OPTICS IN THE TRISTAN ACCUMULATION RING

Susumu KAMADA, Katsunobu OIDE, Hitoshi FUKUMA and Kaoru YOKOYA
National Laboratory for High Energy Physics
Oho-machi, Tsukuba-gun, Ibaraki-ken, 305, JAPAN

ABSTRACT

The scheme of optics calculation and its installation into magnets in the TRISTAN Accumulation Ring(AR) is described. Also presented are operational experiences of the AR optics in the first operating period(from Nov.'83 to July '84).

INTRODUCTION

TRISTAN-AR was originally designed to supply high intensity electron and positron beams to the TRISTAN Main Ring where electron-positron colliding experiments will start in 1986.(1) Although by now there has not been any plan to make colliding experiments in AR. AR itself is endowed with the function of an electron-positron collider. Recently the internal target system(2) was introduced to AR and produces gamma rays for calibration of the experimental apparatus which will be used for colliding experiments in MR. AR is also expected to work as a synchrotron light source by this autumn.

Indeed AR is a multi-purpose machine and must be ready for at least above mentioned four purposes in its optics. In the following presented are the optics handling system of AR and some operational results of the AR optics.

OPTICS HANDLING SYSTEM

OUTLINE OF THE SYSTEM

In Fig. 1 schematically illustrated is the AR optics handling system which builds up into the TRISTAN accelerator control system(3). In the central control room of the TRISTAN accelerators(CCR). operators tell their will through touch panels to the optics handling system which is working under the supervision of KEK NODAL system.

To the touch panels directly connected are the operation computers(OP0, OP1 and OP2) which watch the whole stream of the job, exchange the optics data with the KEK central computer(M200H), make some optics calculations by themselves and transfer resulting data to the hardware computers.

The KEK central computer(M200H) placed 1Km away from the CCR is a general purpose computer prepared for wide variety of usage and also connected to the optics handling system through KEKNET. The M200H serves for the calculation by the optics code MAGIC and offers data storage area of the optics. The library computer(LB0) assists in the data exchange process via KEKNET.(4)

The hardware computers used in the optics handling system are the magnet computer(MG0) and the beam transport computer(BT0) and they are located in respective site buildings.

LATTICE STRUCTURE

There exist four mirror symmetry points in the AR lattice. Two of them are called collision symmetry points and the others are called rf symmetry points.

Each quadrant of the AR lattice is marked off by the collision symmetry point and the rf symmetry point. In the middle of the quadrant, a few normal cells of FODO structure are laying. Matching quadrupole magnets are installed at the both ends of the normal cells, which are QC1, QC2, QC3, QC4, QC5, QC6, QC7 and QC8 on the collision symmetry side and QR2, QR3, QR4, QR5, QR6, QR7 and QR8 on the rf symmetry side.

OPTICS CALCULATION

For finding new optics, two kinds of optics programs are available as in the following. One is the optics program that works on the operation computers and is written in NODAL and furnished with the Newton-Raphson method. The computer code MAGIC is the other one that was originally developed at SLAC furnished with the variable metric minimization method(VMM) and has been modified at KEK to operate on the M200H.(5)

In using the both programs, the operators must give a starting optics which may be a present optics of AR or a recalled optics from the data storage and also have to indicate which quadrupole magnets, namely the QC-magnets or the QR-magnets, should be changed in finding optics.

The calculated optics is given in form of the tracking ratio of the quadrupole magnets(B'l/B*rho) and displayed on a screen with its beta and dispersion functions as

