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 D3.1 Review report on refractory Recycling in Europe

ReSoURCE

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Document description	This document describes the content of the manuscript prepared during the work of WP 3.1 and presents a multistep approach which quantitatively describes the whereabouts of spent refractories in the European waste management system. After the internal review is completed, the manuscript will be submitted to a peer reviewed journal (e.g., Waste Management). After the external review is completed, the published article serves as D 3.1.

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Description of the manuscript to be submitted as peer-review journal content

1. Introduction

During the scope of WP 3 Task 1, the waste management system of the European Union was analysed with the aim to identify the quantity of spent refractories as well as their whereabouts. In order to accomplish this task, a multi-step approach has been conducted. At first, published scientific literature on the topic was analysed to determine the state of knowledge. Followed by the evaluation of reports of producer associations to collect published data for further calculations. Finally, a survey has been conducted using both, the distribution of an online questionnaire as well as telephone interviews with steel and cement producers. Furthermore, 4 case studies of on-and offsite recyclers are presented in this deliverable. The data obtained from these steps were combined to provide an estimation of the current material flow of spent refractories in the European Union. Furthermore, deviations of the thereby calculated values from published literature were investigated. Key questions to be answered were:

- a. What is the quantity of refractories utilized and the volume of spent refractories generated in Europe?
- b. How is the distribution of refractories used and spent refractories generated across various European industries?
- c. What is the specific consumption of refractories in steel and cement production?
- d. What is the wear rate of refractories in steel and cement production?
- e. What is the final fate distribution of spent refractories after breakout, particularly concerning internal reuse, external recycling for the production of new refractory products and landfill?

2. Literature research

Deliverable 1.1 identified the steel and cement industry as the primary consumers of refractory materials, which consequently results in the regular availability of substantial quantities of spent refractories. Therefore, the literature research conducted in WP 3.1 investigates breakout material from steel casting ladles and cement rotary kilns. While analysing available literature, it was discovered that there is a lack on reliable published data on refractory consumption. System boundaries are often not or not clearly specified and the origin of provided numbers is often not transparent. The most influential and complete analysis of refractory material flow in Europe was published by Eschner (2003)¹ and is still used as basis in contemporary reports after 20 years. Therefore, it was decided to use the work of Eschner (2003) for comparison and to fill data gaps that could not be addressed in this study. In total 20 scientific papers had been reviewed and the most relevant information to address the aforementioned key questions was extracted. Hence, the data reported in literature regarding (a) the refractory consumption in the EU, (b) the allocation of refractories to steel and cement production, (c) the specific consumption, (d) the documented wear rate and (e) the final fate distribution were summarized in tabular form.

¹ Eschner, A. (2003). *ECO-management of refractory in Europe*. 8th Unified International Technical Conference on Refractories.

3. Association reports

As steel and cement production were identified as the main consumers of refractory materials, production data of steel² and cement³ as well as available production data of refractories⁴ (considering imports and exports) were analysed, correlated, and extrapolated to estimate the refractory consumption and subsequent volumes of spent refractories generated in 2022 in the EU. The quantity of new and spent refractories of the current year were calculated in case the production values were reported by individual associations.

4. Survey data

Surveying was conducted with the aforementioned key questions (a-e) in mind. While response rate among cement producers was high (9 out of 17 on telephone, 3 out of 7 online), this was not the case for steel producers (1 out of 15 on telephone, 1 out of 14 online). Furthermore, steel producers stated multiple times that they do not have the necessary data. In the context of the online survey, a high percentage of data was not usable for further evaluations as the answers were incomplete.

The data provided by cement producers accounts for about 1 % of European cement production. Furthermore, the given details report a percentage for process loss, an internal reuse, a rate of material provided to external recyclers and the share of material being landfilled. Cement manufacturers highlighted challenges they face in raising the proportion of recycled material. However, participants did not provide specific examples or details regarding these challenges.

The steel production data indicates a high share of landfilled material, while the remaining is either handed over to external recyclers or partly being reused internally (e.g., as slag conditioner). Since the response rate was very low (n=2), no derivations on representativity were made. However, the share of landfilled material is relatively high, indicating potential for improving the waste management practices in these plants.

5. Conclusions and outlook

When combining the results of the multi-step approach, the key questions mentioned can only be answered for the cement industry. This is due the lack of available data for steel production. The study of Eschner (2003) should serve as a reference point for documenting any changes over time but had to be utilized additionally to address any knowledge gaps that could not be filled with contemporary or association reports.

By comparing the work of Eschner (2003) with the survey results (case studies included), there has been a shift to providing more material to external recyclers, even though the total amount of spent refractories has decreased. Further research is needed on the actual waste streams from steel production. However, this is only possible if strong collaboration with steel producers (or their contractors on the breakout business) can be reached.

The conducted research within WP 3 Task 1 can provide a foundation for the initial detailed analysis of refractory material flows, despite the limitations that must be taken into account. Furthermore, a

² Eurofer (2010 - 2023): European Steel in Figures 2010 - 2023

³ Cembureau (2017 - 2022): Activity Reports 2016 - 2022.

⁴ PRE (2011 - 2017): Annual Reports; Trade balance EU27 published online at <http://www.pre.eu/statistics>.

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simple method for estimating future generation of spent refractories is presented. This study also aids in gaining a more comprehensive understanding of the current practices in handling refractory wastes, thereby opening up the possibility to identify areas for improvement.