R&D on Maintenance Technologies for FBR plants in JAEA

—*The status quo and the future plan*—

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2. Inspection, repair and replacement
3. Monitoring of leakage
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5. Maintenance methods
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1. Introduction

New Inspection System : 2008~.

The performance : PDCA (Plan-Do-Check-Action)

Recommendation : Risk Information, ***Condition Monitoring***, etc.

FBRs : ***Invisible*** and ***High Temperature*** environments.

The main monitoring of FBR components :

Detection of Sodium Leakage or ***Cover gas Leakage***.

However, it is important to conduct Periodic Inspections and detect defects in repairable stage for ***Stable and Reliable Operation***.

1. Inspection, Repair and Replacement
2. Monitoring
3. Inhibition of Degradation
4. Maintenance Methods
5. Maintenance program and other techniques

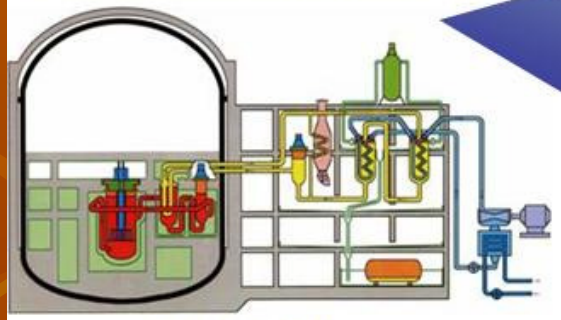
1. Introduction

Inspection, Repair and Replacement
I. Visualization equipment, Vehicle in liquid sodium
I. Inspection of SG double-walled tube
II. Inspection of integrated IHX with primary pump
I. Laser repair technique
II. Repair technique in sodium

Maintenance Methods
I. Heat resistant sensors for condition monitoring
II. Damage simulation analysis methods
II. Health monitoring and fault diagnosis

Maintenance Program
II. Optimization of maintenance system (combination of TBM and CBM)
II. Risk based maintenance and repair guideline
II. Performance evaluation of maintenance actions
II. Rationalization of maintenance actions by the integration of related technologies

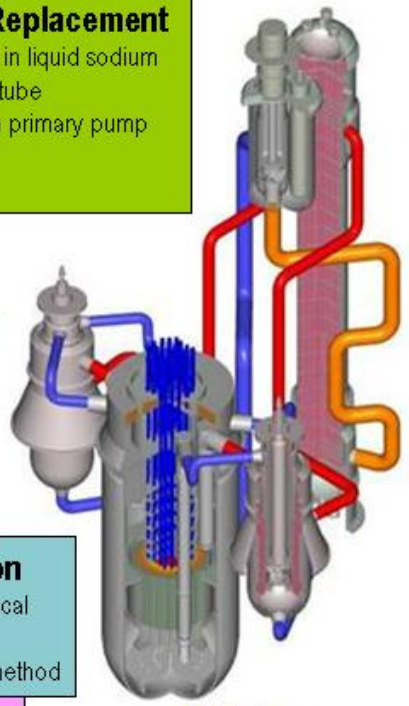
Operation and Maintenance Experience
Results of R&Ds



MONJU

Inhibition of degradation
II. Evaluation method of mechanical strength
II. Environmental management method

Monitoring
II. Monitoring technology in high temperature.
II. Development of sensors, endurance tests in sodium
II. Very small sodium leakage detection system
II. Ultrasonic thermometer and flow-meter, hydrogen detector, and calibration method of sodium level gauge



JSFR 2025~

I. > Phase I (~2015)
II. > Phase II (2015~)

To meet the design requirements for commercial FBR (continuous operation period ≧ 18 months, availability ≧ 90%), development of maintenance technologies, considering the features of sodium cooled FBR, is indispensable to pay attention to both maintainability and repairability from the conceptual design stage.

R&D on FBR Maintainance Technologies

2. Inspection, repair and replacement

Periodic Inspections is important for main components and detect defects in repairable stage.

