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Deliverable D5.5
DETAILED PROGRAMME OF EACH TRAINING EVENT

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Introduction

Today, the refractory companies experience many challenges (e.g. raw material prices, environmental related restrictions) that hinder the continuous development of innovative approaches in material design, process and product functionality. Their competitiveness and sustainability are directly related to the availability of industrial oriented well-educated young engineers who see refractory materials as multifunctional advanced ceramics.

ATHOR provides unique training of 15 ESRs for 540 researcher months dedicated to training, mobility, sustainable recruitment and transfer of knowledge offering them both continuous and discrete training activities. As a general objective of the ATHOR program, the training level of the European researchers in the field of Refractory materials will be increased, especially focussing on the testing and modelling of the thermomechanical behaviour of steel ladle linings (Fig. 1). The involved worldwide network of academic and industrial partners constitutes a valuable assembly of expertise for these training activities. ATHOR will provide advanced training in research methods and various engineering skills, as well as in industrial experience. The ESRs will take advantage of all the leading expertise available to develop their own networks and promote collaboration and discussion between academia and the industry. The interactions during regular events with all ATHOR partners will equally prepare the ESRs for employment in academia or in the industry by consolidating the relationships.

Specific ATHOR training for the ESRs will be delivered through a combination of research training courses (**RTC**), complementary skills workshops (**CSW**), international conferences on refractories (**IC**), plant site visits (**SV**) and more informal discussions at network-wide workshops (**WS**). ATHOR will be supported by the FIRE Federation already committed to promote international cooperation for education and research programs relevant to the refractory industry.

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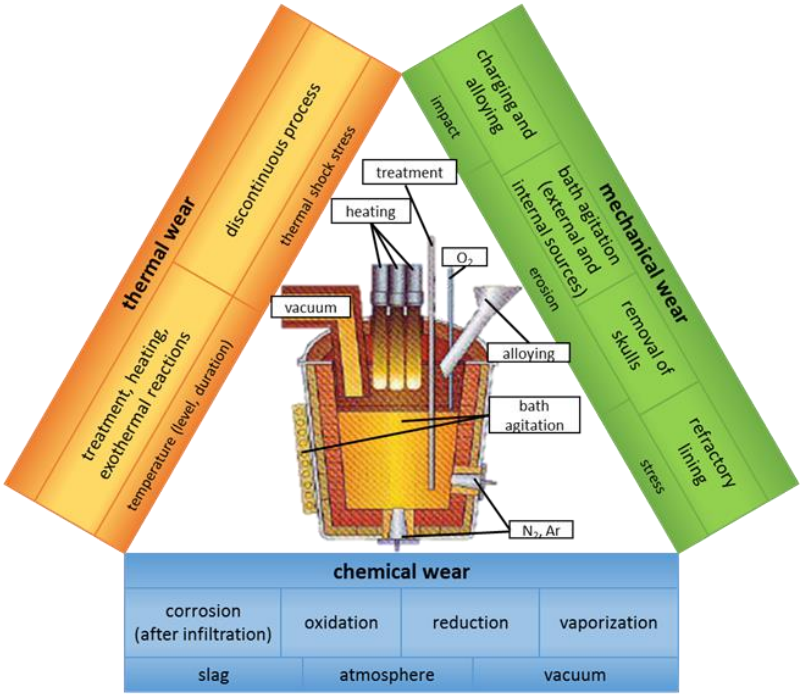

