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EAF steelmaking process with increasing hot metal charging ratio and improving slagging regime

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Abstract: A new electric arc furnace (EAF) steelmaking process with increasing hot metal charging ratio and improving slagging regime simultaneously was developed and applied in a 50 t electric arc furnace for more than a year at No.1 Steelmaking Plant of Shanxi Taigang Stainless Corporation Limited. The essential fact of the new EAF steelmaking process was to charge hot metal in two portions or steps: firstly, 35wt%-40wt% hot metal was pretreated by blowing oxygen in a specially designed reactor for decarburization and improving hot metal temperature and melting premelted slag; secondly, 30wt% hot metal was charged into EAF with high basicity refining slags from ladle furnace (LF)-vacuum degassing furnace (VD) refining process. The results show that the hot metal charging ratio can reach to about 65wt%-70wt% for the new EAF steelmaking process; meanwhile, the tap-to-tap time of a 50 t EAF can shorten by 5-10 min, the electricity consumption can decrease by 35-50 kW·h/t, the lime consumption can reduce by 10.5 kg/t of molten steel, and the content of harmful heavy metals in molten steel can be easily controlled to less than the upper limits of aimed steel specification or grade compared with the traditional EAF steelmaking process. In addition, the dephosphorization ability shows a slight strengthening, however, a small degree of lessening for desulphurization ability is observed for the new EAF steelmaking process, but the weakness of desulphurization ability cannot become an obstacle to its further application since a stronger desulphurization ability can be achieved during secondary refining of LF coupled with VD after EAF steelmaking process.

Key words: electric arc furnace (EAF); charge ratio; slagging; refining slags; lime

1. Introduction

The traditional electric arc furnace (EAF) steelmaking process with all or high ratio of scraps as metallic raw materials can result in a higher content of harmful heavy metal elements to deteriorate aimed steel specifications or grades [1]. Therefore, the normal flowchart and organization of EAF steelmaking can be usually disturbed by charging excessive scraps with complex chemical composition. It has been widely proposed [2-4] that one of the effective measures to avoid and solve this problem is to increase hot metal charge ratio. However, excessive charging hot metal can lead to prolonging the tap-to-tap time of EAF steelmaking process, because large carbon load from the excessively charged hot metal can overburden the decarburization operation during the EAF steelmaking process [5-6].

To fully utilize the advantage of increasing the hot metal charging ratio for shortening the tap-to-tap time of EAF steelmaking process [7-10], it is important to investigate the optimal hot metal charge ratio [11-16].

A new EAF steelmaking process, in which charging hot metal in two steps and recycling ladle furnace (LF)-vacuum degassing furnace (VD) high basicity slags can eliminate the negative effect of high hot metal charging ratio on tap-to-tap time, was developed in this study. The developed EAF steelmaking process to shorten tap-to-tap time, had been applied in a 50 t EAF at No.1 Steel Plant, Shanxi Taigang Stainless Corporation Limited, because the tap-to-tap time of the traditional 50 t EAF steelmaking process should be urgently shortened to fulfill the demand of expanding steel output, and hot metal charging ratio should be increased to treat the surplus hot metal from a new built 4350-m^3 large volume blast furnace. The key know hows of the new EAF steelmaking process can be described as follows: 1) total hot metal was charged into EAF in two steps, *i.e.*, after charging scraps, the first tank of hot metal, which was pre-

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treated by top blowing oxygen for decarburization and temperature elevating, was charged; 2) after a period of switching on electricity to melt the charged scraps, the secondary tank of hot metal together with high basicity LF-VD slags was further charged into the EAF.

In this article, the newly developed EAF steelmaking process was briefly introduced, and the influences of the new EAF steelmaking process on the tap-to-tap time, electricity and lime consumption, ability of dephosphorization and desulphurization, and contents of harmful heavy metal elements were analyzed according to more than a year of industrial practice in a 50 t electric arc furnace. Meanwhile, the economic assessment of the new EAF steelmaking process was also provided.