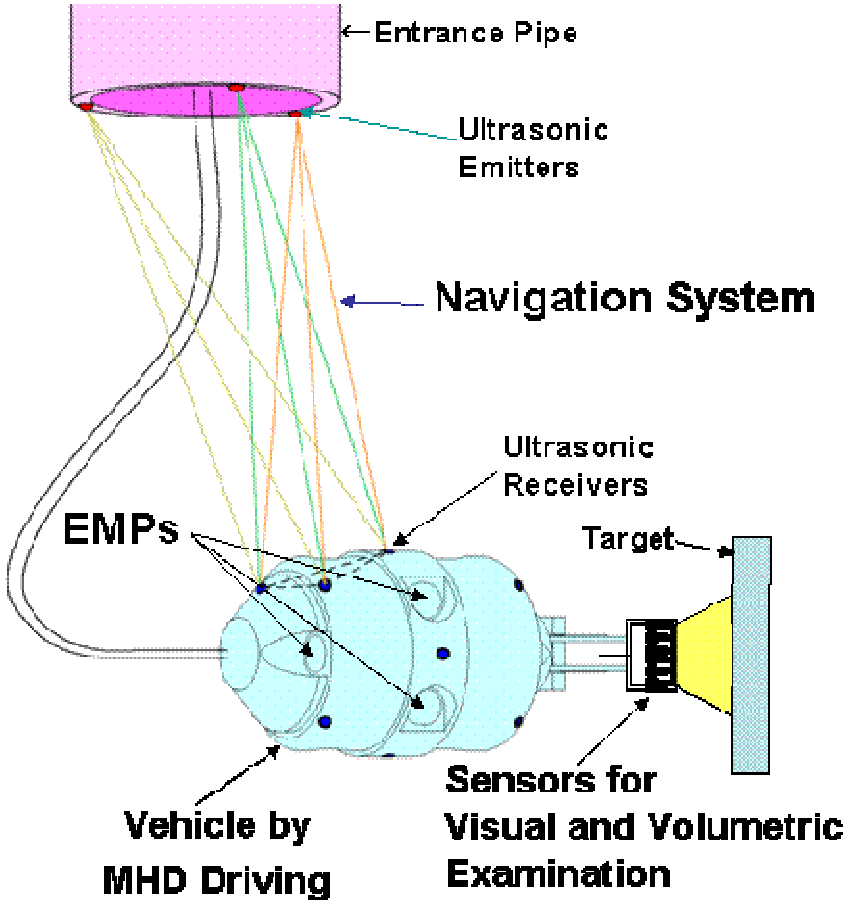
Remote controlled inspection & Repair technology

Core Support Skirt :

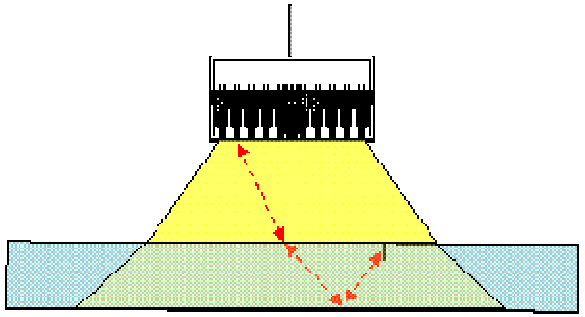
Inspection technology for welding ***under sodium***.

Under Sodium Viewing sensor (USV) and Vehicle in sodium are being developed.

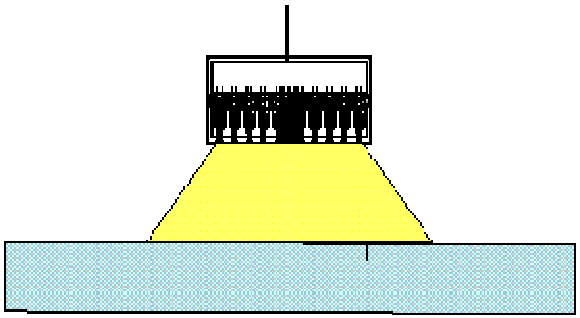
2. Inspection, repair and replacement



1) Under sodium inspection system



2) Volumetric test under sodium



3) Visual test under sodium

Under sodium inspection system and sensors for JSFR

2. Inspection, repair and replacement

Steam Generator :

