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# Design of Radioactive Material Sampling Devices in High Radiation Area Using a Dual Arm Robot

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## 1. Introduction

High-radiation areas are difficult to access due to the high risk of radiation exposure to workers. For environmental investigations around decommissioned nuclear facilities, it is necessary to collect and analyze soil samples, surface samples, and object samples in a stable manner. Currently, most sampling operations are carried out by human workers directly in the radiation zone. Therefore, the development of robotic technology for radioactive material sampling is required to minimize radiation exposure risks and increase the efficiency of sampling operations. In this study, we discuss the design and testing of sampling devices that enables unmanned collection of soil and surface samples using a dual-arm robot in high-radiation areas.

## 2. Sampling device design

### 2.1 Soil sampling device requirements

A soil sampling device is required to collect 5-10 cm of topsoil from soil surfaces located in high-radiation areas. During a soil sampling mission, it is required to collect a minimum of 5 representative samples from a single soil sampling operation, adhering to proper protocols for sample preparation and handling. The soil sampling device should be designed to withstand harsh environmental conditions, including shocks and vibrations, throughout the entire soil sampling process.

### 2.2 Design of soil sampling device

The soil sampling device was designed with two parts: an upper handle-shaped part that is easily gripped by the ARMstrong robot (Fig. 1), and a lower container capable of collecting soil samples. The upper part of the device has an outer diameter of 34 mm and a height of 70 mm, ensuring that it can be gripped by the robot at a 45° angle without any interference. The thickness of the device was designed at 4 mm to ensure lightweight and the ability to withstand stress when gripped by the robot.

The lower part of the soil sampling device was designed with an inner diameter of 50 mm, a height of 51 mm, and a volume of approximately 100 cc. The sampling container has been designed as a single integrated cylinder structure, with the contact part sharply angled at 106° to facilitate soil sampling. A detailed illustration of the soil sampling device is presented in Figure 2.

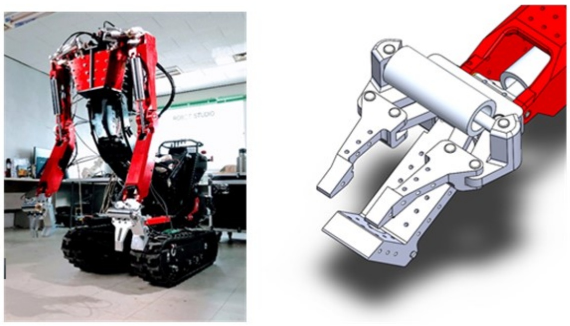

Fig. 1 ARMstrong Robot and a gripper

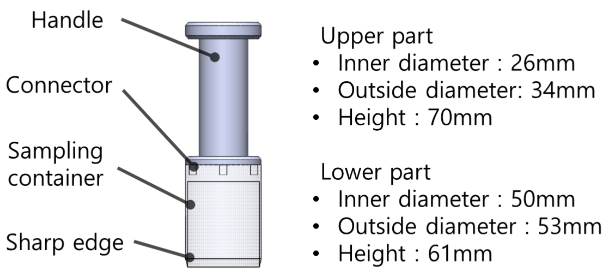


Fig. 2 Soil sampling device design

2.3 Surface sampling device requirements

The surface sampling device should be designed to collect contamination samples from surfaces in high-radiation areas at various angles, ensuring that the samples collected are representative of the surface's radioactivity levels. During a surface sampling mission, it is crucial to collect a minimum of 5 samples, adhering to proper sampling protocols and guidelines to prevent any potential contamination during sample collection, handling, and analysis.

Furthermore, the surface sampling device should be designed to withstand the harsh environmental conditions of high-radiation areas, including shocks and vibrations, throughout the entire sampling process. It should be equipped with a robust and stable mechanism that enables smooth movement across surfaces while maintaining constant contact with the surface to ensure efficient and effective sample collection.

To ensure accurate and reliable measurement of surface contamination levels, the surface sampling device should also be properly calibrated and validated. Calibration involves adjusting the device to produce accurate and consistent results, while validation confirms that the device meets the required performance standards and specifications for its intended use.

2.4 Design of surface sampling device

The surface sampling device is composed of two parts: an upper part and a lower part. The upper part is designed with the same structure as the soil sampling device to enable both devices to be handled by the same gripper.

The lower part of the surface sampling device consists of a cylinder, a wiper support, a wiper fixing ring, and the wiper. The wiper is fixed in place by bolting between the wiper fixing ring and the wiper support. The central part of the wiper support has been designed to be convex to facilitate easy contact during surface sampling. The wiper can be removed and replaced after sample collection. The height of the surface sampling device has been kept the same as the soil sampling device to ensure that the robot can grip both devices using the same motion.

The handle, cylinder, and wiper fixing ring of the surface sampling device have been made of aluminum, while the wiper support has been made of ABS plastic to absorb the contact force. This ensures that the surface sampling device is durable, lightweight, and can

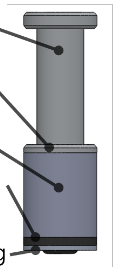


Fig. 3 Surface sampling device design

withstand the shocks and vibrations that occur during the sampling process.

The design of the surface sampling device has been optimized for efficient and safe collection of contamination samples from various surfaces in high-radiation areas.

## 3. Conclusion

In this paper, we discussed about soil and surface sampling devices in high-radiation environments, in place of human workers. The sampling devices were designed with consideration for system requirements, environmental analysis, and robot operating methods. In the future, soil and surface sampling devices will be manufactured and field tests will be conducted in outdoor environments.

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