The FIRE Compendium Series on Refractory Corrosion to match the Education Needs

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FIRE is committed to assist the education of young professionals and engineers of all horizons, to conceptualize, design, implement and organize efficient processes to manufacture the best refractory materials for all and specific users. FIRE education programs and the main accomplishments made since 2007 are at first briefly reviewed. In 2017, to enhance its educational mission FIRE members have undertaken the task to launch a second compendium series of books on the theme of Corrosion, to actualize the knowledge accumulated in the last three decades and to disseminate the main results for the benefit of the widest readership. The essential aspects of the 3 books to appear in 2018 are provided to illustrate the FIRE members’ role in such an endeavour.

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1. Introduction

Two questions are to be answered:
- What type of training education is needed to meet refractory industry needs, in order to focus on innovations?
- What pedagogical tools are required to match the refractory education goals at the graduate level?

Those questions are biased for sure. The answers which will be provided will serve to highlight the role of the Federation International for Refractory Research and Education (FIRE) and justify its latest initiative to step into books edition.

2. The Refractory Education in the Western World

In the last thirty years, globalization, rationalization, mergers and outsourcing have affected and shaped the refractory industry, as well as many other industrial sectors, many of them being major users of refractories. In the same time most of the academic institutions, world-wide, had to adjust to the new business-education paradigm, at first jumping into the Nano-Bio-Computer euphoria, then going through the numerical revolution and entering now in the 4th industrial revolution of big data and artificial intelligence. In refractory engineering education, the downsizing in 1997 was a reality in North America and the lack of suitable modern refractories text book for independent learning was already stigmatized [1]. In 2003, [2], it was recognized that refractory interuniversity consortia type of approach might become an innovative solution. In 2005, the Federation International for Refractory Research and Education (FIRE) became a new reality, to provide responsive education and research programs for the Refractory Industry [3]. FIRE was set to combine education with state of the art research programs and mediate between industrial and academic institutions to provide new graduated researchers able to conceive, design, implement and organize innovative solutions.

3. The FIRE Education Programs

After its incorporation as a non-profit organization in May 2005, to promote refractory related research and education at a global level, it took 27 months to initiate the Fire International Education Programs, first at the master level and a year later at the PhD level, regrouping then 6 institutions: in Austria the Montanuniversitat of Leoben, in Brazil, the Federal Universidade de Sao Carlos, in France two poles, the ENSCI of Limoges and the Polytech of Orléans, in Germany, the Technische Universität Bergakademie, of Freiberg and in USA the University of Missouri-Rolla.

Now in 2017 the academic network is composed of 10 universities, adding from China the Wuhan University of Science and Technology, from Germany the RWTH in Aachen, from Japan the Nagoya Institute of Technology and from Korea, the Seoul National University. In the last 10 years FIRE has granted 43 M.Sc. and 17 PhD certificates to 46 students. It is possible to follow in details the progression in the following references [4-5-6]. At this point the interuniversity collaboration is clearly a valid concept to seduce and recruit the right individuals and make sure that the offer of valuable quality-proven educative programs remains available, being financially supported nowadays by 17 companies and various granting agencies.

4. The FIRE Compendium Series

The new pedagogical tools, FIRE implemented through the years, have served to promote the internationalization of academic institution programs, to facilitate exchanges of students among the different campuses and to intensify the collaboration between professors and industrial members in a true competitive spirit. The latest pedagogical tool of editing books on Refractory Engineering germinated after FIRE organized its first Summer
School, in Orleans in 2012. This was done by invitation to all FIRE former and active graduates and to all FIRE industrial members engaged in R&D. It was then clear that an educative series of books on refractory technology had to be made available, not only as a reference but also for educative purposes. The rules were that the outline of the books had to be accepted by the FIRE Board, and the texts had to peer-reviewed by an Editorial Board Committee selected among the FIRE industrial and academic members.

The first volume appeared in 2015 under the responsibility of Professor Victor Pandolfelli who wrote with Ana Paula Luz and Mariana Braulio, all from the Federal University of Sao Carlos (UFSC), a 732 pages book on “Refractory Castable Engineering”[7]. This book covers the main concepts related to the main steps involved in the composition development of castable mixes (dispersion, particle packing, binders and installation techniques) in their processing (mixing, curing, drying). New advances made on specific castable systems containing MgO, spinel, various carbon sources, and nano-materials were reviewed and are still of actuality.

The second series is on “Corrosion of Refractories”, targeted to reach approximately 1,200 pages, divided in 3 volumes. Volume 2A on” The Fundamentals” was published in September 2017, while volume 2B on “The Testing and Characterizing Methods” and 2C on “The Impacts of Corrosion” are to be published, always by Göller Verlag GmbH, in September 2018.

In volume 2A (453 pages) the principles of thermodynamics and kinetics are reviewed. The importance of wetting, capillarity and infiltration are comprehensively treated. The relationship between the microstructure of corroded samples and the results obtained using thermodynamics data bases to ascertain multi-components systems as well as simulation modeling programs are illustrated through several examples. Its full content is describes in [8].

In volume 2B (299 pages) the traditional testing methods, up to 1600 °C and also up to 2000 °C, for industrial refractories and composite materials, in order to measure corrosion damages and to correlate the results obtained under laboratory conditions and in-plant testing, are described in chapter one. The second chapter does cover both the traditional and the new advanced in-situ methods to characterize the refractory materials once corroded. An entire section is devoted specifically to castables. The last chapter is about a simplified approach on how to minimize corrosion.

Volume 2C (452 pages) is also divided into 3 chapters. To maximize the usefulness of post-mortem analysis of corroded samples, the range of precautions to ascertain that the results are essentially due to corrosion is considered. Then 16 industrial case studies, in the iron and steel, the aluminum, the non-ferrous, the cement, the glass industries as well as in the incinerators, the gasifiers and in the induction furnaces, serve to illustrate the wide range of conditions under which refractories wear down and the pertinent adjustments made to minimize the damages. Finally the impacts on the quality of products in steels and glass melting as well as on the refractory management in steelmaking are illustrated. A section on ultra-high temperature refractory ceramics is added to uncover new horizons.

5. Conclusion

To maintain focus on innovation, the Refractory Industry must be able to recruit the human resources required and to invest in R&D. Since outsourcing of research is favored by several governmental and para-governmental funding agencies in different industrial sectors, it has been worthwhile to make the efforts to have access to such financial support and obtain a fair share of the pie. At this point FIRE has been able to do so and has provided some answers to the two questions initially mentioned in the introduction. It is now hope that the initiative to keep on editing such a series of books will be fully supported by the refractory constituency membership.

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References