2. New EAF steelmaking process

2.1. Flowchart of new 50 t EAF steelmaking process

Differing with the traditional steelmaking process, the current steelmaking flowchart is schematically illustrated in Fig. 1, which is normally run for more than 12 months in No.1 Steelmaking Plant, Shanxi Taigang Stainless Steel Corporation Limited. Obviously, the key difference from the traditional steelmaking flowcharts was that the high hot metal charging ratio and improving slagging regime was adopted by the new EAF steelmaking process.

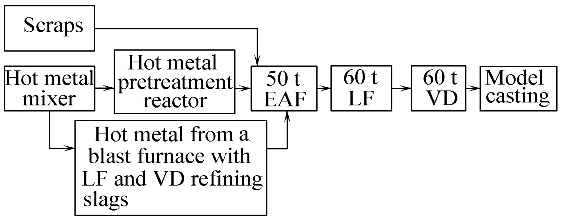

Fig. 1. Flowchart of steelmaking process using the new EAF steelmaking process.

The flowchart of the new EAF steelmaking process with high hot metal charging ratio and improving slagging regime applied in a 50 t EAF steelmaking was described as follows: 1) after charging 20 t scraps, the first portion of 20-25 t hot metal, which was pretreated by blowing oxygen for decarburization and increasing temperature and melting refining slag, was charged into EAF; 2) electricity was switched on and oxygen was blown into EAF for primary melting; 3) the second portion of 20 t hot metal directly from the blast furnace with recycled high basicity refining slags from LF and VD was charged; 4) the refining proceeded with further switching on electricity and blowing oxygen; 5) composition and temperature were determined to fulfill tapping needs.

2.2. Apparatus of hot metal pretreatment

The reactor of the hot metal pretreatment is modified from a common hot metal ladle, in which a cap is added, as shown in Fig. 2. The ladle lining was bricked up with magnesia-carbon bricks, while the oxygen blowing system of a water-cooled oxygen lance was newly designed. The main parameters of the hot metal pretreatment reactor and oxygen lance are summarized in Table 1. The dust collection system of hot metal pretreatment shared the same one with the 50 t EAF because the capacity of the dust collection system was large enough. Although hot metal pretreatment process was extra added in the new EAF steelmaking process, no pretreatment equipment was newly needed except the oxygen lance system, because the related pretreatment equipment, such as hot metal pretreatment reactor, could be transformed from the hot metal ladle.

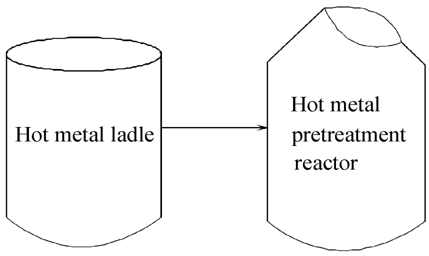

Fig. 2. Schematic illustration of the hot metal pretreatment reactor.

2.3. Hot metal pretreatment for decarburization and elevating temperature

It is well known that there are two contrary effects of improving hot metal charging ratio on the tap-to-tap time of EAF steelmaking process. To promote the positive effect of improving hot metal charging ratio on tap-to-tap time and abate its negative effect, the new EAF steelmaking process took measures to charge hot metal into EAF in two steps or tanks, the first tank of hot metal was pretreated by blowing oxygen to partially decarburize from about 4.0wt% to 1.5wt%-2.2wt%, and increasing temperature from 1553-1623 K to 1773-1873 K.

Being different from traditional hot metal pretreatment, *i.e.*, desiliconization, dephosphorization, and desulphurization, the newly developed hot metal pretreatment technique was implemented in a special reactor, which was similar to an LD steelmaking converter, by top blowing oxygen to decarburization from 4.0wt% to 1.5wt%-2.2wt%, improving hot metal temperature from 1553-1623 K to 1773-1873 K, and premelting lime and other slag-forming auxiliary materials. It should be specially emphasized that the desulphurization ability of the hot metal pretreatment operation was very limited. The variation of chemical composition of the hot metal before and after decarburization and temperature elevating pretreatment by blowing oxygen is listed in Table 2.

