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Design and Development of Tablet Making Machine Using IoT

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Abstract- The pharmaceutical industry, precision and efficiency of tablet manufacturing are required to meet quality standards. In this project, the production process is being modernized by incorporating information and communication technology (IoT) into the production line. The machine performs auto-loading of all important steps including material feeding, compression and ejection and also IoT-powered sensors track parameters such as compression force, tablet weight, and humidity. In real-time, data is data is sent to a cloud-based server, enabling remote monitoring and predictive maintenance. This system guarantees of quality tablet, reduces downtime, and improves efficiency. The resulting machine is scalable and intuitive to use, making it suitable for both small- and large-scale production and brings Smart Manufacturing into the pharmaceutical industry.

Index Terms- Pharmaceutical industry, Material feeding, Compression and ejection, Remote monitoring, IoT.

I. INTRODUCTION

The pharmaceutical industry plays a vital role in healthcare by ensuring the production and distribution of medicines that improve human health. Among various forms of drug delivery, tablets are the most commonly used because they are easy to administer, provide accurate dosing, have a longer shelf life and can be mass-produced efficiently. However, traditional tablet manufacturing processes face several challenges, including reliance on manual intervention, lack of real-time monitoring, inconsistent quality, and high operational costs. These issues can affect production efficiency, the effectiveness of the drugs, and compliance with strict pharmaceutical regulations. To overcome these challenges, the integration of the Internet of Things (IoT) into pharmaceutical manufacturing has become a game-changer. IoT enables real-time monitoring, automation and data-driven decision- making, helping to streamline operations and improve product quality.

This shift to IoT-powered manufacturing in the pharmaceutical industry represents a significant leap forward, driving more consistent, cost-effective, and high- quality production. It also opens the door for smarter, more adaptable manufacturing that can respond quickly to changes in production conditions, helping to meet the growing demand for safe and effective medicine, optimizes resource utilization.

The pharmaceutical industry is highly regulated, requiring manufacturers to comply with Good Manufacturing Practices (GMP) and Food and Drug Administration (FDA) guidelines. Ensuring tablet consistency in terms of weight, hardness and dissolution rate is critical for drug efficacy. In traditional manufacturing processes, quality control is often conducted through sample testing, which may not represent the entire batch. IoT-enabled tablet-making machines overcome this limitation by integrating smart sensors and cloud-based monitoring systems that allow for in-line quality control. This ensures that deviations in production parameters are detected and corrected instantly, reducing the risk of defective products reaching the market. major challenge in conventional tablet production is machine downtime due to unexpected failures. In traditional setups, maintenance is often reactive, occurring only after a machine breakdown. This leads to production delays, increased operational costs and wastage of raw materials.

IoT-enabled machines, however, incorporate predictive maintenance capabilities. by analysing real-time machine performance data, AI-driven algorithms can predict potential failures and notify operators before a breakdown occurs. This proactive approach minimizes downtime, extends equipment lifespan, and improves overall manufacturing efficiency.

Additionally, IoT technology enables remote monitoring and control of tablet-making machines. Cloud-based platforms allow manufacturers to oversee production operations from anywhere, ensuring transparency and quick decision-making. As global demand for high-quality medicines continues to grow, adopting IoT-enabled manufacturing solutions will be crucial for pharmaceutical companies to remain competitive and meet regulatory standards.

II. LITERATURE REVIEW

Krishna et al proposed a commercial tablet counting and filling machine for pharmaceutical companies, controlled using Programmable Logic Controller (PLC). Conventional ways of tablet filling and counting process is observed to be complex, expensive, time consuming and inefficient. This system aims to make this process simple, accurate, as well as cost effective. With a proper user-defined selection input, the desired quantity of tablets can be counted to be filled in the bottles. The entire system is much more flexible and time saving to meet the industrial requirement by continuously moving conveyor [1].