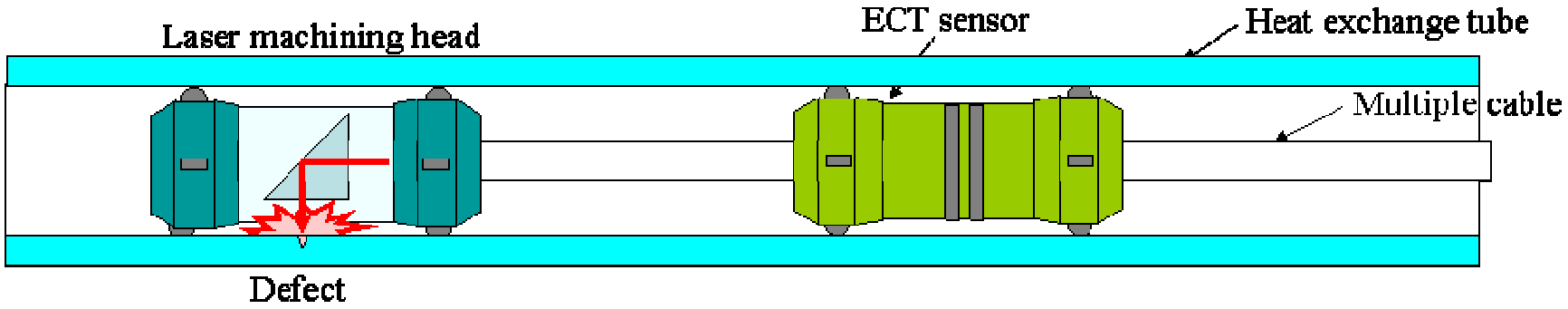
Double walled straight tubes and *Large number of the tubes.* → ***Inspection Efficiency***.

Guide wave sensor is available even when sodium is present on outside of the tubes and at high temperature.

Repair device using laser machining.

ECT for defect detection, Endoscope for defect viewing and ***Laser for repair***.

2. Inspection, repair and replacement



Repair device of SG tubes using laser machining technology

3. Monitoring of leakage

The main monitoring of FBR components is the detection of sodium leakage or cover gas leakage due to through wall cracks at the boundary.
And the detection of water leakage in SG is key issue.

/ Development of sensors and endurance tests in sodium is expected for SG monitoring.
/ *Very small sodium leakage detection system* for dual piping system is to be developed.
/ Ultrasonic thermometer and flowmeter, hydrogen detector, and calibration method of sodium level gauge are important engineering elements.

4. Inhibition of degradation

Demonstration FBR :

High temperature(550˚C), Long service life(60 years)

Material degradation :

