Deliverable D 6.5
Ceramic and refractory science interactive exhibition

Document type	**Deliverable D 6.5**
Document Version / Status	**1.1**
Primary Authors	**Glyn Derrick, glyn.derrick@unilim.fr, UNILIM**
Distribution Level	**PU (Public)**
Project Acronym	**ATHOR**
Project Title	**Advanced THermomechanical multiscale mOdelling of Refractory linings**
Grant Agreement Number	**764987**
Project Website	**www.etn-athor.eu**
Project Coordinator	**Marc Huger, marc.huger@unilim.fr, UNILIM**
Document Contributors	**Glyn Derrick, glyn.derrick@unilim.fr, UNILIM** **Camille Reynaert, reynaert@agh.edu.pl, AGH** **Diana Vitiello, diana.vitiello@unilim.fr, UNILIM** **Djamel Hellal, djamel.hellal@centre-sciences.fr, Centre-Sciences** **Eric Blond, eric.blond@univ-orleans.fr, UORL** **Marc Huger, marc.huger@unilim.fr, UNILIM**

History of Changes

Version	Date	Author (Organization)	Change	Page
1.0	09/06/2021	Glyn Derrick (UNILIM)	First draft	All
1.1	08/07/2021	Marc HUGER (UNILIM)	Final check	All

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TABLE OF CONTENTS

1 Introduction

As part of the WP 6 (Knowledge Dissemination), a new, mobile, scientific exhibition has been created to highlight the importance of refractory materials on our daily lives (a specific output of Task 6.5). The exhibition, called '**Cerami°k - The World of High Temperature Science**', is aimed at the general public with secondary school students (11 - 18 years old) being the main focus. Ceramic science and refractory research issues are featured to promote scientific studies and careers in the refractory field among young people and the general public. It is intended that this exhibition will be animated/presented by ESRs during Open Days organized at all participating institutions, and events for the general public such "Science Festival" in France.

2 Cerami°K - The World of High Temperature Science

The exhibition, currently presented in both French and English, is separated into 4 'islands' each covering a different topic. Each island contains three posters, and a combination of hands-on experiments, videos and display pieces. The exhibition also contains a virtual steel ladle, where participants can test their recently gained knowledge to see how much steel they can safely produce. Cerami°K was presented to the general public for the first time on 9th June 2021, Figure 1. Each island is discussed in the following sub-sections.

Figure 1: Presentation of the Cerami°K exhibition in Orleans, France at the Symposium 'Jacques Poirier' on the 9th June 2021.

The Cerami°K exhibition has been created by Djamel HELLAL and Olivier MORAND (Centre-sciences) with scientific input from the ATHOR ESRs, which has been coordinated by Camille REYNAERT. The editing, in both French and English, of all the contributed texts, selection and sourcing of photos and images as well as development of ideas for hands-on experiments, was conducted with the additional help of Dr. Diana VITIELLO and Dr. Glyn DERRICK. Other contributors that have dedicated their time to the development of this project include; Prof. Eric BLOND, Prof. Marc HUGER, Dr. Jean GILLIBERT, Robert KACZMAREK, Prof. Jacques POIRIER, Dr Sido SINNEMA, Auriane CORDIER, Fifi-Hania EZZEKMI and Aloïs SEGRET.

This has been made possible with funding from the EU, as well as contributions by the Ministère de l'Enseignement Supérieur de la Recherche et de l'Innovation and the Université confédérale Léonard de Vinci and provision of materials, images, videos and simulations from our industrial partners.

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2.1 Island 1 - Ceramics in our society

This island presents the diverse nature of ceramics, explaining the wide range of properties and uses that directly affect our daily lives. Examples of how ceramics are used for applications at high temperature in industry are given, with a particular focus on the history and developments seen in the steel industry. Examples of the posters, hands-on demonstration and industrial display pieces are shown in Figure 2.

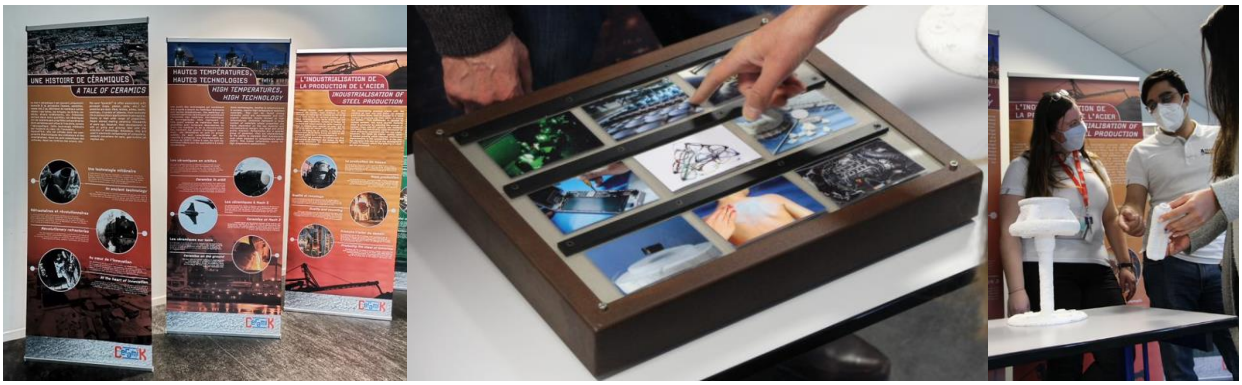

Figure 2: Posters, hands-on experiments and industrial display pieces presented in Island 1.

