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NEW GENERATION IN PRE-HEATING TECHNOLOGY FOR ELECTRIC STEEL MAKING HIGHER PRODUCTIVITY WITH REDUCED POWER[1]

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Abstract

In the steelmaking process, by scrap melting through Electric Arc Furnace route, substantial reduction in electric power consumption and associated increase in furnace productivity can be realized with Scrap Pre-heating Technique which pre-heats the scrap to about 700°C by making use of the sensible heat carried in the furnace off gas. In this respect, CVS Technology has a co-operation with KR Tec GmbH, which developed an ''environmentaly friendly'' and ''high efficiency'' scrap preheating system to be ''superior'' over the existed systems developed so far. This challenge led to the raise of a new and superior '' Environmetal Pre-heating and Continuous Charging (EPC) System''. The EPC System combines the advantages of 100% scrap preheating and continuous scrap feeding through its chambers, without the need of EAF roof opening. EPC prevents totaly, any dust emission and heat loss during furnace charging stage, as it is the case normally for other operations.

Key words: Pre-heating; Environmental; EAF; Technology.

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1 INTRODUCTION

Today's steelmakers are seeking for clever solutions to achive more economical, ecological and flexible operations. These should be realized with less maintenance intensive equipments. These are the main objectives for maintaining commercial superiority comparing the competitors. Continuing increase in electric energy costs, strict rules impossed on atmospheric CO2 emissions and ever tighter environmental regulations for land and waters lead the steelmakers to decrease their energy consumptions and to recycle the waste materials and medias. Scrap preheating phenomena has been used for over 30 years to decrease the electrical energy consumption. It normaly involves the use of EAF hot off gas to heat scrap in the bucket, prior to its charging into furnace. The source of the hot gas can be either solely the off gas from EAF and/or gas from suplementary burner(s). The primary energy requirement for the EAF is for heating the charged scrap to its melting point. Thus, energy can be saved, if scrap is charged to the furnace hot. The preheating of the scrap also eliminates the explosions and increasing the hydrogen content of the steel when the priority to use wet scrap obliged. Hence, the preheating scrap also prevents accidentally equipment damage while reduces EAF electrical energy consumption and increases melt shop productivity. The energy savings' statistics show 30 kwh/ton with the reductions in electrode, refractory consumptions and tap-to-tap timeas well by using the method of the heating the scrap in the scrap bucket.
As EAF fourth hole offgas systems were developed, attempts were made to use the EAF offgas for scrap preheating. A side benefit reported was that the amount of baghouse dust decreased because the dust was sticking to the scrap during preheating. Scrap preheating with furnace offgas is difficult to control due to the variation in offgas temperature throughout the heat cycle. In addition, a temperature gradient forms within the scrap being preheated. Temperatures must be controlled to prevent damage to the scrap bucket and in order to prevent burning or sticking of fine scrap within the bucket.
Scrap temperatures can reach 315°C – 450°C (600°F – 850°F), though; this will only occur at the hot end where the offgas first enters the preheater. Savings are typically only in the neighborhood of 18 kWh/ton – 23 kWh/ton. In addition, as operations become more efficient and tap-to-tap times are decreased, scrap preheating operations become more and more difficult to maintain. Eventualy, scrap handling operations actually started producing reduced productivity and increased maintenance costs.
Some of the benefits attributed to scrap preheating are increased productivity by 10% to 20%, reduced electrical consumption, removal of moisture from the scrap, and reduced electrode and refractory consumption per unit production. Some drawbacks to scrap preheating are that hazardous volatiles are evolved from the scrap, creating odors and necessitating a post-combustion chamber downstream.
In addition spray quenching following post-combustion is required to prevent recombination of dioxins and furans. Depending on the preheat temperature, buckets may have to be refractory lined.

2 DESCRIPTION OF EPC SYSTEM

Environmental Pre-heating and Continuous Charging has many advantages.

2.1 Minimum Dust Emmision

During charging procedure the system is always in a closed and airtight situation which results in minimum pollution level in the meltshop.

2.2 Energy Saving

The EPC reduces the electric energy consumption by approx. 100 kWh/t compared to the conventional EAF.

