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Design of a Micro Hydraulic Power Unit for Nuclear Accident Response Robot

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1. Introduction

In the event of a nuclear accident, it is important to take an initial response to prevent the spread of the accident. For rapid response at the radiation accident site, research on accident response using robots has been conducted, as the case of the DARPA Robotics Challenge (DRC). Although various types of work are required to respond to deal with a nuclear accident, robots equipped with manipulators are essential for making a passage to enter the accident site, manipulating objects such as doors and valves, and handling radioactive materials.

The Korea Atomic Energy Research Institute (KAERI) is developing a dual-arm robot, ARMstrong, to respond to nuclear accidents to perform the aforementioned manipulation tasks at the accident site. ARMstrong robot is driven by hydraulic cylinders and hydraulic motors. The robot has a hydraulic power unit driven by an internal combustion engine, and the hydraulic power unit supplies hydraulic pressure to each actuator of the robot. The internal combustion engine powered hydraulic power units are well-proven technology, capable of producing large output and long-lasting operation. However, the internal combustion engine powered hydraulic power units emit exhaust gas and produce severe noise and vibration. Therefore, it is difficult to utilize them inside the building.

To overcome these limitations, in this paper, we propose a novel motor-powered micro power unit for a hydraulic robot.

2. Limitations of Industrial Hydraulic Power Units

Existing industrial hydraulic power units are designed based on a high safety factor and has low output power compared to their large weight, so it is limited to be used in small-sized robots. Industrial hydraulic power units are bulky and difficult to miniaturize because tanks, pumps, valves, coolers, and hoses are not integrated.

Most industrial power units have a structure that operates based on an engine or AC motor. Although the energy density of the engine is high, it has limitations in operating indoors due to exhaust gas and noise. In case of AC motor power source, energy density is low and bulky, so it is limited as a power source for robot. For example, small power packs used in electric forklifts do not have cooling or overload circuits due to their simple structure.

Fig. 1 Industrial compact hydraulic power units

3. Necessity of the Micro Power Unit

A disaster response robot that performs heavy-duty work requires a micro power unit with instantaneous high-power generation, quick response, and high efficiency. In particular, considering the limited size of the robot working in a narrow area, the micro power unit integrated with a control system and other hydraulic components has very high industrial and technical value.

4. Concept of the Micro Power Unit

The micro power pack is designed based on the integrated structure concept including pump, tank, pipe, valve, filter, heat exchanger and sensors for miniaturization and effective thermal management.

For thermal management, a direct cooling method of hydraulic oil was applied to increase thermal efficiency through variable output control according to the workload and to reduce the size of the system. Designing a heat exchanger-integrated oil tank and pipe structure to effectively reduce the temperature rise of hydraulic oil due to bypass leakage and to miniaturize the system.

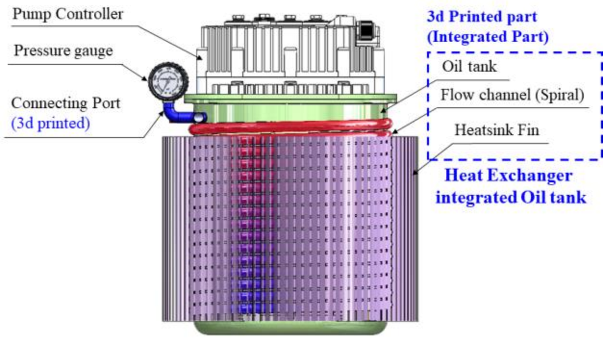

Fig 2. Schematic design of micro power unit

In addition, gear pumps, high-power BLDC motors, and hydraulic circuit accessories were selected to achieve the required output conditions for the micro power pack.

4. Conclusion

In this paper, we discussed the design of micro power unit for disaster response robots. The necessity of a micro power unit for a robot was described, and a conceptual design was presented.

In the future, we plan to continue our research on detailed design, system configuration, control, and performance verification of micro power packs.

REFERENCES

[1] B. Cho et al., "Design of a Compact Embedded Hydraulic Power Unit for Bipedal Robots," in IEEE Robotics and Automation Letters, vol. 6, no. 2, pp. 3631-3638, April 2021, doi: 10.1109/LRA.2021.3061390.