Fig. 1: Classification of different wear mechanisms of steel ladle linings

Training Strategy

The training strategy of the ATHOR program is based on a **personalised approach** for each ESR. After recruitment, each ESR conducts an individual self-assessment under the guidance of the Local Scientific and Training Committees (LSTC), the Recruitment and Skill Progress Committee (RSPC) and the Recruitment Committee. The supervisor(s) and industrial mentor identify the knowledges and skills to be developed for both the successful completion of the research project and for a subsequent professional career. The self-assessment is formulated in a **Personal Career Development Plan (PCDP)**. The ESR and the supervisor(s) regularly review the PCDP, and adapt it if required. Based on PCDP, the ESR develops a tailored network training programme. Following this course of action, each ESR will participate in various training events and courses as part of the Network's activities **in addition to their research project**. These will include formal academic and transferable skills courses, e-learning courses, research training courses on refractories processing, fracture mechanics, simulation and corrosion, carried out as both classroom-based presentations and laboratory-based examinations. Industrial experiences, bilateral and informal roundtable discussions at annual network meetings, site visits, conferences and poster competitions will also be included. Through FIRE, intensive training courses, will be organised each year to provide a broader, more coordinated education and to foster a networking spirit amongst the participants. These network-training activities are mandatory for all ATHOR ESRs, open to researchers of the participating institutions, and are also open to external participants. 50 attendees are expected based on similar recent events already organised by FIRE in 2013.

Background of the involved ESRs

The scientific background of the involved PhD students extends over a wide range of specialization including different engineering disciplines (chemistry, computation, materials, mechanics, mining, structures and technology) as well as mineral processing and materials science. The consideration of the different technical branches and the adaption of knowledge levels pose an extraordinary challenge to the ATHOR training activities, which demands particular attention in every scientific training course, especially in the beginning of the program's run time. Detailed descriptions of the scheduled training courses are given in the following pages.

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Research Training Courses

The research training is implemented through strong relationships between academia and industrial partners across the EU. The ATHOR network is structured to take full advantage of intensive cooperation between academia, raw material suppliers, refractory producers and consumers with a direct link to the FIRE federation. This cross-disciplinary approach throughout the ATHOR value chain will dramatically increase the transfer of scientific knowledge to the refractory-consuming industries in the EU, ensuring their progress on social, environmental and economic aspects. The main scientific objective of the ATHOR network is to adapt and develop the most advanced modelling strategies and experimental technologies to the field of refractory to be able to perform reliable computations and measurement in the temperature range of the applications of these materials. As a key point of the project, all offered events regarding refractory materials and modelling are mandatory for all involved ESRs. A detailed description of the scope and contents of each particular RTC 1 and RTC 2 training event is given below.

Expected results:

The broadly conceived approach of RTC 1 and RTC 2 is covering the many facets of refractory materials. Whereas RTC 1 mainly focus on mechanics, chemical composition and testing, RTC 2 considers the modelling and calculation of refractory properties to simulate new solutions to constructive and property-related challenges. The different scientific background of all ESRs is taken into account. Therefore, especially the first courses of each type enable all participants to adapt the required basics for the upcoming lectures. As a main result of the ATHOR program, a well-structured training program for young refractory engineers will be acquired, which is considered to contribute to the education of an even broader audience after the project runtime.

Research Training Course 1 - Refractory Materials

Part 1: Fracture mechanics of refractories

Scope: Linear elastic fracture mechanics and deviations from linear elastic behaviour, fracture mechanical characterization, testing methods, brittleness and flexibility, wedge splitting test, fractography and structure/property relations.

Scheduled lectures:

- Fundamentals of refractory fracture
- Creep of refractories
- Fracture and creep testing – devices, procedures and some results
- Introduction to simulation of creep and fracture
- Introduction to simulation of thermomechanical lining behaviour
- Practical course: Wedge Splitting Test
- Site visit: RHI Magnesita Technology Center, Leoben

Lecturers (estimated):

Attendants: ATHOR ESRs, master level students of participating universities and companies as well as technical staff and engineers, professors (max. 40 people).

Course	Leader	Contributors	Date/Location	Duration	ECTS Credits
RTC1 Part 1	MUL	MUL, RWTH, UNILIM, RHI	2018, June 12th – 14th, Leoben	3 days (3 x 1 day)	2

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Part 2: Corrosion

Scope: Liquid-solid interaction in refractories - fundamentals of liquid phase sintering, wetting, coating, infiltration, disintegration, anisotropic wetting, solid-liquid interfacial energy, dissolution, flux line corrosion, velocity of Marangoni convection, slagline corrosion in steelmaking, continuous wear phenomena by slags, dependence of corrosion on solubility and evidence of solubility dependence on the matching of basicity, variation of solubility in function of C/S ratio, acidity/basicity.