Table 1. Main parameters of hot metal pretreatment apparatus and oxygen lance

Hot metal pretreatment reactor		Water-cooled oxygen lance	
Items	Parameters	Items	Parameters
Volume	16.5 m^3	Type of oxygen lance	Three-apertured Laval lance
Height	4530 mm	Mach number	1.85
Diameter	3050 mm	Nozzle outlet diameter	20.8 mm
Weight	48 t (steel shell + refractory materials)	Jet angle	≈12°
Steel shell	A3 steel with 25 mm thickness	Oxygen lance length	7500 mm
Working thickness	170 mm	Oxygen flow rate	2700-2900 Nm^3/h
Insulation thickness	50 mm	Oxygen pressure	0.75-0.80 MPa

Table 2. Variation of chemical composition of the hot metal before and after decarburization and temperature elevating pretreatment by blowing oxygen wt%

Hot metal	C	Si	Mn	P	S
From blast furnace	≥4.05	≤0.45	≤0.45	≤0.058	≤0.025
After decarburization pretreatment	1.5-2.0	≤0.27	≤0.26	≤0.023	≤0.025

2.4. Improving slagging regime

Proper foaming slag was of importance for the EAF steelmaking process because foaming slag was beneficial not only for submerging electric arc, reducing the destruction of refractory materials to hearth of EAF by arc irradiation, and improving EAF hearth life, but also for the operation of dephosphorization and desulphurization. Besides increasing hot metal charging ratio, the new EAF steelmaking process took two measures to improve EAF slagging regime by producing high basicity premelted slag during hot metal pretreatment by blowing oxygen in the first tank of charged hot metal, and recycling high basicity slags from LF-VD in the second tank of charged hot metal. Therefore, it was necessary to assess the effects of premelted slag produced during hot metal pretreatment and recycled slags from LF-VD on the new EAF steelmaking process.

(1) Premelting slag during hot metal pretreatment

Compared with the traditional EAF steel process, the new EAF steelmaking process can make slag-forming melt early. Slag in traditional EAF was usually formed as follows: charging slag-forming materials to hearth → charging scraps → charging hot metal → switching on electricity → charging lime and other slag-forming materials again → melting slag-forming materials → blowing oxygen to form foaming slag; whereas the slag-forming process in new EAF steelmaking was: charging slag-forming materials to hearth → charging scraps → charging decarburized hot metal with premelted slag → switching on electricity to form foaming slag.

Adding a reasonable amount of slag-forming auxiliary materials during hot metal pretreatment was useful not only for the new EAF steelmaking process, but also for achieving the aims of decarburization and temperature improving. About 2200-2500 kg lime and 300-500 kg dolomite per heat was charged for pretreating 20-25 t hot metal. All the charged lime and dolomite can be rapidly melted as premelted slag to effectively deplete hot metal spitting and reduce radiation heat released from the oxidization of carbon and silicon in hot metal during hot metal pretreatment.

The premelted high basicity slag had positive effect for improving lime utilization, reducing electricity consumption for lime melting, and finally shortening slag-forming period during the EAF steelmaking process.

(2) Recycling refining slags from LF-VD

From the flowchart shown in Fig. 1, it can be observed that molten steel from EAF would be refined in LF-VD. About 1200-1500 kg high basicity slags was usually left in 60 t LF and VD vessels at temperature around 1773 K. The chemical compositions of final slag from EAF and refining slags from LF-VD are listed in Table 3. Obviously, a reasonable utilization of the left refining slags in LF-VD vessels, which had high dephosphorization ability and high thermal potential, could not only reduce the amount of metallurgical solid wastes, but also decrease the environmental impacts from the viewpoints of environmental protection and comprehensive utilization of resources, simultaneously.

The new EAF steelmaking process could provide an economical and environmental friendly utilization of refining slags from LF-VD during the charging of the second tank of hot metal. The second tank of hot metal with refining slags from LF-VD containing small amount of residual molten steel after model casting could promote slag-forming, shorten slag-forming time, decrease the charged amount of slag-forming auxiliary materials, and reduce the tap-to-tap time of EAF steelmaking process.

