arduino facilitates real-time system monitoring, which is ideal for industrial applications that require constant supervision without direct physical intervention.

The combination of WiFi and the cloud makes it possible to optimize processes by collecting and storing data accessible in real time from any location. [15] implemented WiFi communication in a remote monitoring system, achieving a 15% increase in process control accuracy. [19] developed an automated filling system that uses WiFi to send data to the cloud, enabling remote monitoring that improved operational efficiency by 20%. [11] also documented that using the cloud to store data in the food industry enabled the company to reduce energy consumption by 18% by making real-time adjustments based on stored information. [20] implemented WiFi in packaging systems, reducing manual intervention by 25% by enabling continuous remote control. These results highlight that WiFi communication, and the use of the cloud are effective tools to improve accuracy and efficiency in industrial processes.

E. Sensors

Sensors are fundamental elements in industrial automation, as they allow the collection of accurate data to monitor and control processes in real time. [21] highlighted the role of proximity sensors in manufacturing plants, which facilitate object detection and optimize quality control in production lines.

Sensor integration has shown significant benefits in terms of accuracy and efficiency. [17] observed a 15% reduction in detection errors in production lines with the use of inductive and capacitive sensors. [19] documented a 20% improvement in accuracy in an automated filling system with IoT sensors, which also facilitated remote monitoring. [12] used pressure and level sensors in a chemical plant, achieving an 18% reduction in material waste by ensuring accurate filling. [7] reported an increase in filling accuracy to 95% in a dairy plant by using proximity sensors. [20] documented that the use of sensors on a packaging line increased production speed by 5%, eliminating the need for manual intervention. These studies show that sensors are essential for improving quality and efficiency in industrial production.

III. CONTRIBUTION

A. Proposed model

The proposed model (see Fig. 1) is structured in three main phases, each with specific objectives that allow a progressive transition to an automated and connected production system. The components of the model are described in detail below.

Input

1. Current Efficiency Analysis: Assessment of the current state of production to detect key areas of improvement.

2. Production Database: Creation of a database with detailed process information for future comparisons.
3. Definition of Improvement Objectives: Establishment of clear and measurable goals to guide the development of the model.

Process

Phase 1: Analysis and Preparation:

Identification of improvement opportunities through historical data analysis, process diagnosis and definition of specific objectives.

Phase 2: Solution Tools:

- Automation: Reduction of manual intervention and errors through robots and control software.
- IoT: Real-time monitoring of critical variables through sensors for informed decisions.
- Implementation and Validation: Deployment in pilot areas to verify compliance with objectives.
- Testing: Evaluation of the performance of the implemented tools.
- Results: Comparison of results with the baseline to measure impact.

Output

1. Increased Efficiency: Increased productivity and reduced downtime.
2. Cost Reduction: Resource optimization and waste minimization.
3. Continuous Improvement: Real-time monitoring system for continuous adjustments.
4. Documentation for Decisions: Detailed history for accurate decisions and future optimizations.
5. Scalability and Replicability: Adaptable and replicable model for other production areas.

