Transverse Tracking Studies in the PEFP RCS*

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1. Introduction

The Proton Engineering Frontier Project (PEFP) proposes the 1-2GeV Rapid Cycling Synchrotron (RCS) accelerator as an extension of 100MeV, 20mA pulsed proton linear accelerator [1, 2]. At the initial stage, the PEFP RCS is to have 1GeV extraction energy and a 15 Hz repetition rate and the target beam power is about 58 kW. The RCS is composed of magnet lattice of main ring, injection system and extraction system. The slow extraction scheme as well as fast extraction is considered to provide users with more diverse beam, therefore the resonance control could be important.

The PEFP RCS has a four fold symmetric structure and 5 FODO modules constitute each super-period. Although the low-order machine symmetry can give a dangerous low-order structure resonance, two or four symmetric lattice structure is usually accepted to ensure the space for other essential machine functions [3]. Figure 1 shows the lattice structure and the naming scheme of super-period "A", which are main components of the lattice of the PEFP RCS. In the vicinity of each quadrupole, there are corrector magnets and multi-pole package including the pick-up electrode or beam position monitors to correct closed orbit and any non-linear resonances. The parameters of the PEFP RCS including the basic lattice parameters are represented in Table I.

In this paper, the transverse tracking studies of a single particle are accomplished in the lattice of PEFP RCS such as closed orbit correction, chromaticity correction and the third order resonant beam simulation for a slow extraction. All of this transverse tracking studied are achieved by using the MAD8 program as well as a simulation of resonance [4].

Table I: Lattice Parameters of PEFP RCS

Circumference [m]	224.16
Super-period	4
Betatron Tune(Qx/Qy)	4.39/4.29
Injection energy	0.1
Extraction energy	1.0
Number of dipole	32
Number of quadrupole	40
Number of sextupole	14
Number of corrector	40
Chromaticity (X/Y)	-4.84/4.20
Transition gamma	4.40
Momentum Compaction	0.051

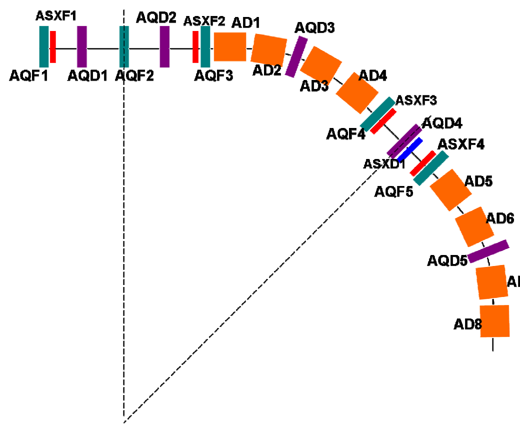

Fig. 1. Lattice layout and naming scheme in "A" super-period

2. Closed Orbit Distortion and Correction

Under the random errors of lattice such as magnetic field errors and alignment errors, the closed orbit distortion (COD) correction should be checked to maintain the beam stability. In this simulation, the magnetic field error is assumed by (dB/B) = 10^{-4} for both dipole magnet and quadruopole magnet, and the displacement errors are dx =dy = ds = 0.3 mm and the rotation error is dθ = 0.2 mrad.

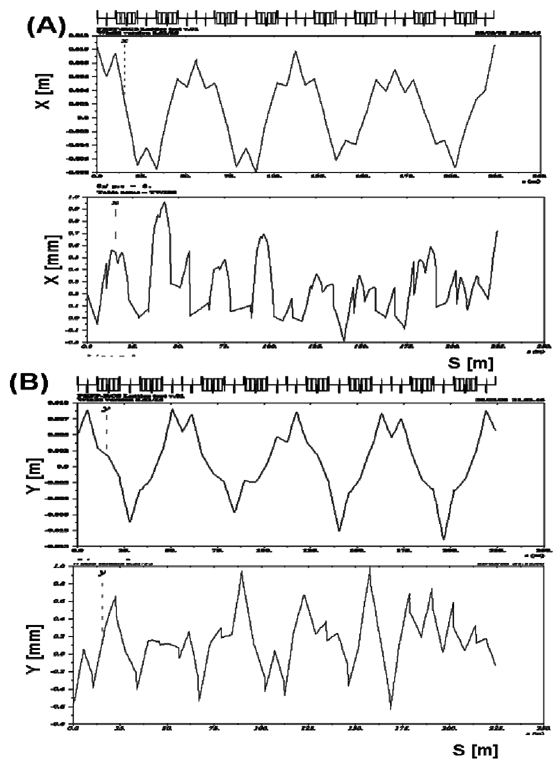

Fig. 2. Closed orbit distortion before correction (upper figure) and after correction (lower figure) for (A) horizontal plane

and (B) vertical plane.

