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

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Material flow analysis applied and validated for steel plant at Sidenor

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Authors:

Partner	Name
BFI	Bernd Kleimt
SIDENOR I+D	Leixuri Fernandez
SIDENOR	Inigo Unamuno
RWTH AACHEN	Felix Kaiser, Tim Reichel, Thomas Echterhof

Dissemination level

PU public ☒

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

Note: 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 5.2, “Material flow analysis applied and validated for steel plant at Sidenor”, is included in work package 5 “Demonstration of retrofitting solutions in Steelmaking use case” of the project.

Within this task, the Material Flow Analysis (MFA) for the steelmaking use case shall be validated and updated if needed in order to accurately represent the current steelmaking process at Sidenor. 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 steel use case

The MFA model created for the steel use case in Deliverable 2.5 aims to provide an accurate representation of the steel production process at Sidenor. 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 Sidenor. Additional information on the production processes and the MFA models, 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

In this use case, the electric steelmaking process from recycled steel scrap is analysed. The model focuses exclusively on the process step taking place at the electric arc furnace (EAF) including any upstream processes. The analysis covers all processes from the provision of primary and secondary resources up to the creation of liquid crude steel. Due to the applied cradle-to-gate approach, all processes of the process route after the EAF are not considered.

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

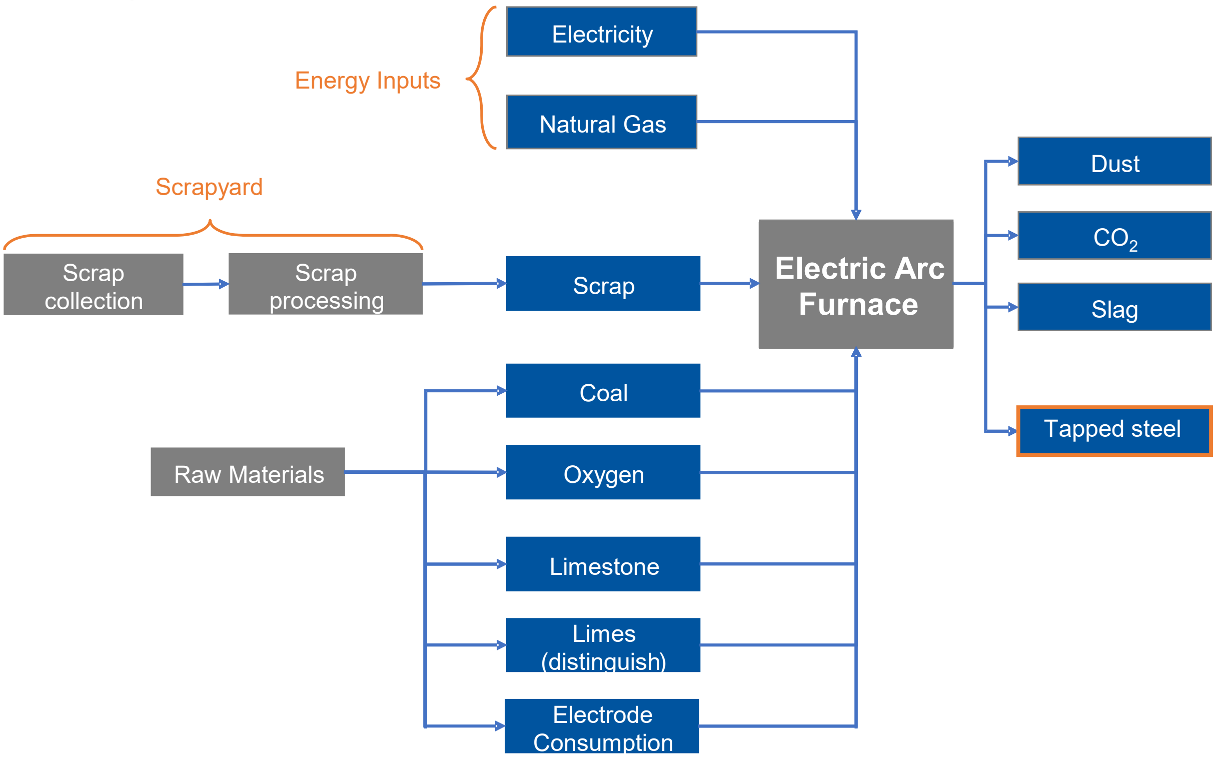

Figure 1 – Flowchart of the steel production through an Electric Arc Furnace

The electric energy input combines the required input for the scrapyard operations and for smelting operation. Compared with the flowchart from WP1, it was decided to leave out the alloying materials, as these are part of the ladle metallurgy and not the actual Electric Arc Furnace process. The off-gas was simplified to the dust and CO_2 components.

