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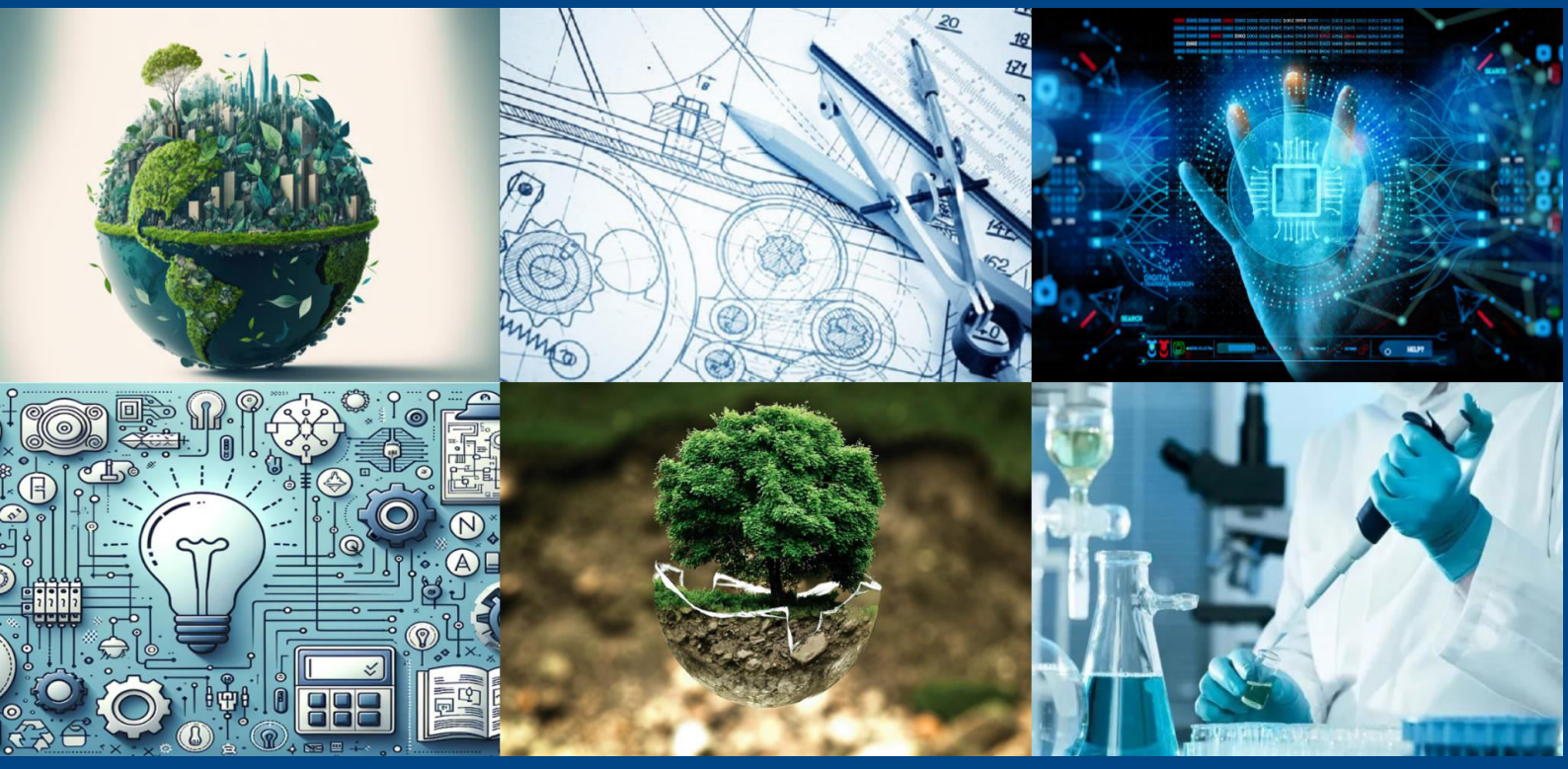

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Pin Hole Detection System by Using Photoelectric Sensor and Poka-Yoke Technique

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ABSTRACT: Poka-yoke is a technique that is used for avoiding human error in the workplace. It is also known mistake-proof method and fails safety working methods poka-yoke is a system it is designed to prevent errors or mistakes made by the operator performing work or process. Today, this concept is used in current industries production system helped design, averages poka-yoke devices per machine in their manufacturing plants, thus validating the concept as beneficial to the industry in this article is used to reducing rejection and customer complaints, detect wrong punching bracket holes and only finish good material is supplied customer reduced wrong assembly bracket. An examination in Precision" list the potential benefits as:

