THE SMART DUAL MOTION EXHAUST SYSTEM FOR ADAPTIVE HEAT REMOVAL AND GAS ALERTING

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Introduction:

The smart dual motion exhaust system for adaptive heat removal and gas alerting is an innovative approach to modern air circulation and cooling systems. Unlike conventional ventilation fans that deliver fixed or limited directional airflow, this system integrates dual motion capability enabling both rotary and orientational movement to precisely direct airflow based on environmental conditions. Designed for both domestic and industrial applications, the system's primary objective is to improve thermal comfort and air quality through intelligent, adaptive operation.

This smart ventilation mechanism employs two fans the front fan, which performs tilting and linear motions to direct air toward high temperature zones, and the rear fan, which remains static to maintain balanced air extraction. The dynamic movement of the front fan allows targeted cooling by directing airflow precisely to hotspots, ensuring uniform temperature distribution within the space. Integrated temperature, humidity, and gas sensors continuously monitor environmental conditions and enable automatic adjustment of fan speed and direction to optimize performance.
The system integrated with IoT (Internet of Things) functionality through the ESP32 microcontroller, enabling real time monitoring and alerting via mobile devices. In the event of gas leakage, the MQ 6 gas sensor detects harmful concentrations and triggers the fans to operate at maximum capacity for rapid removal, simultaneously sending an alert notification to the user. Once safe conditions are restored, a "safe environment" message is transmitted through the IoT interface. This combination of mechanical motion, sensor intelligence, and IoT integration provides a comprehensive safety and comfort solution, suitable for modern smart homes and industrial safety systems.

This project delivers a smart, adaptive, and energy efficient dual ventilation system that adjusts autonomously to environmental changes. By combining thermal and gas sensing with precise mechanical motion, the system achieves superior airflow distribution, reduces energy consumption, and enhances overall user comfort and safety.

Figure 1: Front view of the working model

Objectives:

1. Design and build a dual motion ventilation fan that can move in linear motion, tilt, and rotate to deliver targeted and effective airflow exactly where it's needed.
2. Integration of temperature sensor for detecting temperature and the gas sensor for detecting gas, so the system can continuously monitor the environment.
3. Develop a working prototype that can adjust airflow in real time based on environmental conditions and automatically activate when gas leakage is detected.

Methodology:

The development of the Smart Dual Motion Exhaust System for Adaptive Heat Removal and Gas Alerting followed a systematic and structured methodology to ensure accurate design, efficient performance, and reliable safety operation. The overall methodology includes design, fabrication, sensor integration, programming, testing, and performance evaluation.

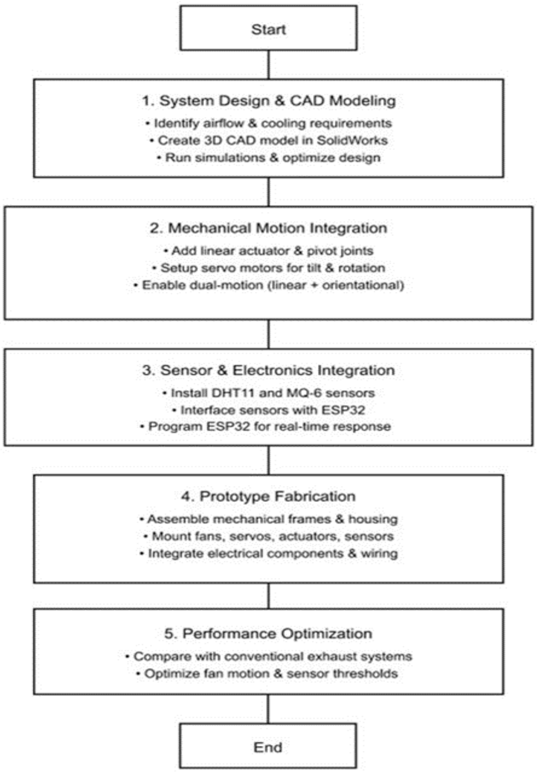

Fig 2: Working flowchart

The Fig 1 illustrates the complete workflow of the Smart Dual Motion Exhaust System, starting from system design and CAD modelling, followed by mechanical motion integration, sensor and electronics setup, prototype fabrication, and finally performance optimization. The flowchart provides a clear step by step representation of how the system is developed, assembled, and refined to achieve intelligent ventilation and gas alert functionality.

The project began with designing the dual motion exhaust fan based on airflow, cooling, and energy efficiency requirements. A 3D model was created in SolidWorks, and design parameters were optimized to reduce power consumption while maintaining uniform temperature control in different indoor environments. Fig 2 shows the Isometric view of the CAD model, highlighting the overall structure and component arrangement of the proposed system.