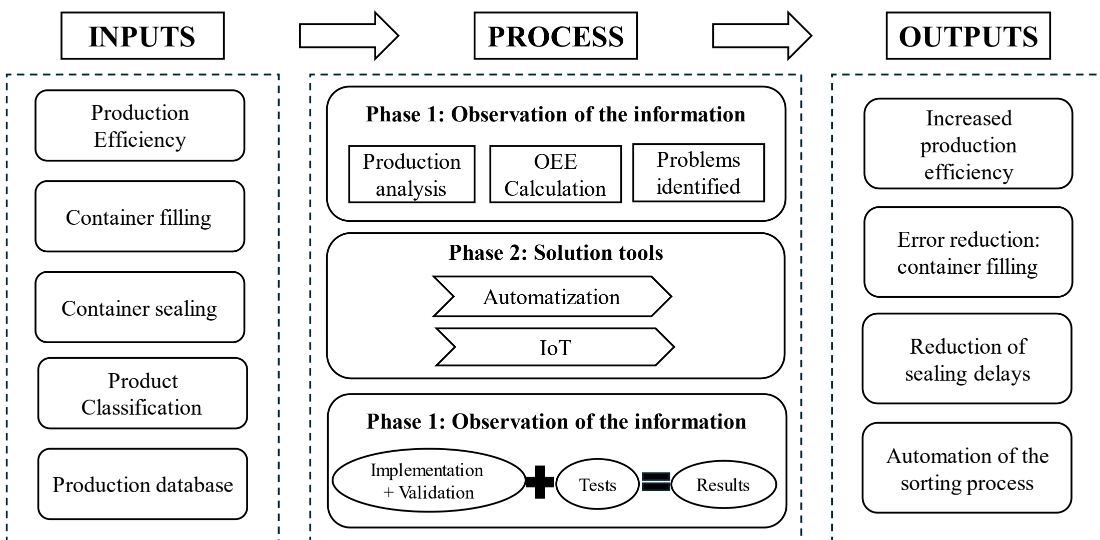

Fig. 1 Proposed model

Phase 3: Validation and Implementation:

B. Proposed design

The proposed design structured in three phases to carry out a proposal is presented. This design aims to improve operational efficiency through an organized methodology that includes the analysis of problem areas, the selection of appropriate solutions and the subsequent validation and implementation of improvements in the production process.

In the first phase, called Observation and Planning, a detailed evaluation of the current process is carried out. This stage includes the identification of recurring problems, such as production stoppages, and the preparation of a specific report for each type of failure. The objective of this phase is to clearly understand the areas of opportunity and the aspects that need to be improved in order to optimize the workflow and reduce inefficiencies.

The second phase, Solution Tools, focuses on choosing the most appropriate automation proposal to address the problems identified in the previous phase. At this point, the implementation of tools such as "Poka Yoke", a technique that helps prevent defects in the process, is considered. The feasibility of the selected proposal is also considered, evaluating whether it is feasible to implement in the company and if it fits the available resources. If the proposal is not feasible, options are re-evaluated to find a more suitable solution.

The third phase, Validation and Implementation, focuses on actually carrying out the automation proposal. If the feasibility of the proposal is confirmed, implementation proceeds, which includes training workers to ensure that they understand the new system and can operate the equipment correctly. Validation tests are carried out to check that the automation is working properly and the results obtained are monitored. Finally, performance indicators are reviewed to determine whether the objectives set, such as the reduction of stoppages and errors in the process have been met.

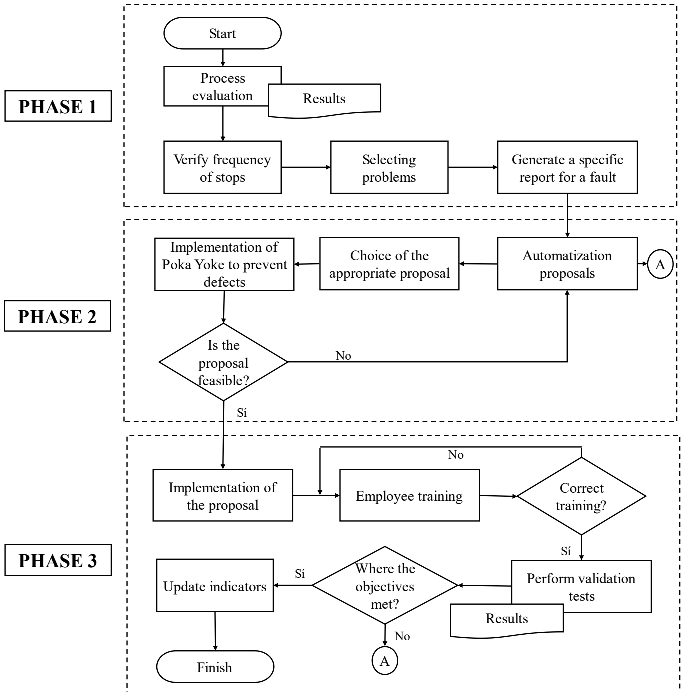

Fig. 2 Proposed design

C. *Indicators*

In the proposed model, indicators are considered in the pre-implementation phase to help identify problems and establish a baseline, then to monitor results and validate the effectiveness of corrective actions.