Table 3. Chemical composition of final slag from EAF and refining slags from LF-VD wt%

Slag	FeO	SiO_2	Al_2O_3	CaO	MgO	P	S
EAF final slag	15.60-20.40	14-27	3.80-7.78	34-50	4-7	0.320-0.560	0.064-0.300
Refining slags from LF-VD	0.36-0.75	8-11	13.00-15.00	52-57	5-8	0.002-0.010	0.970-1.290

The comprehensive effects of both premelted slag from hot metal pretreatment and recycled refining slags from LF-VD could make initial slag form early, avoid the fluctuation of slag basicity when melting newly charged slag-forming auxiliary materials, keep comparatively constant the composition and basicity of slag, and maintain a reasonable height of foaming slag to stabilize electric arc during EAF steelmaking process. All these effects were of benefit to carry out dephosphorization ahead during EAF steelmaking process.

3. Metallurgical effects of new EAF steelmaking process

3.1. Tap-to-tap time and hot metal charging ratio

Tap-to-tap time and electricity consumption are two key operation parameters to evaluate the operation and cost-saving of an EAF steelmaking process. The relationship between hot metal charging ratio and tap-to-tap time for the new and traditional 50 t EAF steelmaking process is illustrated in Fig. 3. It was seen that increasing the hot metal charging ratio from 40wt% to 52wt%-57wt% could reduce the tap-to-tap time by about 7 min, *i.e.*, from 75 min to 67 min; however, further improving the hot metal charging ratio, *i.e.*, greater than 57wt%, could result in a negative influence for shortening the tap-to-tap time. This indicated that 52wt%-57wt% was the optimal hot metal charging ratio for the shortest tap-to-tap time for a 50 t EAF by adopting traditional EAF steelmaking process.

Increasing hot metal charging ratio coupled with decreasing scraps ratio was a beneficial measure to reduce the tap-to-tap time of EAF steelmaking at a fixed EAF capacity. It was easily understood that increasing hot metal charging ratio could improve extra physical and chemical heat, thereby, the melting period of scraps could be shortened, and slag formation could proceed ahead during EAF steelmaking process. All these positive effects could, more or less, make contributions to cut tap-to-tap time, reduce electricity consumption, and decrease iron loss during EAF steelmaking process. For the same reasons, reducing scarps ratio was also beneficial to improve the melting rate and shorten the refining time for EAF steelmaking process.

However, when hot metal charging ratio was very high, a greater difference of carbon content between charged hot metal and expected steel specification could bring out a larger decarburization task, and thus, the tap-to-tap time of EAF steelmaking process could be prolonged and electrode life could be negatively affected [2]. Oppositely, when hot metal charging ratio was very low, corresponding a lower input of extra physical and chemical heat, a lower carbon burden in raw material simultaneously, and a longer melting time of scraps during EAF steelmaking process would be needed, and thus the aim at reducing tap-to-tap time could not be easily realized [2]. Certainly, there was an optimal hot metal charging ratio for a fixed capacity of EAF. Determining the optimal hot metal charging ratio was a challenging task for developing a new EAF steelmaking process for increasing hot metal charging ratio.

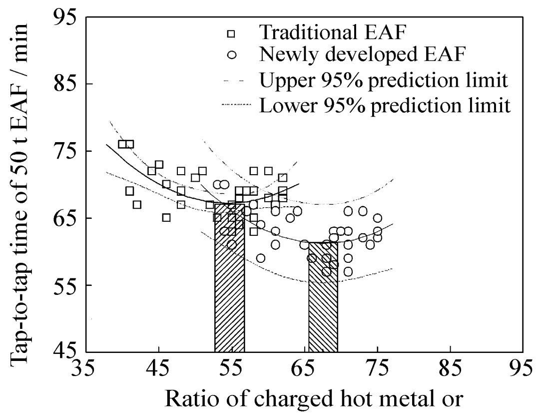

Fig. 3. Relationship between molten iron charging ratio and tap-to-tap time for a 50 t EAF by applying the new and the traditional EAF steelmaking processes.

