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INFLUENCE OF THE BUILDING DISTORTION ON THE CLOSED ORBIT AT THE PHOTON FACTORY STORAGE RING

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Abstract The first measurement of the ring distortion related to the diurnal movement of the beam orbit was performed. In this measurement, the ring really expanded and contracted in a day, synchronizing with the horizontal orbit movement. Furthermore, a strong correlation between the vertical orbit movement and the ring distortion was revealed by measuring the magnet height and strains on the cracks of the ring tunnel. It was confirmed by these results that the diurnal orbit movement resulted from the building distortion due to thermal stress.

INTRODUCTION

At the Photon Factory storage ring, the diurnal movement of the beam orbit had appeared remarkably since the low-emittance operation started.[1,2] Since this orbit movement caused the photon beam to drift with a large amplitude at all the beam lines, it became a serious problem to synchrotron radiation users. We have investigated the cause and mechanism of the diurnal orbit movement, while stabilizing the beam orbit with a feedback system.[1,3,4] It was earlier pointed out that the diurnal beam motion was closely correlated with the meteorological conditions such as outdoor temperature and weather. The fact suggested us that the diurnal beam motion might result from the building distortion due to thermal stress. The floor movement along a beam line in the experimental hall was already measured and compared with a model simulation where thermal stress caused by the sunbeam heating of the ring building was taken into account.[5,6] In this paper, we present the results from the recent measurement of the ring distortion and describe the relation between the ring distortion and the beam orbit movement.

CHARACTERISTICS OF DIURNAL ORBIT MOVEMENT

The diurnal orbit movement has two components: horizontal and vertical components. For each component, the maximum orbit displacement in a day is shown in Figure 1. This is given as a difference between two orbits measured at 15:00 and at 6:00. The shape of the horizontal orbit distortion resembles that of the dispersion function in the ring. This fact suggests that expansion and contraction of the ring produce an apparent momentum deviation of the beam. On the other hand, the third harmonic component is dominant in the vertical orbit distortion. It is associated with the vertical beta-

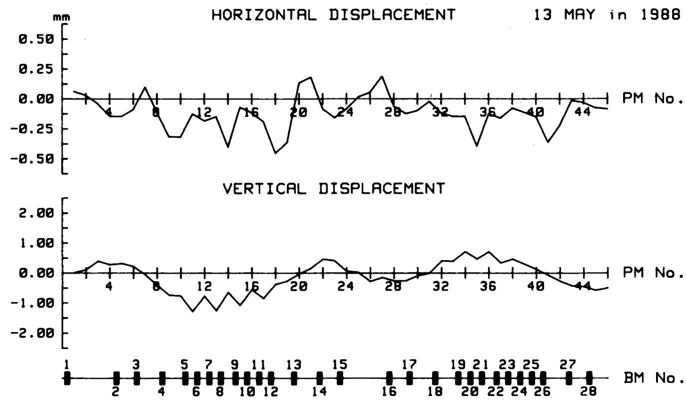

FIGURE 1 Maximum displacements of horizontal and vertical orbits (PM: position monitor, BM: bending magnet).

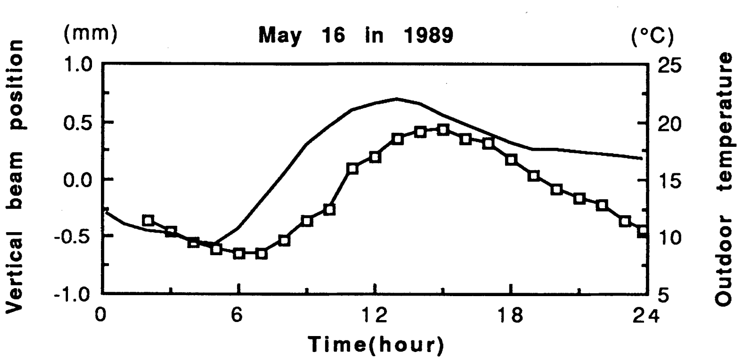

FIGURE 2 Vertical beam position at PM36 (a line with squares) and outdoor temperature (a solid line).

tron tune of the ring (about 3.1). The magnitudes of these orbit distortions depend on the meteorological conditions, while the shapes are almost constant. Figure 2 shows the vertical beam motion at a position monitor (PM36) and the outdoor temperature. As seen in this figure, the diurnal beam motion closely correlates with the outdoor temperature. Also, it is noted that the peak point of the beam position is delayed by a few hours in comparison with that of the outdoor temperature.

MEASUREMENT OF RING DISTORTION

The distortion in the ring tunnel was measured to find out the ring distortion related to the diurnal orbit movement. In Figure 3, the ring lattice components are illustrated.

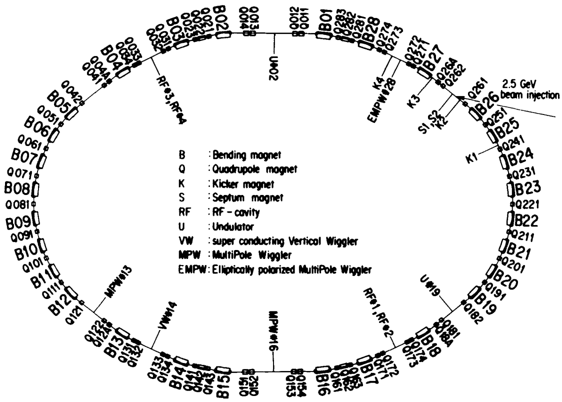

FIGURE 3 Ring lattice components.