Rohit et al established tablet compressing manufacture process with multiple applications in pharmaceutical, dietary supplement, food, cosmetic, diagnostic, and other industries. Actual tablet compressing may be subdivided into four stages: Filling, metering, compression and ejection. The current overall research is oriented on tablet used in the medical field, where the accuracy, weight and drug content is more important. This paper specifically deals with the camphor tablet making machine. In this study various types of tablet compressing machines and tooling methods are discussed. In this work, selection of tooling is done by referring to the TSM (Tablet Specification Manual), which specify the dimensions of punch and dies and other factors affecting the machine [2].
Ismail et al developed die filling is a crucial step in the pharmaceutical tablet manufacturing process. For industrial-scale production using rotary presses, suction filling is typically employed due to its significant efficiency advantages over gravity filling. Despite its widespread use, our understanding of the suction filling process remains limited. Specifically, there is insufficient comprehension of how filling performance is influenced by factors such as suction velocity, filling velocity and the properties of the powder materials. Building on our previous research, this study aims to further investigate the effects of powder properties and process parameters (e.g., filling velocity, suction velocity, fill depth) on suction filling behaviour. A systematic experimental investigation was conducted using a model suction filling system, considering both cohesive and free-flowing pharmaceutical powders. The effect of fill depth on suction filling of these powders was examined at different filling and suction velocities. The results demonstrate that two distinctive flow regimes for suction filling can be identified: slow filling and fast filling [3].

Ervasti et al designed an continuous tablet manufacturing can be conducted by direct compression or with a granulation step such as dry or wet granulation included in the production procedure. In this work, continuous manufacturing tests were performed with a commercial tablet formulation, while maintaining its original material composition. Challenges were encountered. With the feeding performance of the API during initial tests which required designing different powder pre-blend compositions. After the pre-blend optimization phase, granules were prepared with a roller compactor. Tableting was conducted with the granules and an additional brief continuous direct compression run was completed with some ungranulated mixture. The tablets were assessed with off-line tests, applying the quality requirements demanded for the batch-manufactured product. Chemical maps were obtained by Raman mapping and elemental maps by scanning electron microscopy with energy-dispersive X-ray spectroscopy. Large variations in both tablet weights and breaking forces were observed in all tested samples, resulting in significant quality complications [4].

III. EXISTING SYSTEM

The existing tablet-making machine systems are crucial in the pharmaceutical and food industries for producing tablets through the compression of powders or granules into solid forms.

These machines have evolved with technological advancements to enhance production speed, efficiency and accuracy.A typical tablet-making machine consists of several key components: the feeder system, die and punches, compression mechanism, tablet ejection system and control system. The feeder system delivers the powder or granules into the die cavity, ensuring the right amount of material for each tablet. Dies and punches are used to shape the tablets by compressing the powder. The compression mechanism, usually rotary, applies pressure to compact the material into tablet form. After compression, the tablet ejection system removes the tablet from the die. The control system monitors and adjusts parameters such as compression force, tablet thickness and machine speed for better precision and consistency the Fig. 1 shown below.

Fig.1. Existing Tablet Making Machine

Modern tablet-making machines incorporate advanced features to improve performance. These include automatic control and monitoring systems, which regulate production parameters, ensuring uniformity and minimizing the need for manual oversight. High-speed production is another significant feature, with modern machines capable of producing thousands of tablets per minute. Quality control features such as sensors and cameras are used for online inspection, monitoring tablet weight, hardness and appearance to ensure the final product meets strict quality standards. Furthermore, many machines are modular and customizable, allowing flexibility in die sizes, punch designs, and tablet shapes, enabling manufacturers to produce a variety of tablet types on the same machine. The benefits of modern tablet-making machines are clear: they increase efficiency by enabling large-scale production with minimal human intervention, reducing labour costs and improving consistency. The integration of automated quality control and process monitoring ensures high-quality products and minimizes defects. As a result, manufacturers can meet high demand while adhering to stringent quality standards.

IV. COMPONENTS OF EXISTING SYSTEM

Tablet manufacturing machines enhances efficiency, precision, and quality control. Key components of an IoT- enabled tablet press include advanced sensors, such as temperature, humidity and pressure sensors, which monitor critical parameters in real-time.

These sensors collect data on factors like compression force, tablet weight and environmental conditions, ensuring consistent product quality.The data is transmitted to a centralized control unit equipped with IoT connectivity, allowing for continuous machine condition monitoring and predictive maintenance. This setup enables operators to make immediate adjustments, reducing downtime and optimizing production processes.

Fig.2. Image of Feeder System

Additionally, IoT integration facilitates seamless communication between machines and systems across the production line, aligning with the principles of Pharma 4.0 and supporting the vision of cross-production connectivity. a tablet press machine consists of several main components, including the hopper, feed frame, punches, die cavity, turret and control system. Figure 2 shown below the hopper is where the granular material is loaded and the feed frame helps in delivering it to the next stage.

