Industrial Based Conveyor Belt Monitoring and Fault Detection System

[1]Keerthivasan V, [1]Dihneshkumar S, [1]Eniyavan M, [1]Franklin F, [2]G Keerthana
[1]Student, [2]Assistant Professor
[1,2]Department of Electronics and Communication Engineering
[1,2]K Ramakrishnan College of Technology, Tiruchirappalli, India

Abstract: Fire Industrial conveyor belts are widely used in manufacturing industries, material handling systems, warehouses, and production units. Continuous operation may lead to belt cracks, belt cuts, motor overheating, and abnormal current consumption. If these faults are not detected at an early stage, they may cause equipment damage, production delays, and safety risks. This project proposes an IoT-enabled conveyor belt fault detection and monitoring system using an ESP32-CAM, an ESP32 microcontroller, a current sensor, and a temperature sensor.The ESP32-CAM captures images of the conveyor belt to identify visible cracks and cuts using image-processing techniques. An ACS712 current sensor monitors the electrical current consumed by the conveyor motor, while a DS18B20 temperature sensor measures the motor or monitored component temperature. The collected sensor information is transmitted to an IoT dashboard for real-time monitoring. When a belt crack, abnormal current, or high-temperature condition is detected, the system generates an alert and sends an email notification to the user. A motor-control mechanism is proposed to stop the conveyor automatically when a critical fault is confirmed. Additional safety features, including a flame sensor, IR sensor, buzzer, and traffic-light indicators, can be integrated to improve industrial safety.

Keywords: ESP32-CAM, Conveyor Belt Crack Detection, Internet of Things (IoT), ACS712 Current Sensor, DS18B20 Temperature Sensor, Motor Protection, Automatic Fault Alert.

INTRODUCTION

Conveyor belts are widely used in industries, factories, warehouses, and material-handling systems. Continuous operation may cause belt cracks, cuts, excessive motor current, and overheating. These faults can damage equipment, affect production, and create safety risks if they are not identified and corrected quickly [1]. Traditional conveyor inspection methods often depend on manual checking, making continuous monitoring and early fault identification difficult. Integrating sensor technology with the Internet of Things (IoT) can improve fault monitoring, remote observation, and automatic alert generation. IoT allows physical devices to collect and exchange data through network connections, enabling operators to monitor equipment conditions remotely [2].

In the proposed system, an ESP32 microcontroller is used to collect sensor data and support communication with the monitoring dashboard [3]. An ESP32-CAM module captures images of the conveyor belt to identify visible cracks and cuts using image-processing techniques [4]. An ACS712 current sensor monitors the current consumed by the conveyor motor, while a DS18B20 temperature sensor measures the temperature of the monitored equipment [5]. The collected readings are compared with predefined thresholds to identify abnormal operating conditions. When a critical fault is detected, the system generates an alert and activates suitable warning indicators, such as a traffic-light indicator and buzzer [6]. A motor-control circuit can also be used to stop the conveyor when a confirmed critical fault occurs [7].

A key feature of the proposed system is its web-based IoT dashboard, which displays the camera status, belt condition, current consumption, temperature, motor status, and fault notifications [8]. Instead of depending only on a separate display, operators can monitor the system through a laptop or another supported device. Using Wi-Fi communication, the system transfers sensor readings and fault information to the dashboard [9]. When a new belt crack, abnormal current, or high-temperature condition is detected, an email notification can be sent to the operator with the fault details and a camera image,

where supported [10]. Optional flame and IR sensors can further improve safety by providing fire warnings and object-fall detection [11].

The main objective of this research is to develop an IoT-enabled conveyor belt fault detection and monitoring system that integrates camera-based inspection, sensor monitoring, embedded processing, wireless communication, and automatic fault response [12]. The prototype aims to improve early fault awareness, reduce unexpected conveyor downtime, and support timely maintenance. The system's performance can be evaluated by measuring crack-detection accuracy, sensor response, email notification delay, motor shutdown response time, communication reliability, and false-alarm frequency [13].

Materials and Methods

The IoT-Based Fire and Gas Leak Detection System uses an ESP32 microcontroller, a gas sensor, a flame sensor and a DHT11 temperature and humidity sensor. ESP32 is the brain of the system[13]. ESP32 connects to Wi-Fi. ESP32 sends data to a web interface. Gas sensor finds smoke in the air. Flame sensor senses the light from fire. DHT11 sensor records room. Humidity[14]. When any danger appears indicators light up. Buzzer rings loudly to warn people. Laptop hosts a web-based monitoring page. That page displays sensor readings, environmental conditions and system status[15]. ESP32 is programmed with Arduino IDE. Website shows all data collected by the system in time.

