NEWSLETTER

COMPASsCO$_2$

Contents

OCTOBER 31, 2023

Issue : VI

This project has received funding from the European Union's Horizon 2020 Research and Innovation Action (RIA) under grant agreement No. 958418.

Team: 12 partners from 7 countries

Research focus: New particles, metal alloys and heat exchanger

Duration: 1 November 2020 – 31 October 2024

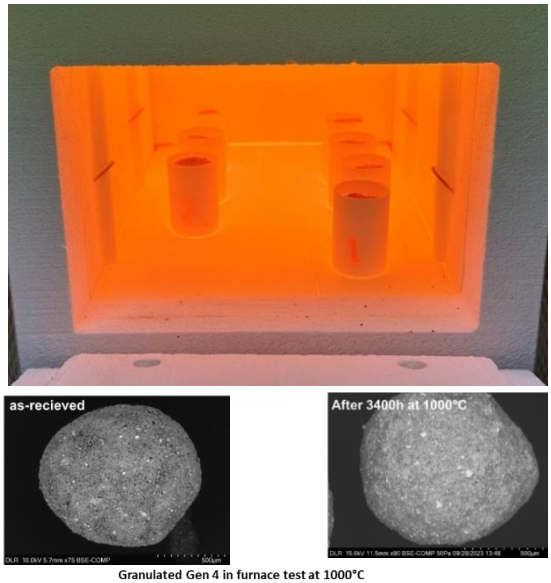
Status of Implementation

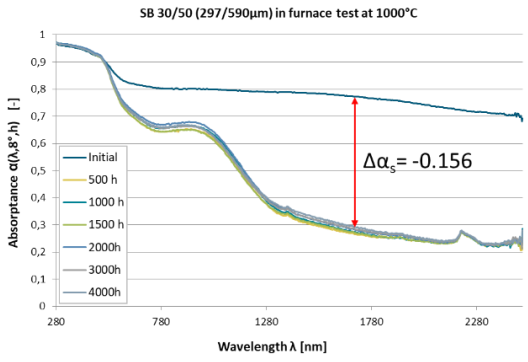
Several results, deliverables, milestones have been achieved. All public deliverables and main activities are freely accessible through the project's website: https://www.compassco2.eu/. The section below summarizes the status of project activities by work package.

WP2 – DEVELOPMENT AND TESTING OF PARTICLES

Testing of the novel granulated particles developed by Saint-Gobain is under completion. The particles will be commercialized under the name FerOx. Current and still on-going data collection is showing that Ferox seems to exceed the performance of state-of-the-art particles proppants

- Same cost range (1€/kg)
- Higher specific bulk energy density (ρb·cp≈ 2.2 J/(cm³·K) vs. ~1.9 J/(cm³·K))
- Higher softening temperature (940°C vs. ~850°C)
- Similar mechanical and optical properties
- Better thermal stability (about one order of magnitude lower absorptance loss than proppants during exposure to 1000°C).





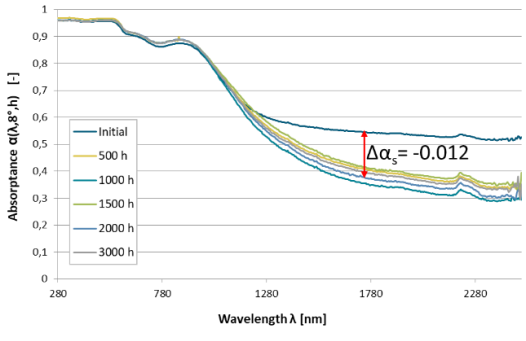


Figure 1: Upper right) thermal stability testing of particles in muffle furnace at 1000°C. Right) SEM images of FerOx particles before and after exposure. Very stable surface and microstructure. Lower Left) Absorptance spectra of sintered bauxite proppants after different exposure times. Strong degradation of optical properties is visible within the first 500 hours of testing. Lower Right) Absorptance spectra of FerOx particles showing much lower degradation and better long term stability.