- Detecting wrong hole punching.
- Simplified wrong bracket punching.
- Easily detect the problem.
- Poka –yoke implementation cost is very low.
- Lower skill worker is required.
- Increased production flexibility.
- Reducing customer complaints.
- Reducing rejection.
- Showing bracket punch defect.
- Easily detect without punching bracket
- This poka-yoke is to implement proximity metal detector sensors.
- It's improved to product quality and reduced rejection of the bracket

Also the implementation safety two push buttons in this machine to going on the safety press operation to avoiding the accident. It can develop by the new system of the press operation or press operation purposethis system's purpose is to avoid the

accident and work done is going very safely. The first system is press paddle is implemented but they are the chance of accident and finally, an accident occurs at the machine and injured the hand fingers. After implementing the hand push button and to avoid the accident. Operator both hand are used to place the job in the fixture and both hands are used to push two buttons and after the machine are working and operation will be done safely. List the potential benefits as given below.

I. INTRODUCTION

In modern manufacturing environments, maintaining high product quality and minimizing defects are essential for sustaining competitiveness, especially in industries such as automotive, electronics, medical, and packaging. One common quality defect in sheet-based or molded materials is the presence of pin holes—small, often invisible holes that can lead to serious performance and reliability issues in the final product. Traditional methods of detecting such microscopic flaws often involve manual inspection, which is time-consuming, error-prone, and inefficient, especially in high-speed production lines.

To address these challenges, this research focuses on the development and implementation of a Pin Hole

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Detection System using a Photoelectric Sensor integrated with the Poka-Yoke technique. The photoelectric sensor, known for its precision and speed, detects changes in light caused by the presence of holes in the material. As materials pass through a detection area illuminated by a light source, any disruption or abnormal passage of light—such as through a pin hole—triggers the sensor. The response can then be used to alert operators, reject faulty parts, or halt the production line for correction.

Poka-Yoke, a Japanese term meaning ―mistake-proofing,‖ refers to techniques designed to prevent errors before they occur or to immediately detect and correct them when they do. Integrating Poka-Yoke into the pin hole detection system ensures that errors are not only identified but are acted upon in real time, contributing to zero- defect manufacturing goals. This proactive approach enhances quality assurance, reduces rework and waste, and increases overall operational efficiency.

This research explores the design, implementation, and testing of a pin hole detection system that combines the reliability of photoelectric sensors with the intelligence of poka-yoke methodology. The paper also presents a review of relevant literature, system architecture, experimental setup, data analysis, and practical implications of deploying such a system in a real-world manufacturing process. Ultimately, this study contributes to the development of automated, intelligent quality control systems that align with Industry 4.0 principles and continuous improvement strategies like Kaizen and Six Sigma.

II.LITERATURE REVIEW

1. Introduction to Poka-Yoke

The term *Poka-Yoke*, a Japanese word meaning *"mistake-proofing"*, was introduced by Shigeo Shingo as part of the Toyota Production System. It is a quality assurance technique used to prevent errors in manufacturing by designing fail-safe mechanisms. Poka-Yoke methods ensure that the right conditions exist before a process step is executed, thereby eliminating defects at the source.

2. Importance of Defect Detection in Mechanical Industry

In the mechanical industry, even minor defects such as **pin holes** in components (e.g., castings, pipes, or press parts) can lead to major failures in product performance, leakage, or assembly line rejections. Traditional quality checks may fail to identify such minute defects, especially when the process is manual and repetitive. This increases the need for **automated or semi-automated error-proofing techniques** like Poka-Yoke.

3. Pin Hole Detection Methods :

Various methods for pinhole detection have been discussed in industrial literature and practice, including:

- **Visual Inspection**: Though widely used, it's prone to human error and inconsistency.
- **Air Pressure or Vacuum Testing**: Detects leaks by checking pressure drop in enclosed components.
- **Dye Penetrant Testing (DPT)**: Effective but time-consuming and not suitable for high-speed production lines.
- **Machine Vision Systems**: Uses cameras and image processing algorithms to detect pinholes automatically. This approach is gaining popularity due to its reliability and speed.

4. Application of Poka-Yoke in Detection Systems

When integrated with Poka-Yoke, these detection methods can become foolproof:

- **Sensor-Based Poka-Yoke**: Incorporating sensors that detect presence, absence, or dimension deviations.
- **Mechanical Poka-Yoke**: Using jigs or fixtures designed to detect incorrect assembly or missing features.
- **Automation with Interlocks**: Machines programmed to halt operations if a pinhole or defect is detected, ensuring no defective part proceeds to the next step.

