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SYNTHESIS OF RESULTS OBTAINED ON SODIUM COMPONENTS AND TECHNOLOGY THROUGH THE GENERATION IV INTERNATIONAL FORUM SFR COMPONENT DESIGN AND BALANCE-OF-PLANT (CD&BOP) PROJECT

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1. Introduction & Context

2. Goals & Objectives



3. CD&BOP : Description of the main technological domains and works performed



4. Some outlines of the program work :

- ISI&R (In Service Inspection & Repair)
- LBB (Leak Before Break)
- S-CO₂ AECS (Supercritical CO₂ Advanced Energy Conversion System)

5. Conclusions

1. INTRODUCTION & CONTEXT

CD-BOP FRAME & TARGETS



Aim :

To enhance the economic competitiveness of SFR through the development of advanced components or related technologies, or through R&D of advanced ECS such as S-CO₂.



Schedule :

CD&BOP PMB began in October 2007 a first set of Collaboration (5 years plan 2007 - 2011), involving 40 researchers over 4 countries (USA, Korea, Japan & France)



Since 2012, a new Project Arrangement has been proposed (2012-2016), including Europe / EURATOM as new partner & Russia / IPPE today as observer

Organisation :

Two meetings per year, organized by a technical secretary from OECD. Between meetings : exchange of deliverables, reporting to the SFR Steering Committee (Annual Work Plan & Annual Financial & Technical Report), Participation to common publications (GLOBAL'09, ICAPP'10, FR'13), yearly definition of the Chair & Co-chair.

Targets :

To gain a coherent overview of all R&D (national programs) and to plan for an harmonized program of work & ease exchange & collaborative works



Status:

The viability of designing SFR components and BOP has been demonstrated with design, construction and operation of previous sodium-cooled reactors. The main objective of this R&D project is related to system performance, or by development on the use of AECS in the BOP that could allow further cost improvements.



Objective: To conduct collaborative research and development of components and BOP for the SFR System. The Project has to satisfy the GIF's criteria of safety, economy, sustainability, proliferation resistance and physical protection. Activities within this Project are addressing experimental and analytical evaluation of advanced ISI&R, LBB assessment, development of AECS with Brayton cycles, advanced SG technologies. Project activities will be based in part on the extensive historical R&D experience with component design and balance of plant for sodium-cooled fast reactors.

Component Design / ISI&R

- Improvement of Ultra Sonic application to NDE
- Core surveillance approach
- Study of sensor type for DWTSG (Double Wall-Tube Steam Generator)
- ISI&R requirements for a GENIV type SFR
- Approach on repair of SFRs and corresponding LASER remote techniques.



Component Design / LBB (Leak Before Break)

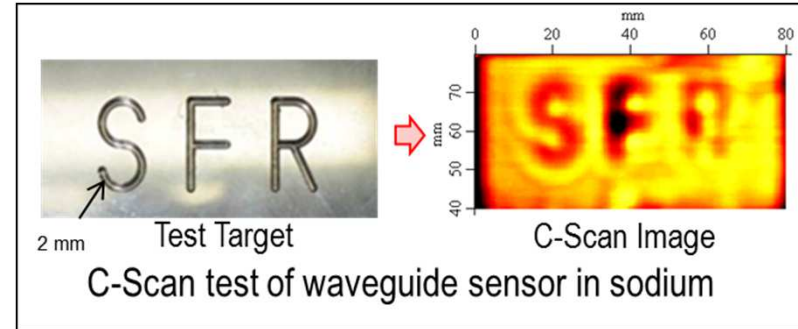
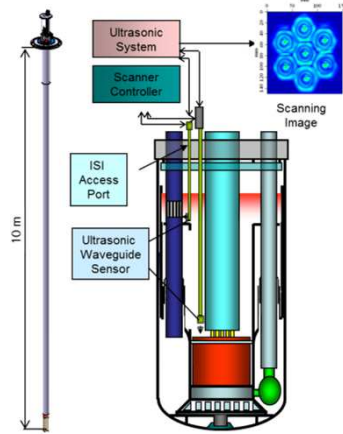
- Experimental study of the kinetics of crack growth under creep condition
- Determination of requirements for sensitivity of sodium leak detection
- Development of the technique of justification of the LBB concept for SFR
- Computational validation of the techniques