Creep-fatigue, Thermal aging, Weld cracking

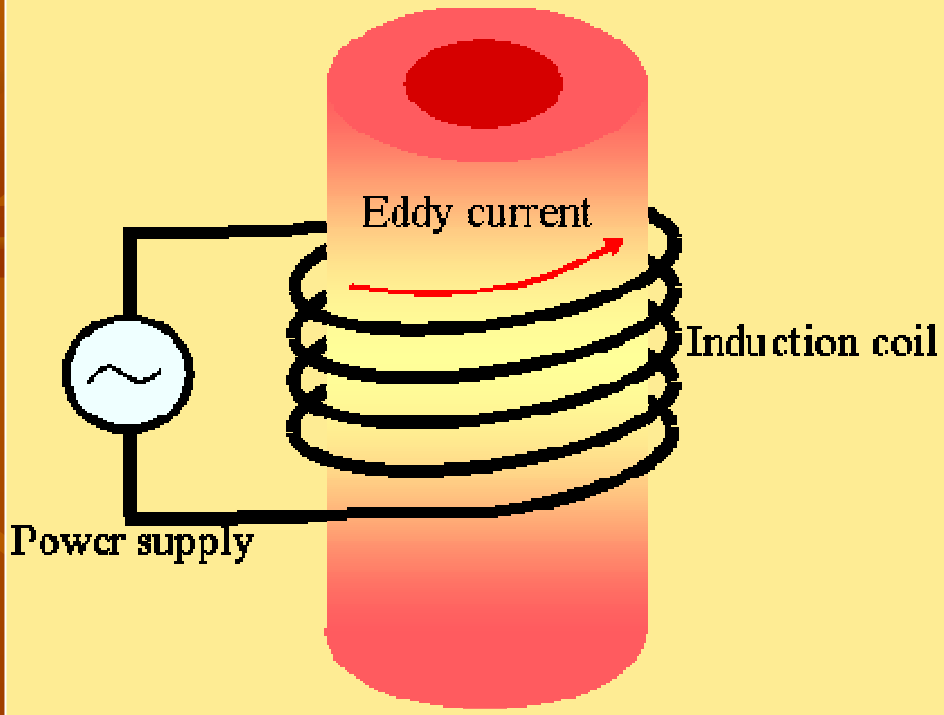
Healing technologies of materials: Heat treatment

Laser heating and Induction heating.

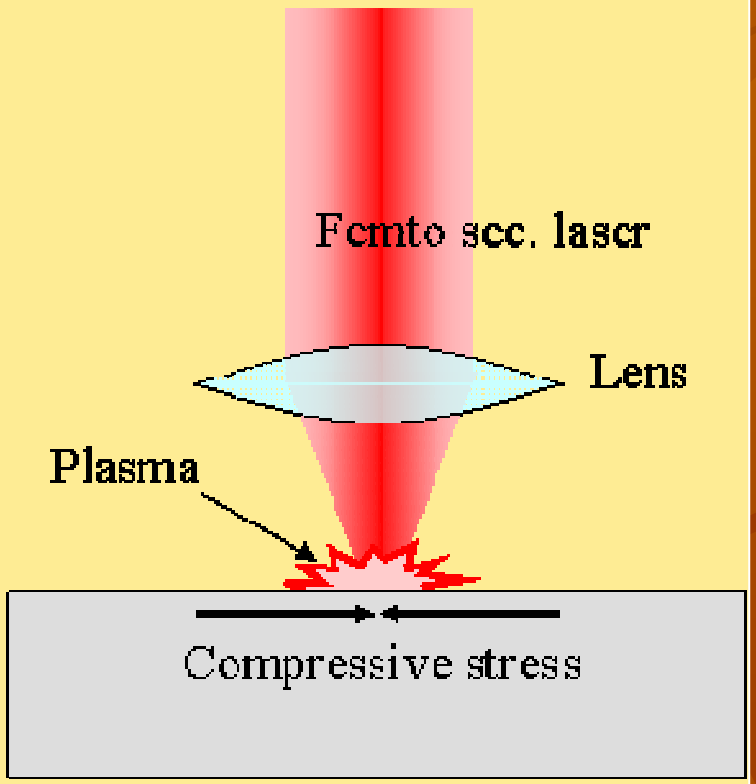
Strengthening technologies of materials: *Peening*

Laser peening suitable for remote work and **Shotless peening**.

4. Inhibition of degradation



Induction heating



Laser peenig

5. Maintenance methods

Time Based Maintenance (TBM) mainly used.

However, ***Condition Based Maintenance (CBM) technologies*** must be developed to attain good performance for safety and reliability.

Monitoring devices (sensors) to measure the current state of operating plant components and ***Processing system*** of the information from the monitoring devices are necessary.

