

PATENT SPECIFICATION

Smart Thermal Insulation Control System

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ABSTRACT

A system and method for dynamically controlling thermal insulation in autonomous mobile robots operating in extreme temperature environments. The system comprises an array of smart thermal sensors, an adaptive insulation control unit, and a machine learning-based optimization engine that maintains optimal operating temperatures for critical robotic components while minimizing energy consumption.

BACKGROUND

[0001] Autonomous mobile robots operating in cold storage environments face significant challenges related to thermal management and component reliability. Traditional passive insulation systems fail to adequately protect sensitive electronics and mechanical systems in extreme temperature conditions, particularly in industrial freezer environments operating at -30 C or below.

[0002] Existing solutions typically employ static insulation or simple heating elements, resulting in either insufficient protection or excessive energy consumption. There remains a need for an intelligent, adaptive thermal management system capable of maintaining optimal operating conditions while maximizing energy efficiency.

SUMMARY OF THE INVENTION

[0003] The present invention provides a smart thermal insulation control system comprising:

- A network of distributed temperature sensors
- Actively controlled insulation panels with variable thermal resistance
- A machine learning-based control algorithm
- An energy optimization subsystem
- Real-time performance monitoring and adjustment capabilities

[0004] The system dynamically adjusts thermal protection based on:

- Ambient environmental conditions
- Component-specific temperature requirements
- Current operational state of the robot
- Historical performance data
- Energy efficiency parameters

DETAILED DESCRIPTION

[0005] Referring to Fig. 1, the smart thermal insulation control system (100) includes:

[0006] A primary control unit (110) comprising:

- A central processing module (111)
- Thermal modeling software (112)
- Machine learning engine (113)
- Power management system (114)

[0007] An array of smart insulation panels (120) featuring:

- Electroactive polymer layers (121)
- Embedded temperature sensors (122)
- Local control modules (123)
- Power distribution network (124)

[0008] The system operates by continuously monitoring both internal and external temperatures through a distributed sensor network (130). The machine learning engine (113) processes this data to predict thermal requirements and optimize insulation settings for each panel independently.

CLAIMS

What is claimed is:

A smart thermal insulation control system for autonomous mobile robots comprising:

- a) A plurality of actively controlled insulation panels;
- b) A distributed temperature sensing network;
- c) A central control unit executing machine learning-based optimization;
- d) An energy management subsystem.

The system of claim 1, wherein the actively controlled insulation panels comprise:

- a) Multiple layers of electroactive polymers;
- b) Integrated temperature sensors;
- c) Individual control modules;
- d) Variable thermal resistance capabilities.

The system of claim 1, wherein the machine learning-based optimization:

- a) Predicts thermal requirements based on operational conditions;
- b) Adjusts individual panel settings in real-time;
- c) Maintains component-specific temperature targets;
- d) Minimizes overall energy consumption.

INVENTORS

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POWER OF ATTORNEY

The undersigned hereby appoints Katherine Reynolds (Reg. No. 58,742) as attorney of record with full power of substitution and revocation to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

Executed on: March 15, 2022

/s/ Dr. Elena Frost

Dr. Elena Frost

CEO, Polar Dynamics Robotics, Inc.

DECLARATION

I hereby declare that I believe I am the original inventor of the subject matter which is claimed and for which a patent is sought; that I have reviewed and understand the contents of the above-identified specification, including the claims; and that I acknowledge the duty to disclose all information known to be material to patentability as defined in 37 CFR 1.56.

/s/ Dr. Elena Frost

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Date: March 15, 2022

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/s/ Dr. James Barrett

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