

POSITION MONITORING OF ACCELERATOR COMPONENTS AS MAGNETS AND BEAM POSITION MONITORS

G. Schmidt, E. Kasel, D. Schirmer, D. Zimoch, K. Wille

DELTA, University of Dortmund, Germany

Abstract

In third generation light sources a large amount of heat load from synchrotron radiation must be dissipated from the vacuum chamber. The synchrotron radiation hits the outer chamber wall and leads to a bending of the vacuum chamber.

Due to the fact that very often beam position monitors are included into the vacuum chamber, they start to move with increased heat load onto the vacuum chamber.

An inexpensive and precise method to monitor this movement has been tested at the Dortmunder Electron Test Accelerator (DELTA). Commercially available Linear Variable Differential Transformers (LVDTs) have been used.

In addition it was possible to demonstrate that due to the vacuum chamber contact to quadrupole magnets the quadrupoles were moving with increasing beam current leading to a significant orbit drift.

1 DELTA STORAGE RING

The DELTA Storage Ring is a 1.5 GeV 3rd generation storage ring for synchrotron radiation production [1].

The stability and reproducibility of the storage ring, especially the beam orbit, is crucial for the operation as synchrotron light source. The stability of the measured beam orbit itself depends on the position of the beam position monitors and the focusing magnets. Therefore the position of quadrupole magnets and beam position monitors was measured.

2 POSITION SENSORS

To allow the monitoring of the large amount of components with sufficient resolution an inexpensive commercially available solution was searched, which allows the direct position measurement of the components. As a good compromise between cost, sensitivity and ease of use, Linear Variable Differential Transformers (LVDTs) were chosen. For the time being 5 sensors from Schlumberger [2] and TWK [3] have been used to make first tests. The next step will be the installation of 25 sensors to monitor quadrupoles and BPMs in one fourth of the DELTA storage ring. This will allow to study, survey and improve the mechanical

stability of the components. After an efficient reduction of the movement of components the sensors will be mounted permanently on important BPMs to allow the correction of the BPM reading by the measured BPM position movement.

3 LINEAR VARIABLE DIFFERENTIAL TRANSFORMERS (LVDTs)

The position sensor works as an inductive half bridge. A position change of a Mu-Metall cylinder inside two solenoids induces an inductance change inside the two solenoids, which is transferred into a position proportional electrical signal (see Fig. 1). A standard measurement range of 5 mm was used. The sensor has a linearity of 0.25 % (10 μ m).

The output signal is connected to the DELTA control system via standard ADC boards.

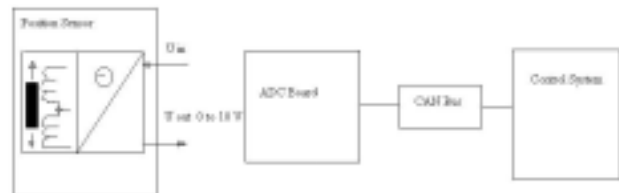


Fig. 1: Working principle of the Linear Variable Differential Transformer (LVDT).

4 FIRST MEASUREMENTS AND RESULTS

DELTA is only operated during the week from Monday morning to Friday afternoon. Especially on Mondays the reproducibility of the machine was difficult. The position monitoring of magnets showed a large movement of magnets during the Monday morning shift (see Fig. 2).

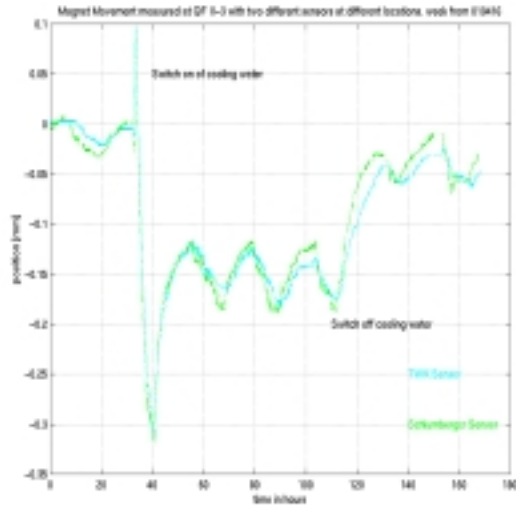


Fig. 2: Quadrupole Position measured during one week with beam stored at low energy (750 MeV) (no influence due to synchrotron radiation). Startup of the machine and daily changes are visible.

