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Scrap and DRI the path to green metallurgy

The accelerating pace of life and the global growth in the prosperity of humankind are leading to a revolution in kitchens. The appearance of an ever-expanding range of prepared meals is making it possible to save time and other resources to cook a light yet nutritional breakfast for a bachelor or a hearty dinner for the whole family.

A similar situation can be observed in the steelmaker's kitchen. In the past several decades, steelmaking technologies that use raw materials with high iron content have become increasingly widespread. These materials only need to be smelted until they reach the required condition to produce quality steel.

Conventional steelmaking and rolled steel production technology includes several large-scale conversion phases. Everything starts with iron ore mining and beneficiation. Blast furnaces then smelt this raw material into hot iron. Finally, foundries turn the hot iron into steel.

However, this complicated technological chain includes processes that have drawn the attention of the entire world in recent years in the drive for long-term sustainability. This includes both the extraction of non-renewable natural resources and the industry's broader environmental impact.

This has led to a global search for metallurgical raw materials that will make it possible to conserve natural resources and energy while reducing atmospheric emissions. In practise, this will limit the need for the construction of new blast furnaces and coke batteries, while making the carbon footprint of steelmaking and rolled steel production considerably smaller.

Such raw materials include ferrous scrap and hot-briquetted iron (HBI), which is a type of direct reduced iron (DRI) technology.

Scrap: just smelt it

Scrap is a recyclable material generated during metal processing or when infrastructure and machinery wear out. After all, sooner or later any machine or mechanism will need to be replaced, and the old ones will be disposed of. Scrap metal recycling makes it possible to reduce the amount of hot metal – and, consequently, iron ore and coke – used by steelmakers. More importantly, it is a clean product that does not need to be processed further to remove waste rock or the various impurities and additives that may be present in iron ore or coke.

Today, the main consumers of ferrous scrap are electrometallurgical enterprises. Scrap can cover up to 100% of their raw material needs. Following relatively simple preliminary preparations, it is loaded into electric arc furnaces (EAFs). They smelt the scrap at high temperatures generated from an electric arc between graphite electrodes and the melt mirror. It takes 40-60 minutes to transform solid scrap to liquid steel. Some more time is needed to bring the final product to the required parameters. It takes slightly more than 1 tonne of scrap and alloying additives to make 1 tonne of liquid steel.

This type of raw material is also used in conventional steelmaking, such as the open hearth and converter methods. This is because when smelting hot liquid iron into steel, excess heat is generated that may be harmful to the steelmaking process and expensive equipment. Therefore, it is not only appropriate, but essential to add a charge of 15-20% scrap into basic oxygen furnaces prior to hot metal charging. It acts as both a raw material and cooling component.

Scrap processing and scrap-ore processing were previously used extensively in open hearth shops. They used a high share of scrap in the raw mix (charging material): 55-75% and 20-40%, respectively. The remaining charging material was hot metal and/or pig iron.

Scrap processing was generally used at large machine-building and steelmaking enterprises that lacked blast furnaces but had sources of scrap available. Following the nearly complete abandonment of open-hearth technology, this steelmaking method is receding into the past. Open hearths have been replaced by EAFs. They require an increasing amount of scrap, which comes from two main sources.

