FINAL REPORT
For Japan-Korea Joint Research Project

AREA	1. Mathematics & Physics (2.) Chemistry & Material Science 3. Biology 4. Informatics & Mechatronics 5. Geo-Science & Space Science 6. Medical Science 7. Humanities & Social Sciences

1. Research Title:

Advanced electromagnetic diagnostic techniques for aging degradation in RPV materials

2. Term of Research: From 7.1.2009 To 6.30.2011

3. Total Budget

a. Financial Support by JSPS: Total amount: 2,400 thousand yen

1st Year 1,200 thousand yen 2nd Year 900 thousand yen

3rd Year 300 thousand yen

b. Other Financial Support : Total amount: 0 thousand yen

4. Project Organization

a. Japanese Principal Researcher	
Name	KAMADA Yasuhiro
Institution / Department Position	Department of Materials Engineering / NDE & Science Research Center (NDE&S-RC), Faculty of Engineering, Iwate Univ. Associate Professor
b. Korean Principal Researcher	
Name	CHEONG, Young-Moo
Institution / Department Position	Nuclear Material Research Center, Korea Atomic Energy Research Institute (KAERI) Principal Researcher & NDE Project Leader

c. List of Japanese-side Participants (Except for Principal Researcher)

Name	Institution/Department	Position
ECHIGOYA Jun-ichi	NDE&S-RC, Faculty of Engineering, Iwate Univ.	Professor
KIKUCHI Hiroaki	NDE&S-RC, Faculty of Engineering, Iwate Univ.	Associate Professor
KOBAYASHI Satoru	NDE&S-RC, Faculty of Engineering, Iwate Univ.	Assistant Professor
WATANABE Hideo	Research Institute for Applied Mechanics, Kyusyu Univ.	Associate Professor
OHTANI Toshihiro	Mechanical Systems Engineering, Faculty if Engineering, Shonan Institute of Technology	Professor
OGI Hirotsugu	Graduate School of Engineering Science, Osaka Univ.	Associate Professor
Nakamura Nobutomo	Graduate School of Engineering Science, Osaka Univ.	Assistant Professor

d. List of Korean-side Participants (Except for Principal Researcher)

Name	Institution/Department	Position
PARK, Duck-Gun	Nuclear Materials Research Div., KAERI	Principal Researcher
JUNG, Hyun-Kyu	Nuclear Materials Research Div., KAERI	Principal Researcher
PAEK, Seung-Hoon	Nuclear Materials Research Div., KAERI	Principal Researcher
PARK, Seung-Kyu	Nuclear Materials Research Div., KAERI	Principal Researcher
KIM, Young-Suk	Nuclear Materials Research Div., KAERI	Principal Researcher

5. Number of Exchanges during the Final Fiscal Year*

a. from Japan to Korea

*Japanese fiscal year begins April 1.

Name	Home Institution	Duration	Host Institution
For Final Fiscal Year(FY2011) Total: 0 persons		For Final Fiscal Year(FY2011) Total: 0 man-days	
Numbers of Exchanges during the past fiscal years			
FY2009: Total 6 persons FY2010: Total 2 persons			

b. from Korea to Japan

Name	Home Institution	Duration	Host Institution
For Final Fiscal Year(FY2011) Total: 0 persons		For Final Fiscal Year(FY2011) Total: 0 man-days	
Numbers of Exchanges during the past fiscal years			
FY2009: Total 3 persons FY2010: Total 2 persons			

6. Objective of Research

The objective of this project is development of electromagnetic diagnostic techniques for aging degradation in nuclear reactor pressure vessels (RPV) materials. Lifetime extension of existing nuclear power plants requires the development of reliable nondestructive evaluation (NDE) techniques for inspection of aged components, and especially evaluation of irradiation embrittlement of RPV steels is a worldwide problem. Our final goal is to develop new NDE techniques for material degradation due to the nano-structural change of lattice defects before crack initiation, which is quite different from the concept of conventional one.

The KAERI has been investigating a magnetic NDE since 1990s, and developed the excellent measurement techniques. The NDE & Science Research Center in Iwate University was established in 2001, and had been investigating magnetic characteristics of aged materials. Currently, there is no group in the world except for NDE & S-RC and KAERI, who are engaging directly in the nuclear RPV problems from this concept. Quite recently, new NDE projects on “magnetic” and electromagnetic “ultrasonic” techniques have started independently in each group. These techniques will realize the precise measurement of the properties sensitive to the degradation of materials used in nuclear RPV and RPV components.

The present proposal mainly focuses on the cooperation in these topics, and the cooperation between NDE & S-RC and KAERI is very important in the development and establishment of these techniques. The aim of this joint project will be mainly the investigation of the magnetic and electromagnetic ultrasonic properties for common specimens, and establishment of the fundamentals of these newer NDE techniques, and ensuring a safe operation of nuclear power plants in the world.

7. Methodology

In this joint research project, magnetic and ultrasonic measurements were performed for thermally aged Fe-Cu and Fe-Cr model alloys in order to demonstrate a feasibility of our NDE methods for irradiation degradation of RPV steels and reactor component materials.

(1) Measurement method

(1-1) Magnetic measurement

Magnetic Hysteresis Loop (MHL) measurement

The MHL is generated by measuring the magnetic induction (*B*) of a ferromagnetic material while changing the magnetizing Field (*H*) called as magnetic hysteresis loop (MHL), *B*-*H* loop. The measurement setup in ring shape samples is shown in Fig. 1.

The structure sensitive parameters are permeability, coercivity and remanence.

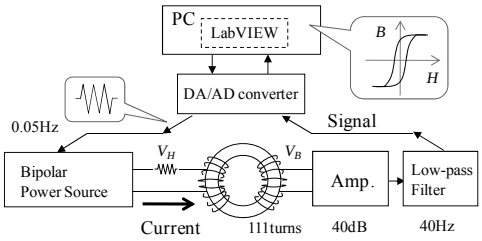

Fig. 1 Set up for MHL measurement.

(1-2) Ultrasonic measurement

Electromagnetic Acoustic Resonance (EMAR) measurement

EMAR is the EMAT measurement in the resonant mode and is a non-contact measurement. The measurement set up for EMAR using parallelepiped specimen in two different configurations is shown in Fig 2. The measuring parameters are resonance frequency and attenuation.

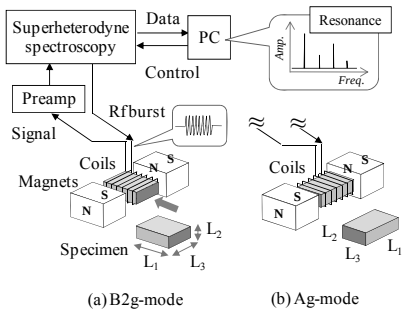

Fig. 2 Set up for EMAR measurement.

(2) Specimens

(2-1) Fe-Cu model alloys

Fe-1wt% Cu model alloy was prepared and systematically isochronal aged for simulation of the irradiation embrittlement in RPV steels.

(2-2) Fe-Cr model alloys

Fe-Cr model alloys with different Cr content ($x =$ 5 , 10, 15, 20, 30, 40, 48) were prepared, and systematically isothermal and isochronal aged. Thermal embrittlement of nuclear reactor components is one of the important degradation problems.