NONDESTRUCTIVE TESTING OF NIOBIUM SHEETS FOR SRF CAVITIES USING EDDY-CURRENT AND SQUID FLAW DETECTION

A. Brinkmann#, W. Singer, DESY, D-22607 Hamburg, Germany

Abstract

For more than 10 years DESY has been operating a high resolution Eddy Current scanning installation with rotating table for non destructive flaw detection on niobium sheets for SRF Cavities. About 2500 sheets have been examined up to now. Several types of defects have been detected and identified using different supplementary methods such as EDX, X-ray fluorescence, neutron activation analysis etc. In order to scan Niobium sheets needed for XFEL Cavity production, new scanning devices have to be built. One improvement of the Eddy Current installations could be the use of a more sensitive superconducting SQUID sensor. A SQUID based scanner system was built and is in evaluation at DESY. A status report will be given.

INTRODUCTION

In 1996 the cavity D6 showed a strong temperature increasing during a RF test. The hotspot was located with a T-map system. Analysis with X-Ray radiograph, Synchrotron Radiation Fluorescence (SYRFA) and Neutron Activation Analysis (NAA) detected a tantalum inclusion 0.2 mm in diameter (Fig. 1). Due to this experience a non destructive testing device for niobium sheet inspection was designed.

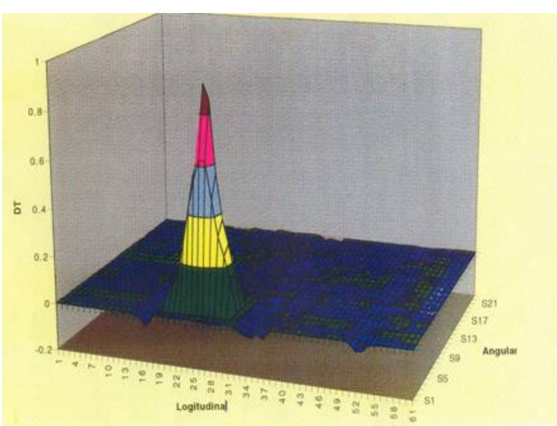

Figure 1: Hotspot found with T-Map.

EDDY CURRENT INSPECTION SYSTEM

DESY and BAM (Bundesanstalt für Materialforschung und – prüfung, Berlin, Germany) developed an Eddy Current Inspection System. About 2500 Nb sheets were inspected up to now [1] (Fig.2).

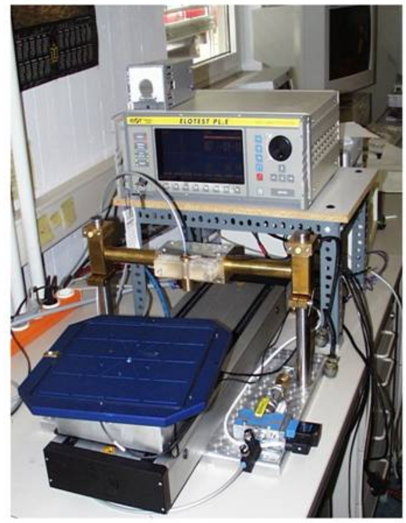

Figure 2: Eddy current inspection system.

Several kinds of flaws and imperfections were found with this system and could be analyzed with either EDX or SYRFA. For example: Fe inclusions (Fig.3-1), Si and Mg in small pits caused by grinding (Fig.3-2), imprints from rolling components (Fig.3-3), etching pits (Fig.3-4). Recently an image of the support frame in the 800° C furnace was found on a Nb sheet coming from evaporation or abrasion (Fig.3-5). On this niobium sheet Cr, Ni and W (1 %) could be detected on the surface using EDX.

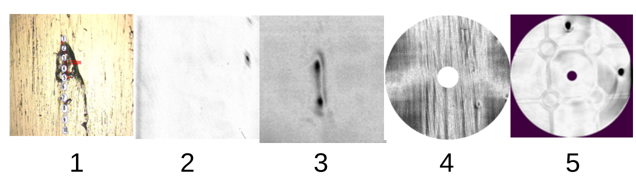

Figure 3: Several imperfections found with the Eddy Current Inspection System (explanation see text).

SQUID SCANNER

New scanning devices are required for the XFEL cavity production. One option is to replace the pick up coil of the conventional device by a superconducting SQUID element. This sensor promises a much higher sensitivity [2]. Therefore a SQUID scanner was developed and built in collaboration between DESY and the Company WSK. An excitation coil induces eddy currents in the sample. But in the case of a SQUID scanner a superconducting SQUID detects the related magnetic field. A compensation coil close to the SQUID cancels the primary excitation field (Fig.4).

arne.brinkmann@desy.de

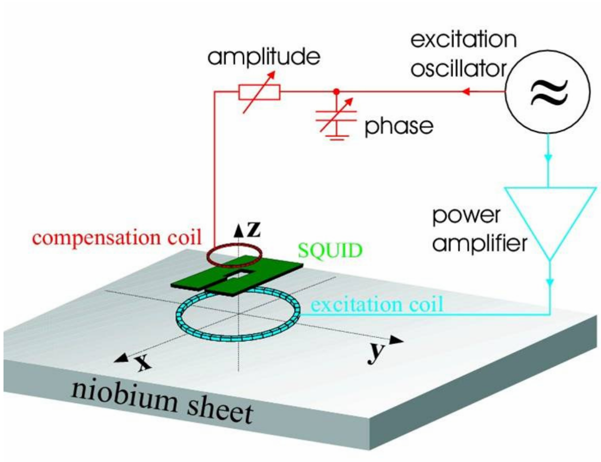

Figure 4: Measurement setup with SQUID.

