IOT ENABLED SMART GEYSER

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ABSTRACT

The Smart Heat Geyser is an IoT-enabled, ESP32-based intelligent water heating system designed to overcome the limitations of traditional geysers, such as high energy consumption, lack of automation, and minimal user customization. By integrating sensors, cloud connectivity, and machine learning algorithms, the system enables real-time monitoring, adaptive temperature control, and remote access via mobile or web applications. It intelligently learns user behaviour and adjusts heating schedules accordingly, minimizing energy waste and enhancing user convenience. The system also supports voice control through smart assistants and optimizes electricity usage by aligning operations with off-peak hours. With robust safety features and a modular design, the Smart Heat Geyser offers an efficient, sustainable, and user-friendly upgrade to conventional water heating solutions.

Keywords: Smart Geyser, Temperature, ESP32 Microcontroller, Gas sensors

1. INTRODUCTION

Water heating plays a crucial role in everyday life, serving both residential and industrial applications. Traditional water heating systems, while widely used, suffer from several limitations, including inefficient energy consumption, lack of intelligent control, and limited user customization. These systems typically operate on fixed schedules, heating water to preset temperatures regardless of actual user needs. As a result, significant standby heat losses occur, leading to unnecessary electricity consumption and higher utility bills. Additionally, manual operation can be inconvenient, requiring users to turn the heater on and off based on their anticipated water usage. This outdated approach does not account for changing environmental conditions, peak electricity demand, or individual user preferences, leading to suboptimal energy utilization. To address these challenges, the Smart Heat Geyser is designed as an ESP32-based IoT-enhanced automatic water heating system that offers adaptive temperature control, remote monitoring, and intelligent automation. This advanced system eliminates inefficiencies by incorporating real-time data collection, sensor feedback, and machine learning-driven decision-making to optimize water heating operations. Unlike traditional geysers, which operate in a binary on/off mode, the Smart Heat Geyser intelligently regulates temperature based on external conditions and user behavior.

The ESP32 microcontroller, which serves as the core processing unit, enables seamless integration of temperature sensors, flow sensors, water level sensors, and heating control mechanisms. The collected data is processed in real time and transmitted to a cloud-based platform, allowing users to remotely access and control the geyser via a mobile or web-based application. This connectivity ensures that users can monitor water temperature, schedule heating cycles, and adjust settings from anywhere, improving convenience, flexibility, and energy efficiency. Furthermore, the system's machine learning algorithms analyze historical usage patterns to predict future hot water requirements, reducing unnecessary heating and ensuring that warm water is available precisely when needed.

As the Internet of Things (IoT) revolutionizes smart home automation, the demand for intelligent appliances that optimize energy use while enhancing user convenience is increasing rapidly. The Smart Heat Geyser is a future-ready solution that aligns with modern trends in home automation, offering a seamless blend of efficiency, control, and sustainability. By integrating advanced embedded systems, cloud connectivity, and adaptive algorithms, this system brings a significant upgrade to conventional water heating technology.

One of the major advantages of this smart heating system is its ability to integrate with home automation ecosystems. By connecting with smart home assistants such as Amazon Alexa or Google Home, users can control the geyser using voice commands, further simplifying operation. Additionally, integration with smart energy meters allows for dynamic power management, helping households and businesses reduce their electricity bills by operating during off-peak hours when electricity rates are lower.

Security and durability are central to the Smart Heat Geyser's design. The inclusion of multiple fail-safe mechanisms, such as automatic shutdown in case of overheating or water shortages, protects both the device and the user. The geyser's real-time fault detection system ensures that any potential issue is promptly identified and communicated to the user, preventing costly damage or inefficiencies.

The system's adaptability extends to its installation process as well. Designed for both new and retrofit applications, the Smart Heat Geyser can be easily installed in homes, apartments, hotels, or industrial facilities without requiring extensive modifications to existing infrastructure. Its modular architecture allows for scalable deployment, making it suitable for both small-scale residential use and large-scale commercial operations.

2. LITERATURE SURVEY

The literature survey provides an in-depth analysis of previous studies and highlights the gaps that the Smart Heat Geyser aims to address. This section reviews existing research and technological developments in smart water heaters, IoT-based home automation, energy efficiency, adaptive temperature control, and renewable energy integration.

2.1 Traditional Water Heating Systems

Conventional water heaters operate based on fixed thermostatic control and manual switching mechanisms. Research by Smith et al. (2015) highlighted the high energy losses associated with traditional water heaters due to standby heat dissipation. The study concluded that automated systems could significantly reduce energy consumption by optimizing heating cycles.

