ALIGNMENT OF INSERTION UNITS IN NSRL RING

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ABSTRACT

The general alignment method of insertion units in NSRL storage ring is described in this paper. In the course of the development of NSRL, some insertion units, for example, the superconducting wiggler, will be installed in its ring. the alignment method will be different from that when the storage ring was originally set up. We took the chance that the pulse septum was once repaired to design a general method for installing insertion units in the ring, which includes adjusting the internal parts of the insertion units and accurately installing them according to the position accuracy in relation to the theoretical orbit. For example, the position accuracy of the pulse septum is, radial Δx: ± 0.1 mm, vertical Δy: ± 0.1 mm, tangential Δz: ± 0.5 mm. The accuracy calculation will also be given and the anticipate alignment progress of the superconducting wiggler in the ring will be given too.

INTRODUCTION

After the NSRL (National Synchrotron Radiation Laboratory) was finally established in 1992, the improvement of the machine has been in progress. Some insertion units have been and will be installed in the ring. For example, a superconducting wiggler will be installed in the ring in 1996. The alignment method of these insertion units is different from that when the ring was originally set up in survey control and measurement procedure etc.. Safer and more accurate methods are designed and experimented.

In the summer of 1993, some details of the pulse septum were broken down during the machine was operating because of a vacuum problem. In the course of repairing and re-installing the septum, we designed a set of method to dissemble, align and re-install it. There were two possible methods when we considered how to finish the task.

First, because the pulse septum is connected with one of the three Kickers (kik1)(Fig.l) and they share one supporting bedplate, we can hoist up all the bedplate with the kik1 and septum on it, and align the septum with kik1 then re-install them in the ring by adjusting the threaded rods supporting the bedplate to make them locate in their theoretical orbit after the septum has been repaired. But this method has some problems: a)The weight of the bedplate with the kik1 and

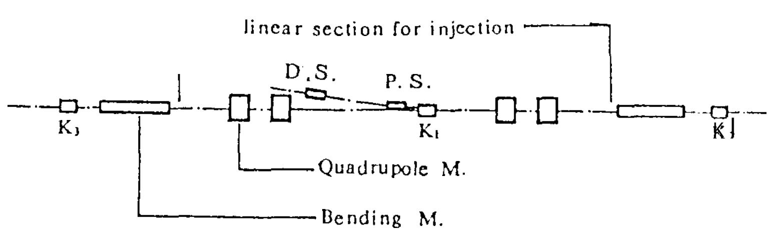

Fig. 1 NSRL storage ring injection system

septum on it is very heavy, so the hoisting job is very difficult and may lead to collision between vacuum flanges because of hoisting control failure. b) The volume of bedplate is very large, there is no a survey plate large enough to meet the operation needs.

The other method is that only the pulse septum is hoisted up. After it is repaired, the internal parts are adjusted and the survey datum-points and datum-lines are transferred, the septum is re-installed in the ring. But there is a problem too, e.g. the alignment between kik1 and septum become more difficult.

Considering the practical condition of NSRL, we choose the second method.

INTERNAL PARTS ADJUSTMENT AND FIDUCIALS TRANSFER

The pulse septum was installed into an ultra-high vacuum chamber(Fig. 2). Before hoisting up it, We closed the nearest vacuum vales of the two sides and loosen the screws of vacuum flanges.

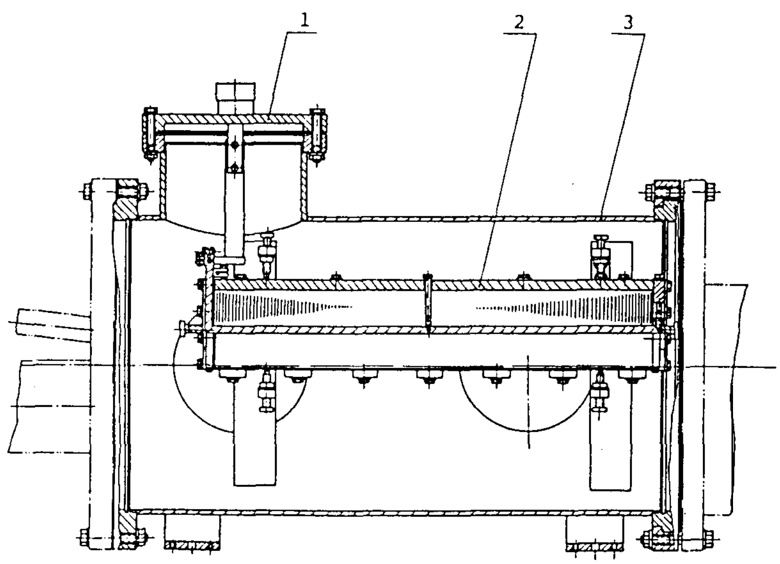

Fig. 2 Structure of the Pulse Septum:
l)High voltage electrode; 2)Magnet core; 3)Vacuum chamber.