V. PROPOSED SYSTEM

This proposed system was designed for small-scale production and research applications, which operates with a single set of punch and die. For instance, the TDP 0 Desktop Tablet Press can produce round tablets up to 10 mm in diameter and 6 mm thickness without the need of electrical power.

1. Block Diagram

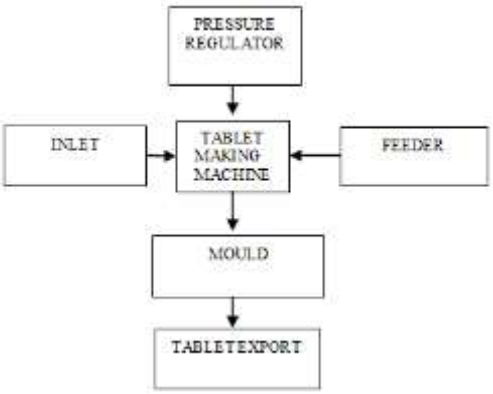

Fig.3. Block Diagram of Proposed System

2. Flow Chart

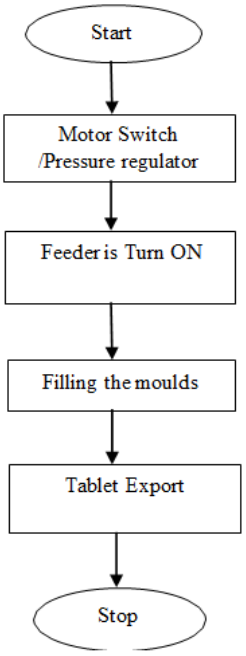

Fig.4. Flow Chart of the Proposed System

3. Description of Tablet Production

Tablet production plays a vital role in the pharmaceutical industry, focusing on the creation of solid dosage forms for medications. This process consists of several important stages, each essential for the efficient production of consistent, high-quality tablets that adhere to strict industry standards.

Working Methodology

- **Material Preparation:** Selection and Weighing of Active Pharmaceutical Ingredients (APIs) and excipients pre-blending of excipients to improve powder flow properties and mixing uniformity.
- **Granulation:** Improve the flow properties and compressibility of powder mixtures and addition of liquid binder to form agglomerates the drying and sieving process of granules, the Figure.5 shown below.
- **Blending:** Blending is an essential process in tablet manufacturing that guarantees an even distribution of APIs and excipients. Effective blending is key to achieving consistent tablet composition, weight and drug potency.
- **Lubrication:** After blending to prevent sticking, improve tablet ejection, and enhance flowability, the lubricant is mixed gently for 1 to 2 minutes to ensure it is evenly distributed without compromising the tablet's integrity. It's important to avoid over-lubrication, as this can interfere with tablet disintegration. The final blend is then checked for uniformity before being sent to the compression machine.

Fig.5. Image of Pressure Regulator

Specifications

Table.1. Specifications of Thermal Image Camera

Die Cavity	Tablet Weight (mm^3)
Powder	50–200 µm
Hopper	10 – 100L
Lubricant	Magnesium strearate 0.5 – 2%
Compression Force	1-20 tons
Tablet Weight	100 – 1000 mg
Flow Function	10 - 50

4. Working of Proposed System

The primary goal of the proposed system is to the tablet-making machine is designed to incorporate modern technologies that boost efficiency, enhance tablet quality and reduce waste during production. It will feature several essential components, each aimed at ensuring a smooth, reliable and scalable tablet manufacturing Sensors and automated systems constantly track essential parameters like blending time, temperature and pressure, making sure that every stage of the production process meets established the system automatically checks the weight, hardness, thickness and visual defects of tablets.

This guarantees consistent product quality and minimizes the necessity for manual quality inspections. The automation system can easily connect with other enterprise systems such as inventory management and regulatory compliance tools, facilitating smooth coordination throughout various stages of production and delivery.

This centralized control and automation strategy greatly improves productivity, quality control and operational efficiency, while also offering the flexibility and adaptability needed for future production scaling.

5. The Applications of Proposed System

The design and development of an IoT-enabled tablet- making machine present numerous advantages across various sectors, particularly in pharmaceuticals, nutraceuticals and manufacturing industries. The system automates the traditionally complex tablet production process by offering precise control over dosage, size, weight, and composition, ensuring uniformity and consistency in every batch.

