The On-line Control Software For BEPC Beam Transport Lines

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Abstract

The on-line control software for BEPC beam transport lines are developed and incorporated in the BEPC control system. The polynomial fitting for the excitation curves of the transport line magnets are carried out, and the polynomials are loaded into the BEPC database. The programs TRANSPORT, MAGIC, COMFORT serving as the tool for the beam transport line computation are compared in the point of on-line control. The design and debugging of the software are accomplished and the operation results are analyzed. As a result, the development of the on-line software provides a powerful tool for BEPC commissioning and operation.

I. GENERAL DESCRIPTION

The beam transport lines of BEPC are designed elaborately in order to obtain high efficiency and enhance the integral luminosity. Fig.1 illustrate their layout.

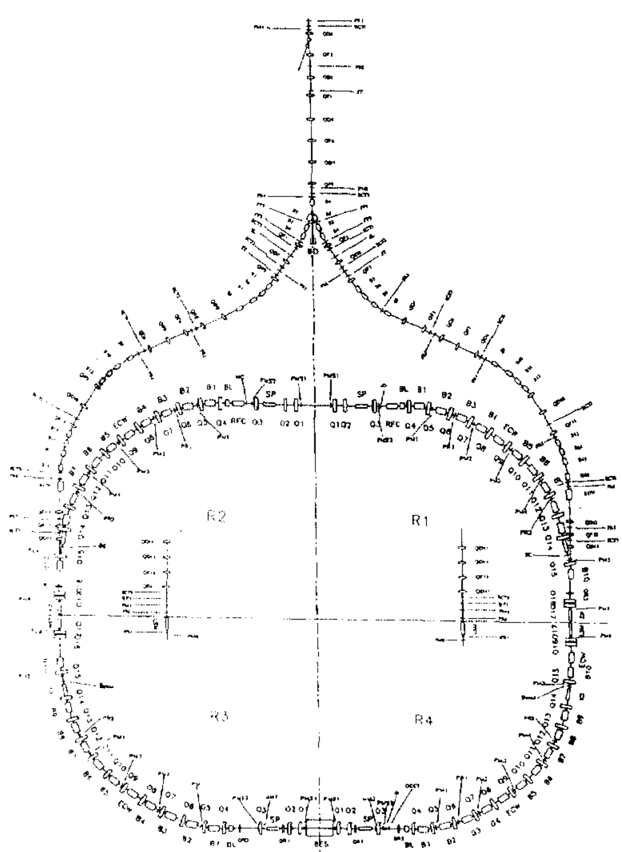

Fig. 1 The layout of BEPC

The beam coming from the linac end is fitted as an upright ellipse at the exit of the common line by TCQ5-8, so that we need not to change the polarity of the quadmagnets when the beam is switched between electron and positron. At the end of the common line, a switch magnet branches off the beams according to the charges it bearing. The two branches of TE and TP are symmetrically designed to transport the electron beam and positron beam to the injection points respectively. In each branch, the beam is bent 60° out and then -60° in and at last 8.015° up to the injection point on the plane of the storage ring. In each horizontal bend region, there is an achromatic section. And in the last vertical bend section, the beam is anchromatized vertically[1]. The efficiency of this transport line running under the optimized model reaches about 80%. But this is only for the primary control, it would be different and inflexible when the conditions of the linac or the ring are changed.

Therefore, for pursuing the high efficiency, the control software are needed to set the operation models of the transport lines on-line so that the variations of the linac exit parameters and the changes of the injection model of the storage ring can easily be fitted. Furthermore, the upgrades of the running models will be carried out much more conveniently and more researches will be done by the means. But on the contrary, we must search the models fitting for the linac and the ring and key the transformed numbers of the corresponding currents of each magnet to the database off-line under the primary control mode. After a deep insight of the primary control of the BEPC transport lines, the on-line control software which resembled the ones of the BEPC storage ring have been developed on the basis of the present operation mode of the beam transport lines.

The tasks of developing and implementing the on-line control software include three broad categories: (A) the study of the computation programs and the off-line analyzing of the transport lines. (B) the study of the polynomial fitting of excitation curves of the magnets. (C) the debugging of the programs and operation study.

II. EXCITATION CURVES FITTING OF MAGNETS

Since magnets are the primary elements of the accelerator, the excitation currents of the magnets are the main parameters for control. The measured data of a magnet are series of separated points, so the curve fitting of these points is needed.

After carefully processing the measured data of magnets, it was found that the magnets of the same group

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have a good consistence, so the sequence of average all fields first or fitting every single magnet first then average them seems not much different. After a meticulous studying of the polynomial fitting, we choose integral field B as a function of excitation current I and zero offset for it does not cause any problem. We selected to fit them to the sixth order and obtain a precision about 0.1% which is about the measurements. The BEPC revised version of fitting program POLYA, which was transplanted from FNAL, was used in this procedure.

As soon as all the polynomials were obtained, we had them loaded into the BEPC database by running a program.

III. THE SOFTWARE ACHITECTURE

The software can be divided into two main processes according to the functions they perform: TMODEL to fit for the models, TRLIN to do graphic displays (see Table 1). The on-line control procedure is shown in Fig.2.

