EXPERIENCE OF BEAM DIAGNOSTIC SYSTEMS IN COMMISSIONING STAGE OF INDUS-2

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Abstract

Indus-2 is a 2.5 GeV synchrotron radiation source under commissioning at this centre. Beam injection trials in the storage ring began in August 2005. Beam diagnostics systems played an important role during commissioning of the storage ring. Beam diagnostic systems installed in the machine include beam profile monitor, orbit measurement system, wall current monitor, DCCT, strip lines, tune measurement system and sighting beam line. This paper describes the diagnostic systems, experience of operation of these systems during commissioning, results obtained and the present status. During the initial stages of beam injection and circulation in Indus-2, wall current monitors, beam profile monitors and sighting beam line proved to be of utmost help. In the current stage of near routine beam operation, the main focus has shifted to the measurement of beam parameters with the objective of improving beam current and lifetime.

INTRODUCTION

Indus-2 is a 2.5 GeV energy dedicated electron synchrotron radiation source. The accelerator complex is composed of injector microtron, booster synchrotron and Indus-2 ring. Two bunches of 550 MeV are extracted from the booster synchrotron and injected in to Indus-2 through 88 m long transport line–3 (TL-3). The length of each bunch is about 1 ns and separation between them is 31.6 ns. The process of commissioning of Indus-2 started in August’05. Initially beam injection was carried out at 450 MeV energy, which was later on increased to 550 MeV to achieve higher accumulation rates. After successful beam accumulation in the storage ring, energy ramping to 2 GeV was done. Table 1 summarizes the diagnostic devices installed in Indus-2. Fluorescent screen type beam profile monitors, wall current monitors, septum hole monitors and sighting beam line were used to transport the beam effectively through the beam transfer line and achieve beam circulation and accumulation in the storage ring during the initial beam injection and commissioning stage. The main focus has shifted to the measurement of beam parameters with the objective of improving machine performance in the current stage of near routine beam operation. Measurement of betatron tunes (Horizontal and vertical) and closed orbit distortion (COD) has been carried out [1,7].

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Table 1: Beam diagnostic devices in TL-3 and Indus-2

S. No.	Name of diagnostic device	Total number
1	Beam Profile Monitor	19
2	Wall Current Monitor	5
3	DC Current transformer	1
4	Beam Position Indicator	56
5	Strip line Monitor	6
6	Sighting Beam Line	1
7	Horizontal and vertical Scraper	3
8	Thick and thin Septum Hole Monitors	2

BEAM DIAGNOSTIC SYSTEMS

An overview of the beam diagnostic systems installed in TL-3 and Indus-2, experience gained during beam commissioning and the results obtained so far are presented in the following sections.

Beam profile monitor

Fluorescent screen beam profile monitors (BPM) are installed in TL-3 and the storage ring for visual observation of beam profile and position in transport line and the storage ring [2]. The BPM uses a fluorescent screen made of chromium-doped alumina, which can be inserted into the beam path by a pneumatic cylinder based linear motion mechanism. The spot of fluorescent light generated by the beam can be viewed by a CCD camera placed vertically above the beam plane. Remote operation of BPM is achieved by BPM interface units kept near the device and video signal multiplexers. A PCI based frame grabber card is used to capture and digitise the image for further processing. Figure 1 shows photograph of a BPM and the inset shows a typical electron beam profile. One-turn beam circulation was confirmed by observing the beam spot at all eleven BPM placed in the storage ring. The septum hole monitor is used to view the position of the beam at the entrance apertures of the thick and thin injection septum. The beam passes through an opening in a fluorescent screen mounted just a few millimetres upstream of the septum aperture. It has been found to be very useful in steering the beam though the injection septum during initial beam injection into the storage ring.

