Study on Nondestructive Evaluation System Using SQUID

李佳榕、洪振義

E-mail: 9511162@mail.dyu.edu.tw

ABSTRACT

ABSTRACT SQUID （Superconducting Quantum Interference Device）is the most sensitive magnetometer now. It can detect the signal as small as 10-14 to 10-15 Tesla, which is one-billionth of terrestrial magnetism. Another, because of the unique properties of the voltage variation periodically with magnetic flux, SQUID has been applied in precision measurement, like the weak magnetic field, current, voltage, inductance, and magnetic susceptibility. Based on the eddy current method, this work proposed the nondestructive evaluation of the metal conductor by using the combination of the transfer coil probe and SQUID magnetometer. We developed all the experimental system including Dewar, magnetically shielding box, and coil. In Dewar, the G-10 fiberglass is used to manufacture the vacuum bottle of liquid nitrogen because of the property of thermal conductivity and non-metal to avoid the influence of the SQUID sensing. In magnetically shielding box, mu-metal plate, copper net, and aluminum plate are used. The first is for anti- terrestrial magnetism and low frequency noise. The others are for isolating the electromagnetic wave of high frequency. Besides, we designed excitation coil and pick-up coil as the gradiometer probe to detect the crack signal. Then the induced current in the gradiometer probe rebuilt the magnetic field inside the magnetically shielding box, which is sensed by SQUID. It has many advantages than the tradition method of the direct sensing by SQUID. For example, the active probe is more practical and convenient than the heavy and large Dewar with SQUID. And the sensitivity is improved due to no limitation of the space between SQUID and sample

Keywords : SQUID ; magnetometer ; eddy current ; gradiometer

Table of Contents

REFERENCES

參考文獻 [1] John P. Wikswo, Jr.,“ SQUID Magnetometers for Biomagnetism andNondestructive Testing: Important Questions and Initial Answers, ” IEEE Trans.Appl. Supercond., vol. 5, No. 2, pp. 74-120,1995.

[2] H. Fukutomi, T. Takagi, and M. Nishikawa,“ Remote field eddy current techniqueapplied to non-magnetic steam generator tubes, ” NDT&E International, vol. 34, pp. 17-23, 2001.

[3] C. Rem, E. M. Beunder, and A. J. van den Akker,“ Simulation of Eddy-CurrentSeparators, ” IEEE Trans. on Magnetics, vol. 34, no. 4, pp. 2280-2286, 1998.

[4] 劉福順，湯明，無損檢測基礎，北京航空航天大學，2002。

[5] 王仲生，無損檢測診斷現場實用技術，北京:機械工業出版，2002。

[6] Yoshihiro Nonaka,“ A Double Coil Method for Simultaneously Measuring theResistivity, Permeability, and Thickness of a Moving Metal Sheet, ” IEEE Trans.Inst.& Measurement, vol. 45, no. 2, pp. 478-482, 1996.

[7] A.Likhachev, V.Polushkin, S.Uchaikin, and B.Vasiliev, Supercond. Sci.Technol.3,148 (1990).

[8] 李家傳，陳積懋，無損檢測手冊，北京:機械工業出版，2002。

[9] C. C. Tai, J. H. Rose, and J. C. Moulder, “ Thickness and Conductivity of MetallicLayers from Pulsed Eddy Current Measurements, ” Rev. Sci. Instrum,vol. 67, pp. 3965-3972, 1996.
[10] W. G. Jenks, S. S. H. Sadeghi, and J. P. Wikswo, Jr., “ SQUIDs for Non-DestructiveEvaluation, ” J. of Physics D: Appl. Phys., vol. 30, pp. 293-323, 1997.
[11] 李冠勳, “ 差動式渦電流探頭於缺陷偵測之最佳激發頻率研 究 ”,國立台北科技大學製造科技研究所碩士論文,2005 [12] J. B. Hull, and V. B. John, Non-destructive testing, London: MacMillanEducation LTD., 1988.
[13] H. Weinstock, “ A review of SQUID magnetometry applied to nondestructive evaluation ”, IEEE Trans. Mag., vol. 27, no. 2, pp. 3231-3236, 1991.
[14] 鄭振宗, “ 直流高溫超導SQUID的特性及其在非破壞性檢測 上之應用 ”,國立台灣師範大學物理研究所博士論文,2001 [15] W G Jenksy, S S H Sadeghiz and J P Wikswo Jry, “ REVIEW ARTICLESQUIDs for nondestructive evaluation ”, J. Phys. D: Appl. Phys. 30,pp. 293 – 323, 1997.
[16] 物理會刊， 5 卷4 期, P.189-193 (1984) [17] 楊謝樂, “ Fabrication And Characterization of High-TC YBa2Cu3Oy Josephson Junction And SQUIDs ”,國立台灣師範大學物理研究所博士論文,1999 [18] 物理雙月刊,24卷5期,P652-665,2002 年10 月 [19] 徐智魁, “ 高溫超導量子干涉元件一階梯度計之製作與特性研究 ”,國立台灣師範大學光電科技研究所碩士論文,2005 [20] J. T. Jeng, H. E. Horng, and H. C. Yang, “ High-Tc SQUID magnetometers andgradiometers for NDE application, ” Physica C, vol. 368, pp. 105-108, 2002.
[21] Jen-Tzong Jeng, Guan-Shiun Lee, Hsin-Chin Hung, Ju-Chien Chen, Wen-SungChiou, Li-Lun Chen, Ji-Cheng Chen, Chiu-Hsien Wu, Hong-Chang Yang, and H. E.Horng, Proc. of 6th European Conference on Applied Superconductivity(EUCAS 2003), Sorrento, 2003.
[22] Tadayuki Kondo and Hideo Itozaki, “ Normal conductingtransfer coil forSQUID NDE ”, Supercond. Sci. Technol. 17.pp 459 – 462, 2004.
[23] Akihiko KANDORI, Daisuke SUZUKI, Koichi YOKOSAWA, Akira TSUKAMOTO,Tsuyoshi MIYASHITA, Keiji TSUKADA and Kazumasa TAKAGI, “ A Superconducting Quantum Interference Device Magnetometer with a Room-Temperature Pickup Coil for Measuring Impedance Magnetocardiograms ”, Jpn. J. Appl. Phys. Vol. 41 ,pp. 596 – 599, 2002.
[24] D F He ,H Itozaki and M Tachiki1, “ Improving the sensitivity of a high-Tc SQUID at MHz frequency using a normal metal transformer ”, Supercond. Sci. Technol. 19, S231 – S234, 2006.