

Thermal Conductivity Measuring System for Nuclear Materials

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1. Introduction

PIE & Radwaste (Post-Irradiation Examination & Radio-active Waste) division at KAERI(Korea Atomic Energy Research Institute) has carried out post irradiation examinations (PIEs) of the nuclear materials and fuels for the Hanaro reactor, CANDU, PWR and newly developed nuclear fuels. IMEF(Irradiated Material Examination Facility) in PIE & Radwaste division has been developing many kinds of PIE technologies. The thermal conductivity is considered to be one of the most important thermo-physical properties for nuclear fuels and materials. The determination of the thermal conductivity of a nuclear material is accomplished by a measurement of the thermal diffusivity and the use of a defining relation for the diffusivity, specific heat capacity and density. The most widely employed technique is the pulse heating flash method proposed by Parker et al[1]. In the flash diffusivity technique, a pulse of energy is incident on one of two parallel of a sample. The subsequent temperature history of the opposite face is then related to the thermal diffusivity. In spite of the many merits in using the pulse heating flash technique, the complexity of the laser flash thermal diffusivity measuring system restricts its use a radioactive environment. Due to a sample's characteristics, the measuring system should be installed in a hot cell or a shielded glove box. Therefore, it is necessary to review, investigate and analyze the related requirement so as to install the measuring system in a hot cell or a shielded glove box. Selected requirement is reflected in the specification of a measuring system and realized requirement is used to solve the related problems.

2. General Requirements of a laser flash thermal diffusivity measurement system for a shielded glove box

Because the measuring system will be operated in radiation environment, the system should be shielded from radioactive radiation and operated using remote control measures(e.g. manipulator or tong). In addition, a radioactive specimen emits volatile fission products during it's use of high temperature test condition. Owing to those characteristics, a measuring system in a hot cell or shielded glove box needs more subsequent functions than ordinary measurement systems. Consequently the following general requirements are needed for its use in the nuclear field. General requirements[2-6]of the laser flash thermal diffusivity measuring system are a remote controllable, a good accessibility and maintainability, a durability for radiation, an easy decontamination, an easy installation in a hot cell or a shielded glove box, and a modular design for an electronic component to prevent it from radiation damage . As seen in table 1 and related figure, the general requirement and it's solution are given.

Table 1 General Requirements and Solutions

	Requirement	Solution	Remark
1	Remote controllable	Grip adoption, Manipulator	Fig 3.
2	Good accessibility and maintainability,	Simple structure design	Fig 1.
3	Durability for radiation,	Selection of proper material, Shielding by lead	Fig 2.
4	Easy for decontamination,	Surface treatment,	Fig 1.
5	Easy installation in hot cell or shielded glove box	Vertical type design to minimize volume	Fig 1.
6	For electronic component to prevent from radiation damage .	Modular type design, Shielding by lead	Fig 2.

3. Technical Requirements of a laser flash thermal diffusivity measurement system for a shielded glove box

There are also technical requirements for a technical and functional performance. Such technical and functional requirements are the following.

- Measurable for a small specimen owing to the limitation of radioactivities.
- Prevention from a contamination by a exhausted gas of a volatile radiation material
- Sample holder and jig of a small and irregular shape.
- Available for a vacuum or protective gas use to protect a sample.
- Non-reaction between a structure material in the furnace and a uranium pellet when heated in a high temperature.
- Air tweezers or equivalent measures to handle a small specimen.
- Closed cooling water circulation system for the furnace. : Fig 3.
- Tool for furnishing LN-2 of the infra-red detector.
- Convenience of operation and sufficient operation area (e.g. specimen loading , fulfilling LN-2) : Fig 4.
- Removal of an interference for each operation (e.g. filter replacement, use of air tweezers)
- Filter selection by considering the period of a replacement, price and capability for filtering a volatile gas (e.g. Cs-137) : Fig 5.

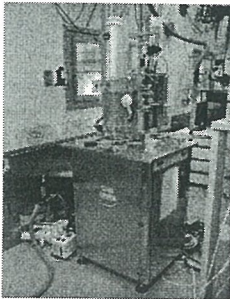


Fig 1. Vertical type design

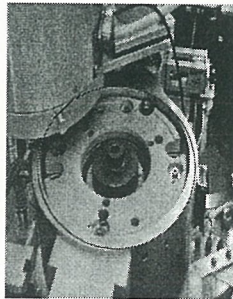


Fig 2. Modular type & lead shielding

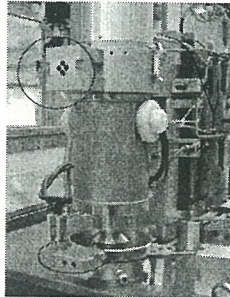


Fig 3. Grip & closed cooling water system

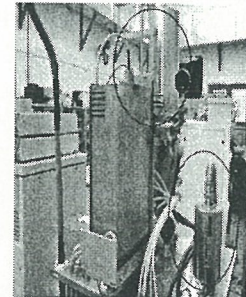


Fig 4. Filter & LN-2 supply system

4. Conclusion

In order to operate in a nuclear radiation environment, the general and technical requirements of a laser flash thermal diffusivity measuring system are reviewed and analyzed. Selected requirements are reflected in the specification of the measuring system and the realized requirements are used to solve the related problems. Taking account of not only the general requirement but also the technical requirement, the measuring system is designed and fabricated. The measuring part except for data acquisition, laser generating part and control unit of the system will be installed in a shielded glove box in the near future.

REFERENCES

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