System Design and Implementation

The proposed IoT-Based Conveyor Belt Fault Detection and Monitoring System uses an ESP32 microcontroller, an ESP32-CAM module, an ACS712 current sensor, and a DS18B20 temperature sensor. The ESP32 acts as the main controller of the system [13]. The ESP32 uses Wi-Fi communication to transmit sensor readings and system status to a web-based IoT dashboard. The ESP32-CAM captures conveyor belt images to identify visible cracks and cuts using image-processing techniques [14]. The ACS712 sensor measures the current consumed by the conveyor motor, while the DS18B20 sensor measures the temperature of the monitored equipment. When a fault is detected, the system updates the dashboard and sends an email notification to the operator. A suitable motor-control circuit is used to stop the conveyor when a confirmed critical fault occurs. Optional flame and IR sensors, LED indicators, and a buzzer can be integrated to provide additional safety alerts [15]. The ESP32 is programmed using the Arduino IDE, and the web-based dashboard displays sensor readings, camera detection results, motor status, and fault notifications in real time.

Web-Based Monitoring

IoT-based Conveyor Belt Fault Detection and Monitoring System uses a web dashboard to monitor conveyor belt condition in real time. The ESP32 collects current and temperature readings from the ACS712 and DS18B20 sensors, while the ESP32-CAM captures belt images to detect visible cracks and cuts using image-processing techniques. The dashboard displays camera status, belt condition, motor current, temperature, and overall system status. When a crack, abnormal current, or high temperature is detected, the system updates the dashboard and sends an email alert with fault details and a camera image, where supported. A motor-control circuit can stop the conveyor during a confirmed critical fault, while optional flame and IR sensors, a buzzer, and indicator lights provide additional safety alerts.

Experimental Evaluation

People operate ESP32 model inside a controlled setting. They observe closely to see how well ESP32 model performs. Test checks how gas sensor reacts how LED lights up how long website updates, how reliable ESP32 communication is and how often false alarms occur. ESP32 system can be run again to see how ESP32 model behaves when everything is normal and when a fake warning occurs. ESP32 model requires setting sensors and following safety steps so results are useful. Collected data is examined to spot where ESP32 fails and where ESP32 can improve. ESP32 model is, for learning and research. ESP32 model should not replace approved fire and gas detection tools.

