Karlsruhe Institute of Technology

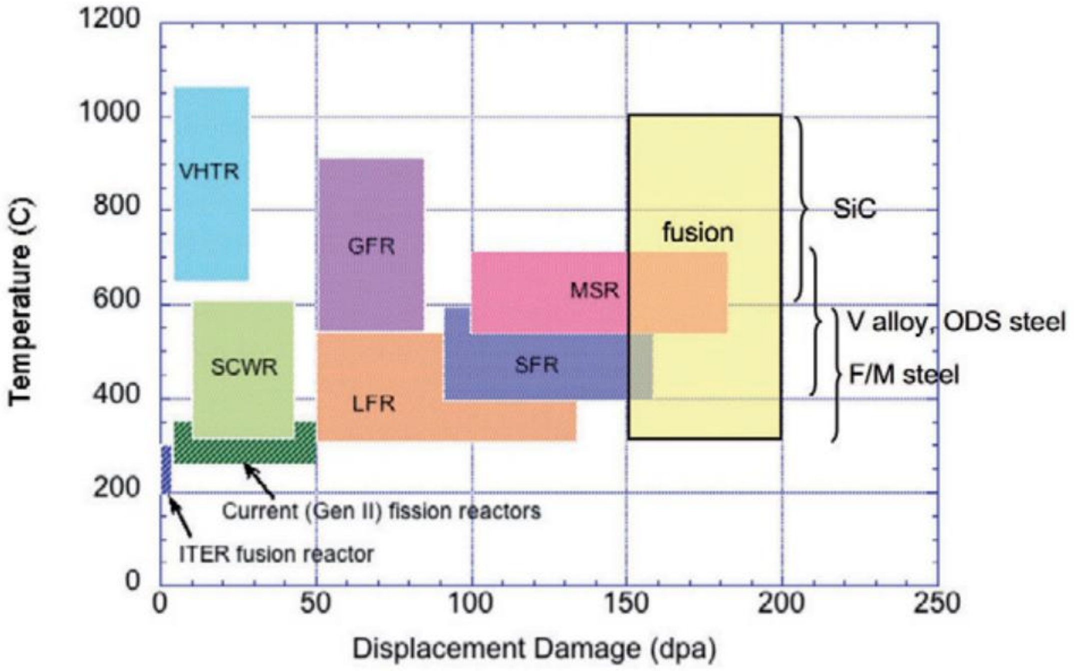
Agenzia nazionale per le nuove tecnolog
l'energia e lo sviluppo economico sosteni

Centro de Investigaciones
Energéticas, Medioambientales
y Tecnológicas

IAEA
International Atomic Energy Agency

Technical Meeting on Synergies between Nuclear Fusion Technology Developments and Advanced Nuclear Fission Technologies

Vienna June 6th to 10th - A. Weisenburger, L. Malerba, M. Utili



Regarding dose and temperature there is "some" overlap between fission and fusion mainly GENIV systems

In addition circulating fluids are common or have common issues

Overview: Structural materials and circulating fluids

- Chapter 3.2 Structural Materials and Circulating Fluids
  - 3.2.1 Neutron irradiation resistant materials (*E. Gaganidze, L. Malerba, M. Sauzay, Y. Dai, C. Kaden,..*)
  - 3.2.2 Temperature and load cycle stable materials (*J. Henry, M. Rieth, Y. de Carlan, J. Aktaa, ..*)
  - 3.2.3 Compatibility with circulating fluids and mitigation strategies (*F. Di Fonzo, M. Utili, A. Weisenburger, P. Szakalos, …*)

Overview: Structural materials and circulating fluids

- 3.2.1 Neutron irradiation resistant materials
  - 3.2.1.1 Qualification and codification of ferritic-martensitic steels up to high dose (100 dpa)
    - a) Mechanical property data and mechanical behaviour rules of base material
    - b) Swelling behaviour data in presence of transmutants (*especially for fusion, less of an issue for fission*)
    - c) Irradiation creep data and rules
  - 3.2.1.2 Qualification and codification of ferritic-martensitic steel welds, as-received and under irradiation
    - a,) b), c) see above
  - 3.2.1.3 Development of methodologies to predict the behaviour of F/M steels under irradiation (for codification and design purposes)
    - a) Microstructure evolution (modelling and advanced characterization) versus irradiation dose:
    - b) Macroscopic changes: radiation-induced embrittlement, swelling, irradiation creep versus irradiation dose
  - 3.2.1.4 Development of advanced methodologies for non-destructive continuous materials health monitoring versus dose
  - 3.2.1.5 Use of ion/proton irradiation to emulate neutron irradiation

Overview: Structural materials and circulating fluids

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- 3.2.2 Temperature and load cycle stable materials
  - 3.2.2.1 Oxide dispersion strengthened steels
    - a) Development of industrially upgradable manufacturing techniques that guarantee property reproducibility
    - b) Development of industrially upgradable non-fusion welding techniques
    - c) Modelling of relevance for the two above issues
  - 3.2.2.2 Creep-enhanced resistant steels
    - a) Identification of compositional tuning and thermo-mechanical treatments to improve creep properties of conventional F/M steels
    - b) Development of predictive methodologies (thermodynamic modelling, data-driven using artificial intelligence, …) in support of the above task
    - c) Development of accelerated methodologies for material optimisation (high throughput fabrication, processing, characterization and simulation, focused on high temperature mechanical behaviour), in support of task a)
  - 3.2.2.3 Design rules for cyclic softening

