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KIC RawMaterials: Iron Balance—Austria

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Abstract: An evaluation of the iron flow in Austria was executed at the RIC ESEE at the Montanuniversität Leoben within the context of the European network EIT RawMaterials. The main idea was to develop a system that visualizes the mass flow of iron and steel of Austria. To build up the system, it was essential to provide all necessary information regarding the production, consumption and inventory as well as information about the trading (including import and export) of semi-finished products, goods and scrap. The boundary conditions for the system were the national economics of Austria in the year 2010. The mass flow software STAN2 was used for visualization of the system. A main objective of the project was the calculation and visualization of the required iron scrap for the steel production in Austria. The influencing factors on the iron balance were identified and the question of the steady state of scrap return was answered.

Keywords: Steel cycle, Scrap demand, Scrap consumption

KIC RawMaterials: Eisenbilanz von Österreich

Zusammenfassung: Im Rahmen des europäischen Netzwerkes „EIT RawMaterials“ wurde ein Projekt am RIC ESEE, Montanuniversität Leoben, zur Erfassung des Stoffkreislaufes für Eisen in Österreich durchgeführt. Die Grundidee für die Projektumsetzung war die Entwicklung eines Systems, welches die Massen-/Stoffflüsse Österreichs in Bezug auf Eisen und Stahl darstellt. Dafür war es notwendig, alle erforderlichen Daten aus Produktion, Verbrauch und Bestand sowie der dazugehörigen Handelsströme (Import- und Exportflüsse) zu erheben. Als Referenzjahr wurde 2010 gewählt, und als Bilanzraum wurde die österreichische Volkswirtschaft definiert. Das verwendete Programm zur Massenstromanalyse und Visualisierung ist die Stoffflussanalysesoftware STAN2. Zielsetzung für das Projekt war, den

Schrottbedarf für die Stahlerzeugung in Österreich zu berechnen und grafisch aufzuzeichnen, um damit alle Einflussgrößen einzeln beurteilen zu können. Als Ergebnis daraus konnte gezeigt werden, dass durch den eigenen Schrottanfall, welcher qualitativ in Frage kommt, der Schrottbedarf nicht gedeckt werden kann.

Schlüsselwörter: Stahlkreislauf, Schrottbedarf, Schrottverbrauch

1. Introduction

Iron scrap is a major input material for the iron and steel industry. Therefore, it is helpful to know how much this industry depends on scrap imports from foreign countries. It is also helpful to have an estimation if and when it will be possible for Austria to supply its own produced scrap to the domestic iron and steel industry. To obtain such knowledge, not only the scrap demand and production has to be considered, but the import and export data has to be collected as well. As a first step, a static model was created in order to calculate and visualize the mass flow of iron and steel in Austria. The approach of this model was already introduced in a previous paper [1]. Based on this static model, a dynamic model was designed. With these two models, a prediction for the future scrap market can be made. Furthermore, the aforementioned question about a steady state should be answered.

2. Static Model

The mass flow program STAN2 was used to illustrate the material flow of iron and steel within the national border of Austria for the reference year 2010. It was necessary to consider the scrap demand of the steel producing industry, the inventory of steel in Austria and the scrap production in Austria. In order to establish a circular flow of iron material, the trade flows for import and export were also included in the balance [1].

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Fig. 1: The basic structure of the system

2.1 Structure

A comprehensive survey of the project is presented in Fig. 1. For the complex system, comprehensive information, such as production data from the industry, consumption, population and information from the trade (import and export) of semi-finished products, goods and scrap, were required [2–5]. Derived from these data, a visualization of the mass flow of iron and steel of Austria with all correlations was possible [1].

2.2 Results

Main results from the project included a visualization of the iron flow during steel production from the major Austrian steel producers and the demand for raw material (mostly involving iron ore) from the global market. Secondly, an evaluation of the iron-stock in Austria was carried out to see the specific consumption of iron in different consumer areas. This is illustrated as a simplification in Fig. 2, whereby the different consumer areas are summarized in the block products (blue circled). As a result of the collected data, it was possible to show that the scrap production of the Austrian population was about 1.7 million tons of scrap, which is 210 kg of iron scrap per capita. However, the requirement of scrap for the industry is about 2.1 million tons, which is 260 kg per capita. This gap between the incoming and outgoing scrap flow has to be closed by purchasing scrap from other countries.

3. Dynamic Model

Based on the static model, it was possible to develop a dynamic model. The aim was to determine whether a steady state of scrap return can be reached, and if so, to forecast when it can be reached. To answer these questions, it is essential to know all the relationships between steel, scrap,

imports and exports. Moreover, it is important to know the qualities of the scrap that will be supplied by the scrap recyclers in the future.

3.1 Relationships

Firstly, all publications and economic statistics of Austria were analyzed in order to collect enough data to identify the essential correlations between the production, demand and qualities. An analysis of the past was necessary for predictions of the future scrap market. The correlations of the past provided the basis of the dynamic model. One of these correlations is shown in Fig. 3, which presents the steel production and the scrap demand of Austria's industry in the last three decades. From 1986 to 2015, the total steel production increased from 4.29 to 7.69 million tons, which represents an increase of about 80%. In comparison, the scrap demand raised from 1.47 to 2.69 million tons, which means a gain of around 84%. The conclusion that steel production and scrap demand behave proportionally can be drawn. Additionally, the scrap demand remains at a level of about 350 kg for the production of one ton of steel. This information was important for the forecasting [3–5].