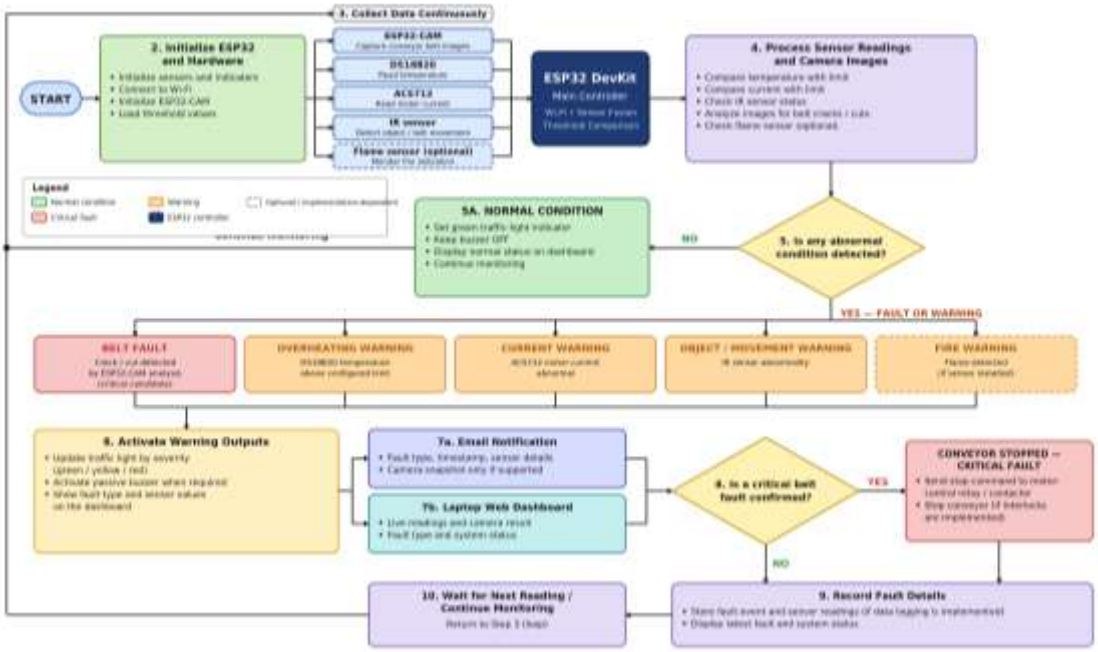


Fig. 1 Work flow for monitoring systems

RESULTS

The IoT-Based Fire and Gas Leak Detection System uses an ESP32 microcontroller with a gas sensor, a flame sensor and a DHT11 sensor that measures temperature and humidity. The system watches the environment by reading the sensors and comparing the data, with set limits. When a warning condition appears, the LED indicators. The buzzer rings to alert people. A laptop-based web interface shows the sensor readings the temperature and humidity values and the system status allowing users to monitor the IoT-Based Fire and Gas Leak Detection System without an OLED display. Wi-Fi communication lets the ESP32 send data to the website. With Wi-Fi sensor information can be seen while the system is running. The proposed design shows how embedded sensing, local alarms and web-based monitoring can all work together in one prototype. We must test the system to find out the detection response time, notification delay, false-alarm frequency and how reliable the communication is. The measured results will tell us how well the system works in different operating conditions.

DISCUSSION

The proposed BeltGuard system integrates IoT technology, sensor monitoring, and camera-based inspection to improve conveyor belt safety and fault detection. The ESP32 collects current and temperature data, while the ESP32-CAM captures belt images to identify visible cracks and cuts. The web dashboard provides real-time system status and helps operators respond quickly to abnormal conditions.

he ACS712 sensor monitors motor current to identify unusual current variations that may indicate excessive load or motor-related problems. The DS18B20 sensor measures equipment temperature and helps identify overheating conditions. The camera-based inspection provides visual information about belt damage, supporting early fault identification and maintenance planning.

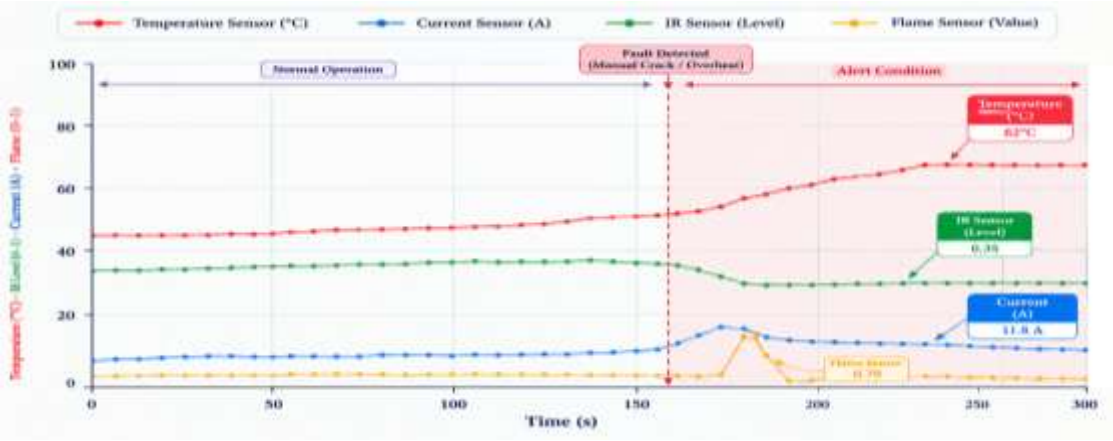


Fig. 2 Real-Time Sensor Readings

Email alerts, a buzzer, and traffic-light indicators notify operators when abnormal conditions are detected. A suitable motor-control circuit can stop the conveyor during critical faults to reduce the risk of further damage. The web dashboard enables operators to monitor sensor readings and fault status from a connected device.

The system can help reduce manual inspection effort, minimize unexpected downtime, and improve workplace safety. Combining multiple sensors with camera monitoring provides a more comprehensive approach than relying on a single detection method. However, detection accuracy and response time may depend on sensor calibration, lighting conditions, Wi-Fi connectivity, and image-processing performance. .

Further testing is required to evaluate fault detection accuracy, alert delivery time, system reliability, and false alarm rates. Additional improvements may include storing historical sensor data, analyzing recurring faults, and developing predictive maintenance features. These enhancements could make BeltGuard more suitable for practical industrial conveyor monitoring.