Balance Of Plant / S-CO₂ Brayton cycle

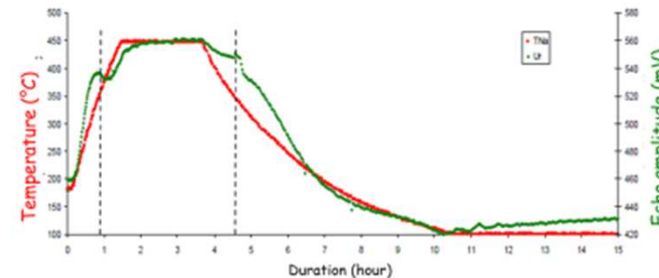
- Conceptual design studies & assessments, including thermodynamic optimization for SFR, studies of S-CO₂ cycle components, conceptual designs for sodium / CO₂ HX, investigation of material including reactions of the CO₂ fluid with candidate materials.
- Studies of technical performance, including investigation of the safety implications of failure of the sodium-CO₂ boundary.
- Experiments investigating the behavior of sodium-CO₂ interactions and heat exchanger phenomena including the performance of heat exchanger technologies for sodium / CO₂ HX.
- Investigation, development and verification of control strategies for S-CO₂ cycles with SFRs (normal operation, operational transients and postulated accidents).
- System level dynamic analyses of S-CO₂ cycles coupled to SFRs (operational transients and postulated accidents).
- Validation of models through comparison with experiment data testing of turbomachinery and HX as well as integral S-CO₂ cycle demos.



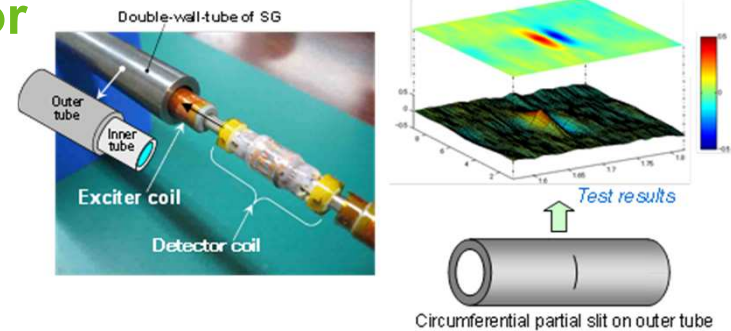
JAEA **KAERI** : Dvlpt of US Waveguide sensor
for Under-Sodium Visualisation



CEA : Study of wetting on US
transmission



JAEA : New Inspection Technology for
DWTSG



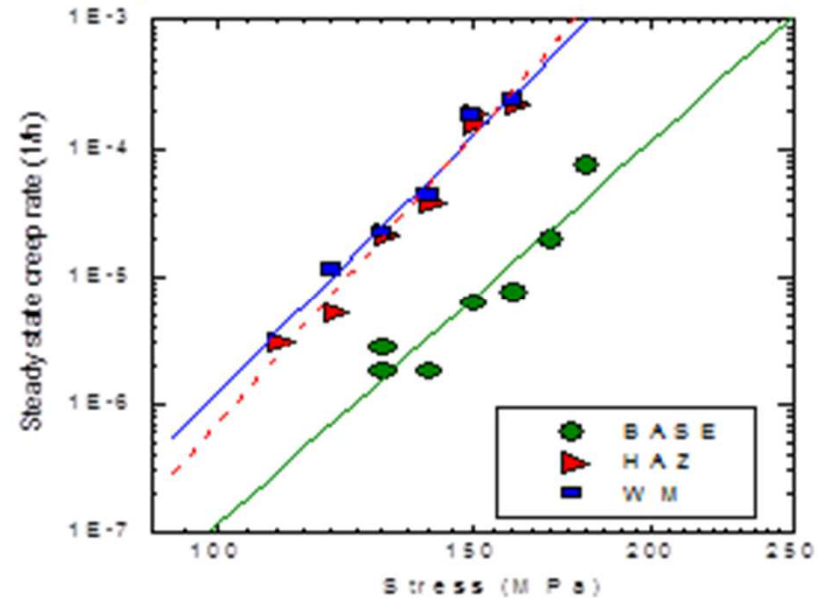


KAERI :

Mod.9Cr-1Mo is a candidate material for SFRs Its lack of data concerning fracture toughness, fatigue crack growth, creep crack growth and creep-fatigue interaction at high T° does not allow a LBB assessment



