ORBIT CALCULATIONS OF TARN AND ITS OPERATION CHARACTERISTICS

A. Noda, T. Hori*, T. Hattori, M. Mutou,
T. Katayama and H. Sasaki**

Institute for Nuclear Study, University of Tokyo
* On leave from Sumitomo Heavy Industries Co. Ltd.
** National Laboratory for High Energy Physics

Abstract

The closed orbits and beta-functions of TARN for various fractional momenta around the central one are calculated by the computer code SYNCH. The work line for an RF stacking process is also studied experimentally by an RF knock-out method. A chromaticity controle system with sextupole magnets is designed and fabricated.

1. Introduction

It is important to choose an optimum operation point to accumulate ions in the storage ring. Especially in TARN, an RF stacking is applied and the momentum spread of the accumulated beam is large ($\sim \pm 3\%$). From the point of view of avoiding lower order single particle resonances, it is desirable to make the chromaticity as small as possible, while some amount of chromaticity is needed to surmount the transverse coherent instability by Landau damping.[1] In order to control the work line, the chromaticities in both horizontal and vertical directions should be variable and a correction magnet system of sextupoles is to be used for this purpose.

2. Numerical Calculation of Closed Orbits and Beta-functions

The lattice structure of TARN is a separated function FODO type.[2] The arrangement of the magnets is shown in Fig. 1. The linear elements such as drift space, dipole and quadrupole magnets can be treated by the use of transfer matrices. In the present calculation, non linear elements such as sextupole magnets are linearized in a neighbourhood of the closed orbit.[3] In TARN, the momenta of injected ions are decelerated by the amount of about 6% and moved to the inner side of the ring.[4] The closed orbits and beta-functions for various fractional momenta are calculated by the method described above. The calculated relations between tune values and fractional momentum is given in Fig. 2 by solid lines.

3. Experimental Study of the Work Line by an RF Knock-out Method

The amplitude of betatron oscillation is increased when an external RF field is applied in a transverse direction and the frequency of the field satisfies the following condition,

$$f_{KO} = m \cdot f_r + c \cdot f_r \qquad (m = 0, \pm 1, \pm 2, \cdots) ,$$

where f_r is the revolution frequency of the ion and c is the fractional part of the ν-values.[5] By applying a pulsed RF in such timing as shown in Fig. 3(a) and observing the resonant frequency, at which the beam is kicked out as shown in Fig.3(b) the ν-value is experimentally obtained. The result is shown in Fig.2 by open circles. The horizontal chromaticity is measured to be smaller than the calculated value.

4. Correction of the Chromaticity by Sextupole Magnet System

The contribution of sextupole magnets to the chromaticities is given by

$$\frac{d\nu_x}{d\delta} = \frac{1}{4\pi}\int \frac{B''}{B_\rho}\cdot\eta\cdot\beta_x \quad ds \qquad \left(\delta = \frac{\Delta P}{P}\right)$$

$$\frac{d\nu_z}{d\delta} = -\frac{1}{4\pi}\int \frac{B''}{B_\rho}\cdot\eta\cdot\beta_z \quad ds.$$

From these equations, it is known that two families of sextupole magnets are needed, which locate at the positions where β_x, β_z and η have different values from each other. Therefore twelve sextupole magnets are used as shown in Fig. 1.[6]

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References

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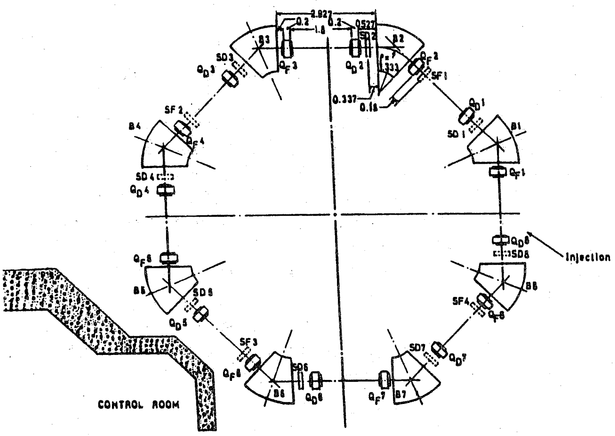


Fig.1 Arrangement of the magnets for TARN.

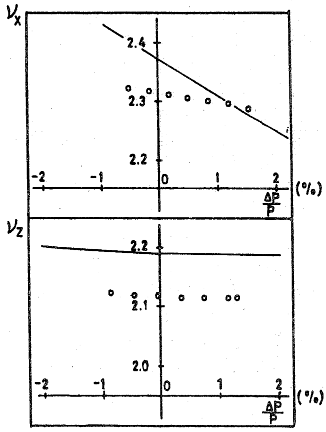
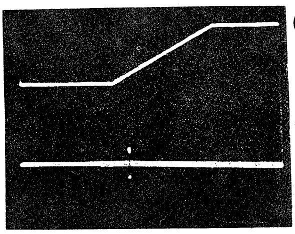


Fig.2 ν-values for various fractional momenta.

Fig.3



(a) Upper; Sweep signal of RF frequency for stacking,
Lower; the pulsed RF.

(b) Upper; Beam signal from ES monitor,
Lower; the pulsed RF.