During hoisting, collision and violent vibration must be avoided in order to keep kik1 and other units in their original accurate position in the ring, some points on which will become its datum-points and reference points when the septum is re-installed. The repair and internal adjustment were conducted on a strictly-tested level plate of 1200 x 1000 mm in a vacuum processing room. After the septum was repaired, it must be restored to its position when it was originally installed in the ring. The original position in the vacuum chamber had been fixed on the optical survey fiducial line through the coil center of kik1. After the iron-core surface was adjusted to level, we can find that: a)The elevation between the iron-core center line (thought as the theoretical beam line) of the septum and the central points of the alignment plate 1 and 2 is 200.01 mm. b) In radial direction, the deviations of plate 1 and 2 to the iron-core central line individually are 0.09 mm and 0.76 mm. Now according to these data, we adjusted the internal parts.

First, the planeness of the iron-core surface of septum was adjusted with level-micrometer to designed requirement.

Second, the iron-core surface was adjusted to level. Because of manufacturing errors, the alignment plates and the surface of iron-core are not exactly parallel. After the iron-core surface was adjusted to level with level checker, we use the bubble-level tester to survey the plate 1 and 2, and record the scale readings (Fig. 3).

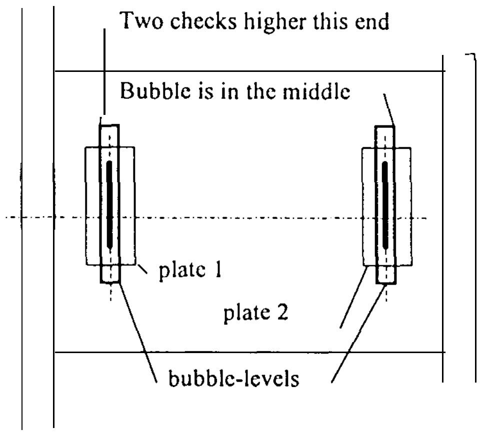

Fig.3 Scale readings of bubble-level on plate 1 and plate 2

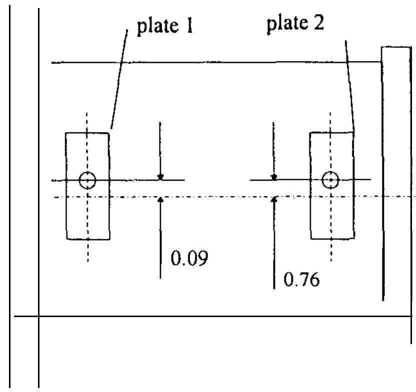

Fig.4 Distances from beam-line to the centers of two copper-targets

Third, in the radial direction, on each of the alignment plate 1 and 2, we mounted a copper-target whose axis must be precisely concentric with the center of the bore on the plate. On each copper-target a line was drawn, whose distance from the center is equal to the deviation, e.g. 0.09 mm on plate 1 and 0.76 mm on plate 2, but has the opposite direction on the vacuum chamber (Fig. 4). Along the direction of the core central line, a T2 transit was set up on one end, and with it a datum-line on the reference of the drawn-lines was erected. We adjusted the iron-core to make the point which is the reference point of the theoretic beam line coincide with the datum-line. Then we transferred the transit to the other end of the chamber and did the same job as above, and repeated all the steps until the two points on the two ends completely coincided with the datum-line. By these steps, we could fix the iron-core radial position.

Forth, in vertical direction, we used the iron-core surface to replace the magnetic field center as the tangible datum. The elevation between the surface and alignment plates was adjusted with the reference of the plates to the original distance by adjusting the screws. Here we used such tools as height-gauge and centesimal-graduation-meter.

ALIGNMENT OF SEPTUM WHEN RE-INSTALLED IN THE RING

In the course of re-installing septum in the ring, all the alignment fiducials were transferred to the alignment plates on the top of the chamber.

First, a T2 transit was set up on a alignment socket on a bending-magnet and a line of sight parallel to the axis of the long straight section was erected by taking a target on a alignment socket on a bending-magnet on the other side of the chamber and a point on the alignment plate on the kik1 chamber as the two end points. We adjusted the chamber push-push supporting screws to make the two drawn lines on the two copper-targets coincide with the line of sight.