Exp. studies are therefore developed





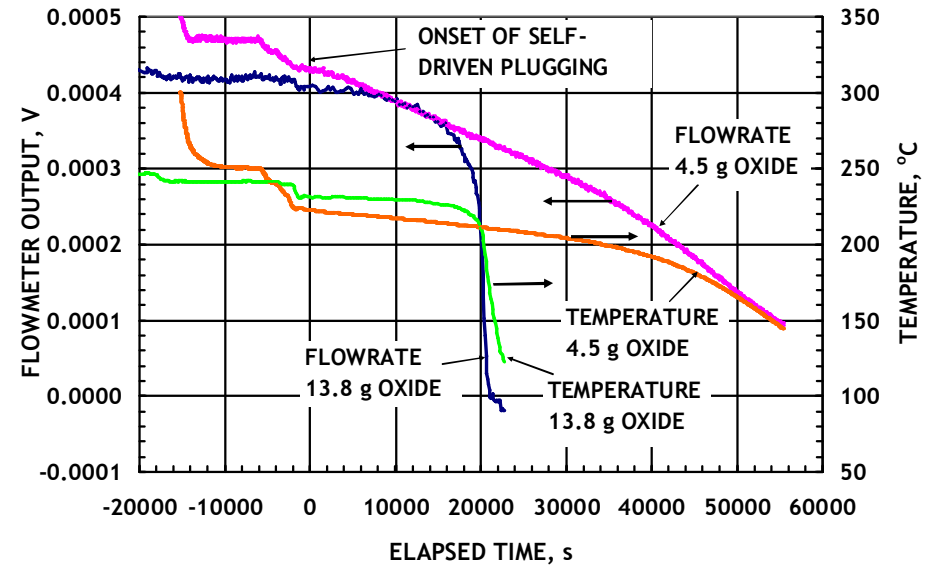
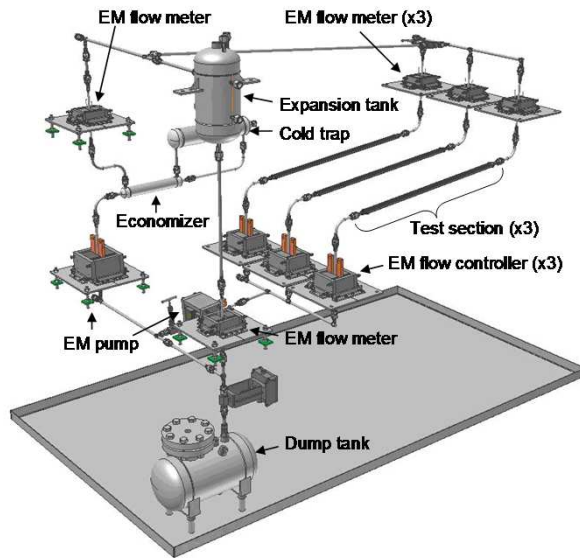
All organisms are working on S-CO₂ cycle



S-CO ₂ R&D items	DOE/USA	JAEA/Japan	CEA/France	KAERI/Korea
1. Power cycle				
1,1 Conceptual design				
(1) S-CO ₂ system	X	X	X	X
(2) Thermodynamic efficiency	X	X	X	X
1.2 Experiments				
(1) CO ₂ -CO ₂ Heat exchanger	X	X		X
(2) Na-CO ₂ heat exchanger	X		X	X
(3) Compressor	X	X		
(4) Turbine	X			
(5) Power cycle (S-CO ₂ loop)	X	X		
2. Operation and control of S-CO₂ cycle				
2,1 Steady state	X		X	X
2,2 Transient state	X		X	X
2,3 Controllability	X		X	
3. Sodium/CO₂ reaction				
3,1 Reaction mechanism	X	X	X	X
3,2 Failure detection	X		X	X
3,3 Safety device regarding HX failure	X			
3,4 Specific Na technology development	X		X	
4. Material tests				
4,1 Corrosion effect vs time		X	X	
4,2 Material compatibility and choice			X	
5. Cost Evaluation				