The hands-on demonstration shows a series of everyday objects that contain ceramics and one that doesn't, the audience needs to find the odd-one-out. Information about the use of ceramics in each object is then provided on the back of each picture along with the answer.

Display pieces in this island could include ceramic moulds used, by SAFRAN, in the production of metal turbine blades for fighter jets.

2.2 Island 2 - Industry, ceramics and its challenges

Moving from the general presentation of ceramics in our daily lives, the audience will be introduced to the importance and impact of the steel industry on our society. From here, the roles of the different refractory ceramics used in the lining of the steel ladle are explained. The public can see and feel (in the hands-on experiment shown in Figure 3) the difference between the different refractories while choosing the correct material for the different locations in the steel ladle.

Figure 3: Posters and hands-on experiments presented in Island 2.

At this point, the general public will be presented with a 'virtual steel ladle'. This is much larger than the other hands-on experiments, and is technically more difficult to set-up, but the interactive experience and competitive nature of the game will be both memorable and educational for the participants.

Participants interact with the 'virtual steel ladle' by constructing the lining of a steel ladle by choosing and placing the different refractory bricks in the configuration they think is best. Once the participants are satisfied with the configuration, the (virtual) molten steel is poured into the ladle. The effect of the different conditions (such-as extreme temperatures and mechanical stresses) on the deterioration of the different refractory bricks is quickly calculated and displayed each time the ladle is filled. The objective is to produce the most steel without exceeding the safety limits.

To achieve this, the refractory bricks have been 3D-printed in different colours, with the simplified technical information displayed on them, Figure 4.

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Figure 4: 3D-printed refractory bricks, with simplified technical information.

A hands-free interface is used to operate the virtual steel ladle through a combination of a projector and webcam. Objects, such as hands or bricks, are then detected via the webcam and this information is then processed via a modified, open-source software. This software has been combined with technical information supplied by Tata Steel which enables the software to quickly calculate the effect of the various different parameters in the different locations in the steel ladle and present instant feedback to the player, see Figure 5.

Figure 5: The virtual steel ladle allows the general public to experiment safely.

2.3 Island 3 - High temperature ceramics: minerals and sciences

Entering into the third island, the audience will be introduced to the properties that the refractory bricks should have in order to be thermo-mechanically and chemically resistant under extreme conditions. The factors taken into consideration during the manufacture of refractory bricks for industrial use are discussed as well as the methods and tools used to analyse their behaviour and degradation at high temperature. Accompanying the posters, hands-on experiments include the use of an infra-red camera to demonstrate the different behaviours of refractory bricks under heating, Figure 6, as well as an Elastoplasticity experiment, Figure 7.

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Figure 6: Posters and Infra-red camera experiment presented in Island 3.

The Elastoplasticity experiment involves the use of a light source, polarising filter and a birefringent material. Applying a force to this material will result in isochromatic lines appearing, these lines indicate how stresses are distributed through the sample. The stress concentration in specific parts of the sample is then demonstrated by examining samples with holes drilled in them. These different samples indicate how the presence of different particles (or holes in this case) could affect the cracking behaviour of refractory bricks used in the steel ladle.

Figure 7: Elastoplasicity experiment presented in Island 3.

2.4 Island 4 - Scientific research / the ATHOR project: providing scientific knowledge to face the challenges

The exhibition is completed with the presentation of the cutting-edge research required to master the production of metals and the durability of the refractory ceramics. Different tests and equipment that can be used at different scales to study the behaviour of ceramics and how the results from these tests can then be applied to numerical simulations is discussed. The state-of-the-art technology used in industry to track the real time degradation of the materials used is also explained. The hands-on experiments that are associated with the posters for this island, Figure 8, show the need to study materials at different temperatures. In the experiment, a weight, fixed to a rubber band which is attached to a stand, is placed on a scale and the rubber band is heated. When the rubber band contracts, lifting the weight slightly, the counter-intuitive nature of the result leads the audience to understand the importance of studying materials at different temperatures.

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Figure 8: Posters and hands-on experiments presented in Island 4.

3 Conclusion

The Cerami°K exhibition has been prepared with the aim of making cutting edge research, in an industry that is unseen, accessible to all. To inspire future researchers, seeds of curiosity will be sown via the audio, visual and kinaesthetic learning materials employed. The language used is clear and non-technical, the images have been chosen to convey, alternatively, the ideas, discussed in the text as well as for their aesthetics. The hands-on experiments have been designed to emphasize the posters, by, for example, being able to feel the different weights and textures of different materials, as well as presenting counter-intuitive observations to inspire the general public to ask questions and think outside the box.

Cerami°K - The World of High Temperature Science, presents complicated, fundamental research in a way that is fun and easy to understand.

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