Fabrication Of Detection of Over Load And Battery Smoke Identification in Four-Wheeler E-Vehicle

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***Abstract*—This paper presents a smart safety monitoring system for electric four-wheelers, focused on detecting overload conditions and identifying smoke emissions from the battery compartment. By integrating a load sensor, temperature sensor, smoke detector, Arduino controller, and relay switch, the system actively prevents hazardous conditions by triggering early warnings and initiating automatic safety responses. The system uses a buzzer and LCD display for user feedback and employs a DC motor to simulate vehicle operation. The goal of this project is to increase passenger safety, prevent component failure, and reduce fire hazards in electric vehicles.**

1. INTRODUCTION

Electric vehicles (EVs) are emerging as the future of sustainable transportation due to their low emissions and energy efficiency. However, the growing reliance on battery-powered systems has introduced new safety challenges, particularly related to thermal management and load handling.

Overloading a vehicle or overheating the battery pack can lead to severe consequences, including equipment failure, fire hazards, and reduced battery life. As EV adoption expands, so does the need for smarter, real-time safety mechanisms that can mitigate these risks effectively.

The proposed system addresses these issues by integrating sensors that continuously monitor critical parameters such as weight, temperature, and air quality within the battery compartmentThe combination of these technologies ensures a comprehensive, responsive safety net for EVs. Furthermore, the modular and cost-effective nature of this system makes it scalable and adaptable across different types of electric vehicles, from personal cars to commercial fleets.

By implementing this smart detection system, the safety and reliability of electric four-wheelers can be significantly improved, reducing the risk of battery-related accidents. This project aims to enhance cargo and the fright safety while ensuring optimal performance and durability of the vehicle's electrical components.

2. OBJECTIVES

The objectives of this study is,

- To detect overload conditions using a load sensor.
- To identify smoke or harmful gas emissions using a smoke sensor.
- To monitor temperature, rise within the battery compartment.
- To provide real-time alerts through buzzer and display.
- To control the vehicle operation via Arduino-based automation.

3. METHODOLOGY

The development of the smart load and smoke detection system followed a systematic engineering approach. Initially, a thorough analysis was conducted on the types of risks faced by electric vehicles, particularly those resulting from overload and thermal anomalies. Based on this study, critical sensing components were selected to address these concerns.

The load sensor was placed strategically to measure the overall load acting on the chassis or seating area. The smoke detector was mounted in proximity to the battery compartment to detect any early signs of thermal runaway or gas emissions. A temperature sensor was embedded to monitor the battery's surface temperature. All sensors were connected to an

Arduino microcontroller, which acted as the processing unit.

The Arduino was programmed to compare real-time sensor readings against safety thresholds defined during system calibration. If any threshold was breached, the Arduino triggered a buzzer for an audible alert and activated a relay to disconnect the motor, thus halting the vehicle operation. The system's output was also displayed on an LCD for real-time visual feedback. The entire setup was tested under various simulated conditions to validate its responsiveness and reliability.

4. SYSTEM COMPONENTS

4.1 **Load Sensor (Strain Gauge or Load Cell):**

A load cell is a sensor that measures force or weight by converting it into an electrical signal. It primarily uses strain gauges, which are sensitive to changes in resistance when deformed by a force. This change in resistance is then converted into a measurable output, typically a voltage, that corresponds to the applied force.Strain gauges are thin, electrically conductive wires or foils attached to the load cell's body. When a force is applied, the load cell deforms, and the strain gauges stretch or compress along their length. This deformation changes the electrical resistance of the strain gauges

Fig 4.1: Load Sensor (Strain Gauge or Load Cell)

4.2 **Smoke Sensor (MQ2)**

Smoke sensors, also known as smoke alarms or smoke detectors, are devices that detect the presence of smoke and trigger an alarm to alert occupants of a potential fire. They are crucial for fire safety, and it's essential to ensure they are working properly.