WP3 - DEVELOPMENT OF METALS

In work package 3 (WP3), one goal is to develop novel chromium-based alloys to obtain enhanced strength, erosion resistance, oxidation and corrosion resistance for high-temperature environments. Due to the relative novelty of these chromium-based alloys, it is important to further understand the alloy properties and behaviour. Specifically, it is important to understand the properties and interactions between particles (WP2), novel chromium-based heat exchanger tube superalloys (WP3), and erosion-corrosion behaviour of the tube surfaces (WP4). For this purpose, a modelling-focused research team in VTT Finland Ltd has developed a computational materials modelling framework to understand the micromechanical behaviour of the particles and the heat exchanger tube surface, illustrated in the figure 2. This framework will be used to develop lifetime estimation models for the particles and tube surfaces, together with the experimental data produced in the project.

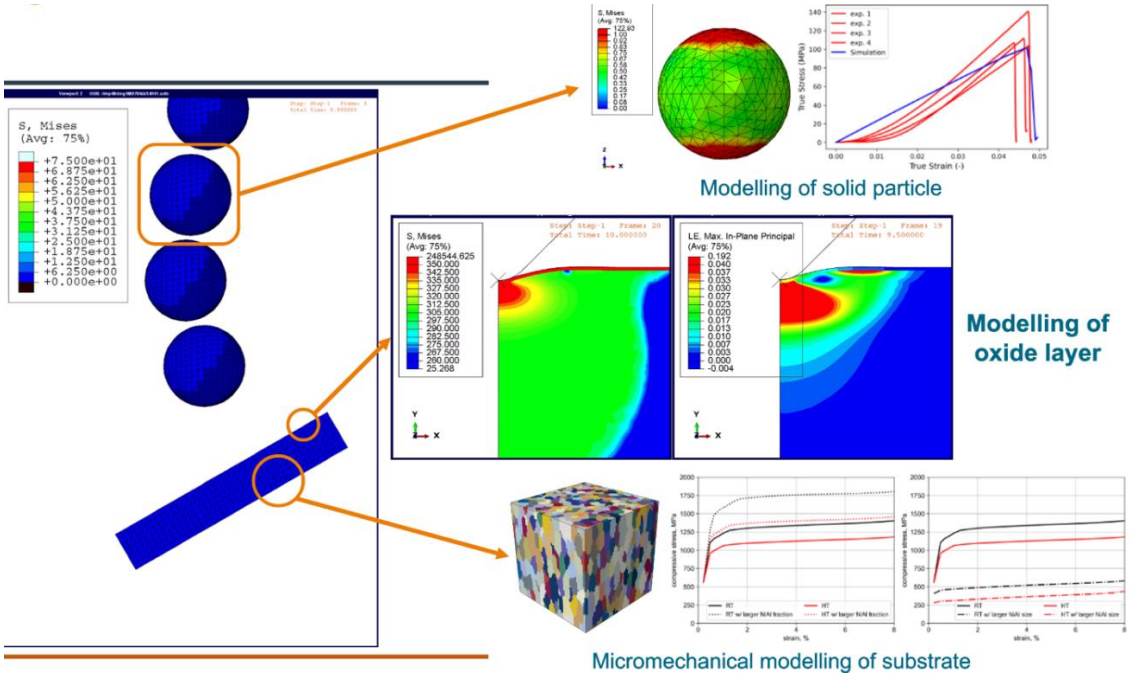


Figure 2: Micromechanical modeling framework to understand the interaction between particles (WP2), the chromium alloy in the heat exchanger tube surface (WP3), and the effect of oxidation on the mechanical behavior of the system (WP4).

WP4 - EVALUATION AND MODELING OF METAL/MEDIUM INTERACTION

The state-of-the-art and new (WP3) materials are being fully characterized for their performance in the COMPASsCO$_2$ heat exchanger aggressive environments. Deliverable 4.1 'Performance in oxidizing and carburizing atmospheres' was submitted by FZJ in September, which focused on the state-of-the-art materials. FZJ has also completed the 250h erosion tests at 600°C (P92), 700°C, and 900°C for all proppants, and the long-term test of 1000h at 900°C (SB 30/50 proppant). CIEMAT has completed the CO$_2$ exposures at 700°C for 5000h on the state-of-the-art alloys as shown in figure below. The electron

