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Boosting energy efficiency and CO_2 reduction through advanced materials and coatings in Energy-Intensive Industries.

The ACHIEF project has produced new high-performance materials and protective coatings, extending the lifetime of equipment and components used in Energy-Intensive Industries (EIIs).

To develop these new materials and coatings, our multifunctional team has developed an integrated **AI tool** that leverages generative models and simulations to create high-performance materials, evaluating their performance under extreme conditions.

The three primary materials developed are **polymer-derived ceramic coatings, high-entropy super alloys** (HESA), and **advanced Cr-steel grade**. Their quality was evaluated by incorporating **advanced sensors**, high-temperature and strain **Fibre Bragg Gratings**, and **electrochemical-based probes**.

Fibre Bragg Gratings are micro sensors, a few millimetres long, embedded in their metallic core an optical fibre. They change properties when exposed to strain or temperature, causing shifts in the reflected wavelength, which allows precise measurement.

Additionally, the corrosion monitoring system, based on Electrochemical Impedance Spectroscopy, provides real-time, quantitative resistance data under operating conditions, enabling early detection of potential failures in critical plant units.

In this context, TUBOS REUNIDOS has produced tubes with the new material that have been characterised confirming their potential to increase creep resistance. CONSTELLIUM, ARCELORMITTAL and TUPRAS have validated these materials and sensors in real-world scenarios, demonstrating their potential to enhance equipment lifespan and operational efficiency.

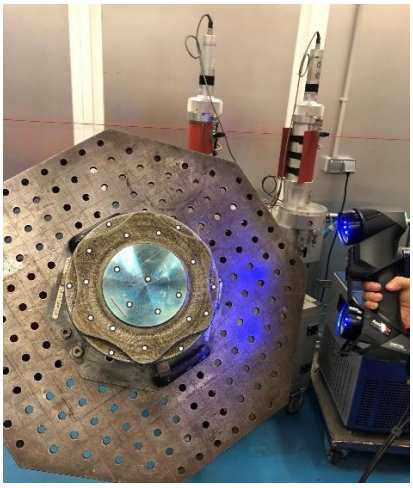
Polymer-derived ceramics (PDCs) developed by CEA were installed at CONSTELLIUM for validation, using fibre optic sensors designed to endure extreme conditions. These sensors monitored local temperatures on refractory walls and bricks exposed to high temperatures in molten aluminium.

Meanwhile, the HESA composites, developed by AIMEN, were evaluated at CONSTELLIUM facilities for their durability and performance under the mechanical, physicochemical, thermomechanical, and tribological conditions encountered during the aluminium rolling process.

ArcelorMittal Sestao validated the HESA material for high-temperature applications where material strength and creep resistance are essential.

The novel HESA compositions was tested with a "star" component prototype, fabricated by AIMEN and VTT, which has been into a water-cooled roll shaft inside the tunnel furnace.

The performance of this setup has been closely monitored using Fibre Bragg Gratings (FBGs) to ensure optimal functionality under extreme conditions



Star component prototype

In the case of TUPRAS, the goal is to extend the operational lifespan of equipment, particularly pipelines and sub-components exposed to highly corrosive environments. This objective is supported by the successful testing and validation of the PDC coating developed by CEA, which demonstrated promising performance under real refinery conditions using Electrochemical Impedance Spectroscopy (EIS) sensors also developed by AIMEN.

Forced outages in the energy industry are primarily attributed to boiler tube failures caused by steam-related issues. In response, TUBOS REUNIDOS has successfully validated a new 11% Cr-Steel with enhanced creep resistance at the laboratory scale, in collaboration with TECNALIA. This innovative material has now been industrially fabricated into boiler tubes.

The ACHIEF innovative solutions have been successfully commissioned and tested, showcasing improvements in the EEIs' energy efficiency, CO2 emission reduction, and equipment longevity. The project's ultimate goal is to enhance energy efficiency by 30%, reduce CO_2 emissions by 20%, and extend equipment lifespan by over 20%.

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