Expansion and Contraction of the Ring

The time variation of a distance (about 6m) between B02 and B03 located near a long straight section was measured. A laser system was used to measure this distance with a good accuracy. The result is shown in Figure 4. The time variation of the expansion between the two bending magnets measured by the laser system qualitatively agreed with that of the ring expansion calculated from the horizontal orbit movement. The total amount of the ring expansion from 7:00 to 16:00 was estimated to be about 1.8mm, by assuming that the expansion rate is constant over the ring circumference (187m in length). This was roughly equal to the ring expansion calculated from the horizontal orbit displacement (about 1.2mm).

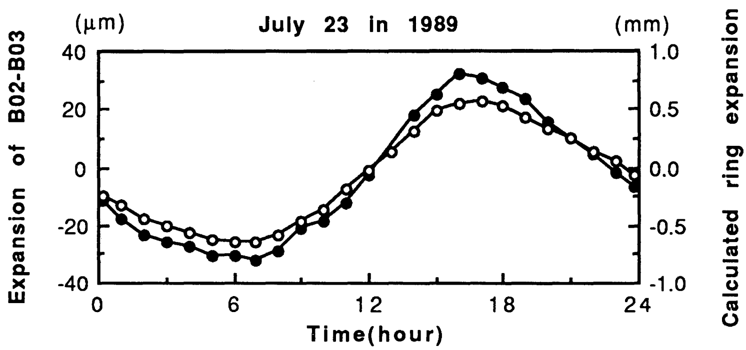

FIGURE 4 Measured expansion between two bending magnets (filled circles) and expansion of the ring circumference calculated from the orbit movement (open circles).

Displacement of Magnet Height

Heights of quadrupole magnets were surveyed with a WILD N-3 precision optical level to examine the ring distortion in the vertical direction. Two quadrupole magnets on the sides of the undulator, Q012 and Q013, were chosen. Relative height displacement of one quadrupole magnet (Q013) to the other (Q012) from 6:00 to 24:00 is shown in Figure 5, together with the

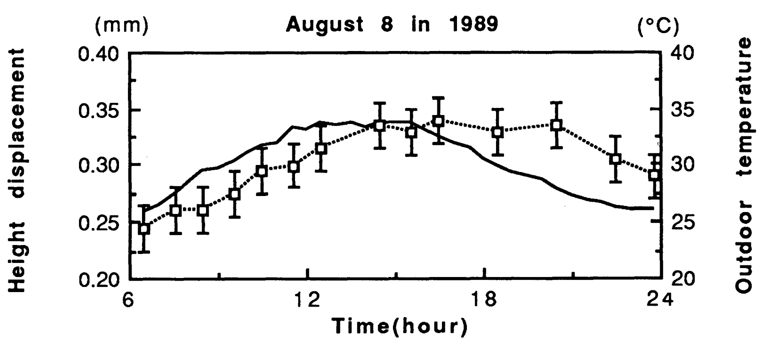

FIGURE 5 Relative height displacement of two quadrupole magnets (squares with error bars) and outdoor temperature (a solid line).

outdoor temperature. The displacement was following the variation of the outdoor temperature with a time lag of a few hours. Such relation to the outdoor temperature was very similar to that of the diurnal beam motion as seen in Figure 2.

Strains on Cracks of the Ring Tunnel

There are a lot of cracks across the ring tunnel. The strains of these cracks were expected to reflect the ring distortion. The strains of three large cracks near B22, Q011 and Q014 were measured. The three-element strain gauges were attached to the three cracks of the wall inside the ring in order to determine three components of strain on the wall, horizontal and vertical extensions and a shear. Every crack had a time variation of strain similar to that of the diurnal orbit movement. Particularly, the crack near B22 revealed a remarkable displacement of the shear. The shear displacement is shown in Figure 6. Such shear displacement will cause an vertical alignment error of the ring magnets and hence contribute to the vertical orbit distortion observed.

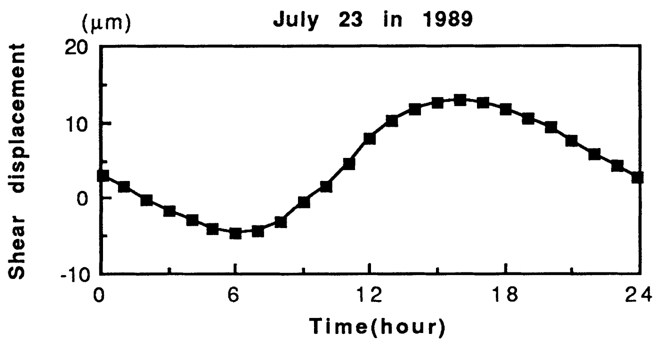

FIGURE 6 Shear displacement on the crack of the wall inside the ring tunnel.

CONCLUSIONS

The measurement of the ring expansion and contraction was in good agreement with the observation of the the horizontal orbit movement. The magnet height and the strains on the cracks were strongly correlated with the vertical orbit movement. These results gave a direct evidence that the distortion of the ring building caused the diurnal orbit movement. However, the extent of this measurement was limited. The measurement of the distortion over the whole ring is, therefore, required in order to obtain a quantitative consistency with the the diurnal orbit movement.

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