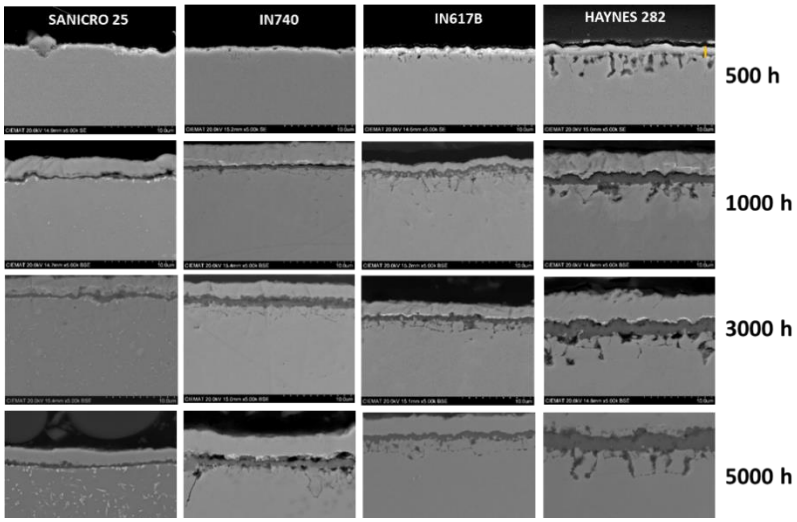


Figure 3: Scanning electron microscopy images of state-of-the-art alloy surface cross-sections after exposure under CO$_2$ at 700°C for up to 5000h. Courtesy of CIEMAT.

imaging of the cross-sections shows the oxide scale formation and changes in the subsurface microstructures, e.g. internal oxidation for Haynes 282. CVR has completed the assembly of their s-CO_2 test system and is working towards initial trials. CIEMAT and DFI are correlating their creep data in air and CO_2, respectively. All of the data, including oxide scale nano-hardness measurements, is being supplied for lifetime modeling at VTT which is progressing.

WP5 – TECHNOLOGY VALIDATION

The experimental facility for particle heating has been completed, as illustrated in figure 4.

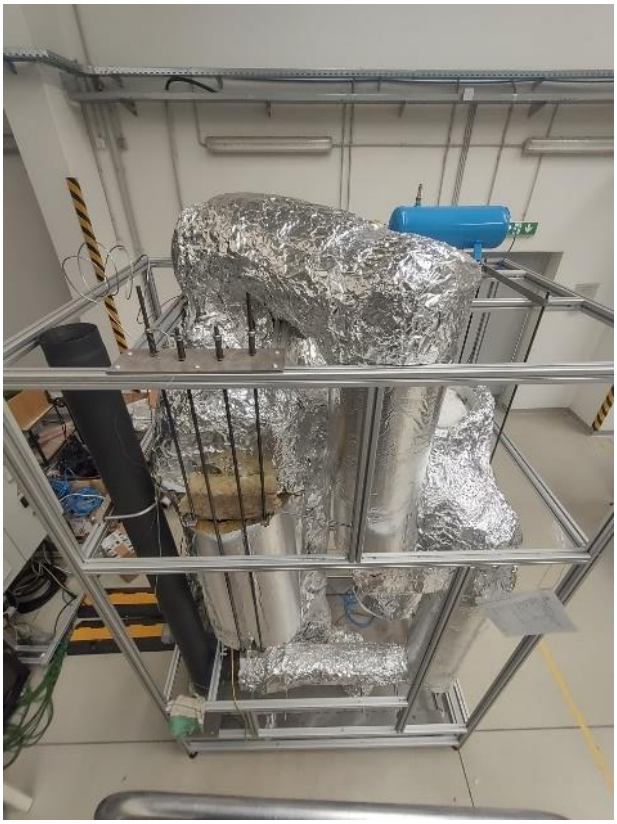


Figure 4: Experimental facility for particle heating (with insulation)

Several continuous experimental campaigns were conducted, during which the particles were heated up to 800°C. These campaigns provided valuable data to assess the performance of the particle heater, the system behaviour and the lifespan of individual component.

For the upcoming experiment, the facility is undergoing reconstruction to accommodate material samples for long-term abrasion exposure. For this, a new bottom section has been constructed (shown in figure 5). Additionally, in order to maintain a stable particle velocity within the test section, a new screw conveyor has been manufactured from Inconel718, using additive manufacturing technology. The new screw conveyor has a larger diameter and promises higher particle flow rates while maintaining a lower angular velocity compared to the previous screw design. The comparison of two designs is illustrated in figure 6. The long-term exposure experiments are scheduled to commence by the end of the year 2023.