5. Review of Relevant Studies and Implementations

- **Pateletal. (2019)** explored Poka-Yoke applications in automotive part manufacturing and showed a 30% reduction in defect rates when mechanical fixtures were used for hole detection.
- **Sahu & Choudhary (2021)** implemented a vision-based Poka-Yoke system for pinhole detection in casting components and reported improved detection accuracy and reduction in inspection time.
- **Kumar & Tiwari (2022)** demonstrated the integration of Poka-Yoke with IoT-based systems for real-time defect

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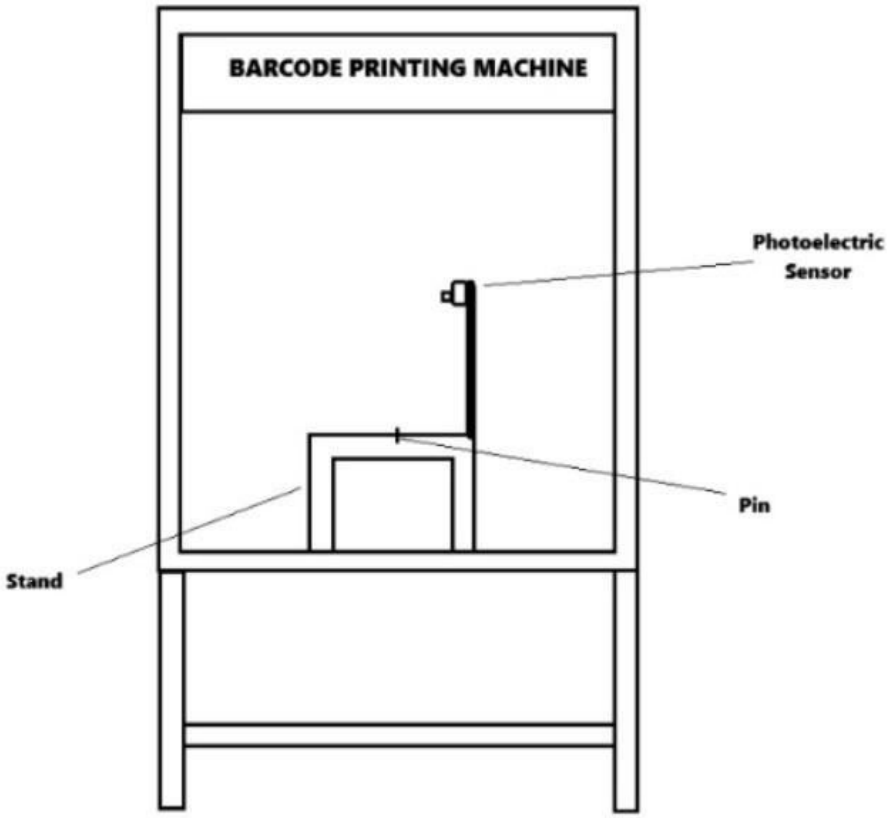
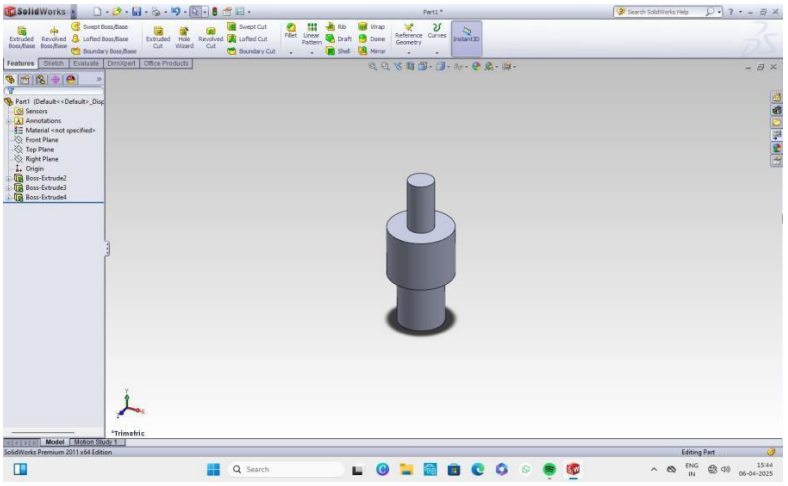
reporting in production lines, improving traceability.

