CHROMATICITY CORRECTION IN KEK MAIN RING

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Two families of sixteen sextupole magnets are used to control the chromaticity, i.e., the dependence of the tune on momentum. They are consisted of those near focusing quadrupoles; S_F, and those near defocusing quadrupoles; S_D. They are separately powered to control horizontal chromaticity ($\xi_H = \partial\nu_H/\partial p$) and vertical one ($\xi_v = \partial\nu_v/\partial p$) independently.[1]

Chromaticity for some correcting pattern are shown in Fig.1. Fig.2 shows correcting current and strength of sextupoles respect to Fig.1.

Chromaticity was determined from measuring kicked coherent betatron oscillations in few hundred revolutions for various momentum shift which was caused by giving offset bias to r.f. feedback. In correction pattern III, measurements were not performed later more than 300 msec after acceleration start, but it is expected from the relation between pattern II and pattern III that chromaticity must be almost zero for those time.

The correcting sextupole current are determined from the matrix equation,

$$\begin{pmatrix} \xi_H \\ \\ \xi_v \end{pmatrix} = \begin{pmatrix} \xi_H^0 \\ \\ \xi_v^0 \end{pmatrix} + M \begin{pmatrix} B''_{S_F} \\ \\ B''_{S_D} \end{pmatrix}$$

where $M_{11} = \frac{1}{4\pi B\rho} \int_{S_F} X_{eq}\beta_H ds$ and other terms are like this.

Dominant terms of ξ_H^0 and ξ_v^0 are due to the variation of the focussing strength of quadrupoles, and sextupoler field (B''_e) in the guiding field. The former is about -8.2 and -7.8 for $\nu_H \simeq 7.1$, $\nu_v \simeq 6.2$, and the latter is about 6.3 B''_e/B and -5.9 B''_e/B, respect to horizontal and vertical. Dominant part of B''_e at injection porch is induced with the finite permeability of the vacuum chamber.

With respect to eddy current, the maximum contribution to B''_e/B is about $-0.33/m^2$ per one bending magnet and its effect is negligibel after 100 msec from acceleration start (see real line in Fig.1(a)). Sextupoler field in bending magnets after 200 msec from acceleration start is larger by about 70 % than the results of field measurements.[2]

Octupoler tune shift is caused by sextupoles[3] and shown in Fig.3. Agreements between the measurement and calculation are good enough. Moreover, the deviations of beta (β_H and β_v) and momentum dispersion function (X_{eq}) are also caused.[4] Fig.4 shows results of calculations. Deviations of β_H and X_{eq} are small but that of β_v is respectively large. In this time these shift and deviation are not cured but they must be corrected.

References

1) A. Ando et al., Proc. 5th Int. Conf. on Magnet Technology, Frascati (1975).
2) T. Kasuga et al., ibid.

3) A. Schoch, CERN 57-21.
4) E.D. Courant and H.S. Snyder, Anal. of Physics, 3 (1958), 1.

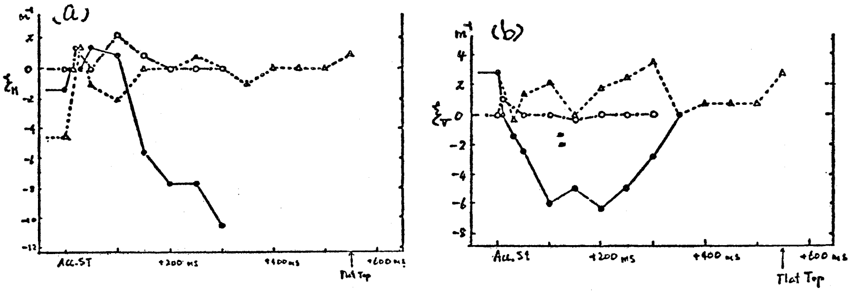

Fig.1 (a) horizontal and (b) vertical chromaticity from the injection porch to flat top start. Closed circle and real line: Pattern I, triangle and broken line: particle II, open circle and dotted-line: Pattern III.

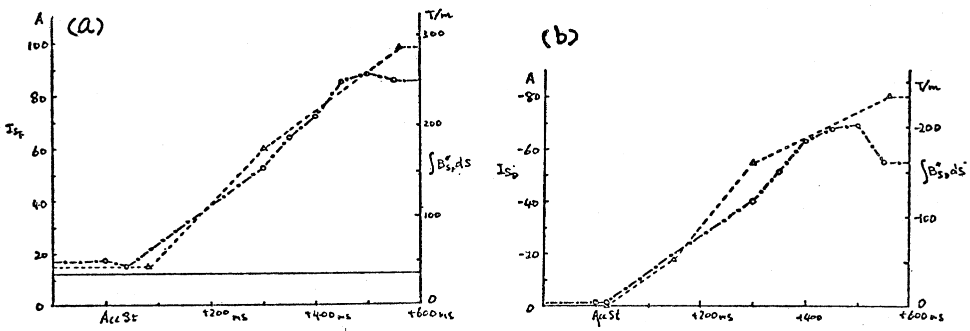

Fig.2 Correcting current and strength of (a) S_F, and (b) S_D (= 0 in pattern I.)

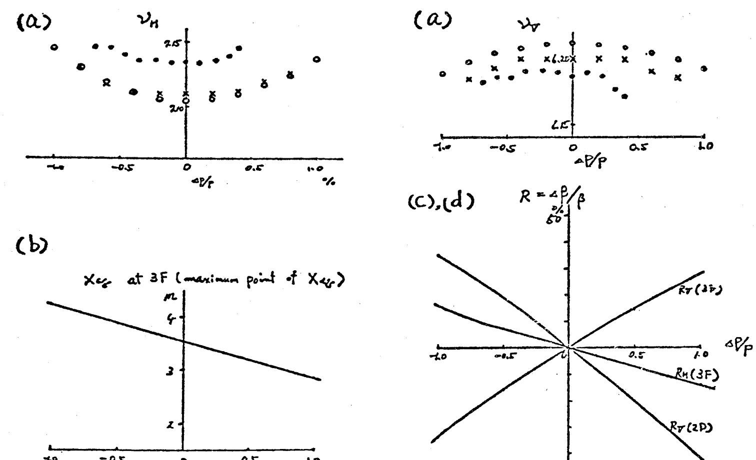

Fig.3 (a) tune shift vs. momentum shift at the injection porch. Closed circle is measurements, open circle is analytical calcualtion, and cross is results of particle tracking.
(b), (c) and (d) are deviation of X_{eq}, β_H and β_V, respectively calculated analytically.