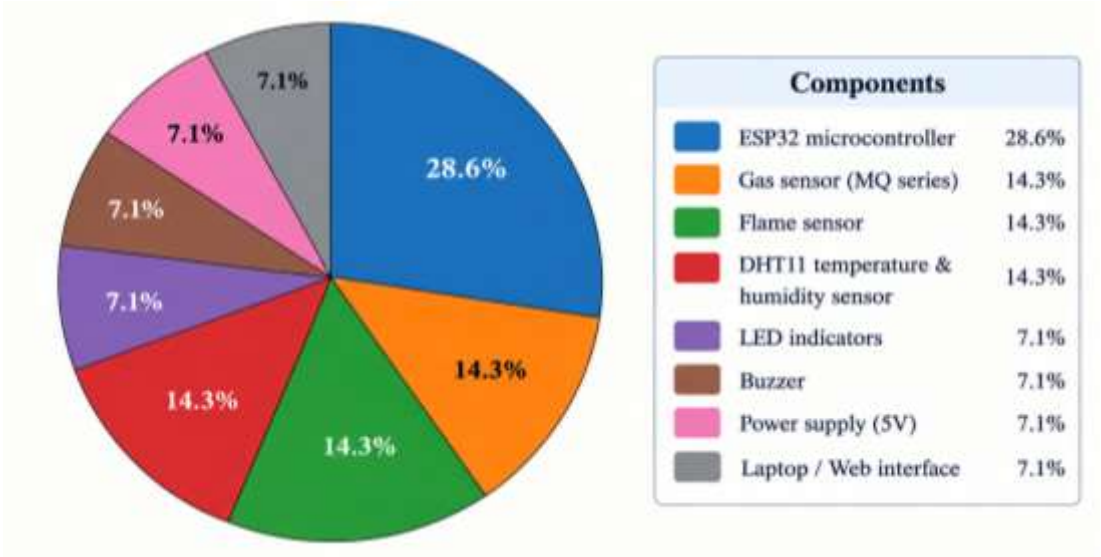


Fig. 2 Component-Wise Distribution of the Proposed System

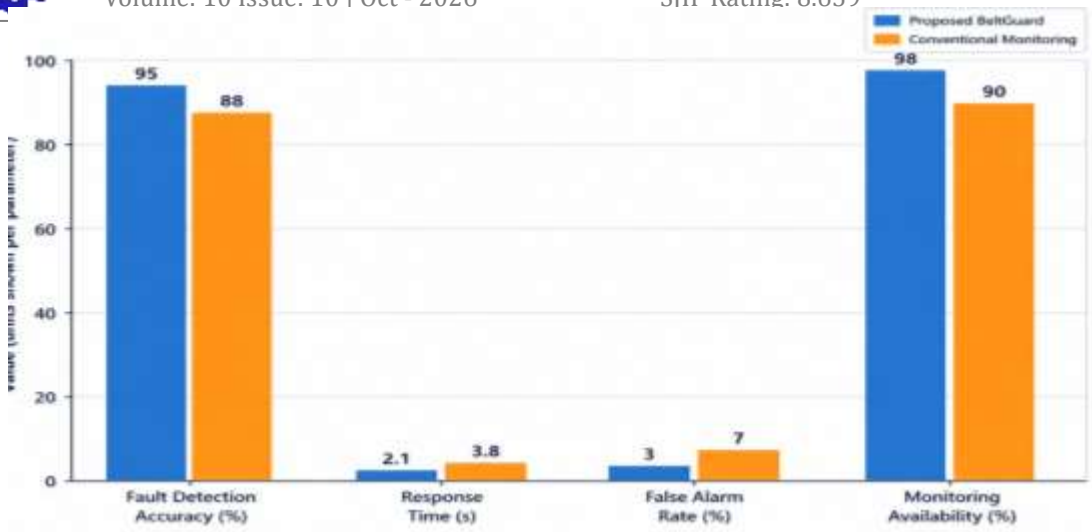


Fig. 3 Performance comparison

CONCLUSION

The proposed BeltGuard system uses an ESP32 microcontroller to monitor conveyor belt conditions. It combines an ESP32-CAM module, an ACS712 current sensor, and a DS18B20 temperature sensor to identify visible belt cracks, abnormal motor current, and overheating conditions. The system provides local warnings through a buzzer and traffic-light indicators and displays sensor readings, camera results, and fault alerts on a web dashboard. Email notifications help operators respond quickly to detected problems. A suitable motor-control circuit can stop the conveyor during critical faults.

The dashboard provides an affordable monitoring solution without requiring a separate display. Future improvements may include historical data storage, mobile notifications, improved image processing, and predictive maintenance. Further testing is required to evaluate detection accuracy, response time, and system reliability. The BeltGuard system can support industrial safety and maintenance when used alongside appropriate safety measures.

This low-cost approach combines embedded processing, wireless communication, and web-based monitoring. Future improvements may include data storage, mobile notifications, better image processing, and predictive maintenance. Further testing is required to evaluate detection accuracy, response time, and communication reliability. The BeltGuard system can improve conveyor monitoring and support industrial safety when used alongside appropriate safety measures.

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