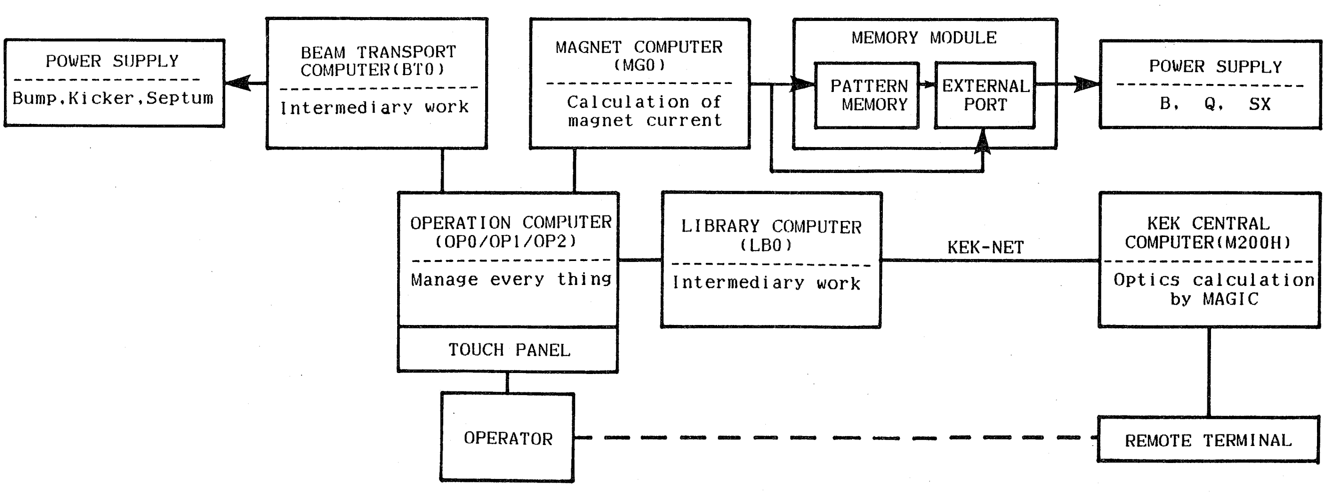
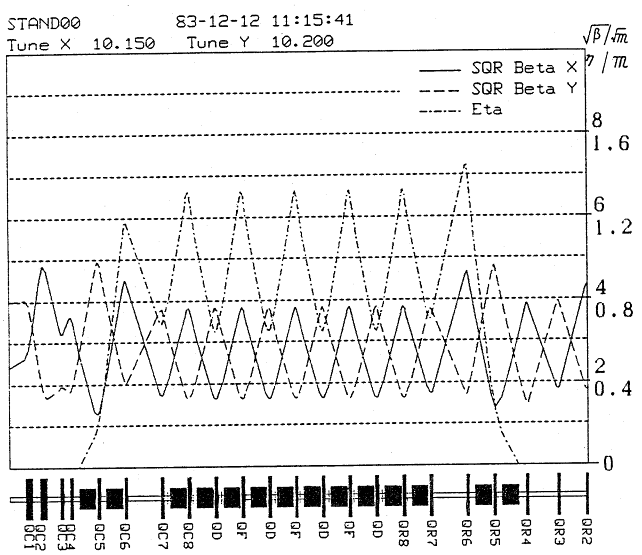
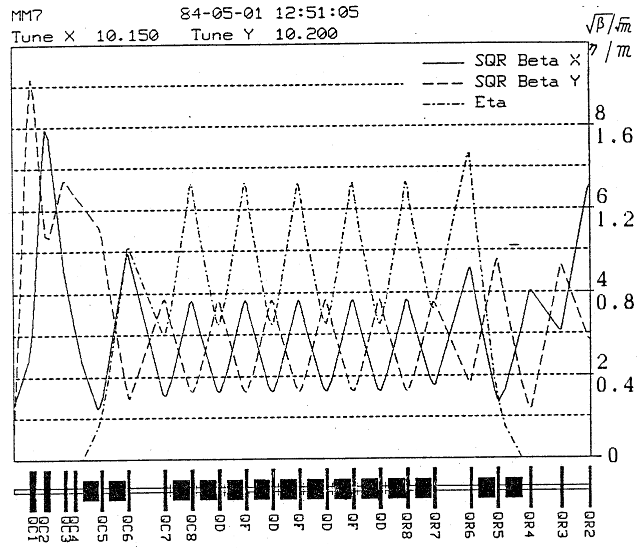