Scheduled lecturers and estimated authors:

- Fundamentals of refractory corrosion (Prof. Spiegel, Salzgitter Flachstahl, Duisburg)
- MgO-C: Decarburisation, solubility, slag reactions (Prof. Pötschke, German Refractory Producers Association)
- Influence of glassy phases (Prof. Zborowski, AGH Cracow)
- Thermo-chemical modelling, FACT Sage, ThermoCalc (Prof. Hack, GTT, Aachen)
- Testing (Prof. Aneziris, University of Freiberg)
- Industrial case studies (Contributing authors: J. Poirier, A. Villalba Weinberg, S. van der Laan, Th. Tonnesen, R. Telle)

Attendants: ATHOR ESRs, master level students of participating universities and companies as well as technical staff and engineers, professors

Course	Leader	Contributors	Date/Location	Duration	ECTS Credits
RTC1 Part 2	RWTH	RWTH, MUL, UORL, TATASTEEL	2018, September 24th - 25th, Aachen	4.5 days (1.5 x 3 days)	3

Part 3: Thermal Shock

Scope: Measurement of fracture energies of brittle heterogeneous materials, thermal shock fracture initiation and crack propagation, fracture toughness and spalling behaviour, damage resistance, transient thermal stress behaviour, role of additives on the thermal shock resistance, correlation between thermal shock and mechanical impact resistance.

Lecturers (estimated):

Attendants: ATHOR ESRs, master level students of participating universities and companies as well as technical staff and engineers, professors

Course	Leader	Contributors	Date/Location	Duration	ECTS Credits
RTC1 Part 3	RWTH	RWTH, MUL, UNILIM, RHI		4.5 days (1.5 x 3 days)	3

Part 4: Field Applications and Case Studies

Scope: Examination of real life examples and post-mortem examples. This module will be led by the Partner organisations, who will introduce the various projects, discuss the reasons that led to the success, failure, design challenges, execution as well as comments on life cycle assessments and related societal and environmental issues such as energy efficiency.

Lecturers (estimated):

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Attendants: ATHOR ESRs, master level students of participating universities and companies as well as technical staff and engineers, professors

Course	Leader	Contributors	Date/Location	Duration	ECTS Credits
RTC1 Part 4	TATASTEEL	ALL POs	*To define*	3 days (3 x 1 day)	2

Research Training Course 2 - Theoretical Basics and Modelling

For educational reasons, the theoretical courses on modelling will start within the second year of the ATHOR program schedule. The contents of these lectures are including very complex mathematical and physical models which need a good adaption of the refractory materials properties before attendance. To give all participating ESRs of the ATHOR program the best chances to benefit from the offered training events despite their scientific background, special attention is paid on adaption of the basic principles and processes related to refractory materials before more challenging courses take place.

Part 1: Thermomechanical modelling

Scope: Thermomechanical modelling and design of structures containing refractory lining masonries; Masonry modelling: linear homogenization, joint state, non-linear homogenization, inverse identification, micro and macro modelling masonry, inelastic properties, model validation; Multi-surface plasticity model: steel ladle, blast furnace, coke oven heating wall.

Lecturers (estimated):

Attendants: ATHOR ESRs, master level students of participating universities and companies as well as technical staff and engineers, professors

Course	Leader	Contributors	Date/Location	Duration	ECTS Credits
RTC2 Part 1	UORL	UORL, UMINHO, TATASTEEL, MAGNESITA	2019, January Orleans	6 days (2 x 3 days)	4

Part 2: Multi-physic coupling

Scope: Overview and modelling of the multi-physic coupling in refractory, thermodynamics of irreversible processes, refractory application - mechanical effect of slag impregnation without phase change - thermo-chemo-mechanical model of swelling induced by oxidation.

