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Development in Bio-Medical Engineering and Healthcare at BARC

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***Abstract* – Division of Remote Handling & Robotics (DRHR), BARC has been engaged in development of automation systems for use in Bio-Medical Engineering and Healthcare. These include Spot Picker Robot for research in Proteomics, Micro-arrayer for DNA analysis and an Automation system for Bioassy of urine samples of radiation workers. These systems have been successfully developed and given to the respective laboratories for lab trials.**

In Healthcare, *Bhabhatron*, a Cobalt based Teletherapy Machine meeting international safety standards, has been successfully developed. This has been commercialised and technology has been transferred to a private industry. More than 30 such machines are in operation in various hospitals in India and a few in abroad. DRHR has also successfully developed *Imagin*, a Radiotherapy Simulator, used in the localisation of Tumour. Presently, four such machines are in operation in various hospitals in India. HDR Source for Brachytherapy has been successfully developed and AERB has given approval for its clinical use. The development efforts are aimed at making cancer treatment affordable to the common people. The paper describes Spot Picker Robot, Micro-arrayer, Automation system for Bioassy, Bhabhatron, Imagin and HDR Source for Brachytherapy. Recent design improvements carried out on these machines are also discussed in this paper.

Key-words – Spot Picker Robot, Micro-arrayer, Bhabhatron, Imagin, HDR for Brachytherapy.

I. INTRODUCTION

In early seventies, it was felt necessary to initiate in-house development work at BARC in the areas of remote handling, application specific automation systems and robotic devices particularly for working in the radiation environment. The tremendous growth in the application of radioisotopes, growing need for setting-up nuclear fuel front-end and beck-end technologies, post-irradiation examination of spent fuel towards health assessment of the plant, remote surveillance in and around nuclear installations, remote operations for nuclear emergencies, etc have necessitated in taking up development activities in the areas of remote handling and robotics. With this mandate, during mid-eighties ‘Division of Remote Handling and Robotics’ was formed in BARC. This paper brings out details of recent development activities in Bio-medical engineering and Healthcare recently carried out at BARC.

II. SPOT PICKER ROBOT FOR PROTEOMICS

This is a 3-axes robotic system designed for precise protein spot excision and to accurately pick spots from 2D gel electrophoresis. It is a challenging task to precisely identify and accurately position coordinates of all the protein spots in the 2D gel images, particularly faint and overlapping spots. Conventional filtering techniques in the image analysis pose difficulty in spot identification due to edge distortion. A non-separable wavelet based technique has been used for image analysis resulting in improved signal to noise ratio and also in minimising spot edge distortion. After detection of spots, excision of individual spots from the gel is another important task. A customised cutting tool with pneumatic actuated placement system has been developed and demonstrated for cutting of spots and disposal in the well-plate [1]. One such machine [Fig. 1, 2, 3] has been built and supplied to RMC, Mumbai.

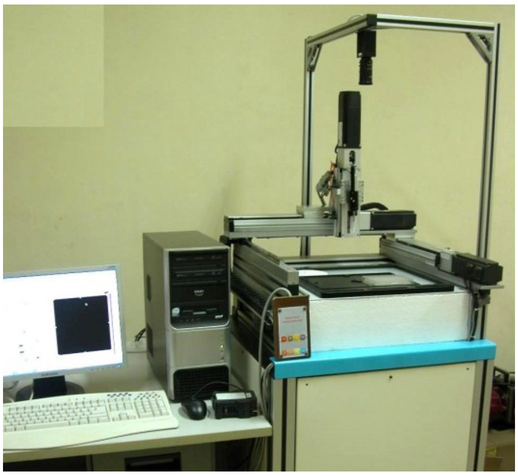

Fig.1: Spot Picker Robot

Fig.2: Spot Cutting Tool

Fig.3:2DGE Image Analysis

III. MICROARRAYER FOR DNA ANALYSIS

The Microarrayer is a very precise computer controlled 3-axes robotics system to deposit high-density, gridded arrays of DNA samples at discrete locations in microscopic quantities using contact printing technique. Such a capability permits gene expression experiments using tiny samples of genetic material, while obtaining simultaneous data on thousands of genes. It promises to make large-scale genetic variation (polymorphism) and high throughput mutation detection [2]. One such system has been built and supplied for lab trials [Fig. 4 and 5].

Fig.4: Microarrayer System

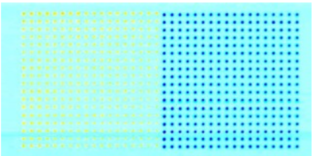

Fig.5: A Typical Genes spot pattern

IV. AUTOMATION SYSTEM FOR BIOASSY

As per regulatory requirements, radiochemical analysis of urine sample of radiation workers is carried out using ion exchange technique to analyse radio-nuclides. This takes about 8 Hours per sample for analysis and necessitates presence of the operator to ensure that the exchange column does not get dried. In order to overcome this, an automation system has been designed to increase the throughput and also to avoid any manual operation.

