A.1 Development and installation of multi-functional beam diagnostic device in TL-1 of Indus

A beam slit cum profile monitor has been installed in transfer line 1 (TL-1) of Indus. It is a multifunction diagnostic device. While it can be used as a slit with adjustable aperture to define the beam (similar to a beam scraper), it can also be used to determine the horizontal and vertical beam profile by measuring the current captured by the slit blade as it scans the beam in transverse direction. A fluorescent screen (Cr doped alumina) is mounted on each blade of the slit (Fig.A.1.1) which enables it to act like a conventional fluorescent screen for visually observing the beam profile by stopping the beam on one blade. As an adjustable "Hole" monitor, it allows a portion of the beam to pass through, while one can view the beam edges falling on the blades.

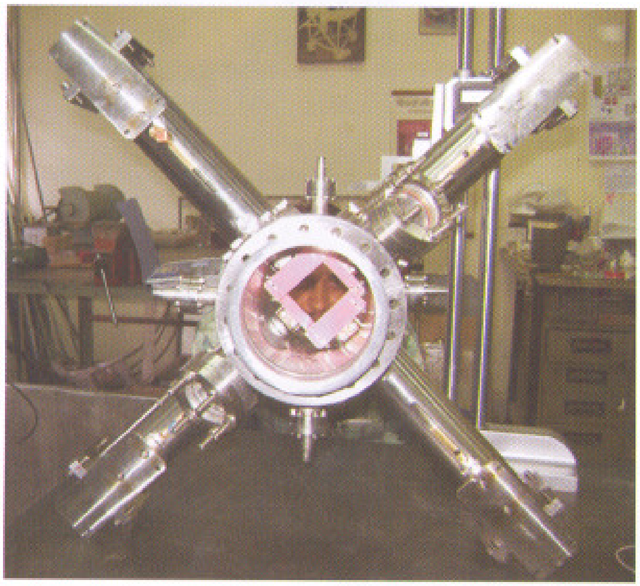

Fig.A.1.1: See through view of the monitor. The four blade movement mechanisms as well as the window for CCD camera placement are seen.

The device has four independent blades, two blades moving in opposing horizontal direction and the remaining two moving in vertical directions. The vertical blades have a linear stroke of 60 mm, and the horizontal blades 40 mm. This arrangement allows for positioning of the hole (and slit) in a field of 60 mm x 40 mm around the theoretical beam centre line. All the parts near the beam line are made of vacuum compatible, non-magnetic materials. The device operates under a vacuum of 10^{-7} mbar. The movement mechanism has a guiding arrangement to precisely maintain the orientation of the blades. It also has an anti-collision arrangement for the blades. The operation is done remotely. The work involved precision machining and welding. Its manufacturing, integration, testing and qualification were done in RRCAT.

Control system for TL-1 beam slit

A remote control for the blade movement is developed (see Fig.A.1.2). A VME based system with serial interface to PC was realized to control and position the blades. The system consists of a clock generator board, a de-multiplexer board, a relay output board, an opto input board, and a 12-bit ADC board. Eight opto-isolated clock signals are given to the stepper motor driver for clock-wise / anticlock-wise motor rotation. For each motor, two clock signals are required. The position of each blade is read from linear pot through ADC board.

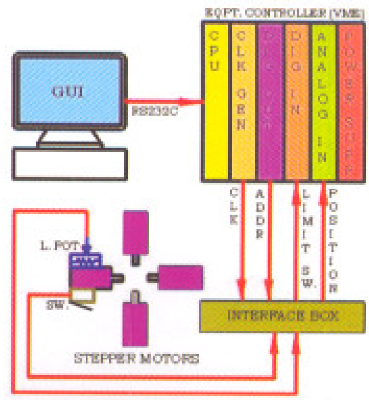

Fig.A.1.2: Block diagram of the slit control system.

Interface

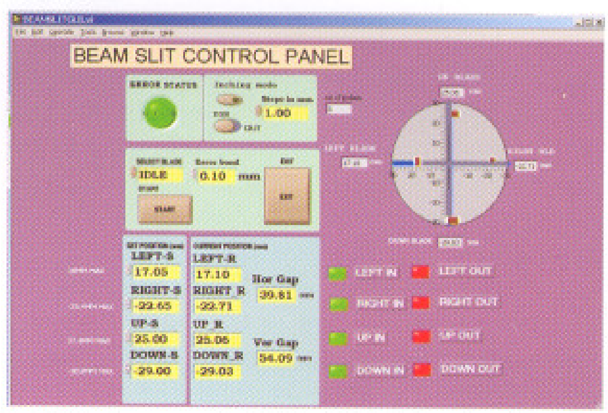

Fig.A.1.3: A screen-shot of the PC display showing control system GUI.

