Remote Handling

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Remote Handling Tools for Radioactive Environments

K. Jayarajan

Raja Ramanna Fellow, Bhabha Atomic Research Centre, Mumbai 400085, INDIA

RDMs installed in hotcell

ABSTRACT

Department of Atomic Energy has been according high priority to safety, including radiation safety. Remote handling tools are used in radiation environments to eliminate or reduce radiation exposure to operators. The tools separate the operators from the task they are engaged in. The article describes a few types of general-purpose remote handling tools developed by BARC for operations in radioactive environments.

KEYWORDS: *Radioactive cells, Remote handling, Master slave manipulator*

Introduction

Radioactive materials and radiation have become unavoidable part of our life. We use them in power plants, industry, agriculture, research, etc. They are also used in medical fields for diagnosis, treatment and palliative care of cancer; and sterilisation of medical products. BARC and many other units of DAE regularly handle radioisotopes during their production and use. To protect human operator from exposure to high radiation, radioisotopes are handled remotely using remote handling tools. Remote handling tools enable the operator to perform the desired task in a hazardous area, while staying away at a safe location. The plants of nuclear fuel cycle, such as fuel fabrication, fuel reprocessing and waste management, as well as the facilities for production and use of radioisotopes, post-irradiation examination and nuclear research employ remote handling tools. In the initial period of DAE, all major remote handling tools were imported. Now, DAE is self-reliant in this technology and can meet all remote handling requirements of the Department.

Remote Handling Tools and Systems

BARC has developed a variety of remote handling tools and systems, such as remote handling tong, master slave systems, robots, automations systems, remote cranes and mobile robots for remote operations in radioactive environment. They include general-purpose and special-purpose systems; autonomous and manually controlled tools; and manipulators with mobility and those without mobility. They also vary in their level of dexterity, payload, proximity to the site, versatility, protective measures, etc. Remote handling strategy and selection of remote handling tool depend on the risks and the complexity associated with the task. The scope of this article is limited to non-autonomous (manually controlled) general-purpose remote handling tools developed at BARC.

Remote Handling Tong

The simplest form of remote handling device is long reach tools, which extend the length of standard tools, providing safe distance between the hazard and the operator. A remote handling tong consists of a gripper, a handle and a rod between them (Fig.1). Based on the requirement, tongs are designed for installation on shielded/sealed walls, for hanging on a carrying system (for use in a water pools), or for carrying directly by the operator.

Fig.1: Remote Handling Tong.

Radioactive Cells (Hot Cells)

Gamma-active materials are handled in heavily shielded rooms, called hotcells, using remote handling tools[1]. The cells are shielded with normal or high-density concrete walls and ceiling of thickness ranging up to 2 m. Hotcells handling alpha-active materials are sealed to prevent leakage of contaminated air into the surroundings. The cells are also maintained at lower pressure, compared to their surroundings. For remote operations, the cells are provided with in-cell cranes, power manipulators and/or master-slave manipulators (Fig.2). Operators can control these devices from operating area, viewing the cell through shielded glass windows or CCTV monitors.

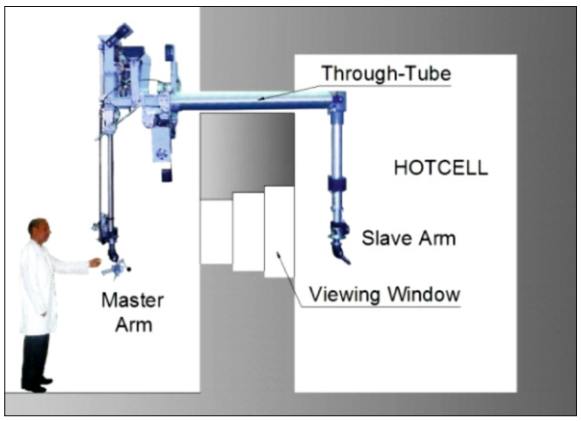

Fig.2: Layout of MSM in Hotcell.

*Author for Correspondence: K. Jayarajan
E-mail: kjayaraj@barc.gov.in

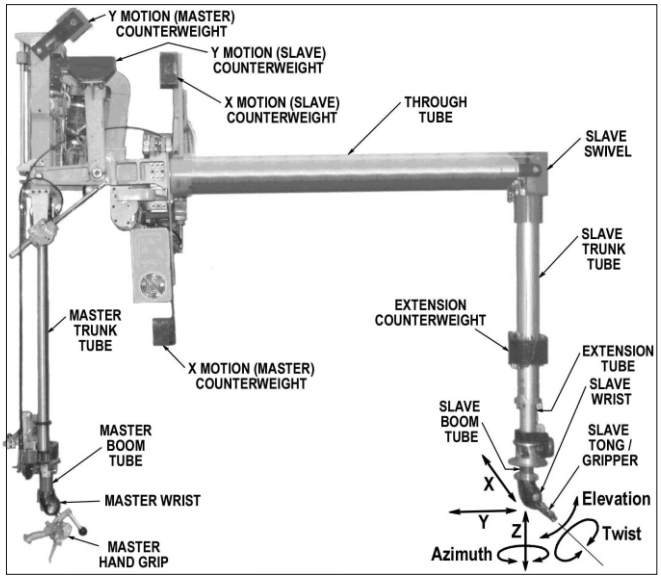

Fig.3: Parts and motions of an MSM.

