Summary of worldsteel's by-product study

Raw materials prices have made recycling economically and environmentally viable. Between 2007 and 2009, an international expert group studied results and good practices in by-product management from around the world. The group focused on dusts, sludges and steelmaking slags, considered the more difficult by-products to be reused. The project used technical exchanges, discussions and a questionnaire addressed to all worldsteel members. Analysis showed that there is great potential for exchange and shared practice to enhance direct reuse and recycling of by-products. This will save energy, raw materials and reduce CO_2 emissions.

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Between 2007 and 2009, the World Steel Association (worldsteel) undertook a global benchmarking study examining the management of some of the more important and challenging by-products arising from the various processes used to produce iron and steel (see *Figure 1*).

The study involved the submission of data and information from 25 companies, covering 60 plants and 24 countries representing, in total, approximately 200Mt of crude steel production, of which 25% was produced via the EAF route.

AIM, SCOPE AND OBJECTIVES

The project was set up with the aim of making steel-producing companies aware of and implement effective by-product management solutions for by-products that pose the greatest challenges in their recovery and use:

- Optimise by-product management by
  - reducing generation of by-products
  - improving external utilisation and value for other uses of the by-products
  - improving internal recovery rates to extract all valuable raw materials
- Share technologies and strategies.

The results were analysed to determine:

- The 'best performers' and ascertain why certain companies/plants apparently performed better than others
- The means and ways by which these best performers achieved high levels of utilisation (therefore low levels of landfill disposal) – both technically and from a management point of view.

A general summary of EU legislation (together with some key results on legislation from the survey's answers) was also drafted, to provide an insight into the evolution of legislation since the last project in 1994. There is also information on current research and development initiatives by the participating companies, aimed at increasing the levels of by-product use.

IMPORTANCE

For every tonne of steel produced in an integrated steelmaking plant, 450-500kg of by-products are produced. The majority of these are slags (around 80%) and around half is blast furnace slag. The majority is used as a valuable resource.

Whereas the landfilling of waste (unwanted material which may sometimes include by-products) was at one time viewed as an inexpensive and technically simple way to dispose of such materials, the same cannot be said today. Increasingly restrictive legislation, high costs associated with more stringent landfill engineering requirements, economic instruments introduced by governments (such as landfill tax), and social acceptability, mean that landfill is becoming more expensive both financially and with respect to corporate social responsibility. The project focused mainly on by-products of significantly high volume that are more difficult to use due to their physical or chemical nature.

BY-PRODUCTS CONSIDERED IN THE STUDY

Slags Slags from the various iron and steelmaking processes account for a significant proportion of the total quantity of by-products produced. Within the scope of the project, information was sought and obtained on basic oxygen furnace (BOF) converter slag, BOF secondary metallurgy slag, BOF desulphurisation slag, electric arc furnace (EAF) slag and EAF secondary metallurgy slag, as these still pose some challenges with regard to their use.

Dusts and sludges The majority of these materials are a consequence of the pollution abatement equipment required to clean the gases and waste water discharges from the ▷