2.3 Independent Scrap Charging

Charging of the scrap basket is done with power-on and independently from the furnace operation. This improves the operation and reduces the power off time. Eliminating the need for EAF roof opening substantially reduces the heat loss from furnace.

2.4 Low Downtimes/ Maıntenance & Less Heat Loss from WCC

No critical water cooled mechanical parts such as fingers, no need for conveyors and no extra water cooled parts requirements which may cause unforeseen stoppages, need intensive maintenance, and lead to excessive water cooling heat losses from the furnace.

2.5 Hıgher Productıvıty

Due to shorter power-on and power-off times. The productivity of the furnace can be increased by 20% compared to the conventional EAF.

2.6 Longer Eaf Roof & Roof Delta Lıves

Due to, there is no need for opening/closing the furnace roof for charging and electric arc is always away from the roof, less arc damage results at roof WCP and the minimized thermal shock additionally helps in extending roof delta life.

2.7 Hıgher Return On Investment

The EPC System features lower conversion cost due to the preheating effect. Furthermore higher productivity because of less power-on and power-off times are assured. Depending on the scrap quality, some yield gain can also be expected.

2.8 Less Flıcker

Related to the flat bath operation, preheated scrap and the constant energy input, a reduced flicker and harmonics level is reached. This also leads to less arc noise generation.

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2.9 Savings For Scrap Treatment

The above saving does not take into consideration the additional saving of approx. 10.00 EUR / t liquid, due to the fact the EPC - System does not require any special scrap treatment.
The new and superior EPC design considers the most flexible operational activities.
The main features are:

- Controlled scrap charging rate through telescopic feeder system;
- continuous charging during power on;
- scrap charging rate is tuned according to melting power/preheating temperature;
- uniform and well controlled bath temperature;
- well controlled preheating temperature;
- flat bath operations;
- reduced arc noise level,(melting preheated scrap,melting flat bath conditions under foamy slag);
- minimized off gas volume related to airtight system;
- environmental benefits;
- charging with closed system, into a separate compartment (EAF roof is closed, dedusting primary line is on);
- minimum fume emission during scrap charging;
- cleaner and safer working area;
- 30% less off gas;
- 30% less dust at the filt;
- direct preheating, charged scrap is exposed to very high temperatures;
- EPC respects to most environmental standards.

The Charging with scrap bucket is only done, for one time, and at the beginning the first heat of an operations cycle or in case of an emergency situation.
The emission control regulations are becoming more and more tight so the emission from the steel making process creates the biggest problem for the producers while thinking, the power saving and the scrap preheating are in manner synonymatically. So the various technologies have been developed to effectively preheat the scrap by the furnace exhaust gas. One of the issues of the EPC System is to charge the scrap independent of the electric arc furnace melting by taking into consideration the environmental aspects. The preheating chamber of EPC is installed beside the EAF upper shell and the preheated scrap resides in this charged continuously, by using the telescopic feeder system, into EAF during power on. Even during charging of the scrap basket into the drawer positioned in the waiting deck, the preheating chamber is closed with the drawer's front wall and hence the furnace and preheating chambers are totaly isolated. This ensures little or no dust escape during furnace charging. The scrap basket will be charged into the drawer of EPC by opening top slide gate and while the charging drawer is positioned in the waiting deck. After charging, top horizontal slide gate is closed and the charged scrap inside drawer is in waiting position. Due to melting and preheating chambers are isolated during charging EPC, melting and preheating don't have to be interrupted. Then, the drawer is forwarded by two hydraulic cylinders towards over the preheating chamber, horizontally, and the scrap falls smoothly into the preheating chamber where it gets preheated. When the drawer is over preheating zone, its rear wall is closing the