5. Maintenance methods

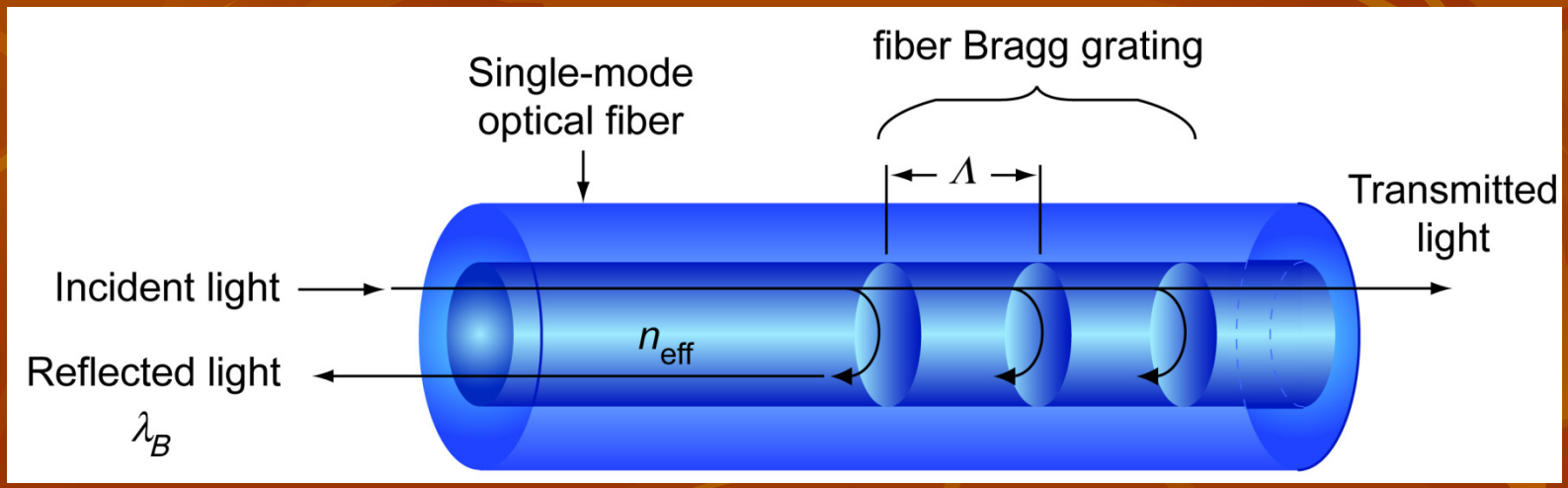
5.1 monitoring device

Fiber Bragg grating (FBG) sensors : a promising sensing device

- intrinsically immune to electromagnetic interference, resistant to corrosion, and durable for a long term use.

- cascaded, or multiplexed as a single sensing arm and have sensitivity to multiple parameters such as temperature, strain, and vibration.

