INVESTIGATION OF INJECTION FOR THE LOW-EMITANCE LATTICE WITH NEW 6.25Ω KICKER MAGNET SYSTEM AT THE PHOTON FACTORY

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Abstract

We installed a 6.25Ω travelling-wave kicker magnet in the Photon Factory to obtain a wide acceptance for the injected beam into the low-emittance lattice. We investigated the injection for the low-emitace lattice of the Photon Factory with this kicker magnet. Since we have a SR monitor which source point is inside of injection bump, we used this monitor for the investigation of the injection. The pulse shape of the injection bump is measured by the imaging system with high-speed gated camera in the SR monitor by using a stored beam. The result of the pulse shape was agreed with the one by using a result of magnetic field measurement. An instantaneous beam profile of the injected beam was observed in turn by turn by using the same focusing system. We measure the turn by turn position of the injected beam from this observation. A smear out of coherent oscillation by nonlinear effect is also obserbed

INTRODUCTION

We installed a new kicker magnet system in 2002 in the Photon Factory (PF) to realize a full aperture injection for the small emittance lattice [1]. The new kicker magnet is based on travelling wave kicker magnet with a characteristic impedance of 6.25Ω. The pulse duration time of new kicker magnet through a magnetic field measurement is 1.25μsec. Since revolution time of the PF storage ring is 0.624 μsec, we can realize full aperture injection with new system. In order to investigate performance of the pulse injection bump with new system, we used an optical observation method with high speed gated camera. Since we have a SR monitor which has a SR source point in the injection pulse bump at the Photon Factory, we can observe directory the performance of injection bump with the turn by turn observation of the position of beam image using the beam profile monitor with a high-speed gated camera. The principles of gated camera operation are well covered in a paper on its application to measure the turn-by-turn transverse beam size at the SLC damping ring [2]. Also one of the authors have used this technique to measure the beam blow-up in KEKB due to the electron cloud effect [3]. The motion of the injected beam is also investigated by same optical observation method.

6.25Ω TARAVELLING-WAVE KICKER MAGNET

A travelling-wave type kicker magnet with a characteristic impedance of 6.25Ω is designed and constructed for the injection [1]. The magnet consists of 30 cells of π-component. Each π-component has a capacitor using an alumina-ceramic plate as a dielectric material to realize a large capacitance. The high voltage plate in the capacitor is insulated by silicon-rubber molding. A photograph of the kicker magnet installed in the PF ring is shown in Fig.1

Fig.1. A photograph of the kicker magnet installed in the PF ring. The kicker magnet is covered with a shield box made of aluminium.

We apply a short end for the output lead of the magnet to excite the magnet with input pulse and totally-reflected pulse from the short end. With this excitation scheme, the peak current in the magnet becomes twice.

PULSE DURATION OF KICKER MAGNET WITH MAGNETIC FIELD MEASUREMENT

The magnetic pulse duration of the 6.25Ω kicker magnet was measured with a single-turned search coil [1]. A result of magnetic pulse duration is shown in Fig. 2.

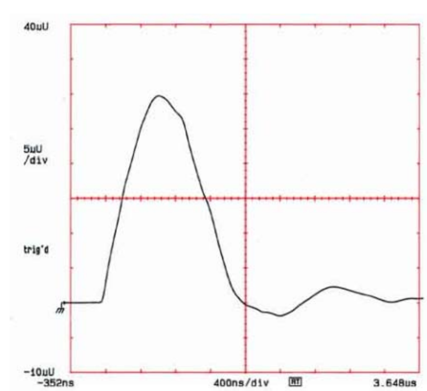


Fig. 2 Magnetic pulse duration of kicke rmagnet measured with single turned search coil.

From this magnetic field measurement, we obtained a result of pulse duration time 1.25μsec.

SETUP OF OPTICAL OBSERVATION

We have a SR monitor which SR source point is located in B27. B27 is located in the injection pulse bump at the Photon Factory [1]. We use 4 kicker magnets to excite an injection pulse bump. The arrangement of kicker magnets is shown in Fig. 3. Since the source bending magnet B27 is located between kicker magnet No.3 and N.4, we can observe the image of stored beam just passing through the bump orbit in the B27.