Based on the flowchart, the input and output parameters have been determined with data according to Sidenor's usual production process and are implemented in the model. Adequate upstream processes for resource supply were modelled using the ecoinvent database.

The oxygen used in the EAF is produced on site via cryogenic air separation. Regarding electric energy, the specific electricity mix of Sidenors provider was implemented as the source of all electric energy.

Evaluation and literature comparison

The original creation of the MFA model was already done in close collaboration with the industrial partner Sidenor. 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 Sidenor. 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 EAF steelmaking industry, deviations from the corresponding literature values are possible.

Other life cycle assessments on the steel production process via EAF were used to compare and evaluate the model. Burchart-Korol [1] describes the considered material and energy flows for both an electric arc furnace and an integrated steel plant. The material flows included for the EAF process are very similar to the model created for the Sidenor, as also scrap, lime, electrode consumption, electricity and natural gas are considered as main input streams, and steel, slag, dust and CO_2 as main output streams. The LCA carried out by Burchart-Korol [1] also lists several other output materials, i.e. different metals, SO_2, NO_2, and water. However, these substances only show very low levels and have no significant influence on the results obtained. In addition, it must be taken into account that the LCA of Burchart-Korol [1] is not a comparative LCA, but a complete assessment of a single state. The completeness of the inventory is therefore much more important than in a comparative LCA, where only the impact of process changes on the most significant key figures shall be shown.

Joshi [2] also describes relevant input streams for the life cycle assessment of steelmaking via the EAF. The main input streams considered are lime, electrode consumption, electricity and gas, which is also in line with the model for Sidenor. Furthermore, Joshi [2] considers alloying elements. However, these were deliberately omitted from the MFA model for the steel use case in this project, since alloying takes place in a separate facility.

Specifically related to output materials, Thomson et al [3] provides an overview of the most relevant streams for estimating GHG emissions associated with the process. The listed flows include coal and natural gas as direct contributors and electric power, oxygen, lime, and scrap supply as indirect contributors to emissions. All of these streams are covered in the model created for the Sidenor use case.

Furthermore, it was verified that the model created is in accordance with the life cycle assessment methodology of the World Steel Association [4]. Here again, as mentioned above, the difference between a comparative life cycle assessment and a life cycle assessment for a single state must be noted. Since the comparative LCA carried out here is intended to show the influence of a change in the process, the simplification of the process to the most important KPIs for which a change is expected is feasible. Nevertheless, the MFA model created for Sidenor covers the most important input and output flows listed in [4].

4. Summary

In this Deliverable, the material flow analysis created for the steel use case of Sidenor has been evaluated. The model created was developed in close cooperation with the industrial partner and compared with other LCAs of EAF steelmaking processes for verification. As a result, it was shown that the model meets the usual standards of a life cycle assessment for the EAF process and includes the most important material and energy flows. Adjustments to the model, as shown in Deliverable 2.5, are thus not required.

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
EAF	Electric Arc Furnace
MFA	Material Flow Analysis
GWP	Global Warming Potential
BFI	VDEh Betriebsforschungsinstitut GmbH
SIDENOR	Sidenor Aceros Especiales
RWTH AACHEN	Rheinisch-Westfälische Technische Hochschule Aachen

6. References

[1] D. Burchart-Korol: “Life Cycle Assessment of Steel Production in Poland: A Case Study”, Journal of Cleaner Production (2013)

[2] S. Joshi: “Product Environmental Life-Cycle Assessment Using Input-Output Techniques”, Journal of Industrial Ecology Vol. 3 Nr. 2 & 3, USA (2000)

[3] M.J. Thomson, E.J. Evenson, M.J. Kempe, H.D. Goodfellow: “Control of greenhouse gas emissions from electric arc furnace steelmaking: evaluation methodology with case studies”, Ironmaking & Steelmaking Vol. 27 Nr.4 (2000)

[4] World Steel Association: “Life cycle assessment methodology report”, Brussels (2011)