Figure 1 / 'Climate transition of the world' Painting 2014

Ecology and economy in secondary steel production – or to meet the goals of the energy and climate transition with profit.

At the end of June 2022, I had a lecture on the topic ' How can companies strive for net-zero targets and at the same time reduce costs? '. This was to initiate a discussion at the MMSteelClub conference in Barcelona.

Well, in the last contribution we have been talking about the change of paradigm, the change from the convection furnace to the preheating furnace. This new gas flow design offers tremendous benefits, such as less burner power for heating cold spots and more economic use of burner energy, less electrode consumption especially less side burn-off (1), less refractory wear especially at the ex-burner areas, less heat losses by vessel cooling (2) and most importantly a controllable and reliable off-gas measurement without aerodynamic influences and dust sediments (3). All together reason enough to change to this new design.

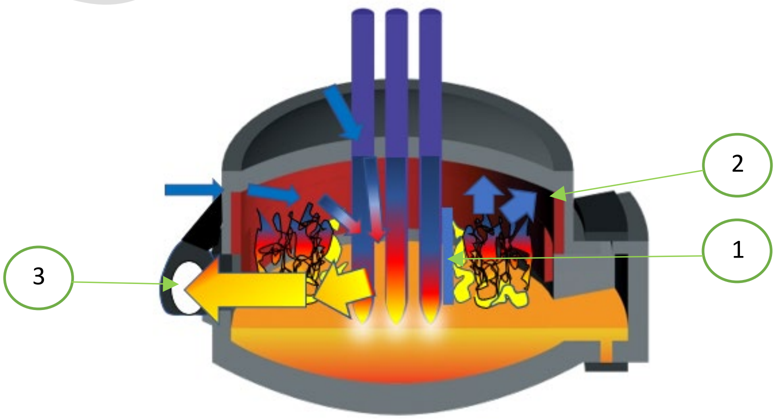

Figure 2 / Benefits of paradigm change

Taking a closer look at one of the benefits, the reduction of burner power – well, you may say, that the reduction of burner power aligns with less off-gas energy. That's right and is good news if there is no further use of the off gas. However, we intend to further use the off gas, so our interest is to takeout the same energy amount as before, but we don't need the radiation part which is reportedly about 80% of the burner energy. The way how we produce that energy is our knowledge.

The heat energy which represents about 40% of the supplied energy, sums up to about 300kWh/t liquid steel. Taking away the heat losses that are hardly usable, the electric resistance heat and the radiation, as well as the reduced vessel cooling of the CORE-EAF, which is at low temperature, then the recuperable energy limits to about 250kWh/t. Let's assume that a good heat transmission would allow to recuperate about 43% of that energy, which means an energy back feed of about 110kWh/t. A good heat transmission between a fluid and a body requires that the fluid flows around the body and that the fluid flows at low speed. Another condition for a good transmission is that the container where the body is kept does not cool the body.

Measurements taken at the ECOSHAFT, the first project of eco-e, show a temperature raise in the container of 1.5-1.8 K/sec., that means that within 4 min. the body has reached a temperature of about 400°C.

So far so good. The cold scrap often contains pollutants. These pollutants, such as paint, coatings, oils, greases, organic matter, etc., burn off when they reach a temperature of about 180°C. That's why when charging cold scrap through the roof, big flames and heat are released to the environment. The enthalpy contained is about 20 to 40kWh/t scrap. When loading cold scrap in a medium-hot container these pollutants do not reach the flame temperature immediately but only burn-off shortly after the start of preheating. The resulting energy can be used entirely to preheat the scrap. The released combustion products are harmful and often toxic. To burn them, reheating is required. Special conditions must be maintained during a limited time to avoid any reforming of the compounds.

Now, the reheated off gas will be guided into a second container, where already cleaned and medium-hot scrap lays. The required condition for complete incineration of the combustion products can be maintained for as long as needed. Considering that, we reach a preheating enthalpy of 185kWh/t (110kWh/t of the off gas, 45kWh/t reheating energy and 30kWh/t enthalpy of the pollutants). Allowing an efficiency of 65% a preheating enthalpy of 120kWh/t can be reached. This corresponds to a scrap temperature of 700 to 750°C.

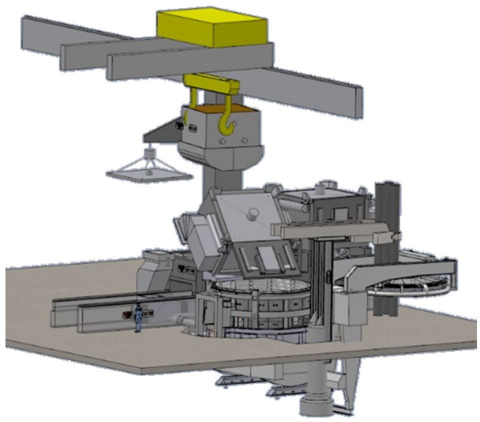

Figure 3 / ECOFEEDER 'scrap charging into furnace'

This was the first step in scrap preheating. As the required temperature for warming the body (=scrap) has been reached in say 4 mins and equalisation of the temperature in the body will take some time, we shall now change the containers, so that the container with the already equalized scrap temperature will now relate to the furnace. The hot exhaust gas with a temperature of approx. 1300°C, now flows into this container. During the next say 4 mins the scrap temperature in this container raises to about 750°C, while the scrap temperature in the container with the not yet equalized scrap temperature gets equalized. This is the second step in scrap preheating.