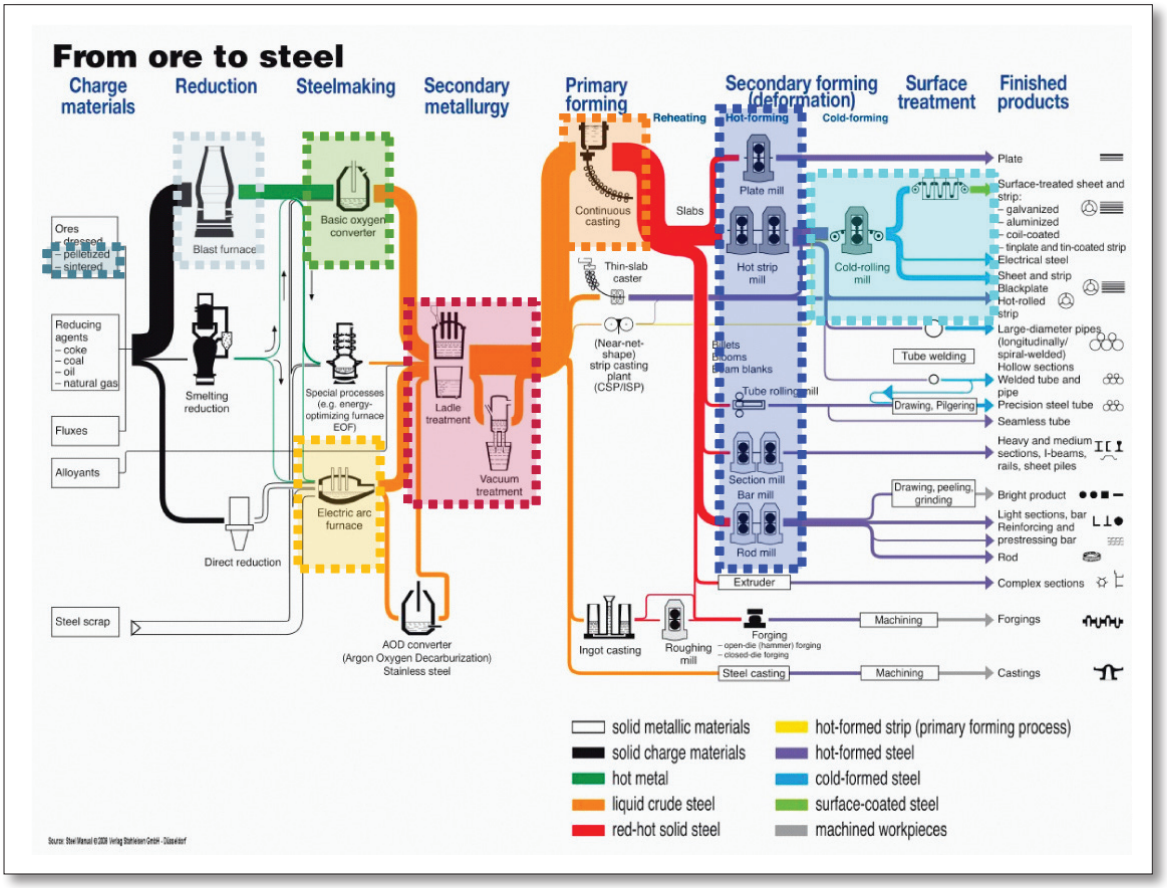

Fig 1 From ore to steel – the processes

various processes. This equipment may be operated dry, wet or a combination of both. The report focuses on the dusts and sludges arising from the iron ore sintering process, the blast furnace itself, the BOF and EAF. It also includes some of the relatively minor sludges arising from the continuous casting and scale from the hot rolling processes.

DATA COLLECTION

The project was divided into two subgroups, one focusing on slags and the other on dusts and sludges. A list of questions from these two groups was later combined and sent to all worldsteel member companies. Questions ranged from general strategy and approach, to management of by-products and more specific technical questions. Part 1 of the project evaluated which companies were the best performers. Part 2 sought to understand why the best performers could reduce the quantity of by-products or maximise their level of utilisation. While Part 1 is more fact-based, Part 2 is more subjective, seeking information on technologies used, managerial approach, the effect of regulation/legislation and whether marketing could influence performance.

Initially, questions related to the potential of reducing the quantity of by-products produced at source. However, after significant debate it was thought that the factors influencing production were numerous and highly complex (improved gas cleaning technology, changes in coke quality, burden quality, blowing practices, etc), and therefore extremely difficult to analyse in detail. In many instances it is also very difficult to influence or alter generation rates without having significant impact/effect on the processes themselves. An open question was therefore drafted on possible factors contributing to production, and a relatively simple analysis and comparison of any answers obtained was carried out.