Fig. 1 Schematic Diagram of the AR Optics Handling System



QF	0.333420	QC4	0.304393	QR2	0.294832	QR7	-0.304540
QD	-0.329486	QC5	-0.306399	QR3	-0.313949	QR8	0.323338
QC1	-0.287052	QC6	0.323254	QR4	0.312972	SD1	-1.331190
QC2	0.365280	QC7	-0.280574	QR5	-0.316047	SD2	-1.331190
QC3	-0.291996	QC8	0.326192	QR6	0.311680	SF1	0.774377

Fig. 2 The standard optics(STAND00) along the quadrant



QF	0.333420	QC4	0.004473	QR2	0.241176	QR7	-0.293557
QD	-0.329486	QC5	-0.138334	QR3	-0.279664	QR8	0.320511
QC1	-0.601278	QC6	0.325156	QR4	0.235601	SD1	-2.319279
QC2	0.505774	QC7	-0.333903	QR5	-0.330210	SD2	-2.319279
QC3	-0.122924	QC8	0.341690	QR6	0.310999	SF1	1.128065

Fi3. 3 The low-beta optics(MM7) along the quadrant

shown in Fig. 2 and Fig. 3.

The injection conditions of the kicker, bump and septum magnets are calculated also by the operation computers to improve the injection efficiency for the given optics.

OPTICS DATA STORAGE

A newly calculated optics and a resulting optics from manual operation of AR can be named arbitrary by the operators and stored into the data storage of M200H. Some of them are reserved in the operation computers also, preparing for quick recalls and KEKNET failures.

OPTICS INSTALLATION

The tracking ratio of the quadrupole magnets for the new optics is transfered to the MG0 and converted into the current values by using the excitation table.

These current values are installed into the magnets in the following two modes. One is the pattern generation mode where the pattern memories of the memory module are totally rewritten then the whole cycle of the magnet excitation is changed into new one. The fine-adjustment mode is the other one where the current values are sent to the external port directly and the optics change is limited to the present stage of the magnet excitation. Both modes are compared in Table 1.

Table 1
Comparison of the optics installation modes

mode	pat.-gen.	fine-adjust.
required time	10 min.	1 min.typically
pat.-operation	possible	impossible
optics change in keeping beam	impossible	possible
possible chance of the instal.	standby-stage	injection and flat-top stages

OPERATIONAL EXPERIENCES

MEASURING METHODS

In the examination of the AR optics measured are betatron tune, chromaticity and beta and dispersion functions as in the followings.

A power spectrum of betatron oscillations excited by the damper system(6) is analysed to measure the tune with the accuracy of 0.001. Chromaticity is calculated by subtracting betatron tune from that of another rf frequency. By changing a tracking ratio and measuring a betatron tune, a beta-function is given in the form of an averaged one in quadrupole magnets fed by same power supply. Dispersion function is measured at position monitors by taking c.o.d.(closed orbit distortion) away from that of another rf frequency(7).

FIRST DAY OPTICS

At the very early stage of the AR operation, some discrepancies were found in the calculation model and cured according to the measured data of the magnetic field. Another correction was made in the excitation table of the quadrupole magnets that had been prepared in a somewhat wrong way from the measured data of the field gradient.

After these improvements, the first day optics(8) was installed into AR in December 1983 and the tune differences between the calculated values and measured ones were found to be 0.006 horizontally and 0.013 vertically.

STANDARD OPTICS

By modifying the first day optics slightly, the AR optics named STAND00 was made as a standard optics for machine studies and also can be used in transferring the beams into MR. The STAND00 optics is shown in Fig. 2 and its parameters are calculated in Table 2. A horizontal and a vertical tunes are measured to be 10.163 and 10.250, respectively. The dispersion function was measured in the STAND00 optics and shown in Fig. 4.

The IT01 optics was made from the STAND00 optics and used so much in the internal target system(2).

LOW-BETA OPTICS

Changing optics from the STAND00 to the low-beta MM7 was done successfully in keeping the beam. During this change, c.o.d.