Second, we set up two optical targets on the alignment plates on the septum chamber and a optical target on the plate of the kik1 chamber, which were used as the datum-points. the deviation of the targets had been calculated and manufactured according to the originally designed value. We set up an N3 level detector beside the chamber and took the target on the kil1 as the datum, adjusted the supporting screws to make the three target centers have the same height.

Third, we put the bubble-level on the plates on the septum chamber, and adjusted screws to make the level show the same readings as that when we had adjusted the internal parts.

All the steps above must be simultaneously and repeatedly conducted until all the position offsets were eliminated in vertical and radial directions, and in level. Here we also used the clamping force of the vacuum flange joints to fine-adjust the axis angle of the septum chamber and to locate it in the direction of the beam line, too.

ACCURACY ANALYSIS

In the course of alignment of insertion units, internal alignment datum-lines and datum-points must be transferred to external ones which are tangible or can be seen. Overlooking the errors of physical quantity, for example, the magnetic field is not always well-defined by the poles, we assume that the magnetic midplane and mechanical central line between poles are coincidental. So the transfer errors come from the survey methods, the tools and operating personnel. Now we take the alignment of the septum as the example to analyze the alignment accuracy.

In vertical direction, the transfer median error M_v is

$M_v = \pm (M_i^2 + M_{h1}^2 + M_{h2}^2)^{1/2}$

where M_{h1} and M_{h2} are the reading errors of the height vernier caliper and here

$M_{h1} = M_{h2} = \pm 0.04$ mm.

M, is the centralizing error of level detector line of sight,

$M_i = (0.1\ \tau \times S)/(2 \times \rho)$.

S--the distance from target to the level detector, where S < 10m

ρ =206265

τ --is the sensitivity of tubular level per 2 mm, here t=10"

so $M_l = \pm (0.1 \times 10 \times 10 \times 1000)/(2 \times 206265) = \pm 0.03$mm

and so $M_v = \pm [(0.03)^2 + 2 \times (0.04)^2]^{1/2} = 0.06$mm.

In radial direction the transfer median error M_h is

$M_h = \pm (M_{t1}^2 + M_g^2 + M_{t2}^2)^{1/2}$

where M_g is th reading error of the vernier caliper, $M_g = \pm 0.04$mm

M_{t1} and M_{t2} are the tracer error in twice transferring

$M_{t1} = M_{t2} = (\beta'' \times S)/\rho = (\upsilon \times p'' \times S)/(v \times \rho)$

β''--the tracer error in angle

p"--human eye's distinguishing ability when sighting under ideal condition and generally p"=10"

v--magnification, here v=34 x

υ --correction factor, here υ =3

S--the distance from target to transit and here s < 10m

ρ =206265

So $M_{t1} = M_{t2} = (3 \times 10 \times 10 \times 1000)/(34 \times 206265) = \pm 0.04$mm

$M_h = \pm [3 \times (0.04)^2]^{1/2} = \pm 0.06$mm.

So, both in the vertical and radial directions, the possible deviations are less than the position tolerance, e.g. ± 0.1 mm.

In tangential direction, the septum is located by the vacuum flanges connected with kik1 and vacuum tube in the ring which had been exactly surveyed, and the deviation must be less than the tolerance, e.g. ± 0.05mm.

CONCLUSION AND ABOUT THE ALIGNMENT OF SUPERCONDUCTING-WIGGLER PLANNED TO BE INSTALLED IN THE RING

When installing the insertion units in a ring, we align it with reference of some alignment datum-lines and datum-points on the parts of ring and on the units themselves. We do so based on an assumption that the magnetic field is well-defined by the ferromagnetic poles and all the mechanical centers coincide with the physical ones.

We transfer the internal fiducials to external ones. Overlooking the failure of the assumption, the key in the alignment jobs is the accuracy of fiducial transfer. High accuracy survey and alignment tools, precisely designed and manufactured alignment targets, and skilled operating personnel are necessary.

But, although we have not failed in alignment based on the assumption so far, we cannot use it anymore in the presence of saturation and for some kind of magnets which have no tangible poles. For example, during the design of the superconducting-wiggler alignment method, we plan to transfer the magnetic center directly to the central lines of two perspective holes on the two sides of the vacuum tube by magnetic field measurement and then transfer them to the alignment plates on its top before it is installed in the ring. Because the iron-core was suspended and the magnetic center is changing with vibration during hoisting, the targets on the holes should be able to be adjusted. before finally installing it, some test must be done to calculate the possible position changes of the core and a series of possible adjusting methods must be designed, too. By the way a better and safer survey and alignment method of the wiggler is being considered and designed.

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