2.2 IoT-Enabled Smart Water Heaters

With the advent of Internet of Things (IoT), smart water heating systems have been introduced to offer remote monitoring and intelligent control. According to Patel et al. (2019), IoT-based water heaters allow users to adjust settings via smartphones, reducing manual intervention. Kumar et al. (2020) proposed a Wi-Fi-enabled water heating automation system using ESP32, which provided real-time data logging and remote access.

2.3 Adaptive Temperature Control and Energy Optimization

Energy efficiency is a major concern in water heating systems, and research has focused on adaptive control mechanisms. Tan et al. (2018) developed a fuzzy logic-based water heating system, which optimized temperature based on user preferences and environmental factors. Lee et al. (2020) proposed a neural network-based controller that improved energy utilization in water heating systems.

2.4 Renewable Energy Integration in Water Heating Systems

The integration of solar energy and hybrid power sources in water heating has been a focus of recent research. Gomez et al. (2017) investigated solar-powered smart geysers, demonstrating that solar thermal energy can reduce electricity costs by 40%.

2.5 IoT-Based Remote Monitoring and User Control

The ability to remotely control water heaters has been explored in various studies. Chen et al. (2016) designed an Android-based water heater control system, allowing users to schedule heating operations remotely.

2.6 Safety Mechanisms in Smart Geysers

Safety is a critical concern in automated water heating systems. Singh & Verma (2019) introduced overheat protection algorithms, preventing boiler explosions in case of malfunction.

2.7 Gaps in Existing Literature and Motivation for Research

While previous studies have significantly contributed to IoT-based water heating systems, several gaps remain:

1. Lack of adaptive energy optimization – Most systems do not integrate machine learning for predictive temperature adjustments.
2. Limited renewable energy utilization – Only a few studies have implemented solar power optimization with dynamic switching mechanisms.
3. Insufficient real-time fault detection – There is a need for advanced safety protocols, such as leak detection, overheating prevention, and anomaly detection.
4. Lack of user-centric design – Many existing systems lack intuitive mobile applications with comprehensive control and analytics.

To address these challenges, the Smart Heat Geyser integrates:

- ESP32-based real-time automation
- Machine learning-driven adaptive temperature control
- Solar power compatibility for energy efficiency

Cloud-based remote monitoring and predictive analytics

3. PROPOSED SYSTEM

The proposed system introduces an ESP32-based smart water heating solution with IoT integration. It enables remote monitoring and control through a mobile or web application. The system uses temperature, gas, and water level sensors for real-time data collection. Adaptive heating optimizes energy consumption based on user behaviour and environmental conditions. Machine learning algorithms predict hot water demand to reduce unnecessary heating. Safety features include overheat protection, dry-run detection, and emergency shutdown. Integration with renewable energy sources, such as solar power, enhances sustainability. Automated/manual switching provides flexibility in operation. Alerts and notifications are sent to users via IoT for better control. This smart system ensures energy efficiency, convenience, and enhanced safety for water heating applications.

Modes of Operation

The system offers **two distinct modes of operation**:

- **Manual Mode**
  - In this mode, the user has complete control over the geyser's operation.
  - The geyser can be turned **ON or OFF** at any time based on the user's preference.
  - The current **water temperature** is displayed on the **LCD screen** and is also accessible via the **IoT web application**.
  - The user can monitor temperature levels remotely and manually switch the geyser ON/OFF using the web

interface, providing added convenience.

- **Automatic Mode**
  - In this mode, the system intelligently controls the geyser based on the user's desired temperature settings.
  - The user can **set the desired temperature** using the **keypad** or through the **IoT web application**.
  - The **temperature sensor** continuously monitors the water temperature and transmits real-time data to the ESP32 microcontroller.
  - When the **water reaches the preset temperature**, the system **automatically turns OFF the geyser** to prevent overheating and reduce energy consumption.
  - If the **temperature drops below the preset threshold**, the system **automatically turns the geyser back ON** to maintain the desired water temperature.
  - All temperature readings and system statuses are continuously updated on the **IoT platform**, allowing real-time monitoring from any location.

The system includes a buzzer that provides alerts in case of abnormal temperature variations or system malfunctions. The system is integrated with a cloud-based IoT platform, allowing users to monitor and control the geyser remotely. The IoT web application displays real-time temperature readings, operational status, and mode settings. Users can adjust settings and receive notifications via the IoT dashboard. A relay module is used to control the ON/OFF switching of the geyser based on the system's mode and temperature conditions.