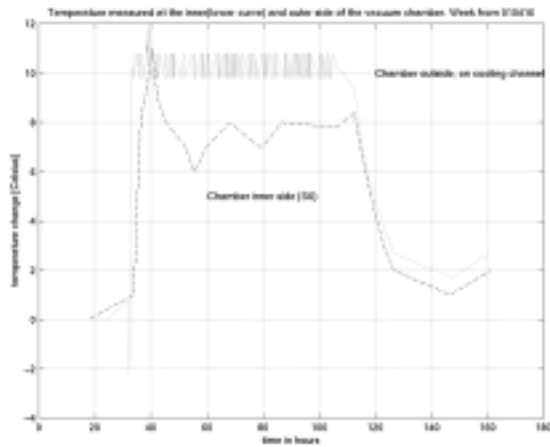


Fig. 3: Temperature development during the same week with low beam energy (750 MeV) (no heat load due to synchrotron radiation).

The effect can be explained by the rise of the cooling water temperature during the startup of the machine (see Fig. 3). The cooling channel is welded to the outside of the stainless steel vacuum chamber to dissipate the heat load from synchrotron radiation. During the start-up of DELTA the cooling water temperature increases. The outside of the vacuum chamber in the cooling channel becomes more than 10 degree Celsius warmer. This leads to a bending of the chamber because the inner chamber part follows with a delay. The temperature sensor reading

shows that it takes more than 4 hours to establish an equilibrium between inner and outer side of the chamber. The position of the quadrupoles follows this bending of the chamber (see Fig. 2 and 3). The vacuum chamber very often has contact to the quadrupole magnets and therefore moves them with the bending of the chamber.

In addition a daily change of the temperature in the hall leads to a temperature change at the inner side of the chamber whereas the outer chamber temperature due to the cooling stays constant. This leads to a bending of the chamber and to a movement of quadrupole magnets (see Figure 2 and 3). The data were recorded during a low energy run of DELTA so that the influence of synchrotron radiation can be neglected.

The third thermal effect is the heat load from synchrotron radiation. As a function of beam current and the cooling water temperature changes. This again bends the chamber and moves quadrupole magnets as visible in Figure 4 and 5.

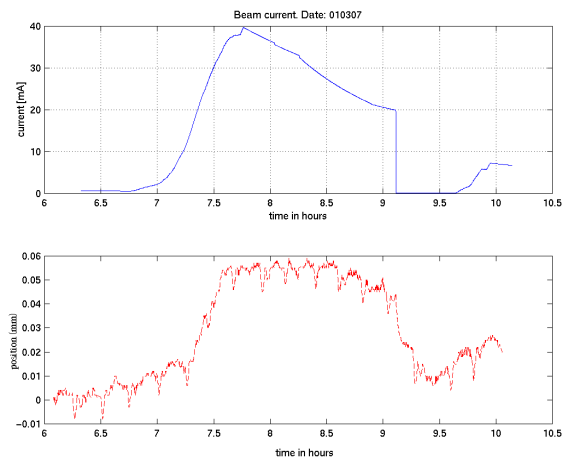


Fig.4: Magnet movement with increasing the beam current at 1.5 GeV beam energy.

The influence of a quadrupole magnet onto the equilibrium beam orbit depends on the position movement and the local betatron function. As a conclusion of the measurement especially some quadrupoles show a strong effect. To stabilise the beam orbit these quadrupoles will be disconnected from the vacuum chamber.

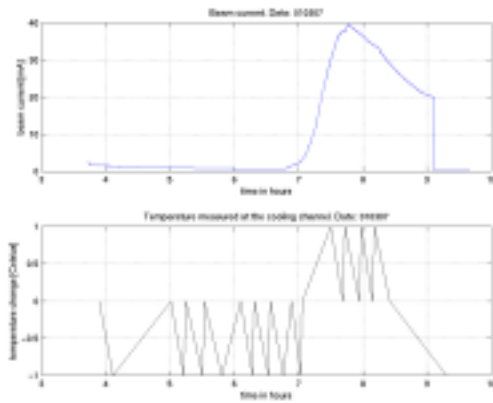


Fig.5: Chamber temperature as function of the beam current at 1.5 GeV beam energy. Synchrotron radiation changes the cooling water temperature.

5 CONCLUSION

The use of position sensors in combination with temperature sensors has allowed to understand the behaviour of the DELTA orbit stability problems. Some quadrupoles have already been located which have a significant position movement and influence on the equilibrium beam orbit. The next step will be to stabilise these quadrupoles.

The low cost and industrial availability of the used sensors will allow to use an increased number of sensors to study the effect of different improvements and changes in the chamber support, chamber design or cooling system.

Finally the position sensors will be used to monitor the position of BPMs and to include this information into the orbit correction scheme.

ACKNOWLEDGEMENT

Thanks to O. Kaul, B. Sarau, R. Fischer, M. Seebach from DESY Hamburg for their support and who made the Schlumberger sensors available to us.

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