General Design Of Project And its Component





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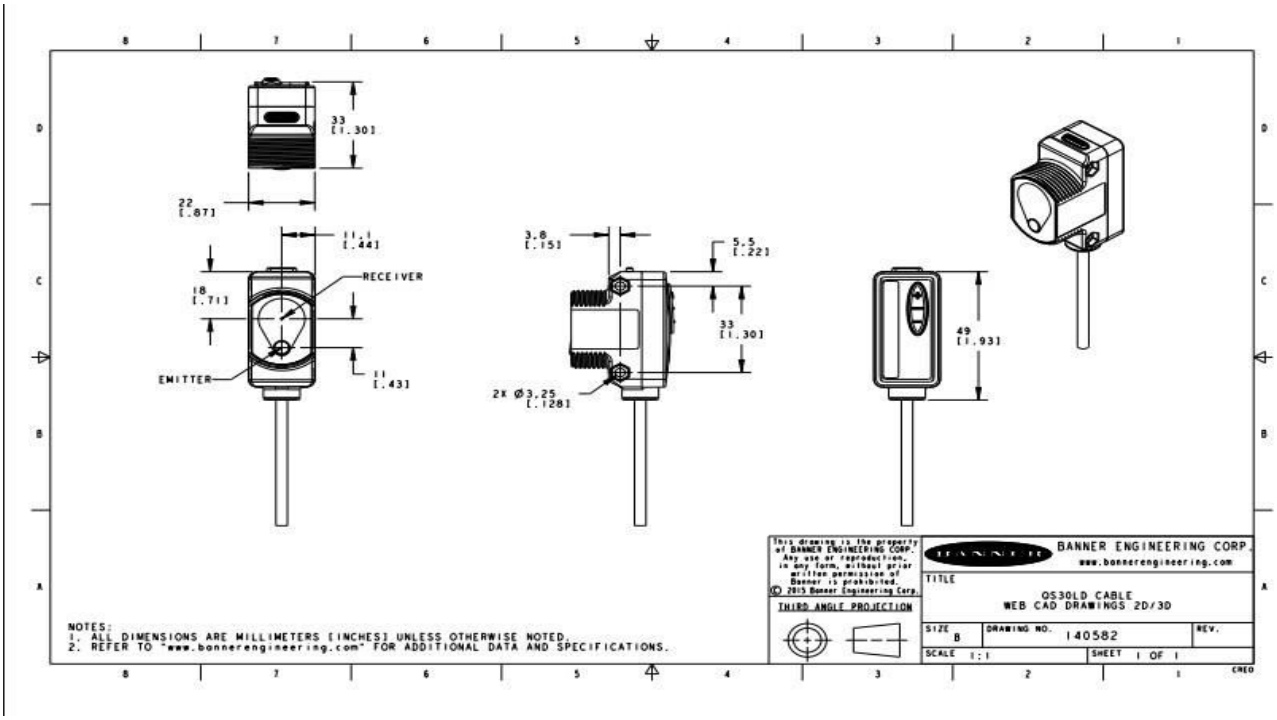

Sensor Information :-

The **Q30 Series** from Banner Engineering is a family of high-performance **photoelectric sensors** known for their **long-range sensing capabilities** and **rugged design**. Housed in a **compact 30 mm enclosure**, these sensors are ideal for demanding industrial applications. They support a variety of sensing modes including **opposed**, **retroreflective**, **diffuse**, and **laser-based** detection. With a sensing range of up to **200 meters**, visible LED indicators, and **IP67/IP69K** environmental protection, the Q30 Series is built for accuracy and durability in tough environments. They are available with **DC or AC power options** and multiple output types, making them versatile for different automation systems.

Required Components for Q30 Series Sensor Setup:

1. **Q30 Series Sensor Unit**
   - Choose the appropriate model based on sensing mode (e.g., diffuse, retroreflective, opposed, laser, etc.).
2. **Power Supply**
   - **10–30V DC** for most models or **24–250V AC** for AC models.
   - Ensure a regulated and filtered power supply compatible with sensor voltage.
3. **Mounting Bracket or Hardware**
   - Mounting kits or custom brackets (sold separately or included in some models) to secure the sensor in place.
4. **Reflector (for Retroreflective Models)**
   - Required for retroreflective sensors to reflect the light beam back to the sensor.
   - Examples: Banner model BRT-51X51C reflector.
5. **Cables or Connectors**
   - **5-pin M12 connector cables** for quick-disconnect models.
   - Pre-wired versions may not require separate cables.
   - Shielded cables may be preferred in noisy environments.
6. **Controller/PLC or Signal Receiver**
   - To interpret the sensor's output (NPN/PNP or relay).
   - Used to trigger machines, alarms, or automation sequences.
7. **Alignment Tools (Optional but Helpful)**

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- Laser alignment tools or setup indicators to ensure proper beam alignment—especially for long-range or laser models.

