CIRCULAR ECONOMY

The missing link

ABSTRACT

Off-gas treatment is the missing link at the commonly applied circular economy – burning plastics, coats, paints, and organics are producing toxic and harmful combustion products in waste incineration as well as in steel production – a new solution for the steel production.

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The missing link

The circular economy is a recurring buzzword, as it is in the steel industry. Already in the last century, experiments were carried out with the aim of reducing the mountains of waste, be it disused tires, unsorted plastic waste or other non-recyclable materials. Unfortunately, the political pressure at that time was not yet great enough to make these attempts successful. In the light of the current environmental discussions, these topics are now being updated and thanks to new findings and possibilities in the field of sorting waste and also thanks to political pressure, the signs of success are good, probably greater than ever before.

For the scrap, which can be reused 100%, the circle closes without further ado, whereby there is still potential for the by-products, such as zinc. Thanks to widespread use, especially in the automotive industry, more and more zinc is produced in scrap. However, the increasing accumulation of galvanized sheets is a headache for the steel industry because the zinc settles in places that are not intended for this purpose. The increasing thickness of the deposits influences the heat transfer, i.e., the efficiency of the cooling system decreases. Zinc evaporates at 907°C and begins to crystallize at about 600°C and is solid again at about 420°C. Zinc has the tendency to settle on cold surfaces, to crystallize. In the normal exhaust gas flow, zinc will therefore settle on all cold vessel walls, e.g., the water-cooled pipes directly after leaving the furnace through the 4th hole. The residue remaining in the exhaust gas is then filtered off as part of the fine dust in the filter house, whereby these are not zinc crystals, but metallic fine dust with impurities. The treatment of this 'waste' is time-consuming and therefore costly.

Household waste: Household waste represents a great potential in the circular economy. Every day, thousands of tons of plastic waste are generated from unnecessary packaging. These are usually recycled or incinerated in industrialized countries, with subsequent exhaust gas treatment, of course. In less industrialized countries, this plastic waste is usually disposed of in nature and this 'natural' deposit ends sooner or later in the sea. In Italy, a granulate made of PE packaging material and low-quality PET waste - the high-quality PET waste is recycled - has been used in the steel industry for some time. There, increased emphasis is placed on the reduction of carbon to produce foamy slag in the electric arc furnace. The separation of chlorine-containing and 'pure' plastics (PET and PE) is now quite possible, so that 80% of the granules used for this purpose consist only of carbon-hydrogen and oxygen compounds. What was the composition of the remaining 20%? How much of the hydrogen contained in it will remain in the steel melt and eventually settle into the grain boundaries of the steel? Does this steel necessarily have to be vacuum treated? What are the conditions for the transport and storage of the granules? What is the size of the granules (granulometry, density, etc.)? What is the behavior of the granules when blown into the oven? Answers to these questions are missing, the steel mills involved are silent, why? Is the use, as some older steelworkers suspect, not as successful as the press would have us assume?

The literature (information document COREPLA (Italy)) speaks of an improvement in output, of a reduction in CO_2 emissions of more than 30% compared to the use of coal dust, of an optimization of the production process, of a reduction of the FeO content in the slag, etc. Theoretically, an improvement in the output can be explained by the reduction of the FeO content in the slag, only this is a few grams per ton of liquid steel (1% reduction of the FeO content in the slag means 0.2‰ or 200g FeO per ton of liquid steel!). The reduction of CO_2 emissions can also be explained, as less carbon is used, but this is also compensated by the C content in the replacement granulate. But what does an optimization of the process sequences in the electric arc furnace look like? How does the addition of plastics change the process? These questions are also not answered – in principle, the addressees remain silent.

Well, whether something about the press hype is true or not is difficult to judge at a distance.

DRI: The use of DRI in electric steel production is associated with a considerable additional expenditure of energy, both electrical and chemical, compared to the use of scrap-only. The slag volume increases, even with a high metallization of the DRI, the gangue content is still over 4% and in addition, the slag is very acidic, which leads to further lime use. For this purpose, 'better' steel can be produced with the use of DRI, deep-drawing grades and special steels are possible thanks to the control of the inclusions and the lower nitrogen content. Does it have to be this way? No! – this does not have to be the case, because with suitable scrap preheating and the use of clean residual gas, the use of preheated DRI (approx. 300°C) is continuously possible and then the energy consumption will drop massively.

Electric energy [kWh/h]	**Liquid iron**	**Scrap preheating**	**Scrap preh. / DRI preh.**	**Scrap preh. / cold DRI**	**Scrap**	**Pig Iron**	**Hot DRI**	**Cold DRI / HBI**
Min.	180	240	250	300	320	325	425	470
Max.	300	300	310	370	520	400	425	600

However, the missing link in the chain of the circular economy in the steel industry is scrap preheating, because with a suitable system the circle can be closed. With suitable exhaust gas routing, e.g., with the ECOFEEDER, the exhaust gas is first cleaned, i.e., the large dust particles, usually CaO, MgO, Al_2O_3 etc. (particles in the range of 0.1-3mm) remain in the first container, after which the exhaust gas is heated for cleaning (combustion of the hydrocarbons) and then flows again through an already hot scrap load, whereby the gaseous zinc is not retained. As a result, the exhaust gas flows to the 'zinc trap', a water-cooled, lattice-like construction, and can crystallize there. The zinc trap with pure crystalline zinc can be periodically removed and cleaned.

The situation is similar with the use of plastic waste. With suitable exhaust gas treatment, e.g., with the ECOFEEDER, any residues that can arise from the combustion of the waste materials are neutralized, i.e., their molecular chains are separated, and the individual building materials burned. And with the DRI, this results in an ideal preheating stage that heats up the DRI safely at an almost constant temperature.

The fact that the ECOFEEDER can also be the missing link in energy-conscious steel production is inferred from the realization that the two-stage scrap preheating not only achieves higher preheating temperatures in a shorter time and that the energy used for post-combustion is not 'destroyed' in a subsequent cooling system but is used for preheating. The furnace fault air is preheated in the ECOFEEDER and serves very directly to reduce the energy input into the furnace and thus to reduce CO_2 emissions. The residual heat transported by a purified exhaust gas can be used directly or indirectly via heat exchangers. In this way, residual heat becomes electrical energy, heats buildings and/or DRI, which can be continuously conveyed into the furnace as an add-on to the preheated scrap. In this way, the additional energy to be introduced for the melting process can be massively reduced, both electrically and chemically.

The circle is closed and energetically optimized. Scrap becomes steel, crystalline by-products, slag and harmless exhaust gas, which is released into the environment at a low energy level.

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