Fig 4.2: Smoke Sensor (MQ2)

4.3 **Temperature Sensor**

Temperature sensors work by providing readings via electrical signals. Sensors are composed of two metals that generate an electrical voltage or resistance when a temperature change occurs by measuring the voltage across the diode terminals. When the voltage increases, the temperature also increases.Temperature sensors work by converting changes in temperature into measurable electrical signals, like voltage or resistance. This is achieved through various mechanisms, including the change in electrical resistance of a material (RTDs), the generation of voltage by junctions of different metals (thermocouples), or the variation in resistance of a semiconductor material with temperature (thermistors).

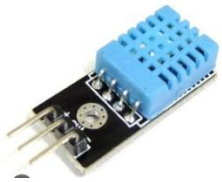

Fig 4.3: Temperature Sensor

4.4 **Arduino Microcontroller**

The Adriano board acts as the MCU in the load cell system. It receives input from the load cells, processes the data, and controls the operation of other components, such as the ignition panel and indication lights, based on predefined algorithms

Fig 4.4: Arduino Microcontroller

4.5 Relay

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches. Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuit.The coil of a relay passes a relatively large

current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages.

Fig 4.5: Relay

4.6 **DC Motor**

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The speed of a DC motor can be controlled by changing the voltage applied to the armature.In any electric motor, operation is based on simple electromagnetism. A current-carrying conductor generates a magnetic field; when this is then placed in an external magnetic field, it will experience a force proportional to the current in the conductor, and to the strength of the external magnetic field.

Fig 4.6: Battery

4.7 Buzzer

A buzzer is an electrical device that produces an audible sound, typically a buzzing or beeping sound. It operates by creating vibrations in a diaphragm, usually through electromagnetic or piezoelectric principles.

Fig 4.7: Buzzer

4.8 LCD Display

A liquid-crystal display (LCD) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals combined with polariser to display information. Liquid crystals do not emit light directly but instead use a backlight or reflector to produce images in color or monochrome.

Fig 4.8: LCD display

4.9 BATTERY

A battery is a device that converts chemical energy directly to electrical energy. It consists of a number of voltaic cells; each voltaic cell consists of two half cells connected in series by a conductive electrolyte containing anions and captions. One half cell includes electrolyte and the electrode to which anions migrate, i.e., the anode or negative electrode; the other half-cell includes electrolyte and the electrode to which captions migrate, i.e., the cathode or positive electrode A separator between half cells allows ions to flow, but prevents mixing of the electrolytes. Each half cell has an electromotive force determined by its ability to drive electric current from the interior to the exterior of the cell. The net EMF of the cell is the difference between the EMF of its half-cells, as first recognized by Volta. Therefore, if the electrodes have EMF and, then the net EMF is in other words, the net EMF is the difference between the reduction potentials of the half-reactions.

Fig 4.9: Battery

5. WORKING PRINCIPLE

The smart load and smoke detection system operates based on the continuous monitoring of three primary environmental variables—load, temperature, and gas emissions. Each of these parameters is sensed by dedicated components and interpreted by an Arduino-based control unit.

Detailed Working Principle

1. Load Detection: The load cell installed beneath the seating or on the axle measures the applied force or weight. This sensor operates by registering changes in resistance as strain is applied. When weight crosses a defined safe limit, the Arduino receives this data and triggers

an immediate alert while disconnecting the vehicle's motor via a relay module.

2. Temperature Monitoring: A temperature sensor installed near or on the battery surface constantly measures thermal variations. If the detected temperature exceeds the critical safety threshold (e.g., 37°C), the Arduino activates the buzzer, displays a warning, and halts motor operation to prevent further heat accumulation.
3. Data Transmission: All sensor readings—load, temperature, and smoke—are continuously collected by the Arduino via analog and digital pins. These inputs are processed in real-time using conditional logic within the Arduino's code. When any parameter exceeds its safe threshold, it is flagged as a hazard. While the data is processed internally, it can also be extended to transmit wirelessly via modules like ESP8266 for cloud or mobile notifications.
4. Ignition Control: Once a hazard is identified, the Arduino triggers a relay module that immediately disconnects the power supply to the DC motor, simulating ignition cutoff. This rapid action stops the vehicle from operating. Simultaneously, a buzzer and LCD display notify the user of the detected issue, ensuring swift and effective safety response.Upon detecting any safety violation, the Arduino executes a digital output command that energizes a relay control pin. The relay acts as an electromechanical switch that breaks the circuit between the vehicle's power supply and the motor.

