**About the Smart Hybrid Incubator Project**

The Smart Hybrid Incubator System represents a convergence of my passion for agricultural technology and my commitment to solving real-world problems through innovative engineering solutions. This comprehensive IoT-enabled device is designed to intelligently simulate and maintain optimal environmental conditions essential for successful egg incubation, specifically targeting the challenges faced by poultry farmers in regions with unreliable power infrastructure.

At its core, this system addresses a critical gap in modern agriculture: the need for reliable, technologically advanced incubation solutions that don't depend entirely on consistent electricity supply. Traditional incubators often fail in rural or developing areas where power outages are frequent, leading to significant economic losses for farmers who depend on poultry farming for their livelihood. The goal was to create a robust, intelligent system that could operate seamlessly in both connected and disconnected environments as it make use of solar power and AC Suppy while providing the precision and monitoring capabilities of modern IoT technology.The inspiration behind designing this system also include the introduction of the humidifier. This is a feature non of the Incubator available Incubator in the market has while it’s a very important parameter that is needed for efficient hatchbility of the eggs.Lastly, the ability to monitor and control the Incubator enviromental parameter.

The system's architecture is built around three fundamental environmental parameters that are crucial for successful egg incubation: temperature regulation, humidity control, and automated egg turning. Each of these components works in harmony, guided by real-time sensor feedback and intelligent control algorithms, to create an optimal artificial environment for egg embryo development.

**Temperature Management System:**

The heating mechanism employs a hybrid approach using both AC and DC power sources. A 60W AC bulb serves as the primary heating element, maintaining a baseline temperature of 36°C, which is scientifically determined as the optimal temperature for most poultry embryo development. DHT11 is used for temperature measurement in the Incubator. When additional heating is required—such as during colder periods or to reach the upper threshold of 38°C—two 12V DC bulbs activate automatically. This dual heating system not only provides redundancy but also ensures energy efficiency by using the most appropriate power source based on availability and demand. The dynamic control system continuously monitors internal temperature through precision sensors and adjusts the heating elements according to value set from the mobile app, maintaining stable conditions within ±0.5°C tolerance.

**Humidity Regulation:**

Proper humidity levels are equally critical for successful hatching, affecting membrane development and preventing eggs from losing too much moisture. The DHT11 is also used to measure the Humidity of the Incubator system.The system incorporates an automated humidifier that activates when internal humidity drops below the required threshold. This component works in conjunction with the temperature control system, as humidity and temperature are interrelated factors that must be balanced for optimal results. The humidifier operates based on real-time sensor data, ensuring that moisture levels remain within the ideal range set from the mobile app during the initial incubation period and 10% more during the final hatching phase.

**Automated Egg Turning Mechanism:**

To replicate the natural behavior of brooding hens, the system features a motorized egg turning mechanism that periodically rotates the eggs. This automated process prevents embryos from adhering to the shell walls and promotes healthy development. The frequency and timing of egg turning can be customized based on the specific requirements of different bird species,using the mobile app.

**Dual-Mode Operation:**

One of the most innovative aspects of this project is its ability to operate in two distinct modes: IoT mode and offline mode. During startup, the system attempts to connect to a pre-configured WiFi network. If successful, it enters IoT mode, enabling comprehensive remote monitoring and control capabilities through a dedicated mobile application. However, if internet connectivity is unavailable or unstable, the system seamlessly transitions to offline mode, continuing operation with preset or manually configured parameters. This dual-mode functionality ensures that incubation processes are never interrupted due to connectivity issues, making it particularly valuable for rural applications.

**Real-Time Monitoring and Data Logging:**

Throughout operation, the system continuously monitors all critical parameters through high-precision sensors which is DHT11. This data is displayed locally on an integrated LCD screen, providing immediate visibility for on-site operators. Simultaneously, all operational data is logged internally for later analysis, troubleshooting, and optimization. This comprehensive data collection capability not only ensures consistent environmental conditions but also provides valuable insights for improving future incubation cycles and identifying potential system optimizations.

A mobile app is develop to monitor and control the incubator parameters. The App displays in real time the temperature,humidity,number of turns per day and the number of days of incubation. The App also contain the part to set the temperature minimum and maximum,humidity minimum and maximum, number of turning of the eggs per day and control of the LED for Candling. The also include a very unique feature of selecting the type eggs in the incubator which helps the incubator on the last 3/4days of incubation. The turning mechanism stops turning and the humidity minimum increase with 10% on these days to soften the shell of the egg and avoid vibration of the eggs.

**How the System is built**

Plywood is choose to make the body of the incubator to reduce the amount of conduction of heat into or out of the incubator. Aluminium foil is used to rap the internal wall of the Incubator so as to make the system conduct and retain the heat inside it.Two 12DC Bulbs are used to generate heat in the system with an AC Bulb when there is electricity. A 5v DC humidifier is used to provide moisture in the incubator. A 12DC Fan is used to distribute the heat evenly in the Incubator then prevent a static air providing a continuous flow of air in and out of the Incubator. 5v servo motor is attached to the egg crate in the Incubator to turn the crate and the eggs.DHT11 is use to measure the temperature and humidity of the Incubator system.

ESP32 is used as the micro-controller of the system which enable 2 core operation the seamless operation of the real time monitoring and logging of the data to the cloud at the same time measuring the Incubator data and activation with the local display of the Information.It is connected to relays for controlling the turning system and the bulbs.It also operates the humidifier through the use of a transistor. The entire system runs on a 12v 7.2Ah Battery which is contiously charged with a 30w solar panel during the day.

**Challenges**

Different type of AC bulb is used to generate heat in the Incubator before getting the 60w to give a 36°C maintaining temperature in the Incubator. Others either generate more than 36degree or less.

Overheating and damaging of the ESP32 untill holes are make around the case for ventilation till it stop damaging.

The development of this system required extensive research into poultry embryology, environmental control systems, embedded programming, IoT connectivity protocols, and user interface design. Each component was carefully selected and integrated to create a cohesive, reliable solution that could withstand the rigors of continuous operation while maintaining the precision required for successful hatching.

**Sponser/Special Prize**

This Project is Sponsored by the Dean of Engineering Federal University of Technology Minna and it won the second best project at the national level of Committee of Dean of Engineering and Technology (CODET) a sub-body of COREN.