The interface box consists of stepper motor drivers, interlocks, and signal conditioning for position sensors. It provides 20 ppm stable reference to position sensors for long-term repeatability. In the interface box, hardwired logic was developed for providing safety interlocks to beam slit assembly. A GUI was developed in LabVIEW for remote control of the blade positions, display of the positions, and avoiding collision. Fig.A.1.3 shows a screen-shot of the PC display showing the GUI. The blades can be positioned in automatic or manual modes.

Qualification

The system was qualified for the movement range and smooth operation under actual conditions of use. It was also tested for its overall accuracy which is better than 0.1 mm. The system was also operated for large number of cycles to test the robustness of the design. The overall calibration factors (for converting positions into voltage and vice versa) for each blade were included in the system.

Installation

The Beam slit cum profile monitor, along with its control system, was installed in TL-1 in the first half of November 2007 (Fig.A.1.4) and it is being successfully used since then for its various functions, from the Indus control room.

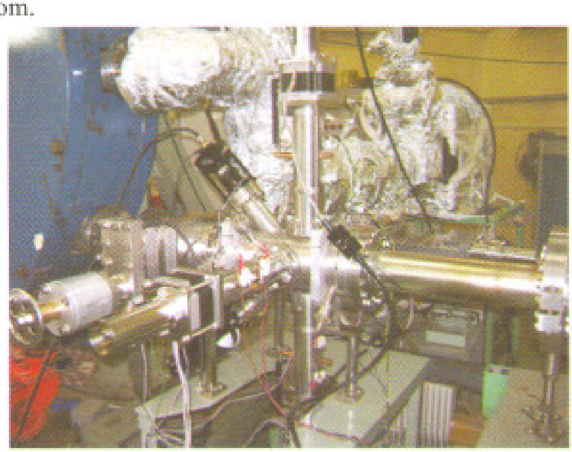

Fig.A.1.4: The monitor integrated in the TL-1. The microtron (blue) is seen on the left.

Utilization

An initial experiment was conducted to measure the horizontal beam profile. Right hand side blade of the slit was moved towards the beam in steps of 0.5 mm in the range of 6 mm to +2 mm keeping other three blades in OUT condition. Fig.A.1.5 shows the plot of signal level of blade current and two fast current transformers (FCT1 and FCT2) located downstream of slit in transfer line1 (TL-1) as a function of the blade position. Fig.A.1.6 shows the beam profile obtained by differentiating blade signal curve with respect to blade position.

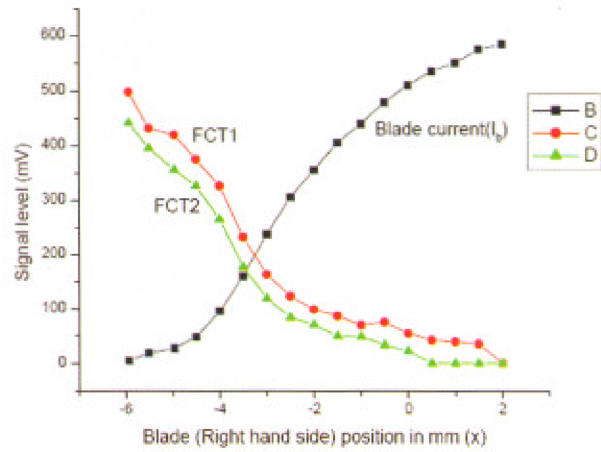

Fig.A.1.5: Variation of the slit blade current (B), FCT1 (C) and FCT2 (D) signals as a function of the blade position.

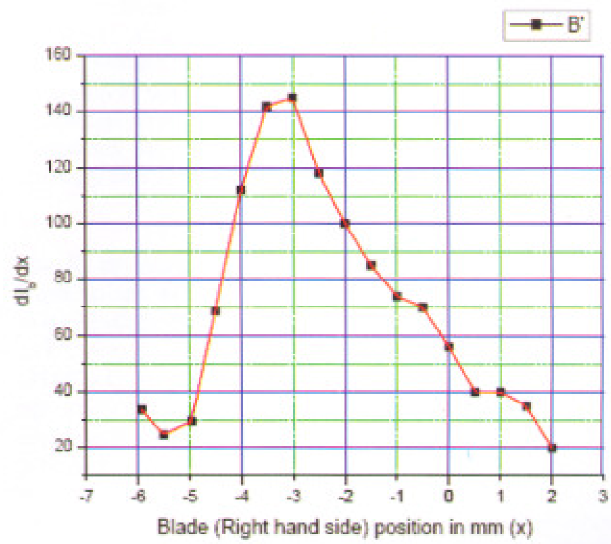

Fig.A.1.6: Horizontal beam profile obtained by differentiating the blade current signal curve with respect to the blade position.

The development and installation of this device was done by a team of engineers from Industrial & Medical Accelerators Section, Beam Diagnostics Section, RF Systems & Controls Division and its manufacturing was done by the Accelerator Component Engineering & Fabrication Division of RRCAT. The ceramic fluorescent screen was precision cut using Nd:YAG Laser in Solid State Laser Division of RRCAT.

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