BALKAN PHYSICS LETTERS

10 February 2010
BPL, **18**, 181016, pp. 126 - 130 (2010)

THE DESIGN OF BOOSTER RING FOR SYNCHROTRON RADIATION OF THE TURKISH ACCELERATOR CENTER

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Abstract. - The Turkish Accelerator Center (TAC) is a project for accelerator based fundamental and applied researches supported by Turkish State Planning Organization (DPT)[1]. The Proposed complex is consisted of 1 GeV electron linac and 3.56 GeV positron ring for a charm factory and a few GeV proton linac. Apart from the particle factory, it is also planned to produce synchrotron radiation from positron ring.
The third generation light source of the TAC complex has three main part, respectively injector linac, booster ring and storage (main) ring. In this study, we investigated that the design of booster ring of the positron storage ring is made to produce third generation synchrotron radiation of the Turkish Accelerator Center Project. The main goal of the booster ring is, to coming injector linac positron bunches which have 0.2 GeV, raising to 3.56 GeV. Thus, the lattice structure of booster ring has been studied.

In the booster ring of the TAC storage ring, the positron beam is injected at 0.2 GeV and ramped up 3.56 GeV. Booster rings are build up with different magnet lattices; the focusing-defocusing (FODO), the double bend achromat (DBA), the triple bend achromat (TBA), particularly, are build up with FODO magnet lattices. We investigated a DBA lattice base on defocusing combined magnet. The use of combined function magnet has the advantage of the reducing number of magnets and decreasing beam emittance by introducing additional damping due to the field gradient. However, this reduces the flexibility of the lattice [2].

Thus, we can consider correction quadrupoles each side around dipole magnets, in order to solve this problem. The particle beam emittance of each lattice structure can be expressed as [3].

$$\epsilon_{x0} = f.\frac{1}{12\sqrt{15}}.C_q.\gamma^2.\frac{1}{J_x}.\theta^3 \tag{1}$$

where θ is the deflection angle of the bending magnet, f is a so called quality factor for each lattice structure, γ is the relativistic Lorentz factor, J_x is the horizontal partition factor and $C_q = 3.84 \times 10^{-13}$m.

1. BOOSTER LATTICE

The optic design of the booster ring has been studied by DBA lattice with 16 superperiod, each with a defocusing gradient dipole magnet and a doublet quadrupole. The DBA lattice, composed of N_p periods with iso-magnetic dipoles and $\theta_p = \frac{2\pi}{N_p}$ bend angle per period, have a minimum emittance given by below eq.(2)

$$\epsilon_{DBA} = C_q.\frac{\gamma^2}{4\sqrt{15}}.\frac{\theta^3}{J_x}.\frac{1}{8} \tag{2}$$

The circumference of the booster ring 204 m and the magnetic lattice with combined function dipole magnets provide an equilibrium emittance as low as 0.35 nm.rad at 0.2 GeV injection energy. However, the positron beam emittance is increased to 110 nm.rad by optic lattice of the booster at 3.56 GeV extraction energy.

Dipole magnetic field strengths must be increased while acceleration from injection to extraction, in order to bind same curvature all positron particles. So, the magnetic field of the dipole should be increased from 0.097 T to 1.72 T. Figure 1 presents lattice functions of the half of the booster ring. It was investigated with MAD-X [4].

Table 1 presents main parameters of quadrupoles and dipoles magnets for lattice option of DBA. Table 2 presents main parameters of the booster ring.

Table 1: Main parameters for quads, dipole magnets for lattice option of DBA

DBA	Quad	Dipole
Number	Q1/Q2/Q3	M1
Length[mm]	400/160/250	1350
Strength[$1/m^2, 1/m^2, 1/m^2$]	1.32/-1.49/1.5	-0.33
Angle[rad]	—	0.196
Magnetic Field [T]	—	min.0.097/max.1.72

Figure 2 presents tune diagram of the booster ring. It was investigated with OPA [5]. It seems the tunes are too close to a destructive sum resonance. Therefore, it has

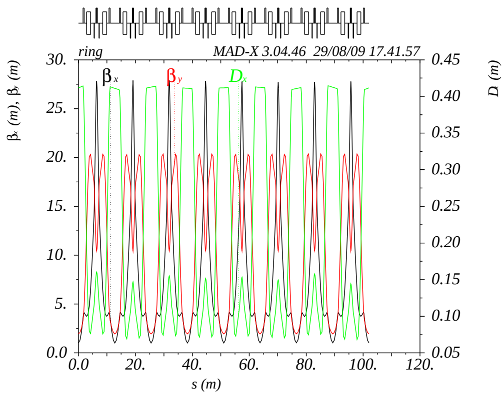

Figure 1: Lattice functions of the booster ring

Table 2: Main Parameters of the booster ring

Booster Ring	Injection	Extraction
Energy spread	0.0007	0.13
RF frequency [MHz]	500	500
Horizontal emittance at 0.2 GeV ϵ_x [nm-rad]	0.35	110
Vertical emittance at 1 GeV ϵ_y [pm-rad]	3.45	1100
Betatron tunes $[Q_x, Q_y]$	9.2, 5.6	9.2, 5.6
Natural chromaticities $[\xi_x, \xi_y]$	-17.3, -15.4	-17.3, -15.4
Beta Functions at long straight section		
Horizontal Beta [m]	3.6	3.6
Vertical Beta [m]	3.3	3.3
Dispersion [m]	0.41	0.41

to been moved closer to non-destructive difference resonance. Figure 3 presents the circumference of the booster ring.

2. CONCLUSIONS

We have studied DBA lattice according to optic design goal for TAC-Booster ring extraction energy 3.56 GeV. However, it need to be optimized according to Dynamic Aperture (DA) and alignment tolerances.

While the positron beam is accelerated at booster ring, dipole magnetic fields should be controlled. On the other hand, the optic design need to be optimized according to RF requirement. During the beam is injected from booster ring to storage ring, the phase of the beam should be kept constant (i.e. isochronous). With the 500 MHz RF frequency, the storage and booster ring have same operation phase.

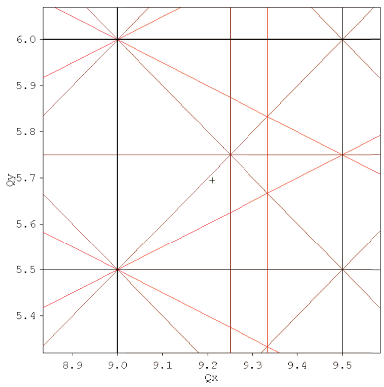

Figure 2: Tune diagram of the booster ring

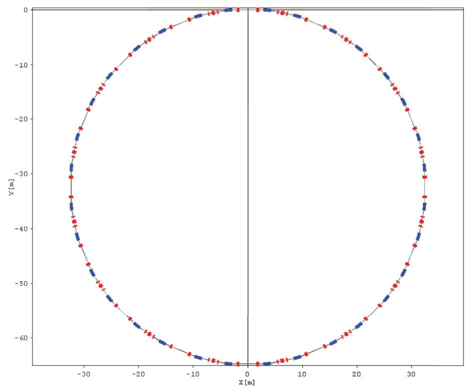

Figure 3: The Circumference of the booster ring

3. ACKNOWLEDGEMENT

The author wants to thank to Turkish State Planning Organization (DPT) for support. Grant No: DPT2006K-120470.

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