Can protecting the environment be economically profitable? Yes, it can, with an ECOSHAFT®!

Composing music is like designing a machine – it starts with a theme, an image which indicates the kind, shows the way to go, and models the form. And the music sounds when there's harmonic, when there's a completion – same as the design.

But our economic system requests results long before the composer has found the harmonics. One of these 'composers' was without doubt Mr Gerhard Fuchs. He was a remarkable man who had a very clear vision of how the energy input to the arc furnace had to be reduced and designed the first shaft furnace in 1987. This invention was for many years the base point in the development of arc furnaces. The recent developments like the Quantum or the COSS design which are a direct heritage from Mr Fuchs or the SHARC design which were designed by competitors of Fuchs but inspired by his shaft idea mark the present top in scrap preheating. But is this really the top?

In fact, especially the Quantum design achieves very good results, but it is still remaining a shaft furnace – witnesses of a trial to reduce the energy input to the furnace to the max without considering the overall outcome. The crux of the shaft idea is definitely the environment. In previous papers[1] we have discussed the issues of scrap preheating in a single-chamber scrap preheating system (preheating in a shaft, on a conveyor or in a basket) and presented the advantages of a two-chamber scrap preheating system with dynamic off-gas flow control. We have shown the importance to include the effect of the integrated post combustion and we have shown the proof of the suddenly released energy by the pollutants and reactive products which are inherent to the scrap in whatsoever density and shape.

It's exactly the energy released by the pollutants which is up to now marginated and excluded from the melting and by that from the scrap preheating as well. We should look at the burning-off of this energy for several reasons. Because it's:

- An economic and ecological cost factor.
- An important amount of energy, which is usually released unused.

[1] ECOSHAFT® - the dawn of a new era in scrap melting and ECOSHAFT® environmentally friendly and economically sound scrap preheating – to usher a new era

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- An environmental threat which is liberated when charging scrap to the furnace directly or indirectly through the shaft system.
- A danger for man and machine

Let's talk about these facts item by item:

The economic and ecological cost factor: well, here we have to subdivide the economic and environmental impact at an open furnace including single and multiple basket systems, and at a single-chamber scrap preheating system like the shaft, conveyor or basket preheating.
At an open furnace the economic effect, inherent to the burning-off of the pollutants is reduced to the loss of energy, energy which has to be invested instead, thus generating additional production costs. These specific costs are usually not identified as they cannot be isolated. However, we can isolate them and proof their existence. The same applies to the ecological costs. They are not identified either, but they are visible and touchable. Look at all the dust around an electric arc furnace. This dust is contaminated, it's enriched by poisonous and dangerous compounds falling down after charging the cold scrap. The dust rains down after having been swirled up by the suction force of the hot fire ball above the furnace. The costs this contamination causes are existing, however, they are not directly referable to the source. Long-term damages and health issues may cause long-tail claims same as in the cement asbestos case. The fact that dioxins and other compounds are not measured at the surrounding of the work place doesn't mean that there's nothing.
At a single-chamber scrap preheating system the things are different. Here the economic effects inherent to the burning-off of the pollutants are known. The necessity of a post-treatment has been imposed by the environmental authorities as the contaminated off-gas could be measured at the chimney. The once promised energy saving compared to the open furnace melted quickly away as shown in the following chart.

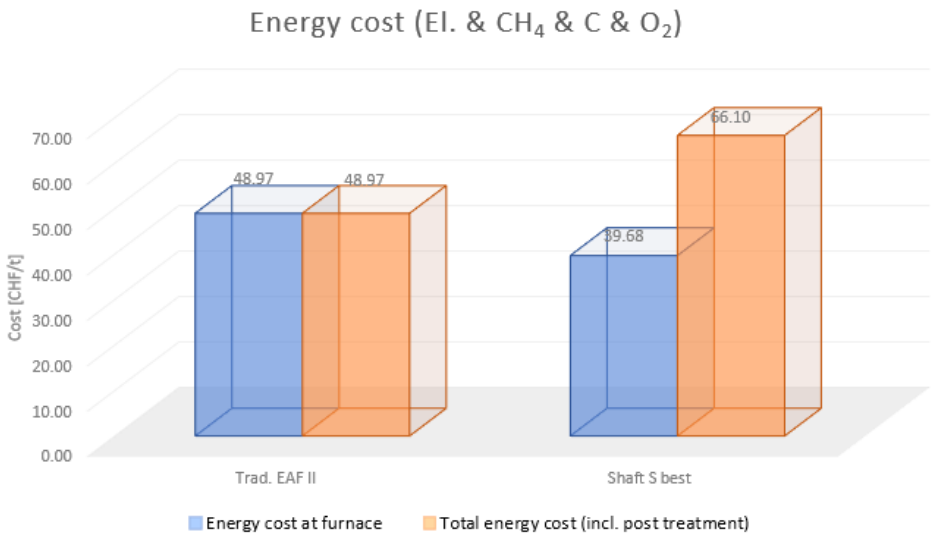

Figure 1 / Cost comparison trad. EAF vs Shaft system (price basis 2015)