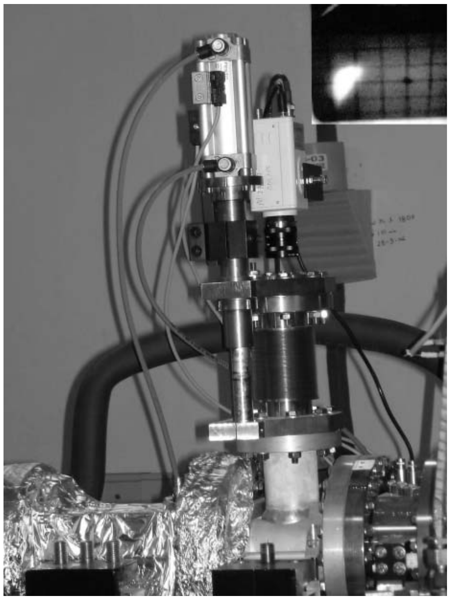

Figure 1: Photograph of beam profile monitor

Wall current monitor

Wall current monitor (WCM) is a non-interceptive beam diagnostic device, which monitors the image current flowing through the inner surface of the vacuum chamber. It is used to observe instantaneous bunch current signal. Four WCM are installed along the length of TL-3 to optimize the beam transport. Figure 2(a) shows typical bunch signals observed in TL-3. One WCM is installed in short straight section (SS-8) of the storage ring, which is used to observe beam injection and circulation in the ring. WCM proved to be very useful during commissioning to observe the circulation and survival of the beam in the ring. It was also used to optimize the timing of injection kicker magnet currents. Noise pickup from the pulsed magnets severely interfered with the bunch signal observation. The noise signal was reduced by using high pass filters at the input of the oscilloscope. Figure 2(b) shows three turn circulation of beam in the ring along with current waveform of one of the injection kickers. The spikes seen in the figure are the bunch signal. Also seen is the noise pickup from injection kickers. Figure 2(c) shows bunch pattern of the accumulated beam.

Sighting beam line

Sighting Beam line (SBL) is primarily used to observe the synchrotron light spot during commissioning of the machine. It is installed at 10^{o} extraction port of beam-line BL-27 of Indus-2 dipole DP-11. SBL is completely situated inside the radiation-shielding wall. Beam line has a mirror chamber with a water-cooled gold plated copper mirror placed at 45^{o} to the beam path. Metallic mirror absorbs the x-rays and reflects the visible part of synchrotron radiation, which is observed with a CCD camera. First synchrotron light was observed on December 2, 2005 using sighting beam line.

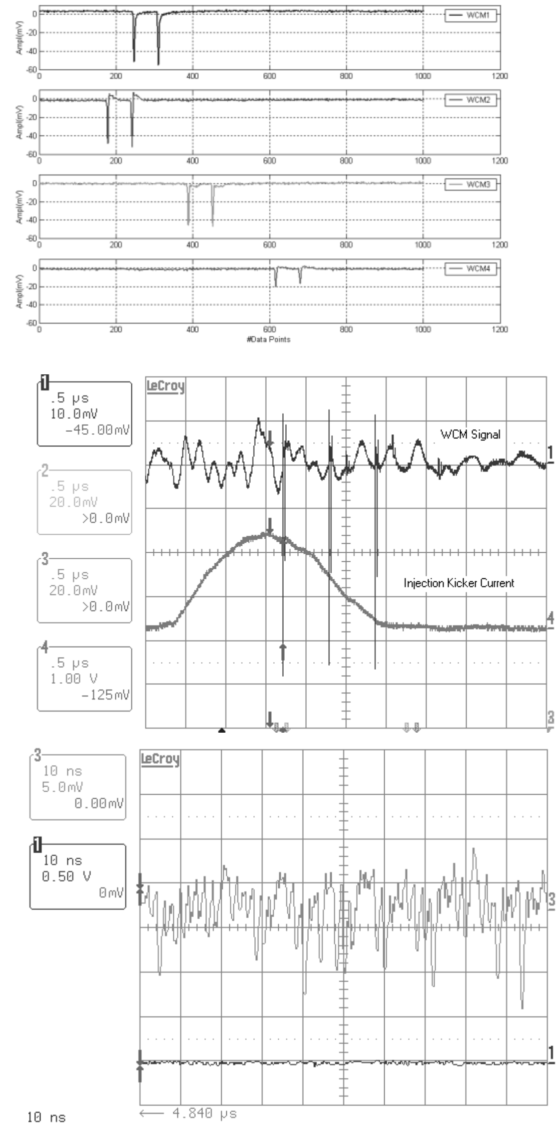

Figure 2 (Top to bottom): (a) Beam signals of TL-3 WCM (b) Three turn circulation of the beam in Indus-2 (c) Stored beam bunch pattern in Indus-2