The new EAF steelmaking process could be charged with more hot metal with a shorter tap-to-tap time, and the optimal hot metal charging ratio was about 65wt%-70wt% with the shortest tap-to-tap time as 61 min compared with the hot metal ratio of 52wt%-57wt% corresponding to the shortest tap-to-tap time as 67 min for traditional EAF steelmaking process. Therefore, the tap-to-tap time could be shortened by 5-10 min for the new EAF steelmaking process compared with the traditional EAF steelmaking process.

3.2. Electricity consumption

The monthly average electricity consumption per ton of steel surveyed for 12 months for both the new and the traditional EAF steelmaking processes is shown in Fig. 4, respectively. It can be seen that the data of monthly average electricity consumption per ton of steel for the two EAF steelmaking processes were scattered in a large fluctuation range; however, it was obvious that a less electricity would be consumed for the new EAF steelmaking process as compared with the traditional one. The average electricity consumption per ton of steel for the new EAF steelmaking process was about 132 $kW\cdot h\cdot t^{-1}$, corresponding to that of the traditional process as 171 $kW\cdot h\cdot t^{-1}$, *i.e.*, about 35-50 $kW\cdot h\cdot t^{-1}$ electricity consumption can be saved.

The reasons of the above-mentioned results were summarized as follows: 1) a great deal of extra physical heat was charged into EAF by charging the first tank of pretreated hot metal at 1773-1873 K; 2) initial slag in EAF could be early formed during the EAF steelmaking process as the charged premelted slag with pretreated hot metal; 3) recycled refining slags from LF-VD with high basicity and low FeO content could make dephosphorization reactions proceed ahead and promote foaming slag formation early.

3.3. Ability of dephosphorization and desulphurization

Dephosphorization and desulphurization are two important fundamental functions to evaluate the refining ability of an EAF steelmaking process. It is well known that forming slag with low temperature, high oxidizing, and high basicity quickly in the initial period during EAF steelmaking process is beneficial to carry out dephosphorization reaction ahead from the viewpoint of metallurgical physical chemistry. A specially designed two-step hot metal charging order applied in the new EAF steelmaking process had two advantages to promote dephosphorization reactions as follows: 1) the pretreated hot metal with premelted slag containing 10wt%-16wt% FeO was first charged into EAF; 2) hot metal with low phosphorous content and high basicity refining slags from LF-VD vessels was charged into EAF. Therefore, dephosphorization reactions could rapidly take place by high basicity slag at a lower temperature in the initial period during the EAF steelmaking process.

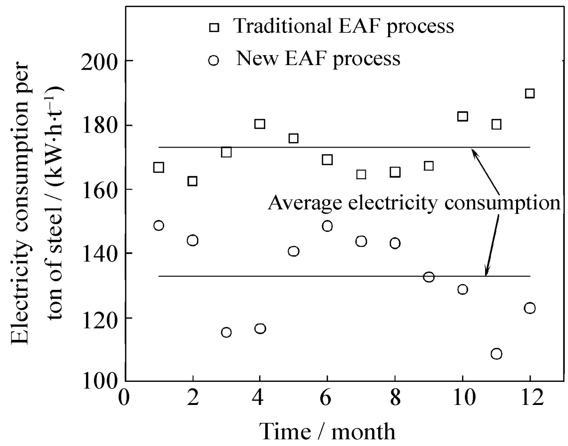

Fig. 4. Comparison of electricity consumption per ton of molten steel for a 50 t EAF by applying the new and the traditional EAF steelmaking processes.

It should be specially pointed out that refining slags from LF-VD vessels contained a higher content of sulfur, and the negative effect of high sulfur content in refining slags from LF-VD vessels on desulphurization reactions during the EAF steelmaking process should be carefully considered. The comparison of phosphorous and sulfur content in molten steel with or without charging refining slags from LF-VD vessels into a 50 t EAF is illustrated in Fig. 5. It was observed that the phosphorous content in molten steel from EAF had no obvious change with or without LF-VD slags charged, however, the sulfur content in molten steel from EAF could increase about 3×10^{-6}wt% with charging refining slags from LF-VD vessels compared with that without charging refining slags during the new EAF steelmaking process.