The energy savings of about 15 to 20% promised for the shaft system compared to the traditional EAF costs had to be revised, thus comparing the total energy costs including post-treatment a loss of almost 35% results. However, the ecological side is solved only by part. The post-treatment, which consists of a reheating vessel and spray-cooling tower (called quench) can't incinerate the compounds or their fractions, it inhibits 'only' the reformatting of the compounds and this only partially. What happens is, the off-gas flow cooled-down by the scrap is reheated in the reheating vessel. In the reheating vessel the off-gas flow is laminar, thus the hot off-gas flowing alongside the cold vessel walls cools-down normally. The reformation of the compounds happens and only the centre stream of the off-gas will reach the quench where the fast-cooling is supposed to happen. We don't know the percentage of success of this process as the aim to respect the environmental specifications is apparently fulfilled.

Figure 2 / Massive fire when scrap charging as pollutants are firing-off

An important amount of energy, which is usually released unused: Looking at the nice fire column in picture 2, one's heart and mind is jumping. There is in fact a massive energy amount going into the air, possibly damaging material and blinding man, but how much energy is just surging off? Well, that's difficult to say.

The data recorded at the ECOSHAFT allow us to calculate the energy which is freed when the pollutants are burning-off (see the document at our home page (download: 'to usher a new era')). This data indicate an amount of roughly 25 kWh/t which is heating-up the scrap load at the two-chamber scrap preheating system. This must be equivalent to that fire column. This energy is usually just disappearing. Economically seen this means to get this energy instead of investing this energy is a benefit of the double. So, saving of approx. 50 kWh/t.
Supposing that the two-chamber scrap preheating would be only as good as the single-chamber scrap preheating system then the difference of these 50 kWh/t would already be a big step forward. Additionally as there are no fingers or pusher needed in zones where cooling of these parts is needed another gain of 10 to 15 kWh/t are due – or as the best working finger shaft system works with an input of electrical energy of about 310 kWh/t the ECOSHAFT® would make it at 250 kWh/t, not considering all the other assets.

An environmental threat: Ecologically seen any burning of coat, paint, oil, grease, plastic or resin represents an environmental threat as dioxins and furans as well as other toxic compounds are deliberated and evaporating. These polychlorinated compounds are cracking when heated and reformate when cooling down. There are three methods to get rid of these compounds, to incinerate the cracked fractions, to inhibit the reformation by fast cooling and to isolate them by powdered activated carbon.
As mentioned here above, the reheating and fast-cooling applied at the shaft system seems to be the only practical solution outside the furnace. Additionally, the application of activated carbon as catcher and isolator of toxic compounds has also been tested. As the result with the application of activated carbon wasn't better than without activated carbon this additional treatment was abandoned.
The third method to get rid of these compounds are widely applied at the production of cement. The furnace for the cement production (kiln), a long, constantly turning tube, is fired by fossil gas burners and some garbage as catalyser. This garbage which is also producing aromatic polychlorinated compounds, is similar to the pollutants of scrap. The off-gas produced by oxy-gas burners and the garbage is streaming through the moving clinker in the tube. The residence time of the off-gas in the kiln is roughly 5 secs before evacuating to cooler zones. The incineration of the cracked fractions happens under specific conditions, among them a sufficient residence time at temperatures above 900°C. The incineration of the fractions of the polychlorinated compounds are proven and documented. The reported conditions at the kiln are similar to the conditions reigning at the second chamber of the ECOSHAFT®, thus an incineration can be assumed at the ECOSHAFT® as well. The incineration method is not only cheaper than the post-treatment by reheating and fast cooling, it is also ecologically sound.

A danger for man and machine: Indeed, fire and dust is a common appearance in melt shops and men and women are exposed to multiple dangers at their work space, but who likes to be hit by falling scrap pieces thrown out of the furnace because of a sudden expansion and who likes the sudden heat impact when the

pollutions burn-off when charging. Material might suffer under the multiple heat peaks (see figure 3), etc. not to mention the health danger of the contaminated dust on skin and inside lungs despite the breathing mask which is a must in these surroundings.