Lecturers (estimated):

Attendants: ATHOR ESRs, master level students of participating universities and companies as well as technical staff and engineers, professors

Course	Leader	Contributors	Date/Location	Duration	ECTS Credits
RTC2 Part 2	UORL	UORL, MUL, TATASTEEL, RHI	*To define*	4.5 days (1.5 x 3 days)	3

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Part 3: Numerical approaches for continuum micromechanics

Scope: Multi-scale composite approach of effective thermal and mechanical properties of refractories, analytical methods for continuum micromechanics, analytical prediction of effective properties of random media, numerical homogenization technics for continuum micromechanics.

Lecturers (estimated):

Attendants: ATHOR ESRs, master level students of participating universities and companies as well as technical staff and engineers, professors

Course	Leader	Contributors	Date/Location	Duration	ECTS Credits
RTC2 Part 3	UORL	UNILIM, RHI, MUL, UORL	*To define*	4.5 days (1.5 x 3 days)	3

Complementary Skills Workshops (CSW)

To enable the ESRs to attend courses improving their complementary skills without increasing the overall travel time during their PhD, a decentralized approach is chosen for carrying out the complementary skills workshops. Attending the pre-existing complementary skills programs of their host universities, it is ensured that the ESRs profit from well-established as well as versatile training courses without additional travelling. Thereby, the arranged procedure supports the ESRs in focussing on their research topics with simultaneous opportunity of self-structuring. To ensure all ESRs choose courses with comparable effort, an exemplary outline for each CSW block is given in the following particular description of CSW 1 and CSW 2. After setting up their CSW schedule in accordance with their host university, both the supervisor(s) and WP5 leaders will evaluate the comparability of the chosen programs.

General procedure for all CSW courses:

1.) ESRs contact host university for attendance to similar courses as mentioned in CSW1.1 description.
2.) The planned courses are communicated to the supervisor(s) and the leader of WP5 (RWTH) to ensure that effort is equal for all ESRs.
3.) In case of lacking comparability, it may be necessary for some ESRs to attend particular CSW lectures during their secondments at other locations.

Expected results:

The decentralized approach enables the ESRs to attend courses improving their complementary skills without increasing the overall travel time during their PhD which is supposed to support the ESRs in focussing on their research topics.

Complementary Research Skills (CSW1) - Research, Communication and Management

Exemplary outline of part 1:

Career Development Planning (1 day): This session will deal with career prospects in both academia and industry and will assist the participants in making effective decisions.

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Networking & Communication Skills (1 day): This practical and interactive course will highlight the skills and benefits of effective networking. Participants will learn how to approach formal/informal networking.

Presentation Skills and Media Training (2x0.5 day): The objective is to develop confidence in the participants and equip them to deliver high-impact presentations and prepare them for interviews and discussions.

Time Management (1 day): this session will cover tools and techniques which can be used to manage time more effectively in five key areas: work planning, email, meetings, phone calls and dealing with people.

Attendants: ATHOR ESRs

Course	Leader	Contributors	Date/Location	Duration	ECTS Credits
CSW1 Part 1	UMINHO	ALL POs	Decentralized	4 days (1 x 4 days)	3

Exemplary outline of part 2:

Project Management (1 day): Basic introduction to project management with a focus on the defining and planning stages.

Change management for an innovative professional environment (1 day).

Personality models: Better comprehension of others (1 day).

Review of leadership competence (2 days): The seminar will give the chance to explore leadership styles.

Attendants: ATHOR ESRs

Course	Leader	Contributors	Date/Location	Duration	ECTS Credits
CSW1 Part 2	MUL	ALL POs	Decentralized	5 days (1 x 5 days)	3

Complementary Skills (CSW2) - Research, Dissemination, Safety Funding and Intellectual Property

Exemplary outline of part 1:

Effective Research Dissemination (2 days): This session will provide advice and information on how to write effective research publications including: 1) dissemination web pages, articles and press releases. Each ESR must prepare research web pages that will be posted on ATHOR website and serve for training; 2) reports (using a standard template for the preparation of Network reports); 3) conference publications and presentations; and 4) journal publications. Each ESR will have to submit at least three papers to Rank A Journals. Critical assessment and reviewing of research papers will also be discussed.

