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Steel stock analysis in Europe from 1945 to 2013

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Abstract

The study of anthropogenic metal stock and flows highlights the quantity of materials being accumulated through the time and enables to estimate potential scrap availability for recycling. Based on dynamic flow analysis of steel in Europe in the period from 1945 to 2013, this communication analyses the steel stock in use, its distribution through 6 industrial sectors and the potential scrap flow. Further, it couples the potentially available scrap with statistics on the quantity of scrap being actually consumed, imported and exported.

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Keywords: dynamic MFA; recycling; steel; stock

1. Introduction

The current European legislation and societal pressure push enterprises towards sustainable management of resources and eco-efficient production [1], [2]. The recycling and use of secondary materials is one of the solutions. Currently steel industry is responsible for 25% of world industrial CO_2 emissions [3]. Metal recycling uses less energy than raw material extraction and transformation.

Accumulated metal stock by modern society in form of products in use represents a significant source of secondary raw materials. A more comprehensive study of metals' life cycles is necessary to improve the sustainable economic development through resource management, emission reduction and progress in urban mining management. Metals are particularly interesting for urban mining because of their capacity to be recycled almost infinitely.

This papers focus is on resource utilization. Using dynamic material flow analysis enables to estimate and analyze the stock accumulated on the territory of the European Union 27, its evolution and the potential scrap generation by end-use sector.

This work is part of the project "Raw material and recycling in Life Cycle Assessment" of the Institute of Technologic Research Materials, Metallurgy and Processes. The project aims (i) to establish a circular economy for the main materials used in economy and (ii) to decrease the environmental impact related to materials. As a part of this project, the present works focus on the evaluation of flows of steel in Europe. Performance of dynamic Material Flow Analysis will enable to understand the recent use of these materials, products lifetime, current in-use stock and future demand.

2. Methodology

2.1. System boundaries

The spatial extent of the study is identical to geographic borders of EU-27 in order to be coherent with a common European legislation framework. Moreover, with the common market, industrial flows are not anymore on a national scale, so the European level is considered more adapted.

The chosen time boundaries are from 1945 to 2013. The establishment of a study through a long period of time enables to observe the evolution of consumption patterns and to consider metal-containing products with a long lifespan.

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The system boundary includes the 4 life stages, as defined in the STAF project (fig. 1) [4]: Production, Fabrication & Manufacturing, Use and Waste management & Recycling. In order to use this generic model for industrial sectors of steel, every stage is subdivided into relevant processes.

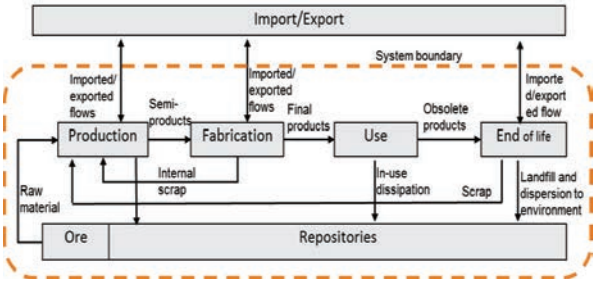

Fig. 1. Generic system definition

2.2. Identification of flows and processes

As indicated on Fig.1, four stages were defined. The Production stage includes processes of raw material and scrap transformation into metal and further production of semi-products.

The stage of fabrication and manufacturing includes two groups of processes: (i) manufacturing of final steel products and (ii) manufacturing of metal-containing goods. The repartition of final steel products within industrial sectors is established, since the waste quantity formed during goods production is sector dependent. Even if usually, processes and flows within this stage are neglected, since they enable a better understanding of industry structure, they will be considered in this study.

During the Use stage, the steel containing products represent the in-use stock of the materials. The period of time between input and output could vary from several months to decades, depending on use sector.

The End-of-life stage comprises processes of product treatment necessary for recycling, e.g.: collection, disassembly, sorting, etc. A part of the scrap is considered as lost and some part is landfilled.

3. Data collection and flow calculations

The number of state-members in the EU has evolved and data doesn't exist on this level. Thus, they were collected and analyzed on the country level and the European perimeter represents the sum of all countries.

3.1. Production

The raw material flow includes materials mined within and outside geographic boundaries of EU-27, as far as they are consumed on the studied territory. Data on production, import, export of iron ore, pig iron, direct reduced iron, crude steel and semi products in form of ingots, billets, blooms, slabs were gathered in the World Mineral Statistics database of the British Geologic Survey and Worldsteel Association.

3.2. Fabrication and manufacturing

Internal scrap is produced while rolling, casting and forming of final steel products. Its share represents usually 10-15% of the crude steel production [5], [6]. This scrap is not included in statistics since it doesn't leave the boundaries of the plans and is recycled directly.

Apparent steel use (ASU) is a method elaborated by Worldsteel to measure steel use on the defined territory. It is calculated as a sum of produced finished steel products and its imports minus exports. This data exist for all European countries since 1967. Previous years were estimated based on crude steel productions.

ASU is further distributed by final steel products and 6 use sectors: construction, automotive industry, other transport, mechanical engineering, domestic electronic equipment and metal goods (Figure 2). These product-to-use matrices were provided by Eurofer association for the majority of European countries and are produced based on adherents' questioning once per five years.

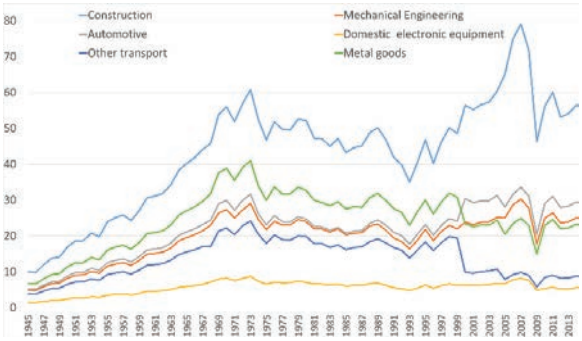

Fig. 2. European steel distribution per sector, Mt

Further, final steel products distributed by sectors are used for the production of steel-containing goods. Process scrap is generated during this process. Process scrap is included in statistics, since it is resold by producing sectors. However its quantity is unknown, as it is mixed with the EOL scrap. The quality and composition of process scrap are well known. On a global level this scrap represents 10-15% of total finished steel consumption [6]. However the quantity depends strongly on the industrial sector and steel products used. That is why yield losses were applied using values published in previous studies [7], [8] and from personal communication of Arcelor Mittal (Table 1). Also an historical yield improvement was used [9].

Figure 3 indicates the quantity of process scrap produced on the European territory from 1945 to 2013. Present estimations (21.3 and 24.1 Mt) are close to quantities reported by IISI for 1995 and 2000 (23.8 and 22.7 Mt) [6].

The next step is to determine the quantity of steel containing products which were exported and imported on the territory. The best way is to calculate the amount of traded steel-