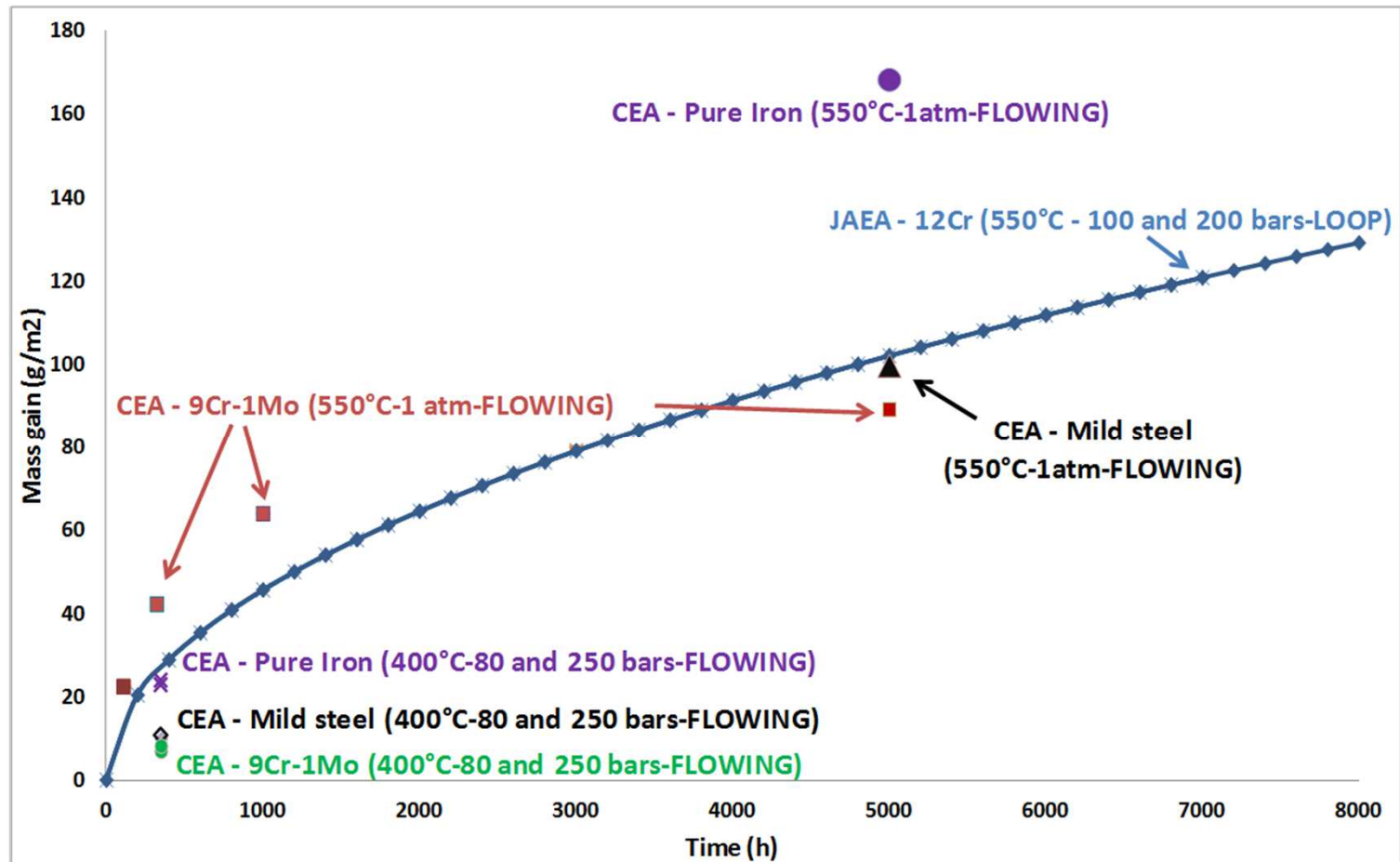



DOE / ANL : Study of the potentiality of plugging a Na HX channels in case of Na pollution





CEA / JAEA : Joint study of material corrosion with S-CO₂ at high temperature



 **Synthesis** : More than 100 deliverables produced in the 1st Program Plan (2007-2012).

 **Perspectives** : Two new members planned in the 2nd Program Plan : EURATOM (S-CO₂, ISI&R, Codification), and in the next future IPPE (LBB, SG)



Conclusions :

The purpose was to highlight the excellence of the works performed and shared by the four member countries since 2007. The CD&BOP Project has largely facilitated exchanges through national research organisms to produce an efficient international network in the field of SFR technology. The enlargement of the CD&BOP PMB to new members is a real asset to confirm the high level of expertise of this international community



The reported work represents the efforts of over sixty individuals at CEA Cadarache, Marcoule and Saclay; DOE/ANL, Kansas State University, DOE/SNL; JAEA O Arai and Monju research centers, Tokyo Institute of Technology, Mitsubishi Heavy Industries, and KAERI.

PMB members would also like to recognize the precious role of the OECD technical secretaries.

The new inspection technology for ISI of double-wall steam generator tubes in JSFR entrusted to Japan Atomic Energy Agency (JAEA) by the Ministry of Economy, Trade and Industry (METI).

Thank for your attention

Any questions?



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