1. IoT Alerts: When connected with IoT (Blynk), the system can send notifications to mobile devices upon alcohol detection or helmet absence.
2. User Feedback: Status updates are displayed via an LCD screen for user interaction.

5. CIRCUIT CHART

Circuit Diagram includes connections between Arduino, sensors, buzzer, LCD, relay, and motor.

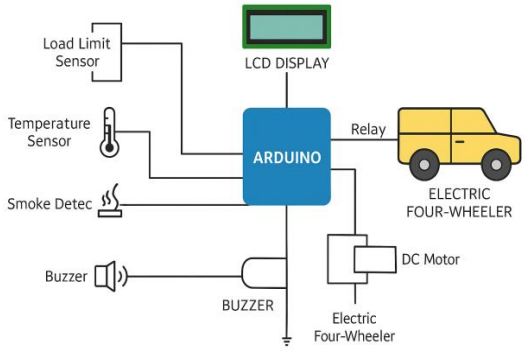

Fig 5.1: Circuit diagram

6. FRAME WORKS

This frame has been designed for the two-wheeler vehicle prototype model for the experimental use to execute the result for this project.

6.1 MATERIALS USED

6.1.1 METAL FRAME

The metal frame is generally made of mild steel bars for machining, suitable for lightly stressed components including studs, bolts, gears and shafts. It can be case-hardened to improve wear resistance

Fig 6.1: Metal frame

6.1.2 SHEET METAL

Sheet metal is metal formed by an industrial process into thin, flat pieces. It is one of the fundamental forms used in metalworking and it can be cut and bent into a variety of shapes. Countless everyday objects are fabricated from sheet metal. Thicknesses can vary significantly; extremely thin thicknesses are considered foil or leaf, and pieces thicker than 6 mm (0.25 in) are considered plate

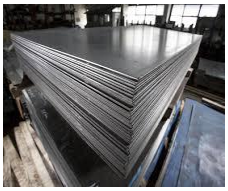

Fig 6.2 sheet metal

6.1.3 METAL STRIP

Metal strip can be designed and manipulated through a large number of processes which are grouped into

categories. They are joining and assembly processes, deformation processes, material removal processes, heat treating processes, and finishing processes.

Fig 6.3 Metal strip

6.1.4 WHEEL

The wheel a simple machine functions by facilitating motion through rolling reducing friction and effort needed to move an object. When a wheel is attached to an axle, it acts as a type of lever, allowing a force applied at the wheel's perimeter to be amplified and transferred to the axle, which then moves the load. wheel reduces friction by facilitating motion by rolling together with the use of axles. In order for wheels to rotate, a moment needs to be applied to the wheel about its axis, either by way of gravity or by the application of another external force or torque**.**

Fig 6.4: Steel wheel

7.2. PROCEDURE

7.2.1 MANUFACTURING PROCESS

Manufacturing processes are the steps through which raw materials are transformed into a final product. The manufacturing process begins with the creation of the materials from which the design is made. These materials are then modified through manufacturing processes to become the required part. Manufacturing processes can include treating (such as heat treating or coating), machining, or reshaping the material. The manufacturing process also includes tests and checks for quality assurance during or after the manufacturing, and planning the production process prior to manufacturing.

7.2.2. SAWING

Cold saws are saws that make use of a circular saw blade to cut through various types of metal, including sheet metal. The name of the saw has to do with the action that takes place during the cutting process, which manages to keep both the metal and the blade from becoming too hot. A cold saw is powered with electricity and is usually a stationary type of saw machine rather than a portable type of saw. The circular saw blades used with a cold saw are often constructed of high speed steel. Steel blades of these types are of resistant to wear even under daily usage. The end result is that it is possible to complete a number of cutting projects before there is a need to replace the blade. High speed steel blades are especially useful when the saws are used for cutting through thicker sections of metal.