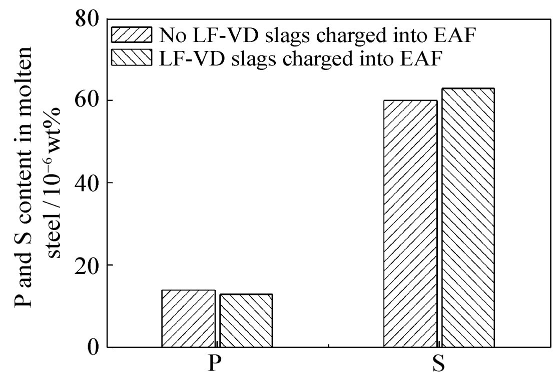

Fig. 5. Comparison of phosphorous and sulfur content in molten steel with or without LF-VD slags charged into a 50 t EAF by applying the new EAF steelmaking process.

It is well-known that LF-VD refining process had strong desulphurization ability for molten steel from EAF, hence, no over standard of sulfur content in aimed molten steel after LF-VD refining was observed since the new EAF steelmaking process was applied. Therefore, the newly developed EAF steelmaking process could be successfully applied in a steelmaking company, which had some strong desulphurization refining processes after the EAF steelmaking process.

3.4. Lime consumption

Lime is the major auxiliary material of slag-forming, lime consumption per ton of steel is one of the key parameters to evaluate the cost-saving level for a steelmaking process. The monthly average lime consumption per ton of steel surveyed from a 50 t EAF by applying both new and traditional EAF steelmaking processes is simultaneously illustrated in Fig. 6. It was observed that although the data of monthly average lime consumption per ton of steel were more fluctuant in a large range, the monthly average lime consumption for the new EAF steelmaking process was much lower than that of the traditional EAF steelmaking process. The average lime consumption, which was surveyed in 12 months, was reduced from 74.8 kg/t to 64.3 kg/t, and about 10.5 kg lime per ton of steel could be saved by applying the new EAF steelmaking process compared with that of the traditional EAF steelmaking process.

The reasons of significant decrease in lime consumption for the new EAF steelmaking process could be summarized as follows: 1) a part of slag in EAF was premelted during the hot metal pretreatment process; 2) high basicity refining slags from LF and VD vessels were recycled to EAF; 3) all measures could promote lime melting, and improve lime utilization efficiency; 4) recycling utilization of refining slags from LF-VD vessels could partially contribute to the reduction of lime consumption.

3.5. Contents of harmful heavy metal elements

The contents of harmful heavy metal elements have become one important problem to contaminate molten steel quality, because the EAF steelmaking process has no significant removing ability for them. The harmful heavy metal elements are easily accumulated in molten steel during the EAF steelmaking process with high scraps charging ratio or all scraps that are recycled from a common society with very complex chemical composition. Under this circumstance, the normal EAF steelmaking process can be accidentally disturbed by high contents of harmful heavy metal elements in molten steel. Therefore, special measures should be taken, such as changing steel specification, mixing with clean molten steel in ladles, or returning molten steel with high harmful heavy metal elements into EAF for diluting them again. The aimed steel specification can not be normally produced when higher contents of harmful heavy metal elements in molten steel are not properly reduced to an acceptable level. Consequently, increasing hot metal charging ratio, meanwhile decreasing scraps charging ratio, is one of the effective measures to solve this problem for the EAF steelmaking process.