Environment, Health & Safety Management (1 day): Participants will learn how to address the different risks associated with Environment, Health and Safety (EHS). These questions are particularly important in the I&S industries. A global EHS approach will be adopted: from raw materials, manufacturing and application to recycling. Practical examples will be given.

Proposal Writing and Funding Opportunities (1 day): Participants will learn where and how to apply for research funding both at a national and at a European level. The content generally required for proposal

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preparation will be introduced (support, costing, project planning, impact, etc.) and discussed through the analysis of successful and unsuccessful examples.

Attendants: ATHOR ESRs

Course	Leader	Contributors	Date/Location	Duration	ECTS Credits
CSW2 Part 1	MUL	UORL, UMINHO, TATASTEEL, MAGNESITA	Decentralized	4 days (2+1+1 days)	4

Exemplary outline of part 2:

Protection of Intellectual Property (1 day): This session will provide information required to make decisions when trying to balance IP protection and dissemination. Using examples and case studies provided by ATHOR partners, important issues will be explored and how these are impacted by disclosures of various kinds.

Case Studies of Commercialisation (1 day): This session will look at a spectrum of case studies to illustrate the challenges, the strategies adopted to overcome them, the lessons learnt and how this feeds back into future research and opportunities.

Find a job in the industry - Job search and application training (1 day): This seminar organised by FIRE will prepare candidates for future job interviews. It offers the chance to experience and train to gain self-assurance. Information about interview structure, typical questions and salary negotiation strategies will be provided. An analysis of a full example interview will be provided and complementary and personalised advices.

Attendants: ATHOR ESRs

Course	Leader	Contributors	Date/Location	Duration	ECTS Credits
CSW2 Part 2	MUL	ALL POs	Decentralized	3 days (1 x 3 days)	2

Exemplary outline of part 3:

Management of research data (1 day): Research data is the base and the result of research work, a reliable and sustainable handling of this valuable science resource increases effectiveness of the research.

Good scientific practice (2 days): Case discussions, problem based learning in small groups, plenary discussion, information inputs will be considered. Definitions of good scientific practice and scientific misconduct, data management, authorship and the process of publication, mentoring, degrees and extent of scientific misconduct, examples for responsible and irresponsible conduct of research, conflict management: how to deal with scientific misconduct, official rules and regulations.

Standardization - Technical basics (1 day): Workshop, introduction, technical terms, practical examinations on databases.

Attendants: ATHOR ESRs

Course	Leader	Contributors	Date/Location	Duration	ECTS Credits
CSW2 Part 3	MUL	ALL POs	Decentralized	4 days (1+2+1 days)	3

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International Conferences

Foreseen Contribution of ESR to International Conferences. All meetings of the ATHOR network will be scheduled to coincide with international meetings and events, such as the annual International Colloquium on Refractories 2018, 2019 and 2020 (Aachen, Germany), the Unified Technical Conference on Refractories (UNITECR) 2019 in Japan, 2021 in North America and the world's largest trade fair Thermprocess/METEC/GIFA in Dusseldorf/Germany 2019, STAHL (annual, Dusseldorf/Germany).

Attendants: ATHOR ESRs, professors and/or supervisors

Course	Leader	Contributors	Date/Location	Duration	ECTS Credits
IC	FIRE	ALL POs	2018, September 26th-27th, Aachen	2 days	-

Site visits

Network-wide Site Visits (6x1 day events): Visits to raw materials preparation plants, refractory-manufacturing plants and refractory-using plants will be organized by the POs as part of the training activities of the Network. The POs have a strong presence in Austria, France, Germany, Netherlands, United Kingdom, and other European countries. The ESRs will then have the opportunity to be in close contact with the industry and directly experience the complex nature of construction projects and manufacturing processes. Furthermore, ESRs will gain an acute awareness of health, safety, and environmental issues.

