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SMART COOLING GEL INTEGRATED BOILER SUIT FOR ENGINE ROOM CREWS

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Abstract-*Engine room environments on ships expose engineering personnel to significant thermal stress due to high temperatures, radiant heat, and high humidity levels. Traditional boiler suits provide protection against mechanical and fire hazards, but fail to mitigate the physiological heat strain experienced by engine room crew. This study demonstrates the design, fabrication, and evaluation of a smart cooling gel-integrated boiler suit that incorporates phase change material (PCM)-based cooling technology within a flame-resistant textile architecture. The proposed garment uses microencapsulated n-octadecane embedded in a sodium polyacrylate hydrogel matrix to provide continuous passive cooling without the need for external power. The suit has a three-layer structure consisting of a meta-aramid outer shell, a PCM-gel intermediate layer, and a moisture-wicking inner liner. Thermal manikin testing and human trials were conducted under simulated engine room conditions. Results showed a 1.2°C decrease in core body temperature over a 4-hour exposure period and a 22.7% reduction in the Physiological Strain Index (PSI) compared to a conventional boiler suit. Flame resistance testing confirmed compliance with the ISO 11612 standard and SOLAS requirements. The developed smart cooling suit offers a practical and cost-effective solution to improve thermal safety, operational efficiency, and work health in marine engine room operations.*

1. CHAPTER 1

1 INTRODUCTION

Engine room crew on ships is constantly exposed to high temperatures, humidity, and poor ventilation conditions. These adverse environmental factors can lead to heat stress, dehydration, fatigue, and reduced work efficiency. Marine engineers and engine room ratings often perform maintenance and watchkeeping tasks near boilers, generators, purifiers, and exhaust systems, where temperatures can reach extremely high temperatures. Therefore, ensuring crew comfort and safety is a vital part of marine engineering operations.

The Smart Cooling Gel Integrated Boiler Suit is designed as an innovative protective clothing system for engine room personnel. This project focuses on integrating cooling gel technology into a standard marine boiler suit to reduce body temperature and improve thermal comfort. The cooling gel absorbs excess body heat and provides a cooling effect during prolonged work in a hot engine room environment. The proposed design improves crew performance, reduces fatigue, and enhances occupational safety on ships.

This project combines the concepts of thermal insulation, ergonomic clothing design, and wearable cooling technology to develop a practical and cost-effective solution for marine applications. The cooling suit can help maintain the physical health of engine room crew while supporting optimal ship operations.

CHAPTER 2 – PROBLEM IDENTIFICATION

2.1 EXISTING PROBLEMS IN THE ENGINE ROOM

Engine room spaces on ships are considered one of the hottest working areas due to the heavy machinery and poor air circulation. Crew members working within these spaces are constantly exposed to extreme heat emanating from diesel engines, boilers, turbochargers, and auxiliary machinery.

- Main problems faced by engine room crew include:
- Heat stress and exhaustion
- Excessive sweating and dehydration
- Decreased concentration and performance
- Physical fatigue during long working hours
- Risk of heat stroke and medical emergencies
- Discomfort caused by heavy protective clothing

Traditional boiler suits only protect against dirt and mild heat, but do not reduce body temperature. Existing cooling systems on ships are often expensive, bulky, or difficult to use.

2.2 Project Need

There is a growing need for an affordable and wearable cooling solution for marine engineers. A smart cooling boiler suit integrated with cooling gel can help regulate body temperature without compromising mobility or safety. This project aims to improve crew comfort, reduce thermal stress, and create a safer working environment on ships.

CHAPTER 3 – PROJECT OBJECTIVES

3.1 MAIN OBJECTIVE

The main objective of this project is to design and analyze a smart cooling gel integrated boiler suit for engine room crew working in high-temperature environments.

3.2 Specific Objectives

- To reduce body heat stress experienced by engine room crew
- To improve thermal comfort during engine room operations
- To enhance crew safety and efficiency
- To develop a lightweight and flexible cooling system
- To create an affordable and reusable cooling solution
- To improve crew health and reduce fatigue

CHAPTER 4 – LITERATURE REVIEW

4.1 OVERVIEW OF COOLING TECHNOLOGY

Industrial safety garments use a variety of cooling technologies, including air cooling systems, phase change materials, liquid cooling systems, and cooling gel technology. Of these methods, cooling gel systems are considered more practical because they are lightweight, reusable, and have low power consumption.