1) *Error rate*

Objective: to monitor and reduce the frequency of failures that affect the accuracy and quality of the final product. According to Duc et al from [25], the application of sensors for task automation resulted in a productivity improvement of 7.8%.

$$Filling\ error\ rate = \left(\frac{Containers\ with\ errors}{Total\ containers}\right) \times 100\% \qquad (1)$$

2) *Correct classification ratio*

Objective: to ensure accuracy in the identification and separation of containers according to their specifications (size). The formula is composed by True Positive (TP) which is when the current and predicted value is true, and total number of items of the experiment (N). According to [26] the sorting performance can obtain improvements of 95% and 96% accuracy and precision, respectively.

$$CCR = \frac{TP}{N} \times 100\% \qquad (2)$$

3) *Improved cycle time.*

Objective: to optimize the duration of each stage in the production process to ensure a continuous process flow. According to Duc et al from [25], the application of sensors for task automation resulted in a reduction of the cycle time by 20 min.

$$Cycle\ time = \left(\frac{Total\ sealing\ time}{Total\ number\ of\ sealed\ units}\right) \qquad (3)$$

IV. VALIDATION

A. *Methodology selection*

According to the authors reviewed in the State of the Art, there are four types of validation they have used during their research: implementations, pilot experiments, simulations and artifacts.

The artifact methodology has the potential to analyze the proposed model and its development in the area affected by the problem. In addition, a better perception of the objectives and how they have been reached can be verified with less uncertainty. It is in the real context of the case study and allows visualizing if the identified problem is reduced or if any further changes need to be made. The risks of this methodology are relatively low compared to the other methodologies, but this is because production did not have to stop for the artifact to be validated.

From the analysis performed, the validation methodology that was executed in this case study is an artifact. This will help the poka-yoke technique together with automation and internet of things technology to validate the project.

B. *Description of the proposal*

To validate the effectiveness of the poka-yoke technique in the filling, sealing and sorting processes, a prototype was developed with the objective of automating these areas that currently operate manually. This prototype uses optical sensors to control and monitor each stage of the process, and is integrated with a system controlled by an Arduino microcontroller, which allows coordination and precision in the execution of automation tasks.

The first optical sensor is located in the first stage of the process and is responsible for verifying the presence of the package on the belt. This sensor acts as an initial control point, emitting a green visual signal when it detects the presence of the container, which allows the system to advance to the next stage.

The second optical sensor is located upstream of the filling station and has the function of measuring the height of the container. Based on this information, the system automatically adjusts the filling time according to the container dimensions for either large or small containers.

After the filling stage, the container is moved to the station where the cap is placed. A piston is activated to push the cap, ensuring that it fits correctly on the container. At this stage, an additional optical sensor is used to confirm the presence of the container before the piston is activated, ensuring that the mechanism only operates when the container is in the correct position.

In the sealing stage, pistons are used to apply the necessary pressure for a uniform and faultless seal. Optical sensors verify the correct positioning of the container in the sealing position, ensuring that the process is executed only when the container is in the correct position, which reduces positioning errors and ensures a tight seal.

For product sorting, the latest optical sensor detects the size of the package. Once the type of container has been identified, the piston is activated to perform the sorting operation. If the container is large, the piston is actuated to push it into a side container. In the case of small containers, the piston is not activated, allowing the container to continue its trajectory to the end of the conveyor belt, where it falls into a container designated exclusively for small containers.

The entire system is controlled by an Arduino, which allows centralized management of the sensors and pistons, coordinating the activities of each process to optimize the workflow. In addition, the system has real-time monitoring through IoT (Internet of Things), which allows observing and analyzing the performance of the process in real time. This monitoring enables early detection of faults and allows timely adjustments to the configuration to improve the efficiency and quality of the process.