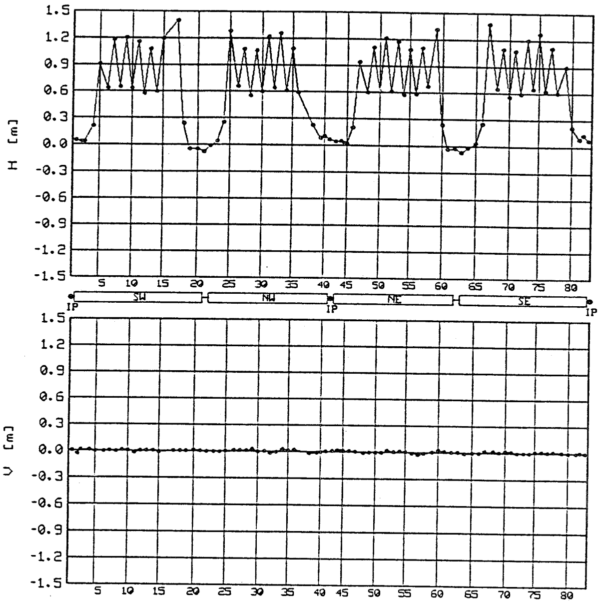


Fig. 4 The dispersion function measured along the AR of the STANDOO optics

corrections were made at the several intermediate steps.

A horizontal and a vertical tunes were 10.162 and 10.259, respectively and an injection rate was very poor. Beta-functions were measured to be 10.9m horizontally and 87.5m vertically in QC1 and 67.1m horizontally and 37.8m vertically in QC2. These show good agreement with the calculated values shown in Fig. 3. Chromaticity was corrected to 2.0 horizontally and -1.1 vertically by using calculated strengths of sextupoles which should provide zero chromaticity. Optics parameters for the MM7 are given in Table 2.

LOW TUNE OPTICS

In the all above mentioned optics, phase advances in the normal cell are 90 degree in both planes. The optics N60D whose parameters are listed in Table 2 was installed into AR to investigate the performances of 60 degree normal cell where dispersion function is quite large. In the N60D optics, an injection rate was very poor and measured tunes were 7.794 horizontally and 9.31 vertically.

OTHERS

For the tune diagram survey, have been prepared are a lot of the AR optics which are based on the 90 degree normal cell and cover a tune range of 9 to 11 in both planes independently, although a systematic survey has not been done yet.

Some optics with non-vanishing dispersion in rf cavities were installed and showed the poor injection rate proportional to the dispersion functions in spite of the long life time of the stored beam.

DISCUSSIONS

During the accumulation of beam, some instability occurs at the beam current of a few tens mA in one bunch with a sextupole strength calculated for zero chromaticity and stops with the increased strength of sextupoles typically by 20 percent. Then the strengths of sextupoles are chosen to 120 percent of the calculated ones usually.

In some optics, the injection rates are so poor in contrast with the long life time of stored beam. Some is caused by the shortage of the transverse aperture for coherent betatron oscillations in the injection process and other may be attributed to the decreased longitudinal aperture for momentum oscillations by big dispersions. A systematic survey of the injection conditions will improve the injection efficiency.

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Table 2
Optics Parameters of the Various AR-Optics

optics name	STANDOO	MM7	N60D
betatron tune(hori/ver)	10.15/10.20	10.15/10.20	7.75/9.25
beta-function at collision point (hori/ver)	5.79m/15.97m	1.60m/0.10m	5.75m/24.61m
dispersion function at collision point	0.m	0.m	0.m
maximum beta-function(hori/ver)	22.3m/23.6m	60.0m/75.8m	2.4m/24.9m
corresponding magnet to "	QC2 QC5	QC2 QC1	QC2 QC1
maximum dispersion function	1.44m(QR6)	1.46m(QR6)	2.42m(QF)
momentum compaction factor	0.012878	0.012746	0.024132
horizontal damping partition number	1.00005	1.00005	0.99987
momentum dependence of "	-91.7083	-90.6724	-164.6645
natural chromaticity(hori/ver)	-13.98/-13.17	-19.32/-23.95	-10.11/-12.79
natural horizontal emittance(2.55GeV)	4.595x10-8 rad*m	4.531x10-8 rad*m	1.344x10-7 rad*m