

PATENT SPECIFICATION

Low-Temperature Hydraulic System Design

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ABSTRACT

A low-temperature hydraulic system for autonomous mobile robots operating in sub-zero environments, comprising a thermally-isolated fluid reservoir, multi-stage pressure compensation mechanism, and smart thermal management subsystem. The system maintains operational stability in environments ranging from -40 C to +25 C through proprietary fluid composition and adaptive pressure regulation.

BACKGROUND

[0001] Conventional hydraulic systems face significant challenges in extreme cold environments due to fluid viscosity changes, seal degradation, and pressure inconsistencies. This invention addresses these limitations through novel approaches to thermal management and pressure compensation.

[0002] Prior art solutions have failed to adequately address the combined challenges of fluid thermal management, seal integrity, and precise actuation control in sub-zero environments, particularly in mobile robotics applications.

DETAILED DESCRIPTION

I. System Overview

[0003] The low-temperature hydraulic system comprises:

- (a) A primary fluid reservoir with multi-layer thermal isolation;
- (b) Proprietary hydraulic fluid composition optimized for -40 C operation;
- (c) Active thermal management system with distributed sensing;
- (d) Adaptive pressure compensation mechanism;
- (e) Smart seal system with temperature-responsive materials.

II. Thermal Management Subsystem

[0004] The thermal management subsystem includes:

- (a) Network of distributed temperature sensors;
- (b) Microprocessor-controlled heating elements;
- (c) Multi-zone thermal regulation algorithm;
- (d) Predictive temperature compensation system.

III. Pressure Compensation Mechanism

[0005] The pressure compensation system comprises:

- (a) Primary accumulator with temperature-compensated precharge;
- (b) Secondary dynamic pressure regulation system;
- (c) Electronic pressure monitoring and adjustment system;
- (d) Adaptive feedback control loop.

IV. Fluid Composition

[0006] The hydraulic fluid composition includes:

- (a) Base synthetic oil with modified viscosity index;
- (b) Proprietary cold-flow improvers;
- (c) Anti-wear additives optimized for low-temperature operation;
- (d) Thermal stability enhancers.

CLAIMS

A low-temperature hydraulic system comprising:

- A thermally-isolated fluid reservoir;
- A multi-stage pressure compensation mechanism;
- An active thermal management subsystem;
- A smart seal system;

wherein said system maintains operational stability between -40 C and +25 C.

The system of claim 1, wherein the thermal management subsystem comprises:

- Distributed temperature sensors;
- Microprocessor-controlled heating elements;
- Predictive temperature compensation algorithms.

The system of claim 1, wherein the pressure compensation mechanism includes:

- Temperature-compensated primary accumulator;
- Dynamic pressure regulation system;
- Electronic monitoring and adjustment capabilities.

DRAWINGS

[0007] FIG. 1 illustrates the overall system architecture.

[0008] FIG. 2 shows the thermal management subsystem components.

[0009] FIG. 3 depicts the pressure compensation mechanism.

[0010] FIG. 4 presents the smart seal system design.

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GOVERNMENT LICENSE RIGHTS

[0011] The U.S. Government has certain rights in this invention pursuant to Contract No. AFRL-FA8650-19-C-2XXX awarded by the Air Force Research Laboratory.

CERTIFICATION

I hereby certify that this patent document accurately reflects the invention as claimed and that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true.

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