Figure 3 / Heat impact on an I/O box which remained open during scrap charging

Now again: Can protecting the environment be economically profitable?

Yes, it's possible! Based on the present production costs of the best performing scrap melting electric arc furnace solution it is possible to achieve a reduction on production costs and at the same time to protect the environment from synthesis products produced when burning aromatic polychlorinated compounds.

Figure 4 / EAF and ECOSHAFT®

The elaborated dynamic off-gas flow system allows to best use the heat and the bound energy of the off-gas inherent to the melting process within the two-container system of the ECOSHAFT®. This allows to reduce the energy input to a new benchmark of 590 kWh/t which reduces the energy cost for electrical energy, fossil energy (natural gas and carbon) and oxygen to a new threshold.

The following comparison (figure 5) bases on information got from different steel plants. The price basis to calculate the energy costs are listed in a separate table (table 1)

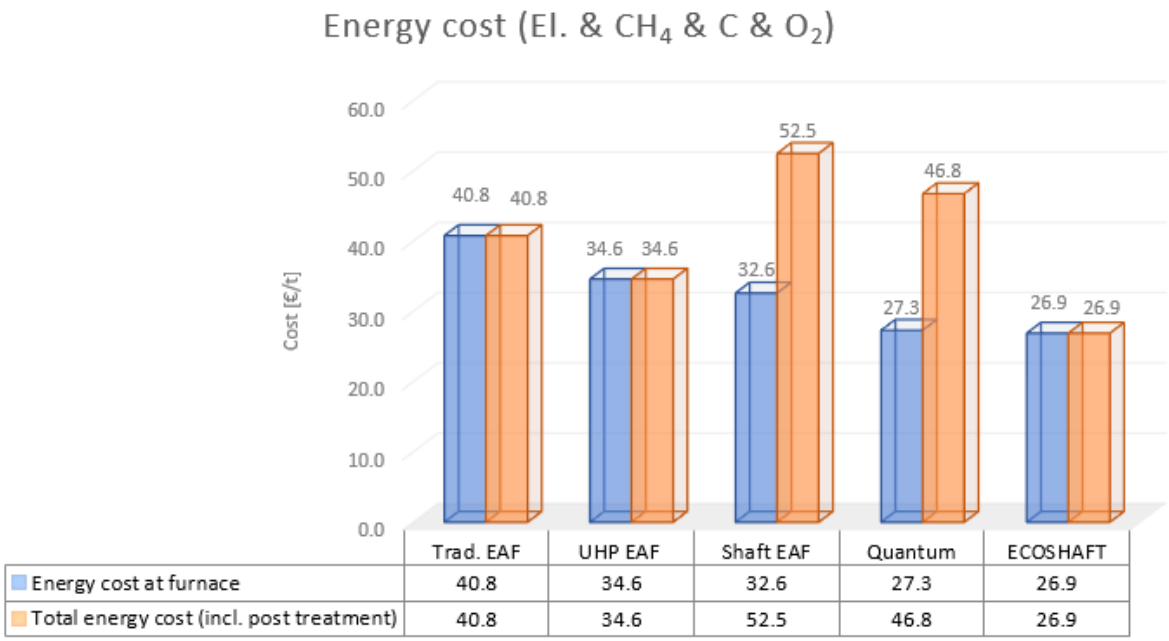

Figure 5 / Energy cost comparison

Text	Unit	Cost/unit
Natural gas CH_4	MWh	€ 26.00
Bulk carbon	t	€ 186.55
Fine carbon	t	€ 207.00
Electrodes	kg	€ 10.00
El. Energy	MWh	€ 40.00
Oxygen high p	Nm^3	€ 0.11
Oxygen low p	Nm^3	€ 0.08

Table 1 / Price basis 2016 (Turkey)

The ECOSHAFT® is available for independent (hydraulic) tilting, cradle tilting and circular tilting of the furnace, it's available with two independent containers or with connecting containers separated by a diaphragm. ECOSHAFT® can be designed to fit into narrow and low furnace bays (min. OHC rail hight 20m above ground) and is

available for special steel applications (without heel) as well as for mass production (with heel).

The two-chamber system of the ECOSHAFT® heralds a new era of energy saving installations: Efficient Scrap Preheating, Economic Ladle Furnaces, and Energy and Space Saving Vacuum Pumps with active over flow prevention.

ECOSHAFT® – uses the furnace off-gas energy to the maximum – a step toward a safe future – a step toward green steel recycling – for the sake of the environment and for the benefit of the steel plant.

Do you need more information? Don't hesitate to contact us, info@eco-eag.com
www.eco-eag.com