Attendants: ATHOR ESRs, master level students of participating universities and companies as well as technical staff and engineers, professors

Course	Leader	Contributors	Date/Location	ECTS Credits
SV1	TATASTEEL	ALL POs	2018, May Lab visit Limoges	-
SV2	TATASTEEL	ALL POs	2018, June RHI Technology Center, Leoben	-
SV2	TATASTEEL	ALL POs	2018, September TATA Steel Ijmuiden	-
SV3	TATASTEEL	ALL POs	*To define*	-
SV4	TATASTEEL	ALL POs	*To define*	-
SV5	TATASTEEL	ALL POs	*To define*	-
SV6	TATASTEEL	ALL POs	*To define*	-

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Workshops

Network-wide workshops allow the ESRs to present their own research results to the other ESRs through communications and/or posters. Detailed discussions with the WP leaders help them to assess and direct their technical progress. The workshops contribute not only to the training because the ESRs attend them and present their work, but also because the ESRs are actively involved in the organisation of these workshops. The workshops give the ESRs a prime opportunity to communicate and discuss their scientific results with an interdisciplinary, intersectoral and international audience.

Each seminar gives the ESRs the opportunity to exchange information about challenges, progress, outline, particular technical problems, define contact with other project topics and to gain insight into the context of all research fields, especially connections between modelling and refractory testing.

The workshops are supposed to take place **decentralized** and to be **self-organized** by the participating ESRs with the aid of a hosting partner providing suitable meeting rooms or lab facilities. There will be two workshops offered on different occasions each year. The attendance of one workshop per year is mandatory.

GENERAL PROCEDURE FOR ALL WORKSHOP EVENTS:

1.) hosting Partner announces date and location
2.) Feedback of participating ESRs
3.) ESRs organize schedule and Agenda
4.) ESRs write down minutes for upload on network web portals

Attendants: ATHOR ESRs, master level students of participating universities and companies as well as technical staff and engineers, professors
Expected results: More informal discussions at network-wide workshops enable the ESRs to exchange their experiences as well as to keep close contact to related topics and give them the opportunity to train their presentation and debating skills within meetings of their subject area.

Course	Leader	Contributors	Date/Location	ECTS Credits
WS1	UNILIM	ALL POs	2018, May, Limoges	-
WS2	UNILIM	ALL POs	2018, September Aachen	-
WS3	UNILIM	ALL POs	*To define*	-
WS4	UNILIM	ALL POs	*To define*	-
WS5	UNILIM	ALL POs	*To define*	-
WS6	UNILIM	ALL POs	*To define*	-

Young Researchers Competitions

Special Young Researchers Conferences and Poster Competitions will be organized in conjunction with the Mid-Term and Final meetings of the Network. As part of their professional training, the ESRs will be in charge to organize and chair the sessions of these events, which will be open to all Young Researchers (not only the ATHOR researchers). ESRs will develop key transferable skills including project and time management, team working, problem solving, communication and networking. These Special Young Researchers Conferences and Poster sessions will be organized as a special session of the annual International Colloquium on Refractories in Aachen. This international conference hosts up to 800 participants. Industrial and research people not from ATHOR network will be invited to attend these events.

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Attendants: ATHOR ESRs, master level students of participating universities and companies as well as technical staff and engineers, professors

YRC1: Poster exhibition
During RTC 1.2 in Aachen in September 2018 a network-wide poster exhibition will be carried out to train the ESRs presentation skills and to give them a prime opportunity to define the focus of their research topics in particular.

Course	Leader	Contributors	Date/Location	ECTS Credits
YRC1	FIRE	ALL POs	2018, September 24th – 25th, Aachen	-
YRC2	FIRE	ALL POs	*To define*	-
YRC3	FIRE	ALL POs	*To define*	-

Version 1. To be updated every 6 months.

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