Figure 2 show the closed orbit distortion before correction and after correction for (A) horizontal plane and (B) vertical plane, respectively. The maximum orbit distortion of x/y is to be within ±10 mm before correction and ±1 mm after correction. The number of used corrector magnets to correct errors is 40, which are 20 horizontal correctors near a focusing quadrupole and 20 vertical correctors near a defocusing quadrupole. The maximum field strength of corrector magnet for the closed orbit correction is 0.016 Tm.

3. Chromaticity Correction

In this section we investigate the chromaticity correction by using the sextupole magnets in the arc section. The natural chromaticity of the PEFP RCS is dQx/(dP/P)=-4.84 and dQy/(dP/P)=-4.84. Assuming a ±1% momentum spread at maximum, the tune spread due to the natural chromaticity become ±0.048 and ±0.042 for a horizontal and vertical tune, respectively.

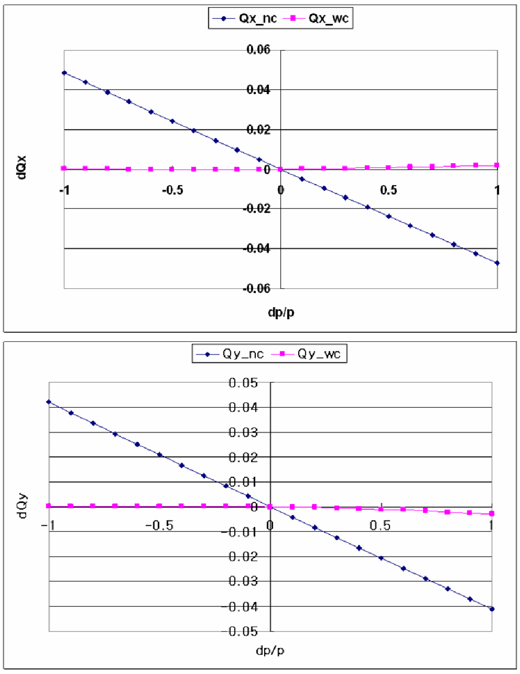

Fig. 3. Tune shift as a function of momentum spread for horizontal tune (upper figure) and vertical tune (lower figure).

The used sextupoles for the chromaticity correction are ASXD1, ASXF3, ASXF4, CSXD1, CSXF3 and CSXF4 and the required field strength to correct the tune spread is 3.6/9.15 (T/m^2) for SFX/SDX, respectively.

4. Resonant Beam for Slow Extraction

The PEFP RCS slow extraction system will make use of the horizontal third integer resonance at the tune 13/3, which is much lower than the nominal tune as shown in Table I. Hence we assume the 1% momentum spread to enter the third integer stopband driven by sextupole fields. A third integer resonance is achieved by two sextupole pairs located at ASX2, CSX2, BSX2 and DSX2. The desired resonance depends on the sign choices of each magnet pair. The signs of each pair in the symmetric points is (+,-) so that the extraction resonance should be the third integer due to the odd harmonic. Figure 4 shows the simulation result of the separatrix triangle due to the third integer resonance. The field strength of used sextupole for the third integer resonance is ±5.378 T/m^2.

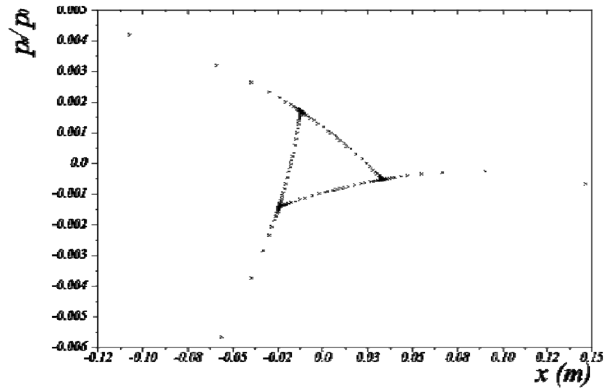

Fig. 4. Simulation results of the separatrix triangle due to the third integer resonance.

5. Conclusions

The transverse tracking studies of a single particle for the PEFP RCS have been accomplished by using the MAD8 program. To achieve the COD correction, we used 40 corrector magnets and 40 beam position monitors. The tune spread due to the natural chromaticity is ±0.048/±0.042 for horizontal/vertical tune, respectively, under ±1% maximum momentum spread. The resonant beam for slow extraction is obtained by the third integer resonance at the tune 13/3.

REFERENCES

[1] B. H. Choi, Status of the PEFP, Proceedings of PAC05 (Knoxville, TN, 2005), p. 576.
[2] B. Chung, Y.Y. Lee and Y. S. Cho, Conceptual design of the PEFP Rapid Cycling Synchrotron, Proceedings of PAC07 (Albuquerque, NM, 2007), p. 2817.
[3] Jie Wei, Synchrotron and accumulators for high-intensity proton beams, Rev. Mod. Phys, Vol. 75, 2003, p. 1383.
[4] H. Grote and C. Iselin, The MAD Program (version 8.19), CERN/SL/90-13(AP).

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