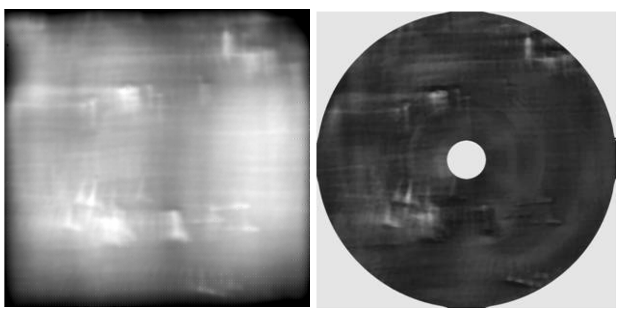

Figure 5: Scan images of SQUID (left) vs. EDDY-Current (right).

In addition the SQUID scanner uses more sophisticated image processing software. Compared to the conventional scanner SQUID images look more distinct (Fig.5). For twelve month the SQUID device is operational at DESY and shows promising results.(Fig.6).

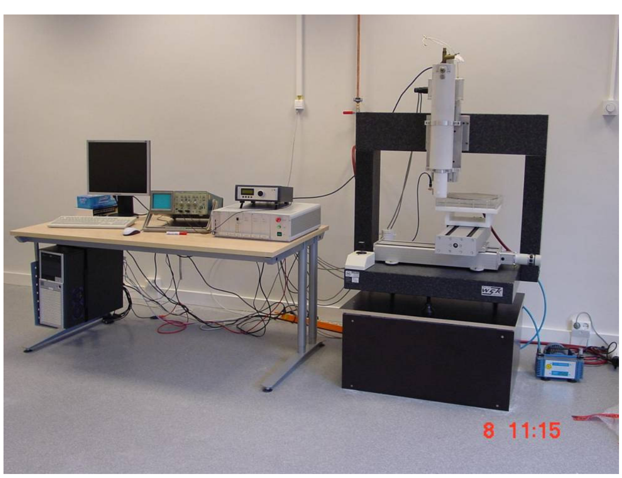

Figure 6: SQUID scanner at DESY.

STATISTICS

Figure 7 shows the number of scanned sheets (in total 2451). Out of these, 231 sheets were declared as „suspicious“ after first scan. Due to this a second scan of the rear side of the sheet was carried out. A large number of these sheets was accepted. Real defects were found only in the first years of the scanning control, e.g. iron and tantalum inclusions. Therefore we conclude the scanning control has a benefit effect to the cleanliness of the later niobium sheet production. We will continue to use the quality control by the Eddy current/ SQUID scanning to assure the high quality of the industrial Nb production.

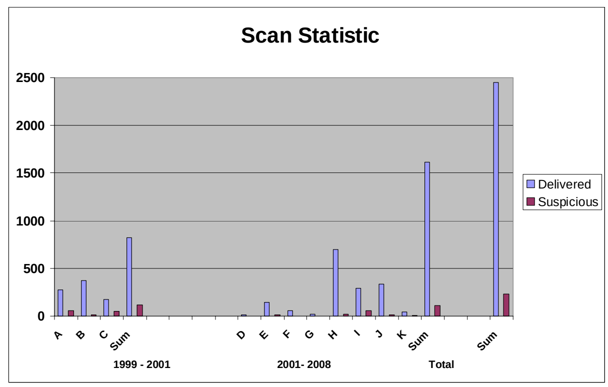

Figure 7: Statistic of scanned sheets, vertical axis shows the number of scanned sheets, horizontal axis batch number and production time of sheets.

SUMMARY

PRO	***CONTRA***
SQUID: More sensitive procedure compared to conventional setup.	SQUID: Only prototype available.
SQUID: Less Lift-Off effect -> no distance control needed.	SQUID: More complicated technique. For operating liquid Helium is required.
EDDY: well-established method. Ready to run systems available from industry.	SQUID: Limited frequency spectrum to 100 kHz. Signal penetrates through the sheet -> analysis is more complicated

Table 1: Comparison of Eddy Current and SQUID Scanner

The eddy current setup has been in operation at DESY for more than ten years. The higher sensitivity of the SQUID element promises to detect smaller defects as compared to the normal conducting device. However, to exploit this benefit improvements of the present software and the cryogenic system are required. Table 1 lists the pros and cons of both systems.

ACKNOWLEDGEMENT

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[2] W.Singer, A.Brinkmann (DESY),F.Schoelz, A.Farr, E.Wappler (WSK), M.Mueck (ez-Squid), “SQUID-Based Scanning System for Detecting Defects in Nb Sheets for RF Cavities”. Proceedings of the 12th Workshop on RF Superconductivity, Cornell University, Ithaca, New York, USA, July 2005.