The optical layout of the SR monitor is also shown in Fig.3 [4]. The light from the synchrotron radiation source magnet follows a 8m path to the underground optical hatch where the focusing system and the gated camera are installed. A doublet lens with focal length of 1000mm is used as a objective lens. The diameter of the objective lens is 80mm. A magnifying lens is installed in front of the gated camera. This focusing system is designed to have an angular acceptance of +/-3mrad and a position acceptance of +/-16mm. These acceptances are wide enough for the observation of the bump orbit and the coherent motion of injected beam.

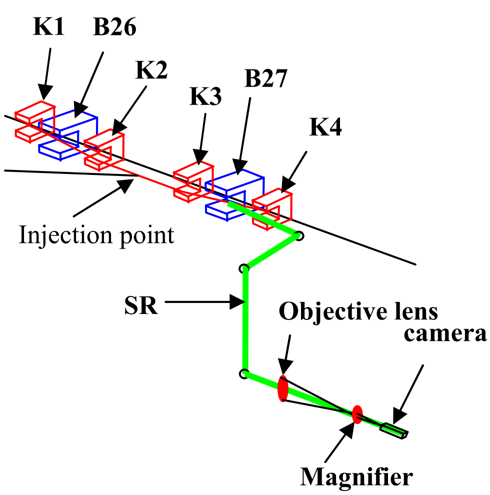


Fig 3. Arrangement of kicker magnets and optical layout of the SR monitor. K1,2,3,4 denote kicker magnet No.1,2,3,4, respectively. B26,27 denotes bending magnet No.26,27.

OBSERVATION OF INJECTION BUMP

In order to investigate pulse shape of the injection bump, we measure the beam position with focusing system by scanning the kicker magnet timing. We can evaluate the pulse bump shape at the injection point to re-scale the measured pulse bump shape at the source point in the bending magnet. A result of the injection bump shape is shown in Fig. 5. From this optical measurement, we obtained a result of pulse duration time 1.25μsec. This result is agree with one from the magnetic field measurement by the single magnet. Considering the bump orbit is exited by four independent kicker magnets, this result shows the timing errors in the four kicker magnet are negligible small.

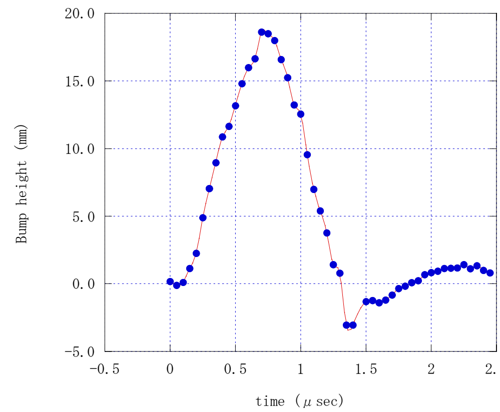


Fig. 4 Duration of injection bump measured by optical observation.

MEASUREMENT OF TURN BY TURN PROFILE OF INJECTED BEAM

A turn by turn image of the injected beam is observed with same optical observation method. At the beginning of the observation, we set the design intensities for four kicker magnets. Figure 5 shows a result of first 15 turns of the injected beam superimposed in one frame of CCD with this condition of injection bump. The beam image separately located in the left side is the beam just came from septum magnet. In the right side, we can see the first 15 turns of the injected beam. The amplitude of coherent motion in this condition is about +/-5mm. From this picture, we can see only the beam come from the septum magnet is located in the injection bump.

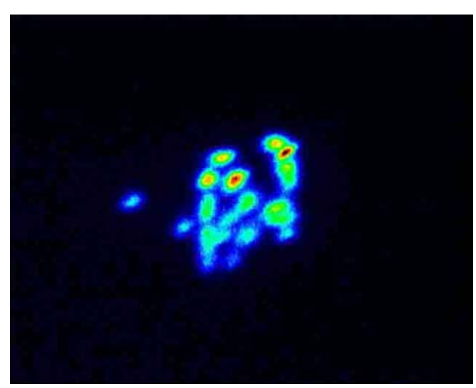
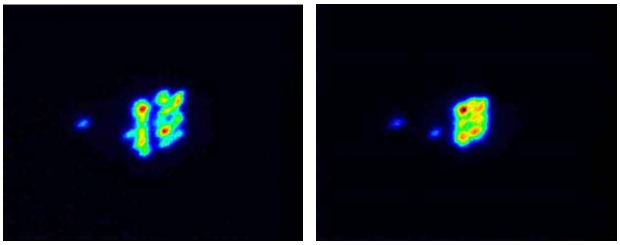


Fig. 5. Result of coherent motion of first 15 turns of the injected beam. The images are superimposed in one frame of CCD

A vertical coherent oscillation is also observed as shown in Fig.5. By using this observation system, we can optimize the intensity balance of four kicker magnets to realize a closed bump. Figure 6 shows two images of first

15 turns of the injected beam observed in the two stages of regulation of the kicker magnets.