Automation system consists of 3-axes sample transfer robot, 12 resign columns and collection beakers. System is built with on-line pH measurement. Aliquot is transferred to the resin column using ceramic valve-less pump and nozzle cluster attached to the robot. After each sample transfer, tip is disposed-off and the new one is used for avoiding any cross contamination. System is designed for handling 12 samples at a time. Overall size of the system is 1600mmx900mmx1200mm. System configuration and monitoring is done using SCADA user interface. The flexibility of the system enables the user to assign any analysis type to any of the columns. The system records each operation for future verification of the process. Secure operator login is used to keep track all user activity such as acknowledgment of alarms and process bypass. Administrator interface is provided to change the parameters of the system, view user activity log and view error events. One such system has been manufactured, installed and is in use for Bioassy in BARC.

Fig. 6 shows photograph of RCA automation system.

Fig.6: RCA Automation System

V. COBALT BASED TELETHERAPY MACHINE FOR CANCER TREATMENT

With the increase in cancer cases detected every year, subsequently growing demand for affordable cancer treatment, BARC initiated indigenisation of telecobalt technology. This is computer controlled system to deliver planned amount of radiation exposure to the designated target safely and accurately. The machine, named as BHABHATRON, confirms international standards IEC-601 and IEC-60601-2-11 and same been type approved by AERB for its clinical use [3]. The technology has been transferred to M/S Panacea Medical Technologies Pvt. Ltd., Bangalore. Presently, about 30 such machines are in operation in various hospitals in India and a few in abroad, which are donated through IAEA. Fig. 7 shows Bhabhatron unit. Key technical parameters are given in Table-I.

Fig.7: Bhabhatron Unit

TABLE I: BHABHATRON-KEY TECHNICAL PARAMETERS

No.	Parameter	Value
1.	Source-to-axis Distance (SAD)	800mm
2.	Source Head Capacity (Max)	250 RMM
3.	Max. Dose Rate at SAD	390 cGy/min
4.	Max. Field Size at SAD	350mm x 350mm
5.	Min. Field Size at SAD	Completely closed
6.	Gantry	Motorised, ±180º
7.	Collimator	Motorised, ±90º
8.	Compliance	IEC-601-1, IEC-60601-2-11
9.	Regulatory Approval	AERB

VI. RADIOTHERAPY SIMULATOR FOR LOCALISATION OF TUMOR

The radiotherapy simulator, IMAGIN is a machine used for radiotherapy planning, prior to the treatment delivery. This helps in the diagnosis and localisation of the tumor, which requires radiotherapy treatment. This machine also confirms international standards IEC-601-1 and IEC-60601-2-29 and same been type approved by AERB for its clinical use [4]. Presently, four such machines [Fig. 8] are in operation in the hospitals in India. Key technical parameters are given in Table-II.

Fig.8: Radiotherapy Simulator: Imagin

TABLE II: IMAGIN-KEY TECHNICAL PARAMETERS

No.	Parameter	Value
1.	Focus-to-axis Distance (FAD)	800-1200mm
2.	Isocenter Height	1280mm
3.	Field size at FAD 1000mm	500mm x 500mm
4.	Field size at FAD 1000mm	400mm x 400mm
5.	Gantry (Motorised)	±185º
6.	Collimator (Motorised)	±100º (0-100º; 260-359º)
7.	Compliance	IEC-601-1, IEC-60601-2-29
8.	Regulatory Approval	AERB

VII. HDR SOURCE FOR BRACHYTHERAPY

Brachytherapy is one of the most efficient ways of treating cancers such as localized uterus cancer and cancers of the head and neck. In this therapy, a radioactive source is placed inside or next to the area requiring treatment. High Dose Rate (HDR) Brachytherapy is a commonly used for treatment of a large number of cancer patients. Applicators in the form of catheters are arranged on the patient. A high dose rate source (often Iridium- 192) is then driven along the catheters on the end of a wire by a machine while the patient is isolated in a room. The source remains in a preplanned position for a preset time to allow controlled doses of radiation to be delivered to the cancerous tissues [5].

Indigenously developed HDR source assembly consists of four high precision miniature SS micro machined components viz. Machine end terminal, Rope joining sleeve, Source retaining capsule and cover and two SS wire ropes of 0.91 mm dia. (machine end) and 0.74 mm dia. (source end). After welding with dummy source, samples were taken for qualification as per AERB/SS/3/Rev. 1 for type approval of sealed source classification C – 53312. Based on the successful qualification, AERB has given clearance for its clinical use [6]. Fig. 9 shows welded samples and Fig. 10 shows full length HDR source assemblies.

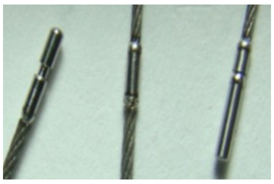

Fig. 9: Welded samples

Fig. 10: Full length HDR Source Assemblies

CONCLUDING REMARKS

The paper brings out a brief account of recent development work pursued at BARC in the area of Bio-Medical Engineering and Healthcare. In order to establish the system performance and reliability, prototypes have been manufactured, assembled and tested in the lab as per regulatory guidelines. Subsequently, design modifications have been carried out. Based on satisfactory performance and type-testing, design has been qualified for field deployment or clinical use in case of machines used in healthcare. The success in development activities described herein truly demonstrates in achieving self-reliance. Moreover, indigenous development of 'Bhabhatron' and 'Imagin' have resulted in making cancer treatment affordable to the common people. Further efforts are continuing in the indigenous development of Digital Mammography for detection of breast cancer, Servo controlled surgical tools, High precision surgical coordinate measuring mechanism for neuro-registration & neuro-navigation and High precision 6-dof robot for robot assisted neurosurgery.

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