Beam position measurement

Four-button electrode type beam position indicators (BPI) are used to measure closed orbit distortion in Indus-2. There are fifty-six BPI in the ring, seven in each unit cell. Out of these, forty BPI are of individual type, which are installed in the straight sections and sixteen are integrated type. One integrated type BPI is embedded in each dipole chamber. Individual type beam position indicators were calibrated on a calibration bench before installing in the ring [3]. The BPI signal processing modules Bergoz MX-BPM[4] are installed in eight electronics racks distributed symmetrically on the equipment gallery. The output of the processing electronics is acquired by 4-channel, 16 bit ADC cards and the acquired data is transferred to the control room, where beam position is calculated by using position algorithm. Four-corrector compensated orbit bumps were created in eight long straight sections of the ring and the beam position observed by two BPI falling within the bump zone to study the performance of the BPI system. This study revealed a bug in the software and wrong cable connection of BPI electrodes at one place. Orbit correction was done in horizontal plane using the best correctors [1,7]. Figure 3 shows a typical display of beam orbit in the main control room.

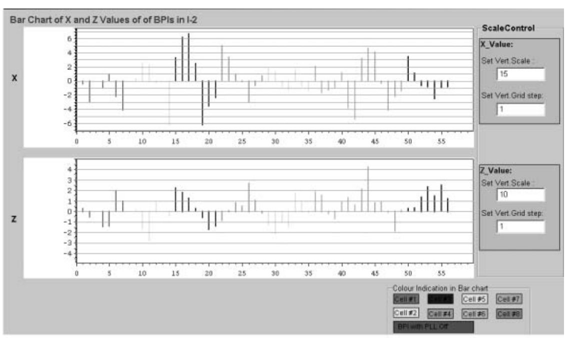

Figure 3: Beam orbit displayed in the control room

Betatron tune measurement

Betatron tune measurement system is based on continuous harmonic excitation method [5]. The measurement system employs a spectrum analyser equipped with a tracking generator. A VME bus based horizontal/vertical plane selector card allows the user to remotely select measurement of either horizontal or vertical tune. The tracking generator RF output, after splitting and amplification, is fed to a strip line kicker. Another strip line located downstream in the storage ring is used as a beam position monitor. The four strip line electrode outputs are used to produce real-time X and Z difference signals proportional to the beam position in horizontal and vertical plane. The position signal is then applied to the RF input of the spectrum analyser to observe the beam spectrum and betatron peaks. The betatron tunes in horizontal and vertical plane have been measured under various beam conditions [1].

Beam current measurement

Stored beam current is measured using parametric current transformer (DCCT) manufactured by M/s Bergoz [4]. A mounting system has been designed and fabricated for installation of PCT toroid [6], which includes features like ceramic gap, high frequency wall current bypass, thermal shield, temperature interlock system and a two layer magnetic shielding. A schematic of mechanical assembly is shown in fig. 4.

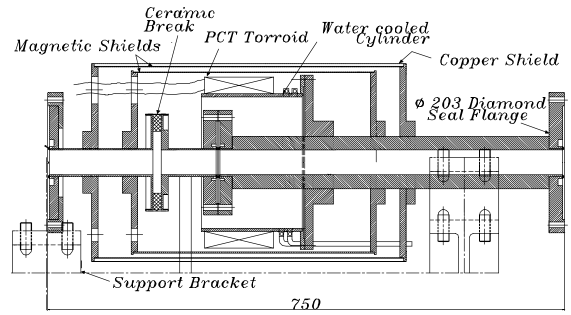

Figure 4: Schematic of DCCT Assembly

CONCLUSION

Beam diagnostic systems of Indus-2 have been commissioned. They have proved to be very useful during initial beam injection and commissioning phase of Indus-2. Exercises are currently being carried out to increase the beam current and energy and efforts are being made concurrently to study and improve the performance of diagnostic systems under different operating conditions. A preliminary exercise has been performed to correct the orbit in horizontal plane using beam position data, which has shown positive results.

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