LOW ENERGY INJECTION IN A COMPACT SYNCHROTRON RADIATION STORAGE RING

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Abstract

A compact 800MeV storage ring with low energy injection has been designed.[1] For low energy injection the main problem is how to get enough beam current in the storage ring. In this paper we will focus on the investigation of the low energy injection progress, the results of numerical calculations about the relations between the injection efficiency and beam energy spread and emittance, the optimum RF voltage and its increasing speed are presented.

Introduction

Low energy beam life time, determined by the Coulomb scattering loss, will be about 65sec for 15 MeV electrons under the vaccum condition 10^{-9} Torr. It is much shorter than the radiation damping time, about 700sec for the same energy electrons. So in our case we couldn't use the radiation damping effect to accumulate electrons in the storage ring, we expect to use a microtron with high current and excellent performance through multiturn injection to accumulate electrons with high effeciency, and quickly to ramp the beam to high energy.

In order to minimize the beam loss in the period of injection and ramping we have worked on the low energy injection progress in detail.[2]

The optimum RF voltage

Injecting into the storage ring, electrons will be captured into the RF phase space, usually the higher RF voltage, the larger phase basket in which more electrons will be captured, but too large RF basket implies more loss of electrons. We have derived the relation[2] between the electron capture efficiency and RF voltage. Fig.1 shows the capture efficiency versus RF voltages.

When D equals to the D_{RFM}, we will obtain the maximum capture efficiency $f_{RM}=0.6$, where

$$D = \left(\frac{eV_0 \sin\phi_s}{\pi h \alpha E_s}\right)^{1/2}$$

V_0 - RF peack voltage
ϕ_s - equilibrium phase of RF voltage
h - harmonic number
α - compact facter of beam trajectory
E_s - injected electron energy

The requirement to the injection beam performance

We have calculated the relations between the capture efficiency and injection beam energy spread, shown in Fig.2. From which we can see that when the beam energy spread is less than 0.5%, and its emittance less than 3 mm. mrad, the capture efficiency will be high and change slowly. So we should choice the injector with beam energy spread less than 0.5% and emittance less than 3 mm. mrad. The microtron with high current output will be the priority to satisfy the requirement of injection.

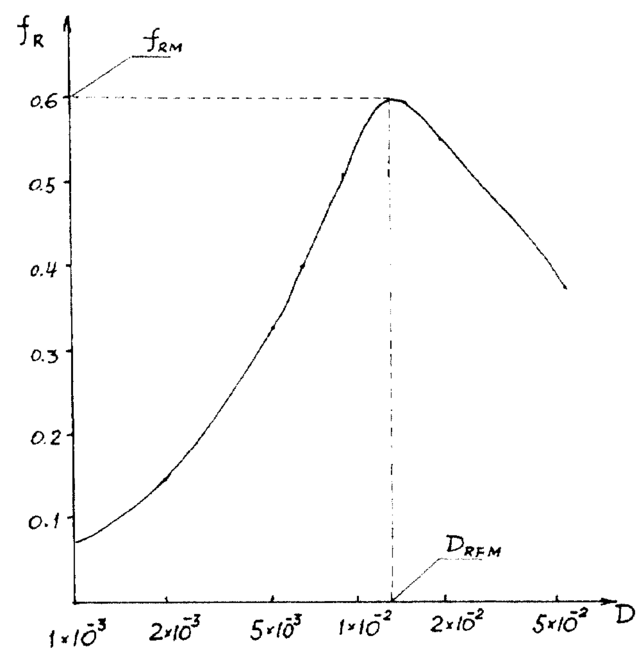

Fig.1 The electron capture efficiency versus RF voltage

The RF voltage increasing rate

The Rf voltage should not be very high at the injection period in order to minimize the beam loss from large radial oscillation. After injection we have to increase the RF voltage quickly to avoid the beam scattering loss, but the voltage increasing rate shouldn't be too high, otherwise it will cause beam loss from the large radial oscillation. There is a optimum RF voltage increasing rate

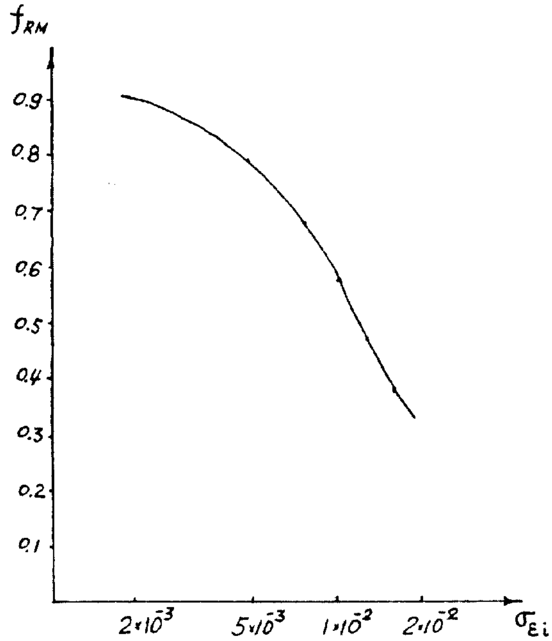

Fig.2 The capture efficiency versus beam energy spread

shown in Fig.3. By using this rate to increase the RF voltage the beam losses will be minimum.

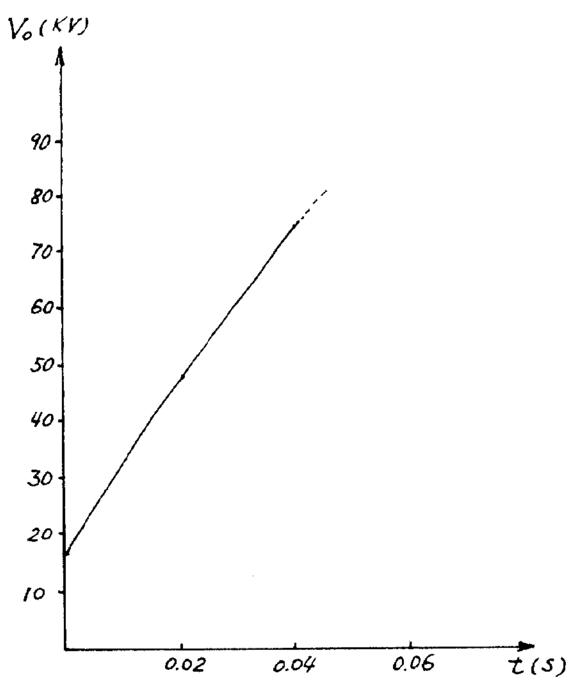

Fig.3 The optimum Rf voltage increasing rate

Summary and Conclusion

All above calculations shows that if we choice an injector with good beam performance and appropriate RF voltage and its increasing rate, the low energy electron capture efficiency will be high enough to accumulate high current in the storage ring. For example, using a microtron[3] with beam intensity 100mA, and 0.5% energy spread and 3 mm. mrad emittance as the injector of a compact storage ring, and supposing the beam transport efficiency 70% and injection efficiency 50%, it is expected 200mA beam current will be accumulated in this storage ring.

Refecence

[1] Liu Naiquan, "A Compact Synchrotron Radiation Source" BNL-51959 (1985)

[2] Liu Guozhi, Graduate dissertation, Tsinghua University (1986)

[3] U.Bizzarri, Nuclear Instrument and Methods in Physics Research, A237, No.1,2, 213-219 (1985).