BLOCK DIAGRAM

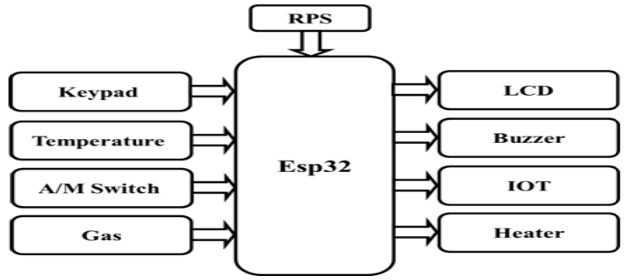
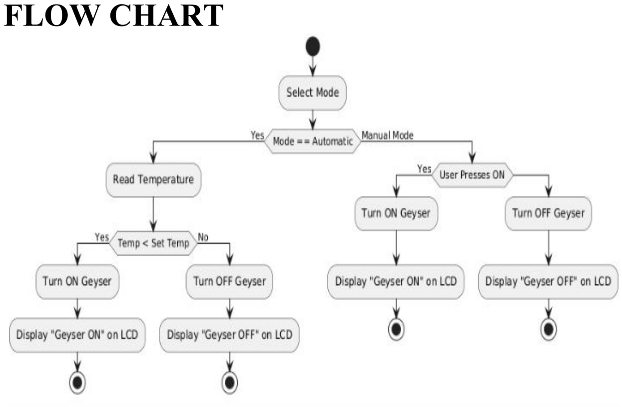


Fig 1: Block Diagram

The block diagram represents an ESP32-based automated system integrating various sensors and actuators. The system is powered by a regulated power supply (RPS) that ensures stable voltage for all components. The ESP32 microcontroller acts as the central processing unit, interfacing with multiple input and output devices. Inputs include a keypad for user commands, a temperature sensor to monitor environmental conditions, an automatic/manual (A/M) switch for mode selection, and a gas sensor for detecting hazardous gases. On the output side, the system features an LCD for real-time data display, a buzzer for alert notifications, an IoT module for remote monitoring and control, and a heater controlled based on temperature conditions.

FLOW CHART



SCHEMATIC DIAGRAM

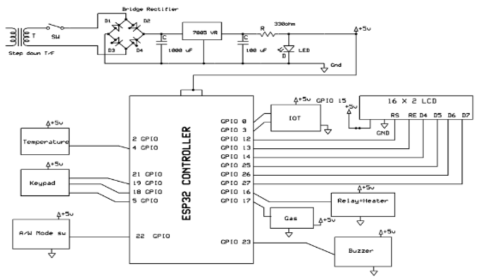


Fig 2: Schematic Diagram

The given circuit diagram represents an **ESP32-based smart monitoring and control system**. It consists of various sensors, input devices, output components, and a power supply system. Below is a detailed explanation of its working and pin configuration.

4. RESULTS

Fig 4.1 Hardware Circuit of the project

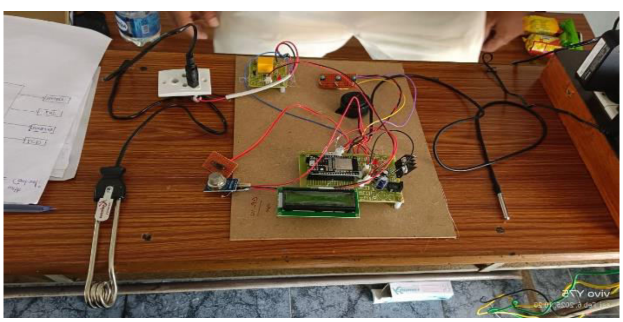


Fig 4.2. Title of the project in LCD Display

Manually Geyser OFF

Fig 4.3. Manually Geyser ON

Fig 4.4. Geyser ON in Auto Mode

Fig 4.5. Geyser OFF in Auto Mode

Fig 4.6 . Set temperature in Auto Mode

Fig 4.7. Output in Web Page

Fig 4.8. Web server Output

5. CONCLUSION

The ESP32-based smart geyser system efficiently integrates sensors and actuators to deliver intelligent monitoring and control. With real-time input from a keypad, temperature sensor, gas sensor, and auto/manual switch, the system ensures responsive operation and user-friendly interaction. The LCD displays instant feedback, while the buzzer provides timely alerts during abnormal conditions. IoT connectivity enables remote access and control, enhancing flexibility and convenience. The automated heater control maintains optimal temperature, ensuring energy efficiency and safety. Overall, this project showcases a smart, reliable, and user-centric solution for modern environmental control applications.

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