Figure 5: Newly fabricated test section for long term abrasion tests.

Figure 6: Comparison of new screw conveyor (3D printed from Inconel718 and heat treated) vs. old design.

New Deliverables are Available

Since the last issue of the newsletter (April 2023), 4 new deliverables have been produced by the COMPASsCO$_2$ team.

D3.3: Production of Optimized Steel/NI Substrates with Advanced Cr Aluminide/Silicide Coatings, Coupons for WP4. The report can be downloaded here.

D3.4: Correlated modelling microstructure mechanical property understanding of the new materials. The deliverable can be downloaded here.

D4.1: Performance in Oxidizing and Carburizing Atmospheres. The deliverable can be downloaded here.

D5.1: Design summary of the commissioned particles loop. The report can be downloaded here.

Papers in Scientific Journals

Four papers were produced by the COMPASsCO$_2$ team during this last 6-month period.

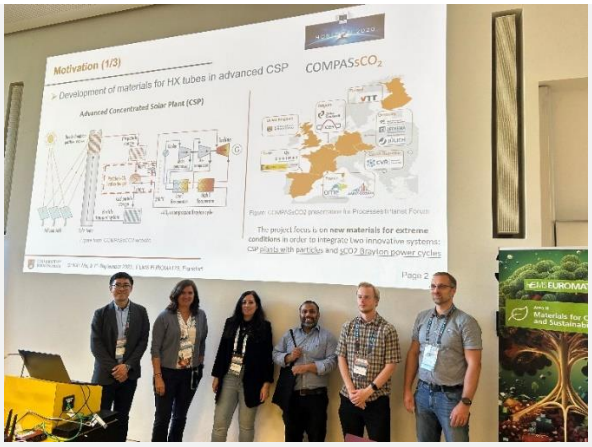
Alkan, G.; Mechnich, P.; Pernpeintner, J, Using an Al-Incorporated Deep Black Pigment Coating to Enhance the Solar Absorptance of Iron Oxide-Rich Particles, Coatings 2023, 13, 1925, https://doi.org/10.3390/coatings13111925

K. Ma et al., Chromium-based bcc-superalloys strengthened by iron supplements, Acta Materialia Volume 257, 15 September 2023, 119183, https://doi.org/10.1016/j.actamat.2023.119183

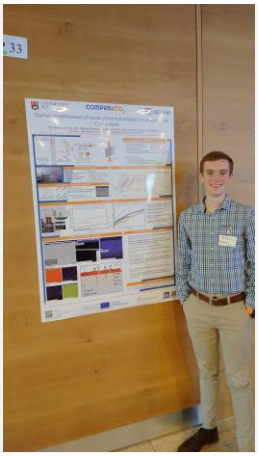
G.P. Smestad et al, Variability and associated uncertainty in image analysis for soiling characterization in solar energy systems, Solar Energy Materials and Solar Cells 259 (2023) 112437, https://doi.org/10.1016/j.solmat.2023.112437

S. Cheng et al., Accurate identification and measurement of the precipitate area by two-stage deep neural networks in novel chromium-based alloys, Phys. Chem. Chem. Phys., 2023, 25, 15970-15987, https://doi.org/10.1039/D3CP00402C

COMPASsCO$_2$ Participation at Conferences



COMPASsCO$_2$ partners participating at the EUROMAT2023 - High-Temperature Alloys and Intermetallic (left)



Tom Blackburn (UoB) presenting his poster at the High Corrosion and Oxidation Workshop 2023 (right)

In order to disseminate results, the COMPASsCO$_2$ team took part in several conferences/workshops, as detailed below.