- a simple, cost effective monitoring system

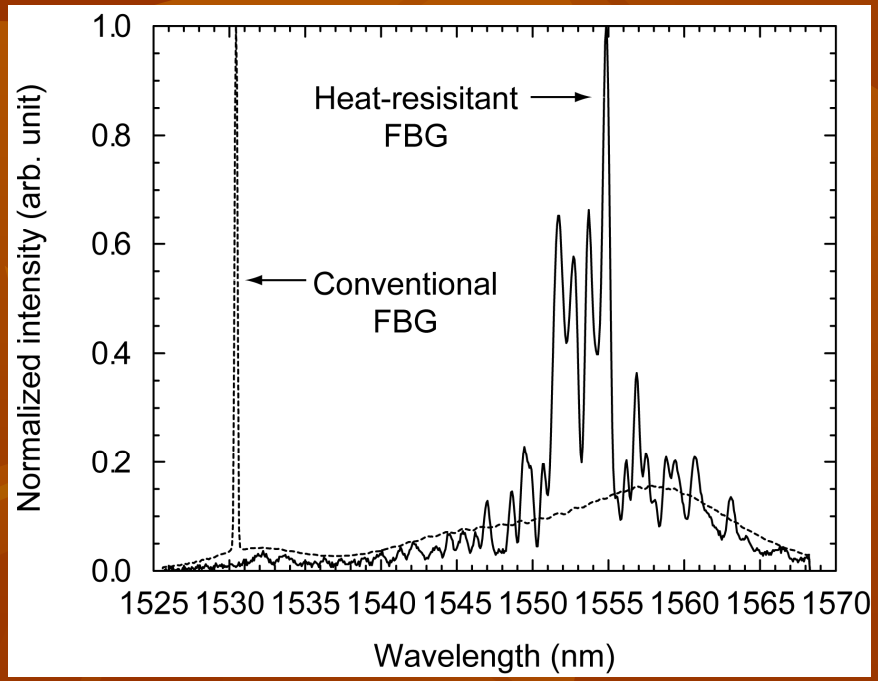


5. Maintenance methods

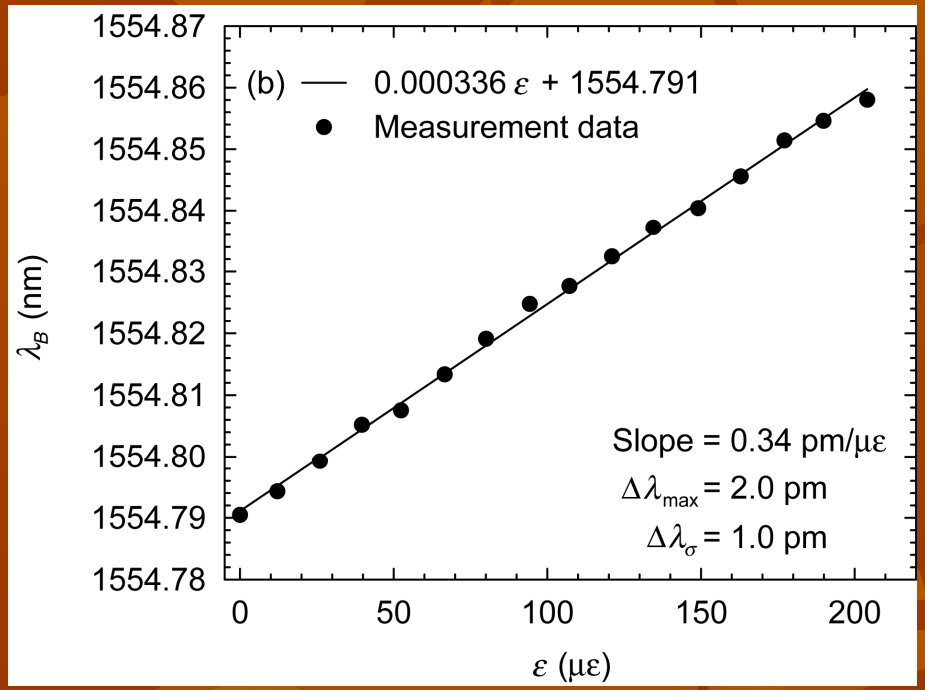
5.1 monitoring device

Heat-resistant FBG : femto second laser

Conventional FBG : UV laser



Spectra of heat-resistant FBG and conventional FBG sensors.