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preheating chamber. A special design of the off gas duct together with a water cooled regulation flap allows to control the preheating effect in the preheating chamber.
The scrap basket will be charged into the drawer of EPC while it is positioned inside waiting deck.
During charging, and when the charging drawer is positioned inside waiting deck, front wall of the drawer closes and isolates the preheating chamber and hence the melting process in EAF and the preheating don't have to be interrupted.
After filling the drawer by the raised scrap basket, the slide gate on top of the EPC system is closed.
EPC, currently developed, is a shaft type- preheat furnace, based on AC technology. The furnace will maintain a large hot heel, (nearly 40%), so that uniform operating conditions can be maintained. Steel is tapped out periodically via a bottom taphole in the furnace.
The scrap charging system consists of two main components, the preheat chamber and the charging deck inside which a drawer operates.
The scrap is fed into the upper part of the chamber from a receiving hopper. The exhaust gas from the furnace flows up through the chamber, preheating the scrap. Scrap preheat temperatures as high as 800°C can be achieved. Gas exit temperatures from the chamber is around 200°C. At the base of the preheat chamber, there are two screw type pushers. These operate in two stages, allowing scrap feed into the furnace at a constant rate. Offgas leaves the top of the preheat chamber and flows to a bag filter. Some gas can be recycled to the furnace to regulate the inlet gas temperature to the preheater.

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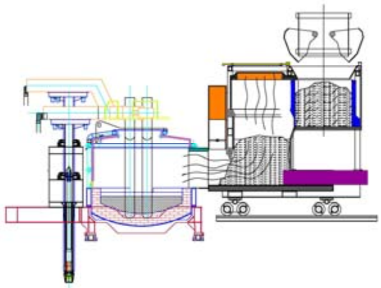
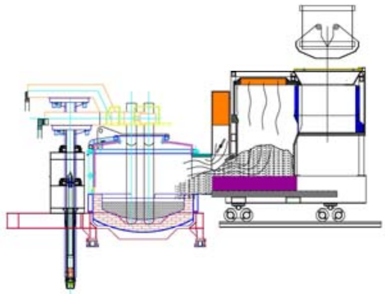
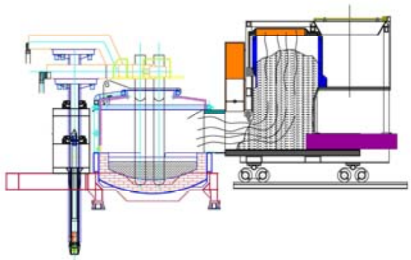
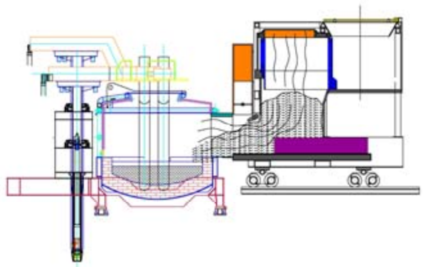
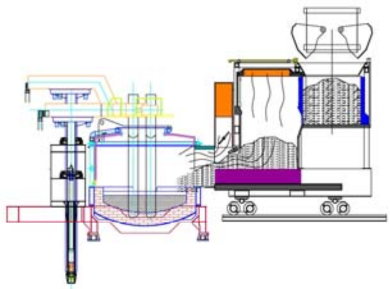
3 OPERATIONAL MODES OF EPC

1. Refining Phase of EAF Preheating of 1st bucket of next heat in pre-heating chamber Charging of next bucket into charging drawer	
2. Preheating inside EPC Start feeding of preheated scrap after tapping Pre-heating chamber half empty drawer can move to waiting/charging position	
3. Charging Preheating Chamber Moving of charging drawer into pre-heating chamber Preheating of 2nd bucket of next heat in pre-heating chamber Off gas flap closed	
4. Preheating inside EPC Scrap bucket in waiting position Continuous feeding of scrap during power on	
5. Charging to Upper Hopper EPC Start feeding of preheated scrap Opening of sliding gate on top Charging of next bucket into charging hopper	

Scrap is fed continuously to the furnace until the desired bath weight is achieved. This is followed by a short refining and super heating period followed by tapping of the heat. Power input is expected to be almost uniform throughout the heat. Most furnace operations are fully automated. Charging rate of scrap into the preheater chamber is fully automated based on the scrap height in the chamber as well as

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temperature of the gas. Furnace feeding rate is interrelated to this, and to the actual power input. Carbon and oxygen injections are controlled based on the depth of foamy slag.