Lead Beneficiary	Title	Event
DLR	Thermal and Environmental Durability of Novel Particles for CST	SolarPACES 2023 - Sydney, Australia 10-13/10/2023
DLR	Mechanical Wear at Elevated Temperature of Novel Particles for CST Receivers	
FZJ	High temperature oxidation and erosion behaviour of candidate materials for concentrated solar power plants with ceramic particles and CO_2 heat-transfer systems	High Corrosion and Oxidation Workshop 2023 - Marktheidenfeld, Germany 25-29/09/2023
UoB	Oxidation behaviour of novel chromium-based bcc-superalloys Cr(Fe)-NiA	
UoB/CIEMAT/DFI	Development of novel chromium-based supperalloys for advanced concentrated solar power	FEMS Euromat 2023 - Frankfurt, Germany 03-07/09/2023
VTT/CIEMAT/UoB	First-principles study on the effect of alloying elements for the interface energetics of Cr-NiAl superalloy toward next generation concentrated solar power	
VTT/SGCREE	Structural integrity at elevated temperature assessment of solid particles for concentrated solar power systems using ICME approach	
SGCREE	New ceramic media for Concentrated Solar Power Plants	ECERS 2023 - Lyon, France 2-6/07/2023
UoB	Mechanical Properties of Novel Chromium Superalloys for High Temperature Applications	Thermec 2023 - Vienna, Austria 2/7/2023
VTT	Ab initio study on the effect of alloying elements for Cr-based superalloys toward next generation concentrated solar power	Euro Nano Forum - Lund, Sweden 11-13/06/2023
DFI	Heat exchangers for particle-based solar thermal power plants: Reduction of high temperature corrosion and erosion through new Cr-Si slip coatings	GFKORR - Frankfurt, Germany 11-12/05/2023

COMPASsCO$_2$ Second Stakeholders Workshop on "Next generation advanced materials for particle/supercritical CO$_2$ heat exchangers"

The Second Stakeholders Workshop of the COMPASsCO$_2$ Project was held on 25 September 2023 in Marktheidenfeld (Germany), at the occasion of the international conference on high temperature corrosion and oxidation. The workshop was organized around two main sessions, the first dealing with advanced materials for abrasive environments and the second one focusing on material behaviour in sCO$_2$ environments. Representatives from the COMPASsCO$_2$ consortium presented the preliminary results of their analysis and had the opportunity to interact with experts from industry and academia to further advance on the work and validate the findings. The meeting, held in a hybrid format, saw the participation of about 60 participants. The presentations of the workshop can be downloaded here.



Meetings

Fifth General Assembly Meeting – The Fifth General Assembly Meeting took place on June 6th and 7th, 2023 in Jülich, Germany, hosted by Forschungszentrum Jülich GmbH (FZJ). The COMPASsCO$_2$ team discussed the overall progress, on-going activities, challenges, and next steps. Several technical visits were also organized to:

- Institute for Energy and Climate Research IEK-2 of Forschungszentrum Jülich GmbH (FZJ) in Jülich
- DLR solar tower and Synlight in Jülich
- DLR laboratories at the Material Research Institute in Cologne

COMPASsCO$_2$ Partners attending the project meeting at Forschungszentrum Jülich

DLR Synlight in Jülich (left)

Institute for Energy and Climate Research IEK-2 of Forschungszentrum Jülich GmbH (FZJ) in Jülich (three pictures on the right)

DLR laboratories at the Material Research Institute in Cologne (left)

Quarterly Phone Conference Meetings - A quarterly phone call took place on September 12th, 2023. It discussed the key results and inputs for the different work-packages and any problems/delays/deviations.

Dedicated WP Meetings – Several dedicated WP meetings were organized to discuss the technical aspects of the project with involved partners.

Sixth General Assembly Meeting – The 6th project meeting will be hosted by the partner Saint Gobain and will take place on January 31st, 2024 in Cavaillon, France. It will discuss the overall progress, on-going activities, challenges, and next steps.

Second Review Meeting – It will be organized along with the Sixth GA meeting in Cavaillon on February 1st, 2024.

How to Get Involved in COMPASsCO$_2$ Activities

Become a member of the project's stakeholders' network

Whether you want to learn more about specific WP activities, collaborate with the consortium or act as an external expert, kindly contact us at contact@compassco2.eu. We will keep you updated about project activities, invite you to attend the project's public events and ask your feedback on the progress and main outcomes of the project.

Check our website and follow us on social media networks

https://www.compassco2.eu/

THANK YOU

For more information

Check the project's website: www.compassco2.eu

Contact us: contact@compassco2.eu

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