(a) (b)

Fig. 6 Two images of first 15 turns of the injected beam observed in the two stages of regulation two kicker magnets. (a):Regulate K4only, (b):regulate K3 and K4.

In the first stage, we regulate the kicker magnets No.4 to find a closed bump condition. The result is shown in Fig. 6 (a). By this regulation, the coherent oscillation of the injected beam becomes smaller In the next stage, we add a regulation of kicker magnet No.3 together with No.4. The result of regulation is shown in Fig.6 (b). The coherent oscillation in the horizontal and the vertical becomes smaller than the result in first stage. The vertical oscillation is still observed. From Fig.6 (b), only the injected beam come from septum magnet is located in left side, and later turns oscillate in the right side like as a bulk. This result shows the injection pulse bump is turn off for the next turn of injected beam.

MEASUREMENT OF COHERENT OSCILLATION OF INJECTED BEAM IN LOW-EMITTANCE LATICE

The coherent oscillation of the injected beam in the first 15 turns of low-emittance lattice is shown in Fig. 7. In this case, we found a better condition for closed bump. The coherent oscillation of the injected beam is observed by measuring the position of injected beam profile. Result for first 25 turns of coherent oscillation in the horizontal direction is shown in Fig. 8. From Fig.8, the amplitude of the coherent oscillation is about +/-3mm. After 25 turns, the beam profile deformed due to strong nonlinear effect and difficult to evaluate the beam position. Figure 9 shows two exampls of deformed beam profile at 50th-turn and 80th-turn.

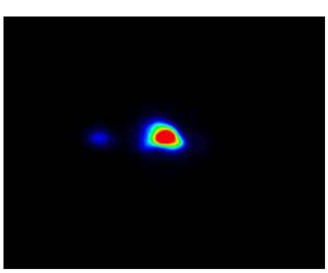


Fig. 7 Coherent oscillation of the injected beam at first 15 turns in low-emittance lattice.

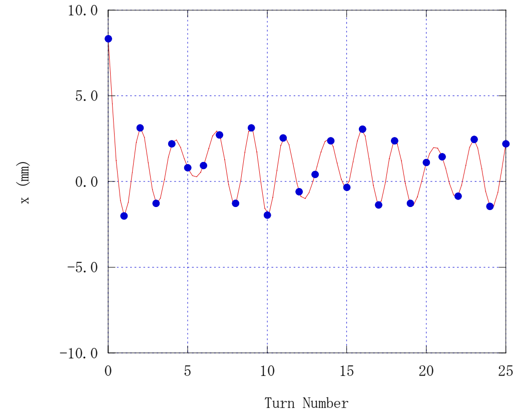
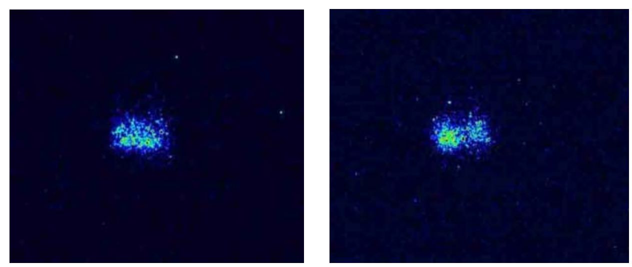


Fig. 8 Coherent oscillation of injected beam in the first 2 turns in the horizontal direction.



(a) (b)

Fig. 9 Deformed beam profiles at 50th-turn (a) and 80th-turn (b).

CONCLUSIONS

We installed a 6.25Ω travelling-wave kicker magnet in the Photon Factory to obtain a wide acceptance for the injected beam into the low-emittance lattice. The injection bump and the motion are investigated by an optical observation method. From the turn by turn observation of the injected beam, we regulated the injection bump. The injection pulse bump is turn off for the next turn of injected beam. We observed the coherent oscillation of injected beam. After 25 turns, the beam profile deformed due to strong nonlinear effect

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