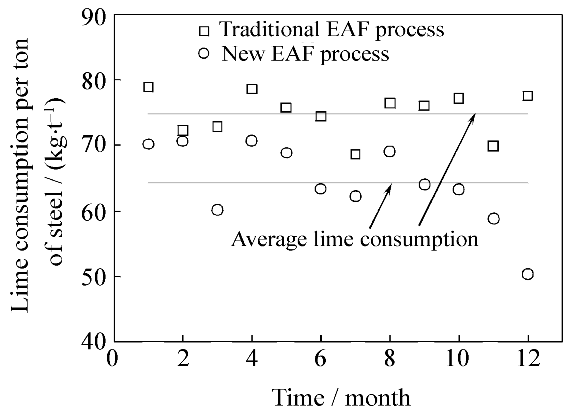

Fig. 6. Comparison of lime consumption per ton of molten steel for a 50 t EAF by applying the new and the traditional EAF steelmaking processes.

The average contents of Cr, Ni, and Cu, as representatives of harmful heavy metal elements, in molten steel both produced from the new and the traditional EAF steelmaking processes in a 50 t EAF for only 12 hearts, are shown in Fig. 7, respectively, because the contents of harmful heavy metal elements are not analyzed for each heats. It should be specially emphasized that 52wt%-57wt% hot metal charging ratio has been adopted in the traditional EAF steelmaking process.

When the traditional EAF steelmaking process was applied for a 50 t EAF, a lower hot metal charging ratio made a longer tap-to-tap time and a higher content of harmful heavy metal elements. Through process improvement of a 50 t EAF steelmaking process, the hot metal charging ratio was increased from 20wt%-30wt% to 52wt%-57wt%, hence, the contents of harmful heavy metal elements was decreased to lower levels, and no obvious over standard of heavy metal contents in molten steel was found in the routine production. The contents of heavy metal elements in purchased scraps from social recycling for a 50 t EAF fluctuated largely, and the statistical results showed that the content of Cr in scraps was 0.14wt%-0.28wt%, the content of Ni was 0.04wt%-0.20wt%, and the content of Cu was 0.05wt%-0.15wt%. When all scraps were used as metallic materials, the yield of Ni and Cu was about 100wt%, while the yield of Cr was about 60wt% and the total metallic yield was about 83.3wt%; hence, high contents of Cr, Ni, and Cu could be obtained in molten steel from EAF steelmaking process. However, when the hot metal charging ratio was increased to 54wt%, heavy metal elements could be largely diluted (Cr 0.046wt%-0.092wt%, Ni 0.022wt%-0.11wt%, and Cu 0.028wt%-0.083wt%), further increasing the hot metal charging ratio to 65%, heavy metal elements could be diluted (Cr 0.035wt%-0.071wt%, Ni 0.017wt%-0.084wt%, and Cu 0.021wt%-0.063wt%).

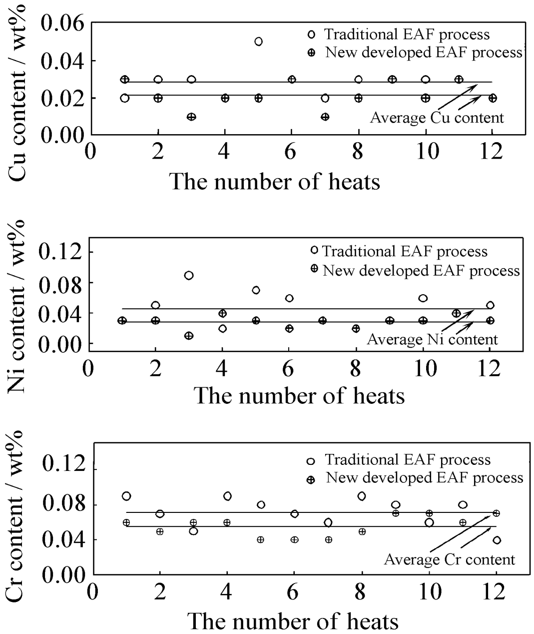

Fig. 7. Comparison of the content of harmful heavy metal elements Cr, Ni, and Cu in molten steel for a 50 t EAF by applying the new and the traditional EAF steelmaking processes.