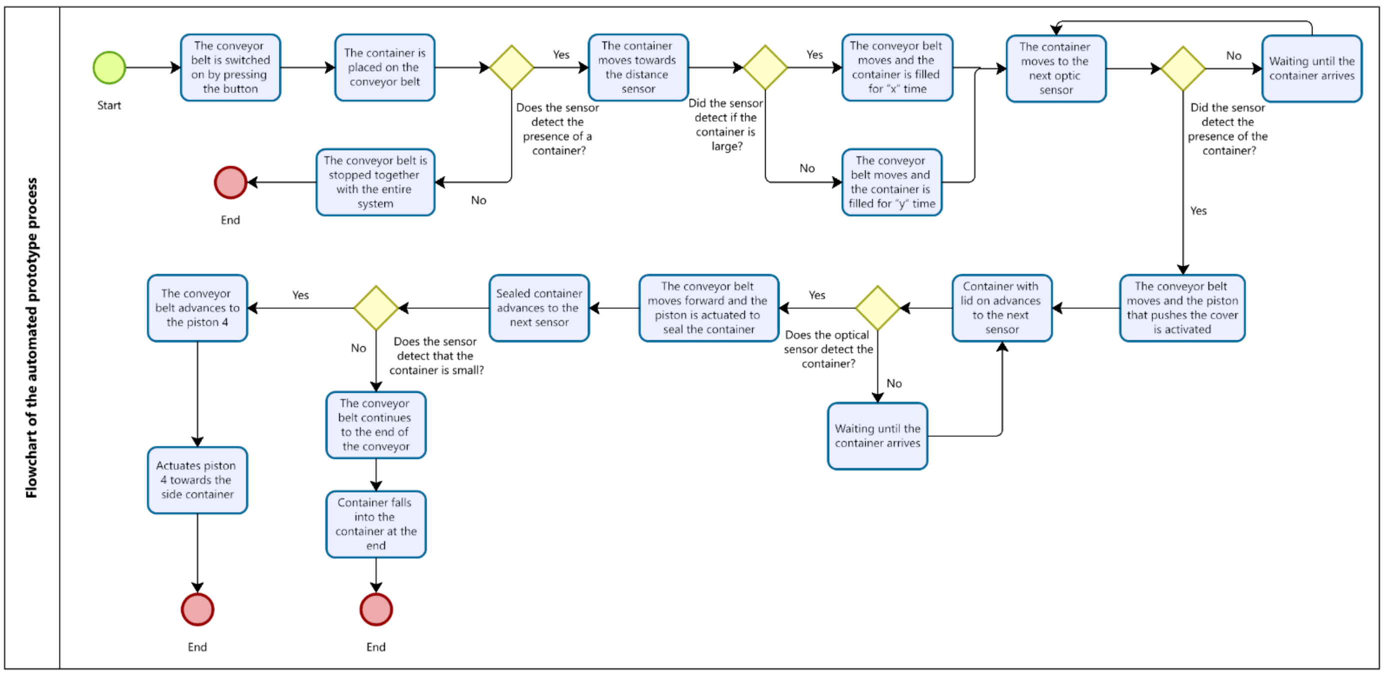

Fig. 3 Proposal validation diagram

C. *Proposal development*

For the development of the prototype, different designs, circuit wiring and Arduino programming activities were carried out. First of all, two types of packaging were designed that are related to the two presentations of the product "poultry feed" offered by the company, which are shown in Fig. 4.

Fig. 4 Small and large container design

The funnel that will be in the filling station, see Fig. 5, and the sorting containers for the containers, see Fig. 5, were 3D printed using PLA as material.

Fig. 5 Filling station funnel

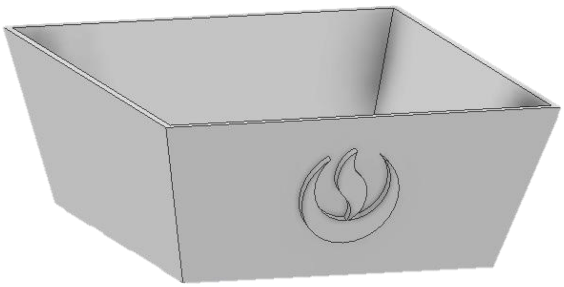

Fig. 6 Container sorting container

The supports for the pistons and the optical sensors for the "filling", "capping", "sealing" and "container sorting" stations were also schematically designed and are shown in Fig. 7.