For those who are used to think in energy balances, here some information: The eco-e tech benefits of three scrap preheating steps, two ex-furnace (two container) and one in-furnace preheating which allows to recuperate approximately 50% of the emitted thermal energy. As at the ECOFEEDER the energy contained in the pollutions is actively preheating the scrap and the reheating energy needed to eliminate the toxic and harmful compounds are also used for the same purpose, an additional benefit results from this free of charge add-on. Additionally, the controlled post-combustion is unfolding its full power right in the scrap (see below).

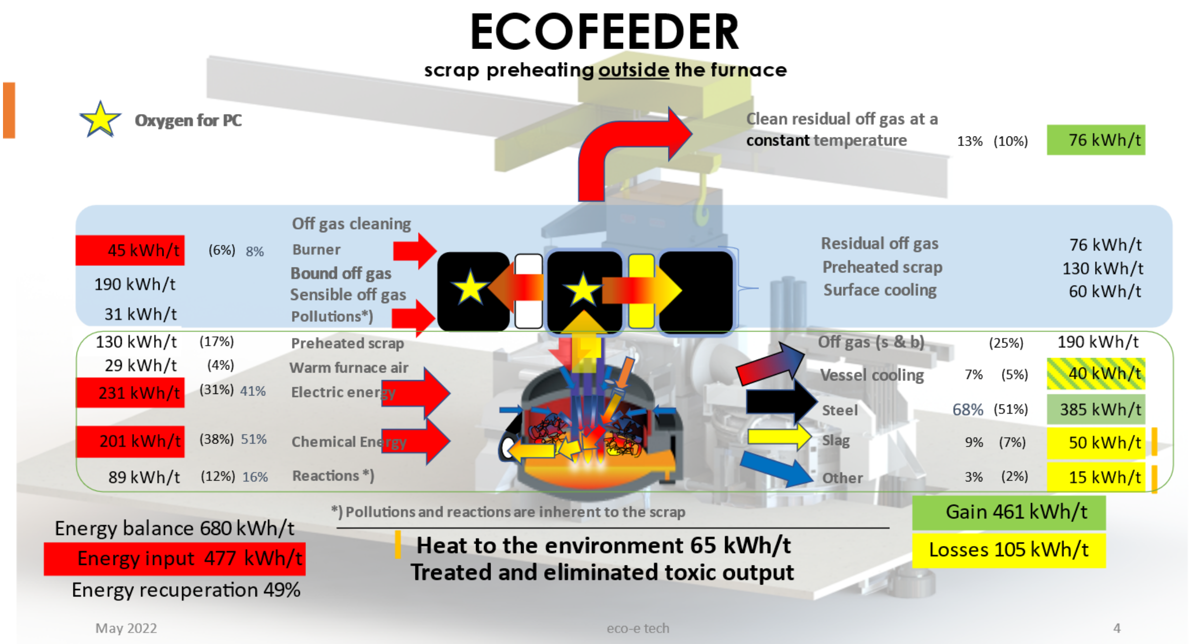

Figure 4 / Energy balance

Importantly, beside the economic benefits, the environmental figures. The amount of heat released to the environment is rock bottom, the losses are minimal. The gain, beside the steel as primary good, the residual heat which may be serving for multiple purpose. The CO_2 level is below the level of the carbon neutrality as part of the produced CO_2 is reused by the process in a new, revolutionary way that even further reduces the electrode consumption.

Here now a summary starting with the scrap coming from the scrap yard.

Step 1: Batch charging of cold scrap into a medium-hot container preferably in 3 batches (depends on scrap density, available space in furnace bay, productivity requirements, target quality, and other metallurgical variables)

Low temperature scrap preheating (warming) for scrap cleaning and drying (first container)

Incineration of combustion products by reheating the off gas and neutralizing the harmful and toxic parts (second container)

Step 2: Change of containers

High temperature scrap preheating in non-oxidising atmosphere (second container)

Controlled post-combustion of CO to raise the scrap temperature (first container)

Preheating of slag farmers to reduce refractory wear in the furnace and avoid adhering of molten scrap to the bottom of the container (both containers)

Scrap loading by container tipping (slip support by the slag builders)

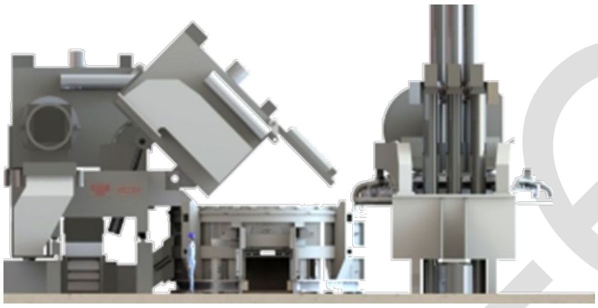

Figure 5 / ECOFEEDER 'side view'

Step 3: In-furnace scrap preheating

Low intensity melting with electrode cooling for longer life.

These three preheating steps enable scrap preheating, which is characterized by **economic benefits** and **environmental friendliness**. This scrap preheating system is particularly valuable because it consumes part of the process's own CO_2.

This very effective preheating procedure is not only completely different from what is known, but also ensures a controlled residual off-gas flow at a given temperature. The exhaust gas is almost dust-free and free of toxic or harmful compounds. This allows for versatile use with many types of applications.

More about the individual proposals will follow in further contributions.

The perfect moment for avoiding the climate change has gone – let's take the second best – and this is NOW!

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