This innovation addresses common challenges such as manual errors, inefficient operations and quality inconsistencies, making it an essential tool for modern manufacturing units A significant application is in the pharmaceutical sector, where maintaining stringent quality and compliance is critical.

The machine, integrated with IoT features, allows real-time data monitoring, performance analysis and automated adjustments to ensure adherence to pharmaceutical standards. This not only boosts production efficiency but also facilitates better traceability for regulatory compliance in the health supplement industry, the machine enables the seamless production of various nutraceutical tablets and capsules with customizable formulations.

The Figure.6 shows below by minimizing human intervention and leveraging automated processes, manufacturers can reduce operational costs and improve output efficiency.

VI. RESULT AND DISCUSSION

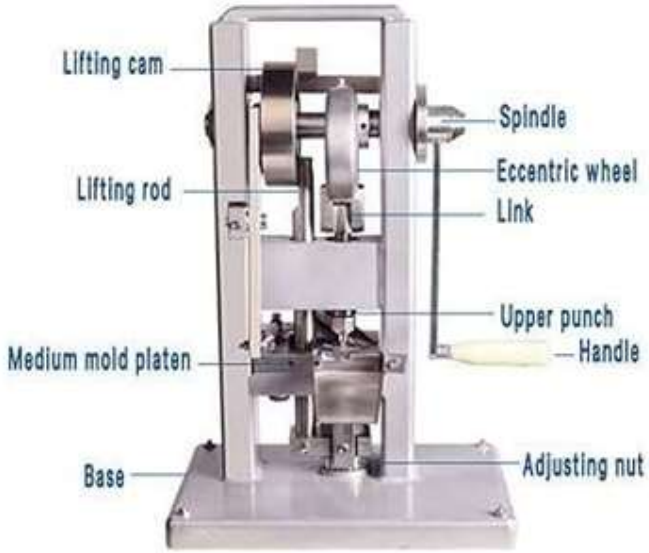

Fig.6[i]. Tablet Making Machine

Fig.6[ii]. Tablet Press Turret

The output that we have obtained the design and development of the IoT-enabled tablet-making machine have demonstrated remarkable improvements in precision, efficiency and automation compared to traditional methods. The system successfully integrates advanced sensors and IoT components, enabling real-time monitoring and control of the production process.

This results in higher accuracy in tablet size, weight, and dosage, ensuring consistent quality in every batch. One of the key observations during testing was the reduction in operational errors, which can often occur due to manual handling in traditional manufacturing. With automated control, production downtime was minimized` and wastage of raw materials was significantly reduced. The IoT-based data logging feature provided valuable insights into machine performance, production trends and error patterns, helping optimize the manufacturing process and improve overall efficiency.

The IoT-enabled tablet-making machine offers real-time production monitoring, providing performance alerts and scheduling predictive maintenance remotely. This capability ensures smooth operations by preventing unexpected disruptions, thereby enhancing overall productivity. Moreover, the machine's versatility allows it to handle various formulations and tablet sizes seamlessly, making it suitable for large-scale manufacturing as well as small to medium-sized operations and laboratory research and development. This adaptability ensures that diverse production needs are met efficiently.

Integrating Internet of Things (IoT) technology into tablet manufacturing has ushered in a new era of smarter and more efficient production systems. By incorporating automated control, real-time monitoring and data-driven decision-making, the traditional manufacturing approach has been transformed, paving the way for future advancements in pharmaceutical and nutraceutical production processes. For instance, rotary tablet presses, designed for high-volume production, feature multiple stations that allow for the simultaneous creation of numerous tablets per rotation. The TPR 500, for example, is capable of producing more than 230,000 tablets per hour, including bi-layer tablets with a set of conversion parts

V. CONCLUSION

Designing and developing an IoT-enabled tablet-making machine represents a significant advancement in modernizing traditional manufacturing processes. By integrating IoT technology, the system offers enhanced automation, precision and control over critical parameters such as tablet size, weight and dosage. This innovation not only minimizes manual errors but also ensures consistent product quality across every batch. Additionally, the remote monitoring and control capabilities empower manufacturers to track and manage production processes from any location, fostering better decision-making and streamlined operations. With its cost-effective and scalable design, the system also presents an affordable automation solution for small and medium-sized enterprises.

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