The Bragg wavelength vs strain for the heat-resistant FBG

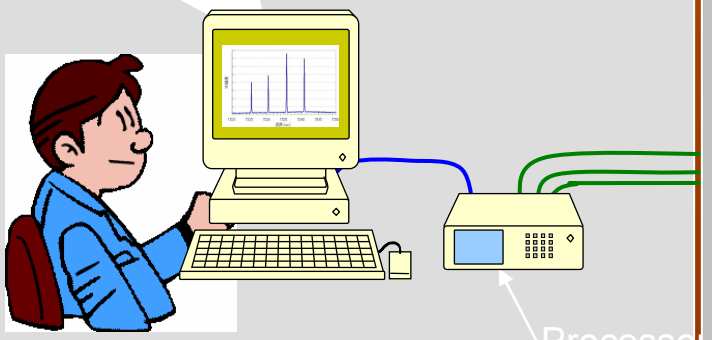
5. Maintenance methods

5.2 Diagnosis system

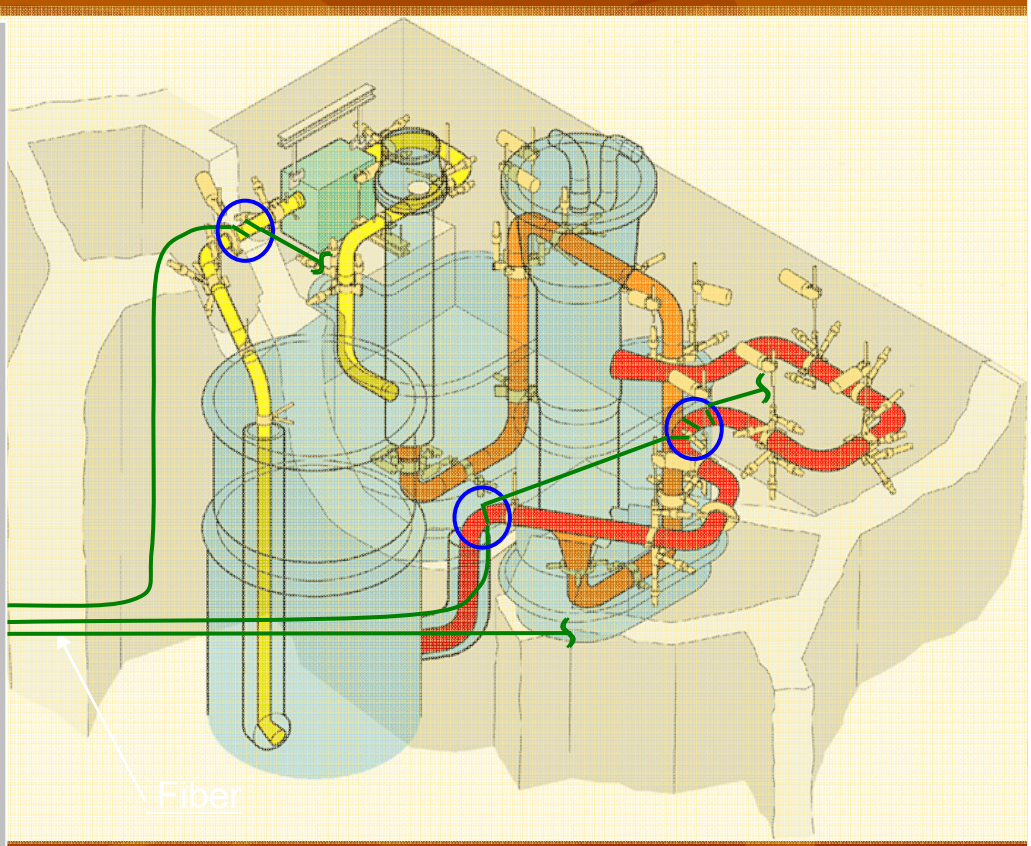
A concept of the diagnosis system by using FBG sensors.

Remote, multiple points, real time, continuous observation of high temperature components

Strain, temperature, vibration, etc.



Processor



Fiber

6. Maintenance program and other techniques

Optimization of Maintenance System is very important in order to attain *High Performance* and *High Quality of the plant operation*.

Combination of TBM and CBM and the *Integration Strategy of the developed technology elements* is effective in making the maintenance program.

Also, *Human Factors* should be considered in composing the system.

7. Sodium test facility for R&D on maintenance technology

Sodium Test Facility planned in Shiraki, Tsuruga near Monju site

- Innovative measurement instrumentation inside and outside of sodium,
- Innovative chemical analysis methods of sodium and its impurities,
- Aging degradation assessment technologies,
- Phenomenological research related to sodium,
- Advanced technology for quality control of sodium and sodium handling,
- Construction of design and safety related database.

8. Concluding remarks

Development of Maintenance methods of FBR plant components needs high level techniques, since Main components are exposed to ***elevated temperature environment*** and the coolant is ***invisible such as sodium***.

Introduction of CBM and good combination of TBM and CBM will be needed in Commercial stage of FBR plants to attain good performance and high reliability of the plants.

R&D on maintenance technologies in JAEA is introduced briefly including the ongoing projects and the expected concept being considered.