To summarise, for each by-product, questions were constructed on subjects such as:

- The quantity generated or collected (along with steel/iron production etc, so that the production could be normalised in relation to the production rates of the main product, ie, iron, steel)
- The levels of recovery, utilisation (either internally or via external 'routes') and disposal (where utilisation is currently not either technically or economically feasible)
- Information on the chemistry of these by-products
- Any issues, concerns or challenges that the companies have regarding these by-products
- Potential solutions, including treatment processes, marketing and other technical solutions that companies may have developed or implemented for the various materials

- Evaluation of relevant regulations in the respective areas of operation, organisational structures, current and potential technologies, marketing strategies and management systems, with a specific emphasis on best performers

Efforts were also made to compare and contrast the results of this study with the previous worldsteel study on by-products from 1994, however, due to the unavailability of data from the earlier study this was not possible in every case.

ANALYSIS

Two key performance indicators were used to identify best practice with respect to the management of by-products at plant level:

- The specific generation rate, normalised against production, ie kg of by-product /steel produced)
- The recovery ratio (internally or externally)

As previously stated, consideration was given to the potential to influence the production process itself, and as such the recovery ratio was chosen as the prime indicator to identify the better performers. To understand why they were better, each individual company response was rated to identify those plants consistently scoring higher for each of the various aspects/influences and to identify any correlation between these aspects/drivers and the degree of by-product use.

Plants which were found to be best performers with respect to the recovery rate of a specific by-product were targeted with a specific set of questions. These were aimed at identifying, and providing details of, any specific technologies developed and/or implemented to improve the use of these materials.

CONCLUSIONS

In the period between the previous study and today, the steel industry has made significant advances in increasing the use of by-products. Consequently, the industry has dramatically reduced the levels of materials it disposes of in landfills. While the use of BF slag has become globally accepted, there are still some concerns over the use of BOF slag, mainly because of its integrity and stability, due in part to its free lime content.

There are no significant changes in the relative generation/collection rate associated with the dusts and sludges. However, in comparison with the earlier studies, there appears to have been a significant reduction in the levels of these materials being disposed of in landfills. Also, while slag in general tends to be recovered/used 'externally', dust and sludge is, on the whole, recovered using 'internal' processes.

This different approach to the two by-product 'streams' suggests that slag is viewed more as a material which should be marketed and managed accordingly, whereas increased legislative and sustainability drivers are leading to the development and implementation of technical and innovative solutions with regards to the issues relating to the dust and sludge streams.

Regarding slag by-products, recycling 100% of BOF or EAF slag is possible today, and achieved in dozens of plants worldwide. No innovation in processing technology is necessary. The key is to manage and sell slags as products, meeting specifications through a quality control system. But markets and regulations change. Increasing the value of these products and implementing sustainable business practices are key drivers and will require a degree of innovation to develop new and more effective applications and markets. A clear trend is emerging: from selling basic aggregates to selling differentiated products which have properties (chemical or mineral composition) for specific applications.

Regarding dust and sludge, from the results of this study, it would also appear that plants having both integrated and EAF routes are more successful in terms of recovering their by-products.

The results also show that best practice/performance cannot be achieved by implementing a single technology or management method in isolation. It is the result of a site-specific management system adapted to the specific national/regional legislation and market conditions.

In addition to the information collected on each of the by-products, the quantities of iron, lime and zinc recovered in total were calculated. Clearly the use of these materials provides significant savings (environmentally and financially), compared to the additional raw materials required and CO_2 emissions generated had these by-products not been recovered.

A review of the legislative situation in the EU and the answers from the survey indicated that legislative requirements vary greatly across the industry. Nevertheless, the EU framework is often used as a reference as more and more countries move towards comprehensive by-product and solid waste legislation. **MS**

PROJECT TEAM

The project team consisted of representatives from the following organisations: ArcelorMittal, Badische StahlWerke GmbH, Baosteel, BlueScope Steel, China Steel, FEhS, Hadeed (part of SABIC), Nippon Steel Corporation, POSCO, Rautaruukki Oy, Salzgitter AG, SSAB, Tata Steel – Corus, TECHINT Group (Tenaris, Ternium), ThyssenKrupp Steel, US Steel Corporation and VDEh.

Jerome Lambert was seconded to worldsteel from ArcelorMittal for three years during which he led the by-products project. He is currently Business Improvement Manager at ArcelorMittal in Europe.

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