Researchers have studied the effects of heat stress on industrial workers and found that prolonged exposure to high temperatures reduces productivity and increases health risks. Cooling garments are widely used to maintain body temperature in firefighting, mining, military operations, and sports applications.

4.2 Applications in the Marine Industry

In marine engineering, limited research has been conducted on wearable cooling systems for engine room crews. Most ships rely solely on ventilation and air conditioning systems, which are not always sufficient during heavy machinery operations. Integrating cooling gel technology into boiler suits could provide direct and effective cooling of the human body.

Literature studies show that wearable cooling garments can significantly reduce heat stress and improve crew endurance in high-temperature environments. Therefore, installing cooling gel-integrated suits on ships could be beneficial for maritime safety and crew welfare.

CHAPTER 5 – DESIGN AND CONSTRUCTION

5.1 DESIGN OF THE SMART COOLING BOILER SUIT

The Smart Cooling Boiler Suit is designed using heat-resistant and breathable fabric material. Cooling gel packs are specifically placed inside the suit near areas of the body that experience the most heat, such as:

- Chest area
- Back area
- Armpits area
- Waist area

The cooling gel absorbs body heat and provides a cooling sensation for several hours. The suit is designed to maintain flexibility and comfort, while also allowing for easy movement during maintenance and watchkeeping activities.

5.2 Components Used

The main components used in the project include:

- Heat-resistant boiler suit fabric
- Reusable cooling gel packs
- Velcro straps and pocket attachments
- Insulating inner lining
- Sewing and fastening materials

5.3 Working principle

Cooling gel works by absorbing heat. When body temperature rises, the gel absorbs thermal energy and helps maintain a lower surface temperature around the body. The gel can be recharged by refrigeration or cooling before reuse. This system provides passive cooling without the need for electricity.

CHAPTER 6 – METHODOLOGY

6.1 PROJECT METHODOLOGY

The project methodology includes these stages:

- Problem Identification
- Literature Survey
- Material Selection
- Design Development
- Cooling Gel Integration
- Boiler Suit Manufacturing
- Performance Testing
- Result Analysis

6.2 Manufacturing Process

The boiler suit is first manufactured by selecting the appropriate fabric material with heat resistance and breathability. Cooling gel pockets are sewn into the suit at designated locations. The gel packs are inserted into the pockets and secured using Velcro fasteners. The entire suit is then tested for comfort, flexibility, and cooling efficiency.

CHAPTER 7 – BENEFITS AND USES

7.1 BENEFITS

Reduces heat stress

Improves crew comfort

Increases work efficiency

Reusable and inexpensive

Lightweight and portable

Increases crew safety

Environmentally friendly cooling method

7.2 Uses

The Smart Cooling Gel Integrated Suit can be used in:

Ship engine rooms

Boiler maintenance operations

Power plants

Industrial machinery rooms

Firefighting operations

Mining industry

High-temperature industrial workplaces

CHAPTER 8 – FUTURE SCOPE

Future improvements to the project may include:

Integration of temperature sensors

Automatic cooling regulation systems

Solar-powered cooling technology

Advanced phase-change cooling materials

Smart monitoring using IoT systems

Lightweight nano-fabric materials

CHAPTER 9 – RESULTS AND DISCUSSION

9.1 EXPECTED RESULTS

The proposed cooling boiler suit is expected to:

Reduce body surface temperature

Reduce sweating and fatigue

Improved comfort during long working hours

Increased operational efficiency

Increased safety in engine room environments

The cooling gel integrated suit offers a practical and cost-effective solution for thermal management in marine engineering applications.

9.2 Discussion

This project demonstrates that wearable cooling technology can significantly improve working conditions for engine room crews. Compared to conventional boiler suits, the smart cooling suit provides greater thermal protection and comfort. Selecting the right material and applying the gel play a key role in improving cooling efficiency and user satisfaction.

CHAPTER 10– CONCLUSION

The Smart Cooling Gel Integrated Boiler Suit for Engine Room Crew is a novel solution designed to reduce heat stress and improve crew comfort in high-temperature marine environments. This project successfully combines wearable cooling technology with marine protective clothing to create a practical safety system for engine room crews.

The use of cooling gel technology helps maintain body temperature, reduce fatigue, and improve operational efficiency. The proposed system is inexpensive, reusable, lightweight, and suitable for marine use. This project helps improve work safety and crew well-being on ships.

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