Retrofitting Equipment for Efficient Use of Variable Feedstock in Metal Making Processes - REVaMP

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Material flow analysis applied and validated for lead plant at Exide

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<u>Dissemination level</u>

PU	public	☒
CO	Confidential, only for members of the consortium (incl. the Commission Services)	☐

<u>Note:</u> Since this report is public, no numerical values for the process parameters of the industrial partners have been included.

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1. About REVaMP

The main objective of the project "Retrofitting Equipment for Efficient Use of Variable Feedstock in Metal Making Processes" (REVaMP) is to develop, adapt and apply novel retrofitting technologies to cope with the increasing variability and to ensure an efficient use of the feedstock in terms of materials and energy.

For this purpose, existing metal production plants shall be retrofitted with appropriate sensors for scrap analysis and furnace operation. Furthermore, the selection of the optimal feedstock in terms of material and energy efficiency shall be improved by application of appropriate process control and decision support tools. Also, a solid scrap preheating system operated with waste derived fuel shall increase the energy efficiency of the melting processes. To monitor and control the process behaviour in an optimal way, model-based software tools will be developed and applied.

The retrofitting solutions will be exemplarily demonstrated within three different use cases from the metal making industry, namely electric and oxygen steelmaking, aluminium refining and lead recycling. The performance of the different technologies will be assessed, and the benefits will be evaluated in terms of economic and ecological effects, as well as cross-sectorial applicability in other process industries.

2. Introduction and Summary

This deliverable D 7.4, “Material flow analysis applied and validated for lead plant at Exide”, is included in work package 7 “Demonstration of retrofitting solutions in lead production use case” of the project.

Within this task, the Material Flow Analysis (MFA) for the lead production use case shall be validated and updated if needed in order to accurately represent the current lead production process at Exide. The MFA methodology is described in more detail in the previous Deliverable 2.5, in which the first version of the MFA models was created. Due to the iterative nature of the process, further evaluation is necessary and can still lead to changes and an improvement of the model.

3. MFA evaluation for lead use case

The MFA model created for the lead use case in Deliverable 2.5 aims to provide an accurate representation of the lead production process at Exide. For this purpose, all relevant input and output flows for the most import process steps were identified and quantified with production data from the plant of Exide. Additional information on the production processes and the MFA model, are given in the reports on Deliverable 1.4 and Deliverable 2.5.

The goal in this deliverable is to further evaluate the model and verify that all relevant material and energy flows have been accounted for in the model. For this purpose, the model is compared with other publicly available life cycle assessments as well as other literature data. If necessary, the results are discussed with the industrial partner and adaptations to the model are carried out.

Current state of the model

The production system under review comprises the following processes: battery breaking and separation of the components, smelting and refining. Within the furnace process all relevant materials, process, energy, fluxes and dust extraction are considered. All upstream processes up to the preparation and delivery of the natural resources are also considered according to the cradle to gate approach. Due to this concept, all processes after the melting furnace are not part of the calculation.

The flowchart below shows all analysed processes and their regarding input and output flows. These flowcharts with the defining system parameters were created in close collaboration with the industrial partner.

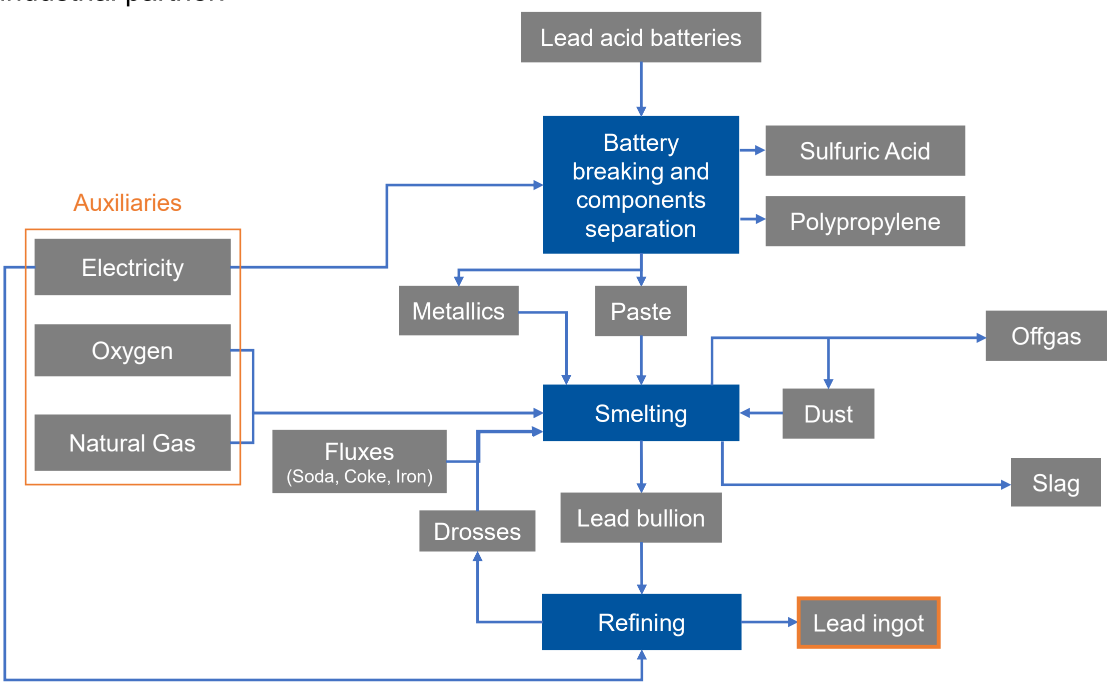

Figure 1 – Flowchart of the lead recycling process

The numeric values of all shown input and output streams are based upon the usual production process at Exide and are implemented in the model. But in this report, no specific production numbers are shown due to the report being public.