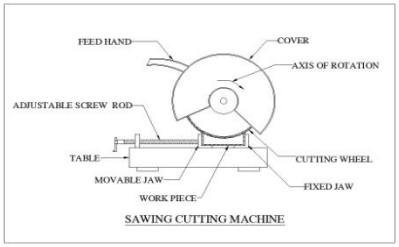

Fig 7.4: Sawing

7.2.3. WELDING

Welding is a process for joining similar metals. Welding joins metals by melting and fusing **1,** the base metals being joined and **2,** the filler metal applied. Welding employs pinpointed, localized heat input. Most welding involves ferrous-based metals such as steel and stain

less steel. Weld joints are usually stronger than or as strong as the base metals being joined.Welding is used for making permanent joints. It is used in the manufacture of automobile bodies, aircraft frames, railway wagons, machine frames, structural works, tanks, furniture, boilers, general repair work and ship building.

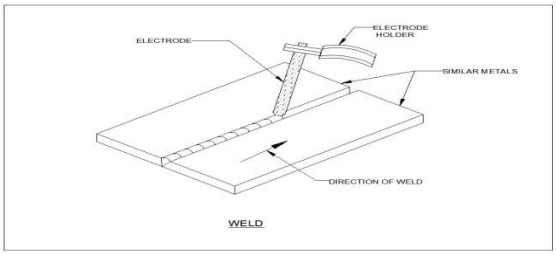

Fig 7.5: Welding

7.2.4. OPERATION

Several welding processes are based on heating with an electric arc, only a few are considered here, starting with the oldest, simple arc welding, also

known as shielded metal arc welding (SMAW) or stick welding. In this process an electrical machine (which may be DC or AC, but nowadays is usually AC) supplies current to an electrode holder which carries an electrode which is normally coated with a mixture of chemicals or flux. An earth cable connects the work piece to the welding machine to provide a return path for the current. The weld is initiated by tapping ('striking') the tip of the electrode against the work piece which initiates an electric arc. The high temperature generated (about 6000ºC) almost instantly produces a molten pool and the end of the electrode continuously melts into this pool and forms the joint.The operator needs to control the gap between the electrode tip and the work piece while moving the electrode along the joint.

7.2.5. DRILLNG

Drilling is a cutting process that uses a drill bit to cut or enlarge a hole of circular cross-section in solid materials. The drill bit is a rotary cutting tool, often multipoint. The bit is pressed against the work piece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the work piece, cutting off chips (sward) from the hole as it is drilled.

8. ADVANTAGES AND APPLICATIONS

8.1 ADVANTAGES

- Enhances safety by detecting overload and potential fire risk.
- Continuously tracks temperature, current, and smoke levels for immediate alerts.
- Provides real-time alerts.
- Automatic motor cutoff prevents battery damage.
- Simple and cost-effective design.

8.2 APPLICATION

1. Electric four -Wheelers – Ensures safe and efficient operation by preventing battery overload and overheating.
2. Public Transport – Enhances passenger safety in auto-rickshaws and e-rickshaws
3. Logistics Vehicles – Prevents battery-related failures in cargo four-wheelers.
4. Industrial Use – Helps in monitoring battery-powered utility vehicles for safe operation.

9. CONCLUSION AND REFERENCE

9.1 CONCLUSION

This project demonstrates a practical and efficient solution for enhancing the safety of electric four-wheelers. The proposed smart detection system integrates essential sensor technologies to provide early warning and protective responses in the event of overload, overheating, or smoke emission. By employing real-time monitoring through an Arduino-controlled platform, the system automates safety interventions such as stopping the motor and alerting the user, effectively reducing the chance of fire hazards and mechanical failures.

One of the core strengths of the system is its rapid detection-to-response mechanism. The Arduino processes incoming data from load, temperature, and smoke sensors and takes swift corrective action, including ignition cut-off and user alerting. This minimizes the risk window between fault detection and action, which is crucial in preventing battery fires and mechanical stress. The use of digital communication via relay ensures the vehicle is physically disconnected from power in unsafe conditions, protecting both passengers and vehicle components.

The system's affordability, scalability, and adaptability make it highly suitable for implementation in both commercial and personal EV applications. Furthermore, its architecture allows for future enhancements, such as GSM-based messaging, mobile app integration, or AI-based anomaly detection.

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