Proceeding of the Korean Radioactive Waste Society
Vol. 2(1), June 2004

Robotic Floor Surface Decontamination System

Kiho Kim, Jangjin Park, Myungseung Yang
Korea Atomic Energy Research Institute, 150 Duck-Jin Dong, Yusung-Ku, Daejeon

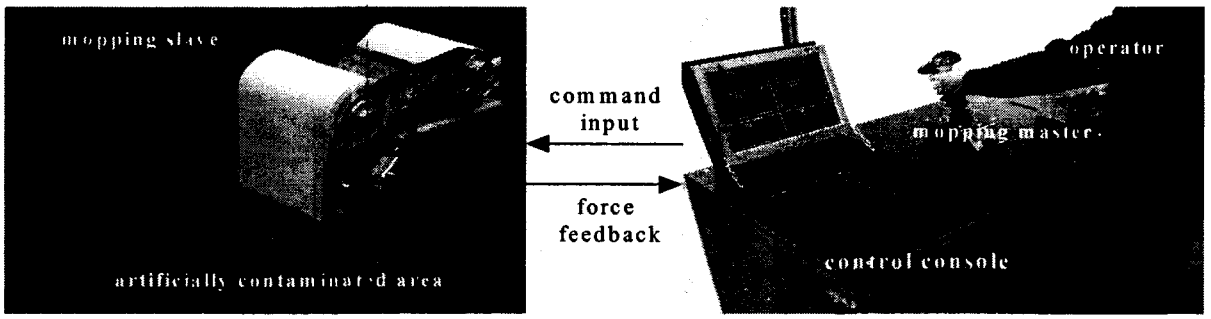
DUPIC (Direct Use of spent PWR fuel In CANDU) fuel cycle technology is being developed at Korea Atomic Energy Research Institute (KAERI). All the DUPIC fuel fabrication processes are remotely conducted in the completely shielded M6 hot-cell located in the Irradiated Material Examination Facility (IMEF) at KAERI. Undesirable products such as spent nuclear fuel powder debris and contaminated wastes are inevitably created during the DUPIC nuclear fuel fabrication processes. Such radioactive waste should be cleaned and disposed of in order to prevent the contamination from spreading inside the M6 hot-cell. Currently, the contaminated M6 in-cell floor at KAERI is being remotely cleaned using both a conventional vacuum cleaner modified for the hot-cell application and a remotely operated cleaning robot with vacuum cleaner. These cleaning methods employing vacuum cleaners, however, have limits of cleaning capability in terms of particulates sustained on the floor. Even after cleaning, there still remain fine dry contaminated particulates emitting radiations on the cleaned floor. Furthermore, contaminated smears cannot also be removed and cleaned by vacuum cleaning methods. The objective of this work was to develop a robotic decontamination system that could be operated remotely from remote location to clean and mop the contaminated floor of the M6 hot-cell efficiently and without endangering human operators.

In this paper, we describe the development of a robotic surface decontamination system for use in the radioactive zone of the M6 hot-cell of the IMEF of KAERI where direct human access to the in-cell is strictly limited. The robotic decontamination system was designed to completely remove the contaminated dry particulates and smears remained on the floor surface by mopping in a remote manner after contaminated loose dry radioactive waste placed on the M6 in-cell floor was cleaned by means of remote vacuum cleaner or cleaning robot. The robotic decontamination system was also designed to completely eliminate human interaction with the hazardous radioactive contaminants. The robotic decontamination system mainly has three subsystems a mobile mopping slave located at the in-cell, a mopping master and a control console located at the out-of-cell. The mobile mopping slave consists of a tracked mobile platform, a mopping tool, and a mopping cloth, which were constructed in modules to facilitate maintenance. They can be separated and assembled easily by remote manipulation. The tracked mobile platform was designed to carry out forward, reverse and steering movements on the in-cell floor climbing over such obstacles as gas tubes and electrical cables placed on the floor. The mopping tool is installed upon the top of the mobile platform. The multi-spring loaded end-tool of the mopping tool guides the mopping cloth onto the floor surface to be mopped and enables the mopping cloth to contact with the floor surface. Floor mopping operation is conducted by

remotely pressing down the end-tool toward the floor surface while the mobile platform moves in any desired cleaning direction. The mopping strength depends on the contact degree between the end-tool and the floor surface and can be adjusted by controlling the pressing force of the end-tool. Used mopping cloth can also be exchanged easily for new one in a remote manner. The robotic decontamination system is operated by teleoperated control, which employs bilateral force reflecting control scheme. In bilateral control, force reflection is added to the mopping master, and motion and force information flows in both directions between the operator located at the out-of-cell and the mopping slave located at the in-cell. Force is the mopping force produced between the end-tool of the mopping tool and the floor surface while mopping. The sensed information of the mopping slave is fedback and used as the command input to the mopping master. As the mopping slave interacts with its task environment to be cleaned, the force feedback is a source of information about the mopping slave at remote site to be presented to the operator. The mopping master is a man-machine interface device that allows real-time interaction between the human operator and the mopping slave. The mopping master enables the human operator to manipulate the mobile mopping slave simply moving it. The human operator located at the out-of-cell can perform a series of floor mopping tasks by controlling the mobile mopping slave via the mopping master. A mopping force occurring when the mopping slave contacts with the floor surface to be mopped can be reflected to the human operator through the mopping master, thus allowing the operator to have a sense of real mopping. The control console provides a control location for the mobile mopping slave. The mopping master is installed on the control console. All functions for controlling the mopping slave and the mopping master are contained in it. The controller, circuitry, power supplies, and necessary software are also installed within the console.

The significance of this development is in providing a robotic decontamination system that can be operated from remote location to clean and mop the contaminated floor of the M6 hot-cell, completely eliminating human interaction with radioactive contaminants. The cleanup and mopping operations at contaminated hot-cell using this robotic decontamination system would have the benefits of improved worker safety, increased facilities soundness and reduced personnel exposure dose rates. Currently, we focus on the mock-up performance test of the developed robotic decontamination system in order to acquire its reliability and stability before it is put into service.

Key Words : teleoperation, mopping robot, force reflection, master-slave, decontaminatio



Contaminated floor surface (in-cell) Safe operating area (out-of-cell)

Teleoperated mopping operation conducted in the mock-up