Exide's lead recycling process mainly involves recycling byproducts as well as supplementing them with externally sourced materials. The recovered metallics and paste from the battery breaking are supplemented with externally bought raw lead material (also in the form of metallics and paste. The same procedure is applied for the lead bullion, where a part of the bullion used in the refining step originates again from an external market.

The electric energy is in parts sourced from an average Spanish electricity mix taken from the ecoinvent database and also from a solar power plant at the Exide plant. The off-gas is simplified to the CO_2-component, as for the other use cases as well. The oxygen being used in the furnace is mostly produced on site, the rest is purchased externally. For the on-site-production, a cryogenic air separation unit is modelled from the ecoinvent database using electric energy. The demand of electric energy of this unit is also included in the model.

Evaluation and literature comparison

The original creation of the MFA model was already done in close collaboration with the industrial partner Exide. The considered parameters were taken directly from the usual production practice. The model was also closely discussed and evaluated, and all assumptions were made in close consultation to be as realistic as possible.

Since this deliverable is intended to be public, no explicit values are given for the production process of Exide. However, these were also compared with values from the literature in order to rule out major errors in the data collection. Nevertheless, due to the variance of products and processes in the lead production industry, deviations from the corresponding literature values are possible.

Other life cycle assessments on the lead production process were used to compare and evaluate the model. Chen el al. [1] describe an Integrated Material Flow Analysis and Life Cycle Assessment of Lead-Acid Batteries. The material flows included for the separation process, the smelting process and the refining process are very similar to the model created for the Exide plant. The main material flows for raw materials, auxiliary materials and energy inputs are very similar, too. The model carried out by Chen et al. also lists several other output materials. However, these substances only show very low levels and have no significant influence on the results obtained.

Davidson el al. [2] describe several best practices concerning life cycle studies in the lead industry. They go into detail on the environmental impact and life cycle assessment of lead battery production and architectural sheet production. The material flows used in this process were compared with the model developed for Exide. In this way, all relevant material flows could be confirmed.

Sullivan and Gaines [3, 4] have conducted an extensive review of the Life Cycle Analysis of battery production. The material flows used in this process were also compared with the model developed for Exide. All the main material flows could also be confirmed with this. The individual material flows vary widely in their amount depending on the specific application. The largest differences were found in the separation process and the refining process.

Tian el al. [5] carried out an environmental impact and economic assessment of secondary lead production concerning lead-acid battery recycling processes in China. Different recycling processes from the lead industry were compared and contrasted. In addition, a comprehensive collection of process data, in particular input and output streams, was compiled. This data was compared with the model developed for Exide to ensure that all relevant material flows were taken into account.

Using the Report “Best Available Techniques” [6], it was possible to classify the process data provided by Exide. All relevant material flows were compared with the data from the BAT report. In detail, the individual material flows vary widely in their amount; however, the respective range of values is reasonable. The ecological impact analysis of Unterreiner et al. [7] was also used to verify the energetic process variables in the MFA Model.

The influence of the modelled upstream processes was also investigated. For the case of Exide, this is especially important, since a large portion of input materials are drawn from external sources. Additional recovered metallics and paste (2/3 of the overall input), as well as lead bullion (ca. 5% of the overall input) are brought in from other plants, since not enough of these materials is produced on site for the process of Exide. These input flows have a large impact on environmental indicators to their flow sizes. The details of these upstream processes where therefore discussed with Exide.

The additional materials originate from a large number of sources. One exemplary supplier process chain was evaluated with information provided by Exide. The process carried out at the site of that supplier was largely similar to the process carried out at Exide. The same scrap types were utilized in a similar process structure (breaking, separating, melting and bullion production). The upstream processes, where the additional material of Exide originate from are therefore assumed to be similar to the process of Exide. To not model the exact same process of Exide as the upstream provider, a similar process was chosen from the ecoinvent database. The same upstream information are also assumed for the later happening evaluation of the retrofit solutions. This way, the environmental impact of these additional resources is estimated at a level representative of Exide’s production praxis, and it can be ruled out that their modelling distorts the model in an unrealistic way.

4. Summary

In this Deliverable, the material flow analysis created for the lead use case of Exide has been evaluated. The model created was developed in close cooperation with the industrial partner and compared with other LCAs of lead recycling processes for verification. As a result, it was shown that the model meets the usual standards of a life cycle assessment for the lead recycling process and includes the most important material and energy flows. The modelling of the upstream processes for the additional raw materials was slightly adjusted to fit the use case of Exide.

The created model will be used as a baseline in the further course of the project. The state of the processes under consideration after installation of the retrofitting solutions will also be recorded and presented as a second version of the model. The results of these secondary models can then be compared with their corresponding baseline created here. This will ensure an assessment of the impact of the new technologies according to the standard practice of Material Flow Analysis and Life Cycle Assessment.

5. List of Abbreviations

LCA	Life Cycle Analysis / Assessment
MFA	Material Flow Analysis
CAR	Cartif Technology Center
BFI	VDEh Betriebsforschungsinstitut GmbH
RWTH AACHEN	Rheinisch-Westfälische Technische Hochschule Aachen
EXIDE	Exide Technologies

6. References

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