8. **Protective Accessories (Optional)**
   - Enclosures or lens shields for added protection in harsh environments.

III. CONCLUSION

The implementation of a **Pin Hole Detection System** using a **photoelectric sensor** combined with the **Poka-Yoke (mistake-proofing) technique** has proven to be a highly effective and efficient solution for quality control in manufacturing processes. This project aimed to automate the detection of minute defects—specifically pin holes—in materials such as metal sheets, plastic films, or other industrial components, which are often invisible to the naked eye or missed in manual inspections.

The core of the system revolves around the **Q30 Series photoelectric sensor** (or a similar high-resolution model), known for its precision, long-range detection, and reliability in harsh environments. By directing a focused beam of light toward or through the target material and measuring the interruption or transmission of light, the system accurately detects even small pinholes. This automation replaces the error-prone human inspection method, thereby increasing accuracy, repeatability, and efficiency.

The integration of the **Poka-Yoke principle** has elevated the system from mere detection to a full preventive approach. Poka-Yoke ensures that:

- Any defective part is identified instantly,
- The production process is halted or an alert is raised,
- Further processing of faulty components is avoided.

By applying this technique, we eliminate the possibility of defective products reaching subsequent stages of production or the end customer, ultimately reducing cost, rework, and customer dissatisfaction.

Key Outcomes:

- Increased defect detection rate with near-zero false negatives.
- Reduced dependency on manual inspection**,** saving time and labor costs.
- Consistent quality assurance through automated monitoring.
- Real-time response using PLC/microcontroller integration for alarms or automated rejection.
- Improved safety and efficiency, aligning with Lean Manufacturing principles.

Future Scope:

- Incorporating vision systems or machine learning for complex defect classification.
- Developing a **multi-sensor array** to detect defects over larger surface areas.
- Integrating with **IoT platforms** for remote monitoring and data analytics.
- Implementing **actuator-based rejection systems** for fully automated rejection of defective items.

REFERENCES

"Poka-Yoke for Filter Pin Detection in Nozzle Holder Body Using PLC"

By S.A. Patil et al. (ResearchGate):
This paper provides a detailed example of how Poka-yoke, specifically the use of a Programmable Logic Controller (PLC), can be implemented for precise pin detection in a manufacturing process.

- **Authors**: Kang, M., Cho, M., Jeon, J.
- **Published in**: *Journal of Internet Computing and Services*, 2012.
- **Summary**: This paper presents a pinhole detection system utilizing an Avalanche Photodiode (APD) sensor, LED illuminator, and fiber optic waveguides. The system can detect pinholes as small as 100 microns at a speed of 1,000 meters per minute. The detection performance is enhanced through SQL-based database analysis, classifying

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detected pinholes by location and size using image detection algorithms.

- **Author**: Kun Huang.
- **Published in**: *Advanced Materials Research*, 2012.
- **Summary**: This paper discusses the design of a practical photoelectric detection system for detecting loopholes in conductive films. The system includes a photoelectric sensor module, signal conditioning module, microcontroller unit (MCU), control module, alarm module, and power supply module. The system achieves the design requirements after installation and debugging, realizing the intended functions

- **Authors**: [Not specified].
- **Published in**: *ISIJ International*, 2017.
- **Summary**: This article introduces a method for detecting pinholes in steel slabs using a combination of Gabor filters and morphological features. The approach aims to address challenges in detecting various sizes of defects in steel products, proposing a filter combination method to enhance detection accuracy.

- **Authors**: Wang, Y., Yu, L., Zhang, L., Bai, L., Guo, X., Li, J.
- **Published in**: *Multimedia Tools and Applications*, 2020.
- **Summary**: This paper analyzes the photoelectric performance of infrared detectors based on image processing techniques. While not exclusively focused on pinhole detection, it provides insights into the performance characteristics of photoelectric sensors in various applications, which can be relevant for understanding their capabilities in defect detection systems.

- **Authors**: Tai, C.-C., Moulder, J. C.
- **Published in**: *Review of Progress in Quantitative Nondestructive Evaluation*, 1998.
- **Summary**: This paper discusses the use of photoinductive imaging for inspecting bolt hole corner cracks. Although it focuses on a different type of defect, the techniques and principles discussed may offer valuable insights into the application of photoelectric sensors for detecting small-scale defects like pinholes.

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