Overview: Structural materials and circulating fluids

- 3.2.3 Compatibility with circulating fluids and mitigation strategies
  - 3.2.3.1 Protective coatings and permeation barriers
    - a) Development of oxide coatings - alumina based coatings and alumina forming and others
    - b) Upscaling of coating technologies to meet industrial demands
    - c) Development of predictive methodologies in support of the above tasks
    - d) Development of accelerated methodologies for material optimisation (high throughput fabrication, processing, characterization and simulation, targeting corrosion resistance), in support of tasks a) and b)
  - 3.2.3.2 Corrosion resistant materials
    - a) Development of (F/M) steels that form self-healing protective coatings, e.g. FeCrAl (*especially for fission, for fusion this solution raises problems of activation*)
    - b) Development of (low activation) high entropy alloys with high corrosion (but also radiation and temperature …) resistance
    - c) and d) like 3.2.3.1
  - 3.2.2.3 Fluid handling and purification
    - a) Experimental validation of purification systems
    - b) Dimensioning of the purification systems and integration in the reactor.
    - c) Numerical modelling of mass transport and activation of corrosion products. Supports a) and b).
    - d) Development of instrumentation

Abstracts submitted

- CROSS-CUTTING ISSUES IN FUSION AND FISSION MATERIALS DEVELOPMENT, *Lorenzo Malerba, M. Utili (CIEMAT)*
- FISSION AND FUSION WATER COOLING CIRCUITS: CHEMISTRY, CORROSION MITIGATION AND MATERIALS, *Claudia Gasparrini, .. (Consorzio RFX)*
- MATERIAL COMPATIBILITY WITH LIQUID METAL AND MITIGATION STRATEGIES: REMOVAL OF ACTIVATION CORROSION PRODUCTS, *Marco Utili, .. (ENEA)*
- COMMONALITIES BETWEEN MATERIALS DEVELOPMENT IN FISSION AND FUSION TECHNOLOGIES *Giacomo Aiello, .. (EUROfusion)*
- THE KEY ENABLING ROLE OF DUCTILE AMORPHOUS OXIDE COATINGS FOR GENERATION IV AND FUSION NUCLEAR POWER PLANTS, *Fabio Di Fonzo, .. (Istituto Italiano di Tecnologia)*
- THE BEHAVIOUR OF MA956 AND 316L-ALUMINIZED STEELS IN SUPERCRITICAL WATER, *Maria Mihalache (RATEN-ICN, Institute For Nuclear Research)*

CROSS-CUTTING ISSUES IN FUSION AND FISSION MATERIALS DEVELOPMENT, *Lorenzo Malerba, M. Utili*

Commonalities between GENIV Fission, Fusion and non nuclear for materials

Heat load, temperature range, compatibility, dose rates (fusion/fission), ..

F/M Steels: - design rules plastic flow localization

Barriers against corrosion and tritium permeation

Automated material optimization

Contributes to all three sub-chapters

FISSION AND FUSION WATER COOLING CIRCUITS: CHEMISTRY, CORROSION MITIGATION AND MATERIALS, *Claudia Gasparrini, ..*

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Commonalities between GENIV Fission, Fusion

- *Water Chemistry, Corrosion, stress corrosion cracking,*
- *ACP (activated corrosion product) codes based on Fission*
- *Steel development P91 for VHTR vessel – 9Cr for Fusion, ODS*

Contributes to

- *3.2.2 Temperature and load cycle stable materials*
- *3.2.3 Compatibility with circulating fluids and mitigation strategies*

MATERIAL COMPATIBILITY WITH LIQUID METAL AND MITIGATION STRATEGIES: REMOVAL OF ACTIVATION CORROSION PRODUCTS, *Marco Utili, .. (ENEA)*

Commonalities between GENIV Fission, Fusion – liquid metal as cooling fluid

- *using corrosion resistant materials - low activation*
- *controlling liquid metal chemistry to minimize corrosion*
- *reducing velocity and temperature - if applicable*
- *purifying the liquid metal – cold trap*
- *protective coatings*

Contributes to 3.2.3 Compatibility with circulating fluids and mitigation strategies

COMMONALITIES BETWEEN MATERIALS DEVELOPMENT IN FISSION AND FUSION TECHNOLOGIES *Giacomo Aiello, .. (EUROfusion)*

Commonalities between GENIV Fission, Fusion

- *316L as vessel material – welding procedures*
- *9Cr F/M steels – optimization by TMT (thermal mechanical treatment) and different composition*
- *ODS variants of 9Cr steels – different production routes*
- *DDC-IC (DEMO Design criteria for In-Vessel Components)*
- *Simulation of irradiation and damage*
- *Coolant compatibility*

Contributes to all three sub-chapters

THE KEY ENABLING ROLE OF DUCTILE AMORPHOUS OXIDE COATINGS FOR GENERATION IV AND FUSION NUCLEAR POWER PLANTS, *Fabio Di Fonzo, .. (Istituto Italiano di Tecnologia)*

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Commonalities between GENIV Fission, Fusion

- *Ductile Amorphous Ceramic (DACs) by PLD – as corrosion barrier and tritium permeation barrier*
- *First (GenIV) based on Al_2O_3 demonstrated corrosion resistance in Pb at 550°C*
- *Fusion: based on Al_2O_3 Corrosion resistant in PbLi and in contact with Li_4SiO_4*
- *Some interaction with Li – ternary LiAl-oxides – different oxides by PLD*

Contributes to 3.2.3 Compatibility with circulating fluids and mitigation strategies

THE BEHAVIOUR OF MA956 AND 316L-ALUMINIZED STEELS IN SUPERCRITICAL WATER, *Maria Mihalache (RATEN-ICN, Institute For Nuclear Research)*

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Commonalities between GENIV Fission, Fusion

- *SCWR as coolant for fission and fusion*
- *MA956, Aluminized 316 and 304L tested in SCW at 550°C and 25MPa*
- *MA 956 behaves best*

Contributes to 3.2.3 Compatibility with circulating fluids and mitigation strategies

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