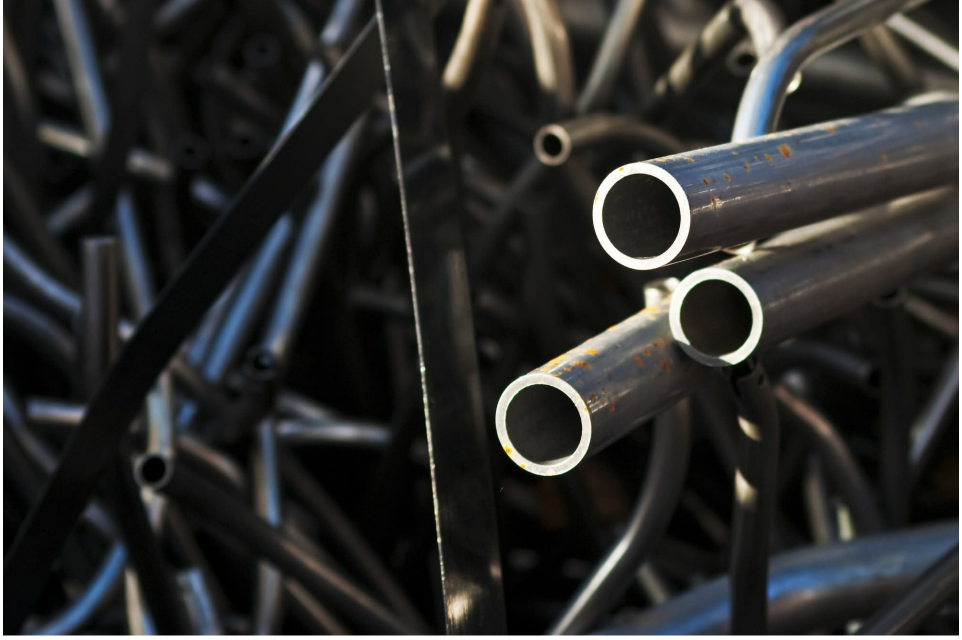
The first source is the outside world. Scrap is processed by scrapyards, specialised companies that prepare and deliver recyclable metal to steelmakers. Recyclable scrap is also generated inside steelmaking plants and machine-building enterprises. This is in the form of metal that cannot be used as a finished product for a variety of reasons. For instance, bloom cuts at steelmakers or shavings at machine builders. However, efforts to improve efficiency and reduce resource consumption have advanced the development of steelmaking and foundry technologies. This, in turn, has reduced the amount of recycled scrap that is available. For instance, the widespread introduction of continuous casting technology has essentially eliminated the generation of bloom cuts at steelmakers.

In addition, new technological processes in steelmaking are imposing increasingly high requirements on the secondary raw materials in use. This makes ferrous and non-ferrous scrap preparation and processing increasingly complicated and expensive, both in Ukraine and globally.

In some regions of the world, there is a shortage of scrap. This has driven steelmakers to search for new sources of raw materials with high iron content.

DRI route: eliminating costly processes

Steelmakers have long been interested in the direct reduction of ore into iron, bypassing the energy-intensive blast furnace and coking processes. While the first serious research in this field began in the mid-1900s, notable results were not seen until the 1970s. That is when the first industrial-scale plants for HBI and DRI production were constructed. The process was not efficient enough until natural gas started being used.



Such plants produce high-quality products with an iron content of up to 96-98% in special furnaces using ore pellets and fuel (gaseous or solid carbon) to ensure the required temperature. Depending on the shape of the finished products, they can be described as briquettes (hence the names hot-briquetted iron, or DRI, and cold-briquetted iron, or CBI), pellets, nuggets and so on. They essentially substitute scrap steel or pig iron.

Several popular DRI production technologies currently exist. The most common of them use natural gas as a reducing agent or high temperature source. The best-known suppliers of equipment for such plants are Midrex Technologies and Hyl Technologies. Because of the high cost of natural gas, this process has been widely used only in countries with considerable reserves of this resource. For instance, in the Gulf states or Latin America.

In other regions, it was nearly impossible to construct such industrial plants for a long time. In the 1990s, the development of HBI technologies that do not rely on expensive natural gas started. For example, Japan's ITmK3 process uses pulverised coal as a reducing agent instead of natural gas. This process can use both the coking and thermal coals mined in Ukraine and other regions of the world. This solution is now allowing even Ukrainian mining and beneficiation plants to consider the technology.

Amid the predominant focus on reducing atmospheric emissions and carbon footprints, new methods of direct reduction without the use of coal as an energy source and reducing agent are being extensively developed throughout the global steel industry. While hydrogen appears to be the most attractive fuel in this regard, the complete substitution of natural gas and various qualities and types of coal will require significant investments to increase hydrogen production capacity.

Besides, the direct reduction of iron requires very high-quality raw materials (high initial iron content with minimal impurities), which will also necessitate the development of the technology and production capacity to make pellets that meet the required parameters. Nevertheless, this method for obtaining pelletised raw material in combination with increased use of scrap is very important in the context of contemporary environmental and climate trends, and is capable of achieving a wholesale change in the structure of the ferrous metallurgy process route in the short term.

The green future of steel and humankind

In recent years, there has been a steady global trend of reducing the carbon footprint and transitioning to green technologies in steelmaking. Simply put, this is a way to reduce atmospheric CO_2 emissions, mitigate environmental impacts and use recycled resources. One of the primary methods to achieve these goals is limiting the use of environmentally unfriendly steelmaking technologies, such as coke and blast furnace production.

It is inevitable that research will continue and new technologies will gradually appear in the steelmaker's kitchen as the global community keeps a close eye on the industry's impact on the climate and global economy.

The expanded use of ferrous scrap and the DRI/HBI production process is a vital contribution from steelmakers to improve the future for everyone in the world.