4 CONCLUSION

Without doubt, current trends indicate that high levels of both the electrical and the chemical energy are likely to be employed in the furnace designs for future as well. The changing shares of the different energies will be dependent on the cost and availability of the various energy forms in a particular location. There are many new processes for steelmaking which are now being commercialized. In almost all cases the goal is to minimize the electrical energy input and to maximize the energy efficiency in the process together with several technologies have attempted to maximize the use of chemical energy into the process. These processes are highly dependent on achieving pseudoequilibrium where oxygen has completely reacted with fuel components (carbon, CO, natural gas, etc.) to give the maximum achievable energy input to the process. Other processes have attempted to maximize the use of the energy that is input to the furnace by recovering energy in the offgases (Fuchs shaft furnace, Consteel, EOF, IHI Shaft). These processes are highly dependent on good heat transfer from the offgas to the scrap. This requires that the scrap and the offgas contact each other in an optimal way.

All of these processes have been able to demonstrate some benefits. The key is to develop a process that will show process and environmental benefits without having a high degree of complexity and without affecting productivity. There is no perfect solution that will meet the needs of all steelmaking operations. Rather, steelmakers must prioritize their objectives and then match these to the attributes of various furnace designs. It is important to maintain focus on the following criteria:

- To provide process flexibility;
- to increase productivity while improving energy efficiency;
- to improve the quality of the finished product;
- to meet environmental requirements at a minimum cost.

With these factors in mind, the following conclusions are drawn:

- The correct furnace selection will be one that meets the specific requirements of the individual facility. Factors entering into the decision will likely include availability of raw materials, availability and cost of energy sources, desired product mix, level of post furnace treatment/refining available, capital cost and availability of a trained workforce;
- various forms of energy input should be balanced in order to give the operation the maximum amount of flexibility. This will help to minimize energy costs in the long run, i.e. the capability of running with high electrical input and low oxygen or the converse;
- energy input into the furnace needs to be well distributed in order to minimize total energy requirements. Good mixing of the bath will help to achieve this goal;
- oxygen injection should be distributed evenly throughout the tap-to-tap cycle in order to minimize fluctuations in offgas temperature and composition. Thus, postcombustion operations can be optimized and the size of the offgas system can be minimized. In addition, fume generation will be minimized and slag/bath approach to equilibrium will be greater;

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- injection of solids into the bath and into the slag layer should be distributed across the bath surface in order to maximize the efficiency of slag foaming operations. This will also enable the slag and bath to move closer to equilibrium. This in turn will help to minimize flux requirements and will improve the quality of the steel;
- the melting vessel should be closed up as much as possible in order to minimize the amount of air infiltration. This will minimize the volume of offgas exiting the furnace leading to smaller fume system requirements;
- scrap preheating provides the most likely option for heat recovery from the offgas. For processes using a high degree of chemical energy in the furnace, this becomes even more important, as more energy is contained in the offgas for these operations. In order to maximize recovery of chemical energy contained in the offgas, it will be necessary to perform post-combustion. Achieving high post-combustion efficiencies throughout the heat will be difficult. Staged post-combustion in scrap preheat operations could optimize heat recovery further;
- operations which desire maximum flexibility at minimum cost will result in more hybrid furnace designs. These designs will take into account flexibility in feed materials and will continue to aim for high energy efficiency coupled with high productivity. For example operations with high solids injection, iron carbide or DRI fines, may choose designs which would increase the flat bath period in order to spread out the solids injection cycle. Alternatively, a deeper bath may be used so that higher injection rates can be used without risk of blow through;
- operating practices will continue to evolve and will not only seek to optimize energy efficiency in the EAF but will seek to discover the overall optimum for the whole steelmaking facility. Universally, the most important factor is to optimize operating costs for the entire facility and not necessarily one operation in the overall process chain. Along with added process flexibility comes greater process complexity. This in turn will require greater process understanding so that the process may be better controlled. Much more thought consequently must enter into the selection of electric furnace designs and it can be expected that many new designs will result in the years ahead. As long as there is electric furnace steelmaking, the optimal design will always be strived for.

By the consideration of above items, CVS Technology and KR Tec companies has developed new patented solution in Pre-heating technology.