Table 1.
The Main Functions of TMODEL and TRLIN

Process	Subtask	Functions
TMODEL	TCOMFWRT	Preparing input data file, spawning COMFORT, processing output file and putting the results into database
	TCOMFPT	Print out the output file of COMFORT
TRLIN	TRDSP	Read the output file of COMFORT and display curves on the screen
	TRPRT	Print out the Twiss parameters whole line

TMODEL manages two programs: TCOMFWRT and TCOMFPT. The first program TCOMFWRT fetches the data of the currents for every main magnet at present from database and turns them into the strength and then writes a COMFORT input data deck to spawn COMFORT running. If it goes without any error, TCOMFWRT reads its output file and transforms the strength to currents of the corresponding magnets and put them into the datbase for updated model. If it is satisfying, this model can be put into running. In this procedure, the branch to be fitted is also specifies . The second program TCOMFPT is used to print out the COMFORT output file for the off-line analysis.

The process TRLIN includs two programs: TRDSP and TRPRT. TRDSP displays the horizontal or vertical β, η and σ functions and relevantly TRPRT prints out the twiss parameters of the current model graphically along the transport line. All the communications among them and database are enactivated via the touch panel and dispatched by the task control process AVTX. The touch panel programs are written in FORTH language.

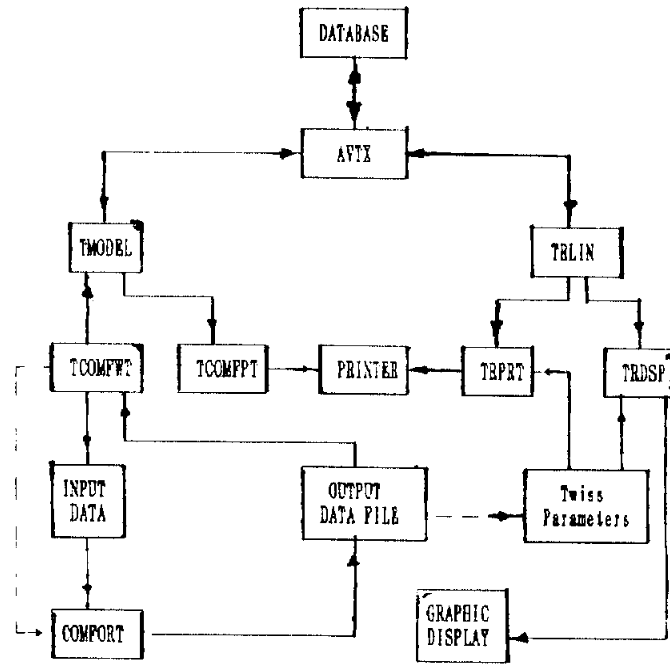

Fig.2 On-line Controll Procedure

This on-line control software has been accomplished and put into operation. The results seem satisfying and promising.

IV. THE SOFTWARE DEVELOPING AND IMPLEMENTING

The wellknown programs as TRANSPORT, MAGIC and MAD are powerful for optical calculation and accelerator design, but for the purpose of on-line control, they are too slow and memory intensive for the control system from our study, which is in agree with other results [2,3]. We take the advantage of COMFORT as the main on-line fitting program, and that also matches with the storage ring. (see Table 2)

Table 2.
A Brief Comparision of The Computer Codes

Program	Size (blocks)	Speed (seconds)
COMFORT	450	12
MAGIC	500	94
TRANSPORT	1120	25

The positions and the number of the fitting points, the variables and the target parameters and others used for the on-line control software are also carefully analyzed and calculated. We selected three key positions as fitting points: the exit of the common line, the end point of horizontal bend section and injection point. These are enough based on the off-line studies and the design catalog[1]. The initial parameters of the beta functions are computed and loaded into the database according to every operation mode. The debugging of the programs are categories into three steps: off-line progressing, debugging and on-line commissioning. After all these being finished, the software is put into real application. Fig.3. shows the Twiss parameters along the transportline fitted on-line.

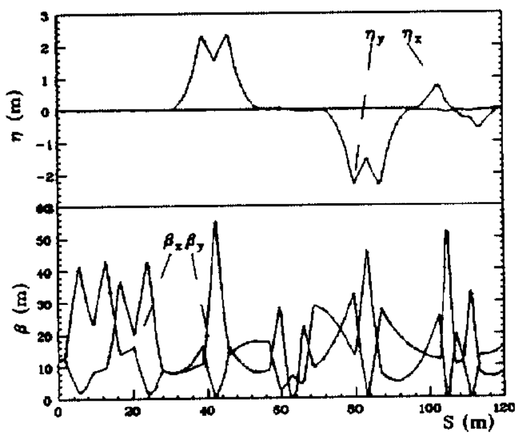

Fig.3 β and η Functions Along the Line

For the perfect on-line control of the BEPC beam transport system, the beam diagnostic devices needed. A beam emittance measurement system in the common line is installed, which uses the three-kick method to vary the appropriate quad-magnet gradient three times and to measure the sizes of the spot on the profile monitor downstream and calculates the twiss paremeters and emittance at linac exit. Besides the acquired design theoretical values that the linac must fit, we can also take out the real measured parameters to fit for initial values.

V. CONCLUSION

The software serves as a useful means for fully bringing out latent potentialities of BEPC transport line and storage ring, raising the efficiency of the beam transportation and injection, as well as the integral luminosity of the collider. It is also a good tool for the researches of theories and experiments of the beam transportation and injection in order to carry on further studies of the occasional injection problem of BEPC. And it has taken a important role in the experiment of the current limitation of the ring versus injection energy.

VI. ACKNOWLEDGEMENT

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