In-Cell Cranes and Power Manipulators

In-cell cranes and power manipulators are used for handling heavy objects in hotcells. Power manipulator has a series of links and joints, powered by electric motors. Usually, crane has a hook for lifting the load, while power manipulator has a gripper for handling the payload. In addition to positioning the gripper at the desired location, power manipulators can orient the gripper in the desired direction. They are usually controlled by push button switches or joysticks. Their modular construction enables easy maintenance/repair/replacement of components and sub-assemblies.

Master Slave Manipulators

Master slave manipulators (MSMs) are the most widely used general-purpose remote handling tools used in nuclear industry[2]. In master slave manipulation, human being is part of the process, and his/her manipulative abilities are extended to the remote site.

An MSM consists of two arms: the slave arm, which is usually located in the hotcell and the master arm in the operating area/control station. When the operator grasps and manipulates the master gripper, the motion of his/her hand is reproduced at the slave tong, performing the intended task. Usually, the master arm and the slave arm are made geometrically similar. MSMs are usually used in pairs, and operator manipulates the master arms using both the hands. MSMs may be Mechanical Manipulators or Servo Manipulators.

Mechanical Manipulators

A mechanical MSM provides a mechanical linkage between the operator at the control station and the hazardous task areas inside the hotcell. Most of the mechanical MSMs are of through-wall type, where the slave arm is located in the hotcell, the master arm in the control station and the through-tube connecting these arms in the shielded wall (Figs.2&3). They are complex mechanical systems with 6 to 9 degrees of freedom and a gripper. Six joints and the gripper of MSMs are powered and controlled directly by human operator. In addition, their major joints are provided with electrically actuated indexing motions to increase their range, to ease operation and to prevent loss of view of hotcell areas during handling. From the task area, operator gets visual feedback

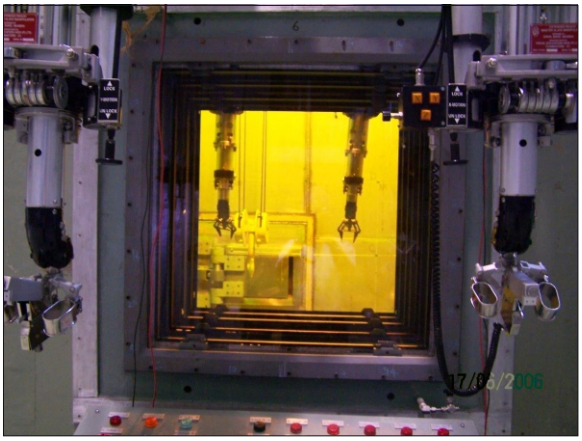

Fig.4: A pair of ERMs installed in a hotcell.

Fig.5: A row of RDMs installed in hotcell.

through a shielding window (Fig.4). Mechanical MSMs are suitable, where the work area is not too large and the force/torque requirements are within the capabilities of the operator.

Mechanical manipulator may be of articulated type or telescopic type. BARC has developed a variety of mechanical MSMs, such as Articulated Manipulator, Model-8 Manipulator, Extended Reach Manipulator (ERM) (Fig.4), Rugged Duty Manipulator (RDM) (Fig.5) and Three-Piece Manipulator (TPM)[3]. They vary in their payload (4.5 kg to 45 kg) and reach (1 m^3 to 20 m^3). Provision for shielding and sealing are offered in a few models. Also, in a few models, grippers of the slave arm are made remotely replaceable. In TPM, entire slave arm can be remotely replaced for its maintenance and repair. Often, the slave arms are provided with gaiter (booting) to protect it from contamination and to prevent leakage of contaminate air into the operating area. Using counterweights, all major joints of the manipulator are mechanically balanced to reduce operator's efforts for moving the arms in any direction.

Servo Manipulators

Unlike mechanical manipulators, which are mechanically powered by human operator, servo-manipulators are powered by electric (or hydraulic) actuators. A servo-manipulator system consists of two kinematically similar arms: master arm and slave arm. The mechanical power sources of the slave arm are electric motors, which are connected to all (usually six) joints and gripper of the slave arm. The controller continuously monitors the corresponding joint angles of the master and the slave, using the joint angle sensors, like synchro, potentiometer or encoder. It also drives all slave

Fig.6: Control station and master arm of indigenous Servo Manipulator at WIP, Trombay.

Fig.7: Slave arm in the hotcell, as seen by the operator in CCTV monitor.

Fig.8: Suspendable servo manipulator (SSM).

Fig.9: SSM retrieving waste pieces fallen on the floor of hot cell.

motors in real time to match the configuration of the slave arm to that of the master arm. In a few models, motors are provided on master joints also, to enable the operator to feel and control the forces/torques acting on the salve gripper.

Usually, slave arms are mounted on transporters to increase the reach of the slave arm. The transporter also allows the slave arm to approach hotcell equipment from different directions and provides flexibility in equipment layout in the cell. As the effective range of the slave arm is only limited by the range of the transporter, in general, single pair of slave arms can serve hotcells of any size. The presence of external power source reduces operator's handling effort and fatigue. In addition, servo-manipulator can be designed for high payload, as the force/ torque available at the slave arm is not limited by the strength of human operator.

In hotcells using servo manipulator, task area is viewed using CCTV cameras mounted on the slave arm and at different locations in the hotcell (Figs. 6, 7, 8, 9).

BARC has developed a few models of servo manipulators, such as Servo-Manipulator (Mark-1), Advanced Servo Manipulator (ASM), Four-Piece Servo Manipulator (FPSM), Portable Servo Manipulator (PSM) and Suspendable Servo Manipulator (SSM)[4,5,6].

Conclusion

BARC has developed the state-of-the-art remote handling tools for use in various radioactive areas of the department. Now, DAE is self-reliant in this technology and can meet all remote handling requirements of the Department.

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