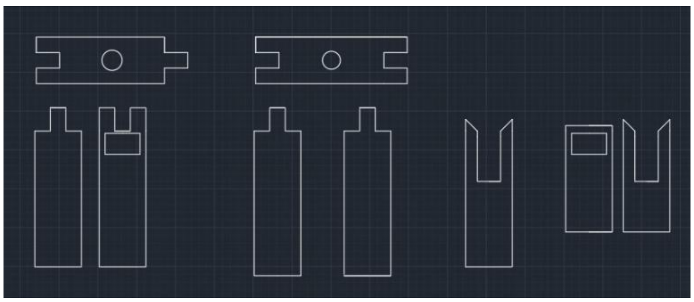

Fig. 7 Piston support of the station "lid placement"

For the prototyping assembly, connections were made from the Arduino to the breadboard and from the breadboard to the pistons, sensors, relay modules, conveyor belt and external source. Fig. 8 shows the connections made on the motor belt, which were soldered for safety, to the breadboard, relay module and the Arduino.

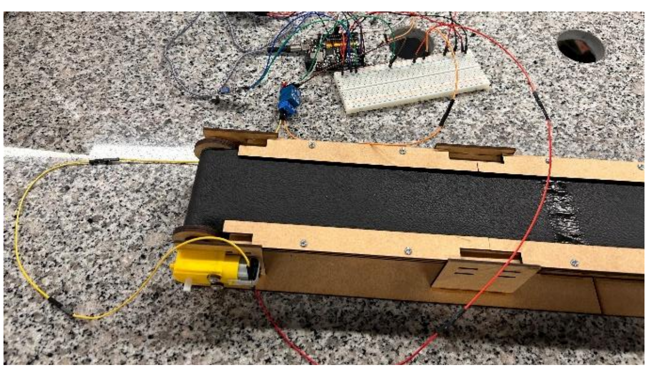

Figure 8 Conveyor belt connections

Similarly, Fig. 9 presents the connection of one of the optical sensors and Fig. 10 shows the connections made in the 8 relay module, which is linked to the pistons, in one of the pistons and the external source to the Arduino and breadboard.

Fig. 9 Connection of the optical sensor

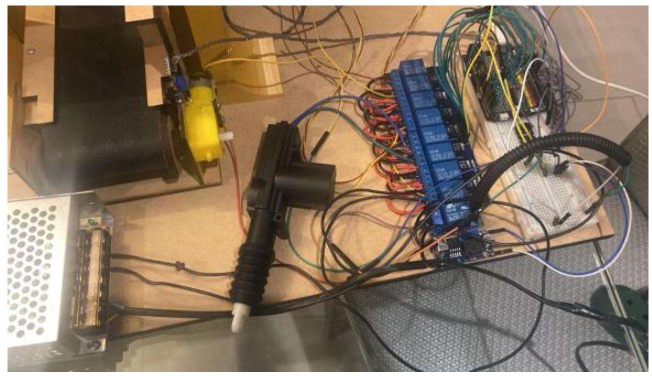

Fig. 10 Piston connections, power supply and relay module 8

Finally, for the operation of the prototype, the programming of the actuators and inputs was carried out, according to the packaging production process, in the Arduino IDE program.

A brief fragment of the programming carried out for the project is presented in Fig. 11 and Fig. 12. The first shows the initialization of the inputs and outputs of the project, the sensors and pistons respectively; while, in the second, the logic can be seen that when the sensor detects an object, it is associated with the large container and, finally, the time in which the servo motor is activated will depend on the variable "size".

```
pinMode(PISTON_TAPA_A, OUTPUT);
pinMode(PISTON_TAPA_B, OUTPUT);
pinMode(PISTON_TAMANO_A, OUTPUT);
pinMode(PISTON_TAMANO_B, OUTPUT);
pinMode(MOTOR_FAJA, OUTPUT);
pinMode(INDICADOR, OUTPUT);

pinMode(sensor_inicial, INPUT);
pinMode(sensor_tamano, INPUT);
pinMode(sensor_llenado, INPUT);
pinMode(sensor_votador, INPUT);
pinMode(sensor_tapa, INPUT);
pinMode(sensor_selector, INPUT);
```

Fig. 11 Part of the initialization programming code

```
if (digitalRead(sensor_tamano) == LOW) {
  Serial.println("Vaso grande detectado");
  tamano = 1000;
  delay(200);
}

if (digitalRead(sensor_llenado) == LOW) {
  digitalWrite(MOTOR_FAJA, HIGH);  // PARA FAJA
  Serial.println("Vaso en posicion de llenado");
  delay(200);

  servo.write(45);delay(500);// Hacia adentro
  servo.write(90);delay(tamano);// Detenido
  servo.write(135);delay(500);// Hacia afuera
  servo.write(90);// Detenido
  digitalWrite(MOTOR_FAJA, LOW);  // AVANZA FAJA
  delay(1000);
}
```

Fig. 12 Part of the loop programming code

As a result, Fig. 13 shows the prototype of the filling, sealing and classification process of poultry food containers sold by the company under study.

