COLD-RESISTANT ACTUATOR DESIGN PATENT

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Assignee: Polar Dynamics Robotics, Inc.

ABSTRACT

A cold-resistant actuator system for autonomous mobile robots operating in sub-zero environments, comprising a thermally-insulated housing containing novel electromagnetic drive mechanism with integrated thermal managemen

proprietary lubricant composition maintaining viscosity at temperatures belo
-40°C. The system enables precise robotic movement and positioning in extr
cold conditions while preventing mechanical failure and maintaining operati
efficiency.

BACKGROUND OF THE INVENTION

[0001] Autonomous mobile robots operating in cold storage and industrial fr
environments face significant challenges related to actuator performance and
reliability. Conventional actuator systems experience reduced efficiency,
increased power consumption, and potential mechanical failure when expose
sustained sub-zero temperatures.

[0002] Existing solutions have failed to adequately address the combined
challenges of thermal stress, lubricant viscosity changes, and power efficienc
in extreme cold environments. This invention provides a novel approach to

maintaining consistent actuator performance across a temperature range of +
to -45°C.

DETAILED DESCRIPTION

I. System Components

[0003] The cold-resistant actuator system comprises:

(a) A thermally-insulated composite housing constructed of reinforced polym
matrix;

(b) Electromagnetic drive mechanism utilizing rare-earth permanent magnets

(c) Proprietary low-temperature lubricant composition (Formula BC-217);

(d) Integrated thermal management system with passive heat distribution;

(e) Temperature-compensating control electronics; and

(f) Sealed bearing assemblies with cold-specific surface treatments.

II. Thermal Management System

[0004] The thermal management system incorporates:

(a) Multi-layer insulation with vacuum-sealed chambers;

(b) Heat-reflective coating application (Patent No. 15/443,219);

(c) Strategically positioned thermal sensors; and

(d) Microprocessor-controlled heat distribution network.

III. Novel Features

[0005] Key innovations include:

(a) Self-regulating thermal compensation;

(b) Adaptive power management based on temperature conditions;

(c) Predictive maintenance algorithms utilizing thermal data;

(d) Rapid cold-start capability without pre-heating; and

(e) Extended operational life in sustained sub-zero conditions.

CLAIMS

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A cold-resistant actuator system comprising:

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A thermally-insulated housing;

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An electromagnetic drive mechanism;

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A temperature-stable lubricant composition;

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An integrated thermal management system; and

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Control electronics optimized for cold environment operation.

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The actuator system of claim 1, wherein the lubricant composition maintains

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The actuator system of claim 1, wherein the thermal management system pro

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The actuator system of claim 1, further comprising predictive maintenance ca

DRAWINGS

[0006] Figure 1: Cross-sectional view of actuator housing

[0007] Figure 2: Thermal management system schematic

[0008] Figure 3: Control system architecture

[0009] Figure 4: Performance data graphs

INVENTORS

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GOVERNMENT RIGHTS

[0010] This invention was made without government support. The governme

rights in this invention.

INCORPORATION BY REFERENCE

[0011] All publications, patents, and patent applications mentioned in this specification are herein incorporated by reference to the same extent as if eac individual publication, patent, or patent application was specifically and individually indicated to be incorporated by reference.

FIELD OF THE INVENTION

[0012] This invention relates generally to robotic actuator systems and specifically to actuators designed for reliable operation in extreme cold environments including industrial freezers, cold storage facilities, and temperature-controlled logistics operations.

CERTIFICATION

I hereby certify that this patent application contains no material which is subject to export control restrictions under U.S. Export Administration Regulations.

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