3.2 Difficulties

Three difficult points existed for the dynamic model. The first point involved published data. A deviation can be seen for the life cycle of products, which leads to different scrap production per year. Moreover, data of the iron stock from Austria differed widely from the various literature sources. As an example, Pauliuk et al. quoted an iron stock per capita from more than 15 tons [6]. Compared to Warrings, who identified a value of five tons per capita, which is around three times less than Pauliuk et al. [2, 6–13].

The second difficult point was that the scrap qualities of each product accruing every year are relatively inaccurate.

Fig. 2. A simplified overview of the system

Fig. 3: The relationship of steel production and scrap demand

Fig. 4: Forecast of the scrap demand and the scrap production for the next thirty years

Due to the lack of information about the exact qualities, a simple mathematical approximation was set up to integrate the unknown qualities into the dynamic model. This approximation was based on the home scrap production from the static model and the data of scrap import. The amount of the imported scrap was assumed as the part of scrap which was not accrued from Austria with the appropriate quality. The difference of the scrap production and the scrap import, divided by the scrap production, was the simplified approximation of the scrap quality.

The third point was the illegal trade of scrap, which is, in fact, a problem for the whole scrap industry in Austria. It is assumed that 65,000 to 155,000 cars disappear illegally out of Austria, which represents about 60,000 to 150,000 tons of iron scrap [14, 15]. All these inaccuracies have an influence on the accuracy of the system.

3.3 Results

Hereafter, two scenarios from the dynamic model are discussed. Both graphics have the same structure and show the scrap demand in comparison with the scrap production. Both are based on an average life cycle of the products of 26 years. To integrate the influence of the difficulties, three additional trends are illustrated in the two graphs, Fig. 4 and 5. These trends are named 90, 80 and 70, which represent the amount of scrap by means of only 90, 80, or 70% of the scrap production. Therefore, these trends are flatter than the scrap production. Fig. 4 presents the total amount of scrap production, regardless of scrap qualities and assuming that the steel production remains relatively constant. It is clear that within the next 10 to 20 years, Austria should produce enough scrap to supply the steel industry by itself. By considering the qualities of the different scrap types, only a part is usable for the industry. As

Fig. 5: Forecast of the scrap demand and the usable scrap production for the next thirty years

previously mentioned in Sect. 3.2, the consideration of the qualities was done by an approximation. This influence of the varying scrap qualities is illustrated in Fig. 5. According to this influence, Austria will not be able to supply its own steel industry at any time with enough usable scrap accruing from the iron stock.

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References

1. Montanuniversität Leoben, Chair of Waste Processing Technology and Waste Management: 13th Recy & DepoTech Conference, Montanuniversität Leoben, Austria, 2016
2. Warrings, R.: Charakterisierung anthropogener Ressourcenlager in Österreich am Beispiel Stahl – eine Bottom-up Analyse, Wien, Universität für Bodenkultur, Masterarb., 2015
3. World Steel Association: Steel Statistical Yearbook 2016, Brussels, Belgium, 2016, https://www.worldsteel.org/en/dam/jcr:e5a8eda5-4b46-4892-856b-00908b5ab492/SSY_2018.pdf. Accessed 20 Jan 2019
4. Statista GmbH: Metallindustrie in Österreich – Statista Dossier, Hamburg, Germany, 2016
5. Statistik Austria: Der Außenhandel Österreichs Gesamtjahr 2010, Series 2, Vienna, Austria, 2011
6. Pauliuk, S.; Wang, T.; Müller, D. B.: Steel all over the world: Estimating in-use stocks of iron for 200 countries, *Resources Conservation and Recycling*, 71 (2013), pp 22–30
7. Cullen, J. M.; Allwood, J. M.; Bambach, M. D.: Mapping the global flow of steel: from steelmaking to end-use goods, *Environmental science & technology*, 46 (2012), no. 24, pp 13048–13055
8. Golubev, O. V.; Korotchenko, A. S.; Chernousov, P. I.: Predictions of scenarios for the consumption of scrap metal in ferrous metallurgy, *Metallurgist*, 54 (2011), iss. 9–10, pp. 649–655
9. Lee, H.; Sohn, I.: Global Scrap Trading Outlook Analysis for Steel Sustainability, *Journal of Sustainable Metallurgy*, 1 (2015), no. 1, pp 39–52
10. Müller, D. B.; Wang, T.; Duval, B.: Patterns of iron use in societal evolution, *Environmental science & technology*, 45 (2011), no. 1, pp 182–188
11. Müller, D. B.; Wang, T.; Duval, B.; Graedel, T. E.: Exploring the engine of anthropogenic iron cycles, *Proceedings of the National Academy of Sciences of the United States of America*, 103 (2006), no. 44, pp 16111–16116. <https://www.pnas.org/>
12. Pauliuk, S.; Milford, R. L.; Müller, D. B.; Allwood, J. M.: The steel scrap age, *Environmental science & technology*, 47 (2013), no. 7, pp 3448–3454
13. Wang, T.; Müller, D. B.; Graedel, T. E.: Forging the Anthropogenic Iron Cycle, *Environmental science & technology*, 41 (2007), no. 14, pp 5120–5129
14. Martinelli, W.: Internal review, Interpretation Marktdaten, Leoben, Austria, 2016
15. Martinelli, W.: Internal review, Schrottkreislauf, Leoben, Austria, 2017