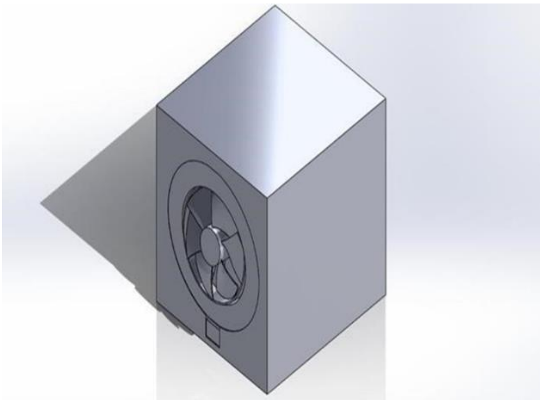

Fig 3: Isometric view of CAD model

Next, linear and rotary motion mechanisms were incorporated. Sliding rails, and servo driven joints were added to enable tilting, rotation, and forward backward movement. This dual motion setup allows the fan to automatically adjust its direction and target specific heat zones in rooms of various sizes.

Smart sensing capabilities were then integrated. The DHT11 temperature sensor and MQ6 gas sensor were connected to the ESP32 microcontroller to provide real time monitoring and automatic fan adjustment.

A prototype was fabricated using materials like steel and acrylic. It included two fan units, one capable of tilting and rotary motion and one for continuous exhaust along with multiple servo motors and sensors for dynamic airflow control.

The system underwent testing to evaluate temperature responsiveness, and gas detection accuracy. Experiments confirmed that the fan could detect heat changes, reposition itself automatically, and respond to LPG leakage by activating exhaust and sending IoT alerts.

Results showed improved cooling coverage, faster response to temperature changes, lower power usage, and better overall thermal management due to the automated dual motion design

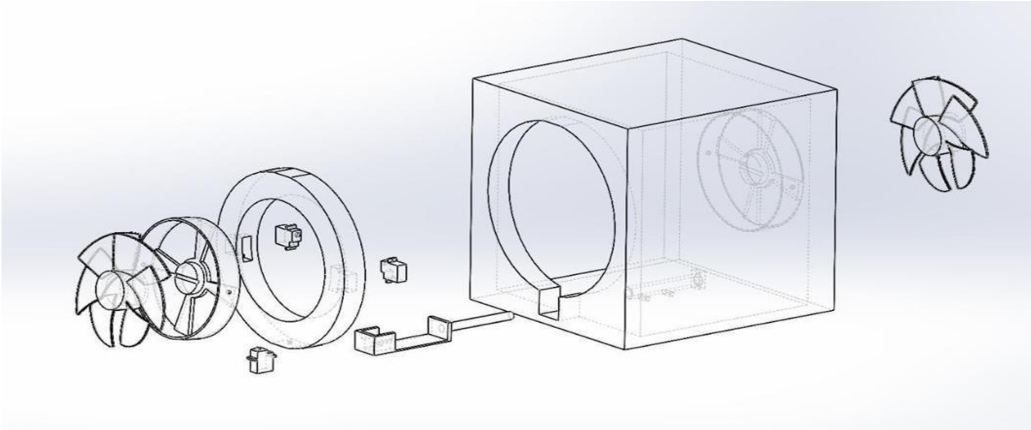

Fig 4: Exploded view of CAD model

Fig 3 illustrates the exploded view of the model, clearly showing the individual components and their assembly arrangement, with each part displayed in its respective position for better understanding of the overall structure.