It can be observed from Fig. 7 that the average contents of Cr, Ni, and Cu in molten steel at melt down presented large fluctuation during the traditional and the new EAF steelmaking processes. However, the contents of Cr, Ni, and Cu in molten steel produced from the new EAF steelmaking process were obviously lower than that produced from the traditional EAF steelmaking process, respectively. In addition, the average content of Cr, Ni, and Cu could be reduced from 0.0717wt% to 0.0558wt%, from 0.0459wt% to 0.0283wt%, and from 0.0283wt% to 0.0217wt%, respectively, by applying the new EAF steelmaking process. This indicated that the contents of Cr, Ni, and Cu in molten steel could be reduced by 22%, 38%, and 23%, respectively, for the new EAF steelmaking process as compared with that for the traditional EAF steelmaking process.

Lower contents of harmful heavy metal elements in molten steel produced from the new EAF steelmaking process were mainly caused from as low as 30wt%-35wt% scraps charging ratio. The dilution of 65wt%-75wt% hot metal, in which almost no harmful heavy metal element was contained, could make lower contents of harmful heavy metal elements in molten steel. More than a year of practice showed that no over standard Cr, Ni, and Cu content in aimed steel specification had occurred in a 50 t EAF.

4. Economic assessment

The average tap-to-tap time could be shortened by 8 min per heat by applying the new EAF steelmaking process; hence, about 50000 t of molten steel could be further produced annually. Based on the price index in the year 2007, the higher oxygen utilization efficiency could decrease the oxygen consumption by 5.01 $Nm^3 \cdot t^{-1}$, correspondingly reducing the cost by 2.76 yuan RMB/t; the shortened refining time could save the electricity consumption by 39 $kW \cdot h \cdot t^{-1}$, while correspondingly saving the cost of 9.75 yuan RMB/t; the longer service life of electrodes could reduce the electrodes consumption by 0.61 $kh \cdot t^{-1}$, thus reducing the cost by 10.06 yuan RMB/t; reducing 10.5 kg lime consumption per ton of steel could bring saving the cost of 6.3 yuan RMB/t. Meanwhile, the fixed costs of the new EAF steelmaking process, containing workers salary, management costs, and so on, could be reduced by 28.09 yuan RMB/t.

However, the new EAF steelmaking process also increased some costs: 1) refractory material in hot metal pretreatment reactor could increase the cost by 17.32 yuan RMB/t; 2) the investment of hot metal pretreatment process could also add a cost of 17.5 yuan RMB/t; however, the investment cost was recouped in one year. Therefore, the net profit of the new EAF steelmaking process could be obtained by subtracting the increasing cost (17.32+17.50=34.82 yuan RMB/t) from the decreasing cost (2.76+9.75+10.06+6.30+28.09=56.96 yuan RMB/t) as 22.14 yuan RMB/t in the first year, while from the second year onward, the net profit would be 39.64 yuan RMB/t because the investment cost of hot metal pretreatment was totally recouped in the first year.

5. Conclusions

A new EAF steelmaking process with increasing hot metal charging ratio and improving slagging regime has been developed and successfully applied in a 50 t EAF for more than a year as a sophisticated and routine EAF steelmaking process. The major advantages of the new EAF steelmaking process can be summarized as follows.

(1) Hot metal is charged into EAF in two portions or steps: firstly, 35wt%-40wt% hot metal is pretreated by blowing oxygen in a specially designed reactor for decarburization, improving temperature, and melting premelted slag; secondly, another 30wt% hot metal is

charged into EAF with high basicity refining slags from LF-VD refining process. Therefore, the hot metal charging ratio is as high as 65wt%-70wt%, and the slagging regime is improved by adding premelted slag and LF-VD refining slags.

(2) The new EAF steelmaking process can realize great EAF operation parameters, such as shortening tap-to-tap time by about 5-10 min, saving electricity consumption by 35-50 $kW\cdot h\cdot t^{-1}$, and reducing lime by 10.5 kg/t.

(3) The content of harmful heavy metal elements Cr, Ni, and Cu, can be reduced by about 22%, 38%, and 23%, respectively; meanwhile, the dephosphorization ability is slightly strengthened, and no obvious weakness of desulphurization ability can be found for the new EAF steelmaking process.

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