Intelligent Safety Helmet

TEAM 112

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Introduction

- **Problem Statement:**

  The smart helmet aims to improve safety in hazardous industrial environments by monitoring gas levels, vital signs, and falls in real time. It detects gases like H_2S, LEL, and SO_2, tracks health data, and sends alerts to a central system, enabling faster emergency response and accident prevention.

- **Constraints & Specifications:**

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Constraint 1	Weight: Must be less than 1.3 Kg
Constraint 2	Design Capacity:
Constraint 3	Comfort & Safety: Ensure safe and comfortable helmet design
Constraint 4	Resist Corrosion:
Specification 1	Helmet Hardness: Hardness must equal 150 HV or more
Specification 2	Response time for gas detection system:
Specification 3	Sensors Accuracy:
Specification 4	Battery Capacity: Minimum 2000mAh
Specification 5	Thermal Resistance coefficient:
Specification 6	Distance between nose & detector: less than 15 cm to ensure quick response
Specification 7	Heart rate sensor accuracy: HR sensor must be accurate within 2 bpm
Integrated specification 1	Power & Sensor Compatibility: battery can sustain all sensors for 8+ hours
Integrated specification 2	Balancing weight distribution while integrating sensors without compromising comfort or safety
Integrated specification 3	Using insulating materials to prevent overheating while maintaining sensor accuracy.
Integrated specification 4	Meeting ANSI, OSHA, NFPA standards

Prototype Design
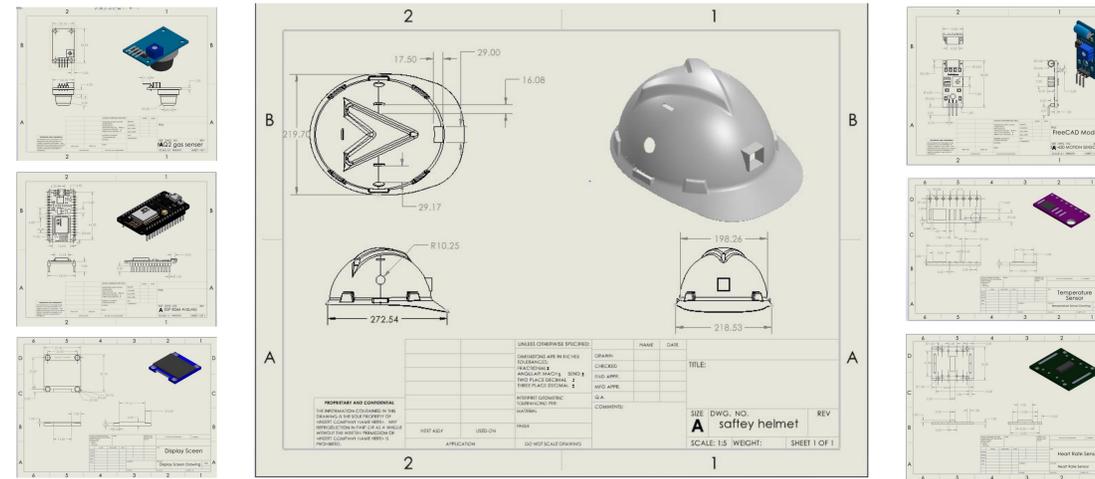
- A 3D-printed carbon fiber safety helmet designed for hazardous environments, equipped with H_2S and LEL gas detectors, shock, temperature, and heart rate sensors. All components, including a display and battery, are connected to an Arduino and ergonomically mounted for real-time monitoring and alerts.

- **Ergonomically Designed:**

  Using the AHP method, ABS + Carbon Fiber was chosen for its high impact resistance, moderate weight, and thermal properties. The carotid pulse point was selected for the heart rate sensor due to its stable signal and low motion interference. The helmet's center of mass was only 0.533 cm off the head's natural CoM, confirming its ergonomic balance and safety.

- **Stress & Displacement tests:**
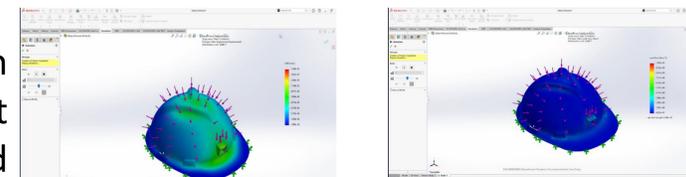
  The stress and displacement tests showed that the helmet handles loads very well, with low stress and minimal deformation. The safety factor was high, and the helmet stayed stable under pressure. However, using a fully fixed base may have made it seem stronger than it is in real conditions.

Testing / Validation

- Sensors detected gases (H_2S, SO_2, LEL) within 7–8 seconds.
- Accuracy stayed within ±5% of actual concentrations.
- Sensor placement averaged 11.8 cm from the breathing zone (within spec).
- Materials resisted corrosion after 72-hour exposure to toxic gases.
- Sensors remained stable up to 55°C, with minor noise at higher temps.
- Maximum stress was 1.12×10^6 N/m², well below the material's yield strength.
- High safety factor of 44.6, indicating strong resistance to loading.
- Minimal deformation observed (1.50×10^{-3} mm), showing structural stability.

Conclusion

- In conclusion, designing the gas detector and vital signs reader helmet requires balancing economic, environmental, and regulatory constraints to ensure safety, compliance, and sustainability. Despite Arduino's limitations, thoughtful planning can overcome challenges, ultimately enhancing worker safety.