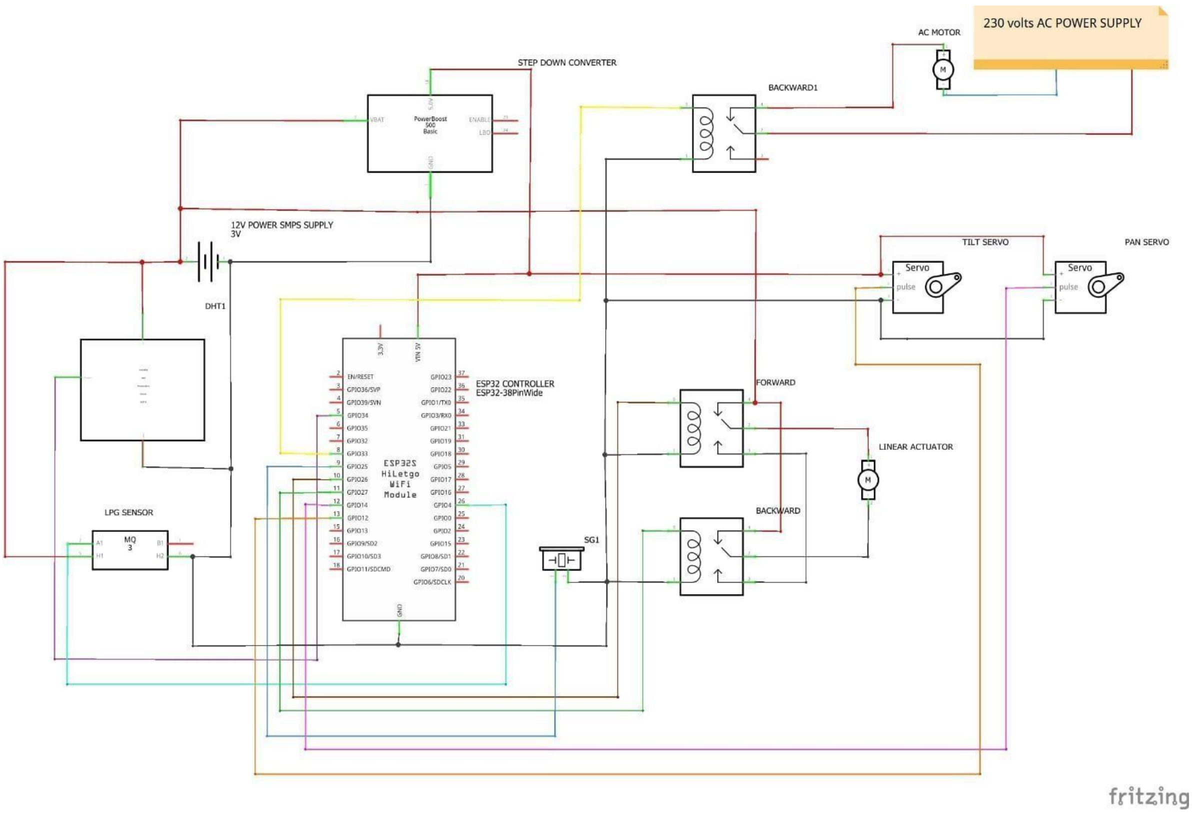

Fig 5: circuit diagram

The fig 5 shows complete electrical circuit diagram layout of a The Smart Dual Motion Exhaust System for Adaptive Heat Removal and Gas Alerting controlled by an ESP32 microcontroller. A 12V SMPS power supply and a step-down converter provide the required voltages for all components. The ESP32 receives data from sensors such as a DHT11 temperature sensor and an MQ-6 LPG gas sensor. Based on sensor readings, the controller drives multiple actuators:

- AC exhaust fan motor
- Linear actuator
- Pan and tilt servo motors
- Relay modules for forward and backward motion control of actuator

The relays manage direction control for both the linear actuator and fan mechanism, while the servos handle dual axis movement. Overall, the circuit integrates power management, sensing, control, and actuation to enable automated ventilation and gas alert functionality.

The model has dimensions of 50 cm in length, 50 cm in breadth, and 50 cm in height. It features a box shaped structure that houses all the essential components, including the fan, linear piston actuator, and servo motors for motion control. The linear piston integrated into the system is capable of moving forward by 10 cm, enabling the required linear motion for the exhaust mechanism.

Result and Conclusion:

The smart dual motion exhaust system for adaptive heat removal and gas alerting was successfully designed, developed, and tested to overcome the limitations of traditional ventilation systems. The main aim of this project was to create a smart and adaptive fan capable of distributing air evenly while ensuring environmental safety through automated sensing and control. By combining mechanical motion, sensor technology, and IoT connectivity, the system delivers intelligent ventilation that adjusts dynamically to temperature variations and gas levels in its surroundings. The working prototype proved that incorporating both rotary and linear movement significantly enhances airflow efficiency compared to static fans. The ESP32 microcontroller served as the brain of the system, processing real time data from the DHT11 temperature and humidity sensor and the MQ 6 gas sensor. Based on these readings, the fan automatically adjusted its speed and direction. With servo motors enabling tilting, rotation, and horizontal movement, the fan could effectively direct airflow toward warmer zones, creating more uniform cooling throughout the area. The integration of IoT technology added another layer of functionality and convenience. During gas leakage conditions, the MQ 6 sensor detected the presence of harmful gases, prompting the fan to activate automatically for rapid ventilation. At the same time, a notification alert was sent to the user through the IoT platform. Once safe conditions were restored, the system sent a “Safe Environment” message, reinforcing reliability and user confidence. These automated, real time responses showcased how the system enhances safety while maintaining energy efficient operation.

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Future Scope:

1. This system can be further enhanced to become even smarter and more precise. By using advanced, high accuracy sensors and more powerful microcontrollers, developments of the proposed system may incorporate high precision sensing technologies utilizing advanced thermal imaging and multi gas detection modules to improve hotspot localization accuracy. Integration of high-performance microcontrollers or edge computing platforms such as STM32 or NVIDIA Jetson is expected to enhance processing capability, enabling real time environmental inference and dynamic actuation.

2. Artificial Intelligence and Machine Learning techniques can be implemented to predict thermal variations and gas accumulation patterns. Including ultrasonic scanning and LiDAR, may be integrated to facilitate point-based zone identification for precise actuator targeting.

3. Incorporation with advanced safety management systems including fire detection, emergency ventilation protocols, and automatic power isolation mechanisms can further improve operational reliability. Energy sustainability may be enhanced by adaptive power management.

4. Future versions may also support seamless user interaction via voice, enabling compatibility with smart home assistants. These enhancements will allow the system to evolve from a reactive mechanism to an autonomous, self-optimizing ventilation solution suitable for precision cooling, and industrial automation