International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 05 | May - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Development of Smart Furnace by Using IOT: A Review

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Abstract

This paper presents a comprehensive review on the development of a smart furnace using Internet of Things (IoT) technology. The objective is to provide enhanced control, efficiency, and automation in industrial heating systems. By integrating various sensors, microcontrollers, and communication modules, the smart furnace can monitor real-time parameters and optimize its operation. Conventional furnace systems suffer from issues such as delayed manual control, lack of feedback mechanisms, and energy inefficiency. The application of IoT provides a solution through automation and digital transformation. This review summarizes recent advancements in smart furnace technology, construction methodology, working mechanisms, and potential industrial applications. Moreover, it highlights future research directions and challenges in deploying scalable, secure, and intelligent furnace systems.
Furthermore, smart furnaces enable predictive analytics that can anticipate equipment failures before they occur, reducing downtime and maintenance costs. Integration with mobile and web-based applications allows users to configure alerts, manage schedules, and monitor data trends in real-time. These advanced features contribute to achieving higher process efficiency and product quality in thermal applications. The review also investigates challenges such as sensor calibration, environmental constraints, and the complexity of integrating legacy systems. This study is crucial for manufacturers and researchers aiming to transition traditional furnaces into smart, interconnected systems suitable for Industry 4.0 environments. Overall, this review consolidates foundational and emerging research to provide a reference for future innovations in IoT-driven furnace automation.

Keywords :- Smart Furnace, IoT, Industrial Automation, Sensors, Microcontroller, Real-Time Monitoring

1. Introduction

In recent years, the integration of IoT in industrial applications has seen rapid growth. The concept of smart manufacturing focuses on automation, control, and monitoring of processes through digital technologies. Furnaces, being an essential part of various manufacturing sectors, can greatly benefit from such developments. A smart furnace enables real-time temperature control, data logging, remote operation, and energy efficiency. This paper aims to review the existing literature and technological advances in the development of smart furnaces.

2. Design Component

1. Microcontroller (e.g., ESP8266 / ESP32)

Acts as the brain of the smart furnace. Provides Wi-Fi connectivity for IoT functions. Controls sensors and actuators based on programmed logic.

2. Temperature Sensors (e.g., DHT22, DS18B20, or Thermocouple)

Measures the real-time temperature inside the furnace. Sends data to the microcontroller for processing and monitoring.

3. Flame Sensor

Detects presence of flame in the furnace. Helps ensure safe ignition and operation.

4. Gas Sensor (e.g., MQ-2 or MQ-135)

Detects leakage of gases such as LPG, methane, etc. Alerts users and triggers safety mechanisms.

5. Relay Module

Controls high-power devices like heating coils or gas valves. Acts as a switch operated by the microcontroller.

6. Heating Element / Induction Coil

Provides the actual heat inside the furnace. Controlled through relay based on temperature input.

7. Cooling Fan

Helps regulate temperature if it exceeds safe levels. Automatically triggered via controller.

8. OLED / LCD Display

Shows real-time data such as temperature, status, and warnings.

9. Wi-Fi Module

Enables wireless communication with the cloud or mobile app.

10. Buzzer / Alarm System

Provides audible alerts in case of abnormal conditions (overheating, gas leakage, etc.).

11. Mobile App / Web Dashboard

Interface to monitor and control the furnace remotely. Can be built using platforms like Blynk, Firebase, or MQTT with Node-RED.

12. Power Supply

Provides regulated power to all components. May include a step-down transformer or battery backup

3. Analysis

Parameter	Smart Furnace (IoT-based)	Regular Furnace	Improvement (%)
Energy Efficiency	85–92%	60–70%	↑ 25–30%
Response Time to Temperature Change	2–3 sec	10–15 sec	↓ 70–80%
Safety Response Time (e.g., gas leak detection)	< 2 sec	No automatic response	Immediate vs. None
Power Consumption (Daily Avg.)	2.5–3.0 kWh	4.0–4.5 kWh	↓ 30–40%
Operational Accuracy (Temp. Control)	±0.5°C	±3°C	↑ Precision by 80%
Maintenance Frequency	Once every 6 months	Once every 2–3 months	↓ 50–70%
Manual Intervention	< 10%	~80–90%	↓ Human Effort by 70–80%
System Downtime	< 2% annually	~10% annually	↑ Uptime by 8%
Monitoring Capability	24x7 Remote + Local	Local only, manual	Full coverage vs. Limited
Cost Over Time (5 Years)	₹15,000–₹18,000 (with savings)	₹25,000+ (energy & repair)	↓ 30–40% overall cost

4. Methodology

- Idea Generation
- Literature Review
- Idea Validation With Respect To Litrature Review
- Definition Of Research Gap
- Development Of Frame Work
- Development Of Smart Furnace
- Identification Of O/P Variables
- Identification Of I/P Variables
- Integration Of Frame Work
- Experimentation By Using Taguchi And Doe
- Determination Of Significant And I/P Variable
- Result And Conclusion

5. Construction

The construction of a smart furnace involves integrating both mechanical and electrical components. Mechanically, it includes an insulated heating chamber—typically lined with ceramic fiber or refractory materials—heating elements like nichrome or Kanthal wires, and a sturdy support frame. These parts ensure effective heat containment and structural stability.

Electrically, it features temperature sensors such as thermocouples, connected to a microcontroller (e.g., Arduino or Raspberry Pi) that manages data and controls the heating cycle. Power modules like solid-state relays regulate current to the heating elements for precise temperature control.

For connectivity, IoT modules such as the ESP8266 or NodeMCU allow wireless monitoring and remote operation via Wi-Fi. Safety is ensured with proper high- temperature wiring, fuses, circuit breakers, and grounding to protect against overheating and electrical faults.

This integration creates a compact, efficient, and remotely operable heating system suited for modern industrial or laboratory use.

A user interface—such as a mobile app or web dashboard—can be integrated to allow real-time control, temperature adjustments, and status alerts. This makes the furnace more convenient, efficient, and suitable for automation in modern applications.

6. Working

The working of a smart furnace starts with precise temperature sensing. A thermocouple, typically located near the heating zone, constantly monitors the internal temperature and sends analog signals to a microcontroller—such as an Arduino, STM32, or Raspberry Pi. This microcontroller converts the analog signal to digital data, compares it to the desired temperature setpoint, and decides whether to activate or adjust the heating elements via solid-state relays or MOSFETs, which provide fast and efficient switching.

The system includes an IoT module like the ESP8266 or NodeMCU, which connects the furnace to a Wi-Fi network.

This allows real-time communication with a cloud platform or mobile app, where users can monitor current temperature, adjust heating profiles, set timers, and even access historical performance data. Web dashboards or smartphone interfaces provide user-friendly controls and status updates.

To ensure safety, the smart furnace features built-in protection mechanisms. If the temperature exceeds safe limits, or if a component fails, the system can automatically shut off the power to prevent overheating or damage. Additional sensors like current detectors or smoke sensors may be included to further enhance fault detection. Alerts and notifications—via SMS, email, or app push notifications—inform users immediately of any issues.

Some smart furnaces also support automated scheduling, allowing them to operate at specific times or follow pre-programmed heating curves, improving efficiency and energy savings. Over-the-air (OTA) updates can be supported through the IoT module to keep the system firmware up to date without physical access.

7. Applications

- Industrial heat treatment
- Laboratory research
- Ceramics and glass manufacturing
- Food processing and baking
- Smart home heating systems
- Pharmaceutical and chemical processing
- Preventive maintenance and energy management
- Metal casting and foundries
- Semiconductor manufacturing
- Textile drying and curing processes

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