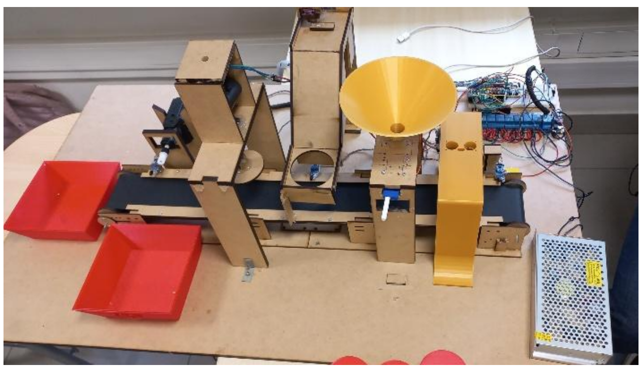

Fig. 13 Final prototype

D. Performance indicators

In this study, the key performance indicators (KPIs) used to evaluate the impact of automation and IoT integration on the poultry feed production process were presented. The key indicators selected were:

- Efficiency
- Raw Material Waste
- Process cycle time
- Defect rate

The main objective of the implemented tools was to optimize production efficiency, reduce raw material waste and improve precision in critical phases of the production process. The automation of the sorting, filling and sealing processes, combined with real-time monitoring using IoT sensors, allowed for more efficient management of resources and an improvement in the quality of the final product.

Table I is presented below, which compares the key performance indicators before and after the implementation of the technological solutions. The table shows how the applied tools have improved the results compared to the company's initial situation.

TABLE I
COMPARISON OF INDICATORS OF THE CURRENT SITUATION AND THE RESULTS OBTAINED

Indicator	Current Situation	Results obtained	Improvement %
Operational Efficiency	74.28%	89%	21.4%
MP waste	3.20%	1.92%	40%
Cycle time	17.50 min/cont.	14 min/cont.	20%
Defect rate	1.95%	0.50%	74.4%

As can be seen, the results obtained are due:

1. *Operational efficiency:* Operational efficiency increased by 21.4%, from 74.28% to 89%. This increase was achieved thanks to the implementation of automation in the sorting and packaging process, which allowed greater continuity in the workflow and reduced downtime due to unplanned stops. Additionally, the use of IoT sensors allowed production variables to be adjusted in real time, improving overall efficiency.

2. *Raw material waste:* Raw material waste decreased from 3.20% to 1.92%, which represents a reduction of 40%. This improvement was achieved by optimizing the filling and dosing processes, which are now controlled more precisely by sensors. Automation made it possible to adjust the use of resources according to specific demand, avoiding excess raw materials.

3. *Process cycle time:* The cycle time per container was reduced by 20%, going from 17.50 minutes per container to 14 minutes per container. This improvement is due to the optimization of work routes and the integration of automated systems that accelerated the sorting, filling and sealing stages. IoT sensors helped adjust workflow in real time and minimize inefficiencies.

4. *Defect rate:* The defect rate in container sorting and packaging decreased by 74.4%, from 1.95% to 0.50%. This significant decrease in defects is due to the implementation of proximity sensors and automation in the packaging classification process by size. Improved accuracy in the packaging process and reduced human error were key to this improvement.

E. Project feasibility

In order to validate the economic impact generated by the implementation of the project, a cash flow is constructed for the 5-year duration of the project. In year 0 (2024), there is an investment of 20,235.18 dollars that the company must allocate to carry out the proposal. For the following years, operating costs were considered to be part of the project being carried out successfully. Table 2 presents the summary of said cash flow.

TABLE II
PROJECT CASH FLOW

Year	Net Cash Flow
2024	- $ 20,235.18
2025	$ 7,427.30
2026	$ 9,313.55
2027	$ 10,041.87
2028	$ 11,349.15
2029	$ 12,077.47

Likewise, five metrics are considered that justify how viable and profitable the project is for the company. These are: Net Present Value (NPV), Internal Rate of Return (IRR), Benefit-Cost Ratio (BCR), Opportunity Cost of Capital (OCC) and the Discounted Payback Period (DPB)

To calculate the OCC, Formula 4 was used, which is composed of "β", which is the risk factor associated with the sector under study, the Country Risk Premium (PRP), the risk-free rate (Rf) and the expected market profitability (Rm) giving a value of 7.63%.

$$OCC = R_f + \beta\left(R_m - R_f\right) + CRP \qquad (4)$$

Considering the value of the OCC, the IRR needs to be higher than this to be acceptable. However, the NPV must be calculated to obtain the IRR. Formula 5 presents the variables required for its calculation, among which the initial investment (I), time (t) and the cash flow at time "t" (CFt) are considered. For the study, the NPV value is S/71,522.07, which is acceptable because it is greater than zero

$$NPV = -I + \sum_{t=1}^{t} \frac{CF_t}{(1+r)^t} \qquad (5)$$

With the NPV value, the IRR is calculated using the same formula, but replacing the value of the discount rate "r" and setting the formula equal to zero as presented in Formula 6. The result is 36.43%, which is higher than the OCC and means that the project is profitable.

$$NPV = -I + \sum_{t=1}^{t} \frac{CF_t}{(1+IRR)^t} = 0 \qquad (6)$$

Formula 7 allows the calculation of the BCR whose value must be greater than 1 for the project to be profitable. For the study, the value of the BCR is 1.97 times which means that the proposal is beneficial compared to the costs.

$$BCR = \frac{\left(\sum_{t=1}^{t} \frac{CF_t}{(1+r)^t}\right)}{|I|} \qquad (7)$$

Finally, the DPB is calculated with a value of 2.50 years, which means that the company will recover the initial investment after that time. This value is not necessary to measure the viability of the project but seeks to demonstrate that the company will be able to generate and recover its profits after this period of time.

V. DISCUSION

In the packaging process of the food sector, there has been a growing presence of automation and use of different technological tools of the fourth industrial revolution. Within these tools, the ones that are most frequently applied are the Internet of Things, Machine Learning and artificial intelligence [6], [8], [9], [10], [11] and [19]. Automation and technological tools have rarely been used together to solve the present problem, but in the few cases that it has been used it has provided positive results and evident improvements in productivity indicators [13]. In the present investigation, it is presented that the joint application of these tools will be to obtain positive results and the focus of the present investigation is that it be implemented in the areas that would benefit the most.

Automation aims to increase productivity and reduce operating costs. The implementation of automation can be complete or per production subarea. In the case study it was applied to the filling, sealing and sorting process, similar to the packaging, packaging and sorting processes [12], [16] and [20]. The way it is presented is both in simulation and in prototype.

The implementation of the Internet of Things in food production processes is the lowest compared to other economic sectors and is the highest among 4.0 technologies. [9], [10], and [11].

CONCLUSION

The implementation of the IoT automation and monitoring system has increased operational efficiency by 21.4%, going from an initial 74.28% to 89%. This improvement is due to the reduction of downtime and the real-time adjustment of production variables, which optimizes the workflow and guarantees greater continuity in the process.

Automation in the filling and classification processes has allowed us to reduce raw material waste by 40%, decreasing from 3.20% to 1.92%. This precise control was achieved through sensors that optimize the use of resources based on specific demand, minimizing surpluses and improving the use of inputs.

The cycle time per container has been reduced by 20%, going from 17.5 minutes to 14 minutes. This positive change is due to the integration of automated systems and real-time monitoring, which speed up the classification, filling and sealing stages, allowing greater speed in the production flow and eliminating inefficiencies.

The implementation of proximity sensors and the automation of the sizing process have reduced the defect rate by 74.4%, from 1.95% to 0.50%. This significant improvement ensures greater precision in packaging and reduces the incidence of human error, optimizing the final quality of the product.

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