Demir Çelik Endüstrisinde Pota Fırınlarında İstenilen Kalitede Çelik Üretiminde Proses Analizi

Process Analysis in Production of Desired Quality Steel in Ladle Furnaces in Iron and Steel Industry

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***Özetçe*— Demir çelik sektöründe demir üretimi hurdanın elektrikli ark ocaklarında veya demir cevherinin bazik oksijen fırınlarında eritilmesi ile başlayan bir süreçtir. Hurdanın eritilmesi ile elde edilen sıvı çelikten istenilen kalitede demir üretebilmek için elde edilen sıvı çeliğin içinde bulunan alaşımların oranları büyük önem arz etmektedir. Çelik üretiminde, karbon oranını istenilen düzeye indirmek, mangan ve silisyum ve diğer kimyasalların oranlarını reçetede öngörülen değerlere düşürmek ve kükürdü mümkün olduğunca sıvı çelikten uzaklaştırmak gerekmektedir. Pota ocağına aktarılan sıvı çelik belirli aralıklarla analiz edilerek olması gereken oranlar elde edilene kadar kimyasal alaşımların ilavesi devam eder. Sıvı çeliğe ilave edilen kimyasal alaşımların hem maddi açıdan hem de kalite standartlarına uygun olması açısından eklendiği oranlar olması gerekenden eksik yada fazla olmaması gerekmektedir. Çünkü bahsedilen alaşımlar dolar ile alınan ve uzun vadeye yayıldığında ciddi maliyet kalemleridir. O nedenle oranların çok doğru bir şekilde ayarlanması gerekmektedir.Tüm bu metalurjik süreçler karmaşık, çok değişkenli sistemlerdir. Yapılan incelemelere bakıldığında pota ocağındaki sıvı çeliğe eklenecek olan alaşımların (FeSiMnPOTP, AltelPOTP, GrnKrbnPOTP, FeMnOrtCPOTP, KirecPOTP, FeSiPOTP, AlPOTP, FlşptPOTP vb.) olması gereken kalite standartlarına uygun hale gelmesi için bir dökümde ortalama 4 defa prova yapılır iken bu işlemin en az 2 ve en fazla 6 defa tekrarlandığı görülmektedir. Pota ocağındaki sıvı çelikten numune alınması, alınan numunenin kimyasal analize gönderilmesi, kimyasal analiz sonucunun gelmesi ve istenilen kalite standartlarına uygun oranlar elde edilmedi ise bu süreçlerin tekrarlanması ortalama 45dk'yı bulabilmektir. Bu süreler ciddi zaman kaybına neden olmaktadır. Bu nedenle bir sonraki dökümün zamanı planlanan süreden daha geç başlanmak zorunda kalınmaktadır. Buda daha sonraki proseslerin (sıvı çeliğin sürekli dökümlerde kalıplara dökülmesi, haddehanede şekillendirilmesi, kalte testlerinden geçmesi vb.) gecikmesine neden olmaktadır. Günümüzde teknolojinin ilerlemesi ile birlikte yapay zekanın demir çelik sektöründe de kullanılması prova sayılarını en aza indirerek maddi ve zamansal iş gücü kaybını en aza indirmek zorunlu bir yaklaşım olacaktır.**

Anahtar Kelimeler*— Pota ocağı; Sıvı çelik; Yapay zeka.

***Abstract*—Iron production in the iron and steel industry is a process that starts with the melting of scrap in electric arc furnaces or iron ore in basic oxygen furnaces. The proportions of the alloys in the liquid steel obtained from the liquid steel obtained by melting scrap are of great importance in order to produce the desired quality iron. In steel production, it is necessary to reduce the carbon rate to the desired level, to reduce the proportions of manganese, silicon and other chemicals to the values prescribed in the prescription, and to remove sulfur from liquid steel as much as possible. Therefore, alloys are added (FeSiMnPOTP, AltelPOTP, GrnKrbnPOTP, FeMnOrtCPOTP, KirecPOTP, FeSiPOTP, AlPOTP, FlşptPOTP etc.). Each alloy added has a chemical that acts. For example; If it is desired to change the aluminum ratio of liquid steel, AltelPOTP alloy is added. In the analysis results, it is observed that the aluminum ratios have changed. The liquid steel transferred to the ladle furnace is analyzed at certain intervals and the addition of chemical alloys continues until the required ratios are obtained. Chemical alloys added to liquid steel should not be less or more than they should be, in terms of both material and quality standards. Because the mentioned alloys are serious cost items when purchased in dollars and spread over a long term. For this reason, the rates should be adjusted very accurately. All these metallurgical processes are complex, multivariate systems. Looking at the examinations made, it is seen that while the alloys to be added to the liquid steel in the ladle furnace are rehearsed for an average of 4 times in a casting, this process is repeated at least 2 and at most 6 times. Taking samples from the liquid steel in the ladle furnace, sending the sample for chemical analysis, obtaining the result of chemical analysis and repeating these processes if the desired quality standards are not obtained, the average time is 45 minutes. These periods cause serious waste of time. For this reason, the time of the next casting has to be started later than the planned time. This causes delay in the subsequent processes (pouring liquid steel into molds in continuous casting, forming in the rolling mill, passing through quality tests, etc.). Today, with the advancement of technology, the use of artificial intelligence in the iron and steel industry will be a mandatory approach to minimize the number of proofs and minimize the loss of material and temporal labor.**

Keywords—Crucible furnace; Liquid steel; Artificial intelligence.

I. INTRODUCTION

Iron production in the iron and steel industry is a process that starts with the melting of scrap in electric arc furnaces or iron ore in basic oxygen furnaces. In electric arc furnaces, scrap is melted by a graphite electrode. Then the liquid steel is transferred to the ladle furnace to set the steel grade required by the customer. In steel production, it is necessary to reduce the carbon rate to the desired level, to reduce the proportions of manganese, silicon and other chemicals to the values prescribed in the prescription and to remove sulfur from liquid steel as much as possible. The liquid steel transferred to the ladle furnace is analyzed periodically and the addition of chemical alloys continues until the required proportions are obtained. In the literature, there are systems that integrate artificial intelligence to increase processes and performance in different areas of steel production. For example, an ANN method has been applied to improve the model estimation ability for rolling force [1]. A long-term learning method using a neural network has been proposed to improve the accuracy of the rolling force estimation in the hot rolling mill [2]. Regarding the annealing process, a dynamic modeling method has been proposed for the quality control of a real large-scale continuous annealing process using a generalized scaling and pruning RBF neural network to create the required dynamic quality control model [3]. Regarding the decision to operate in iron production, a fuzzy-based SVM multi-classifier has been proposed to provide a more direct indicator for operators to check the hot metal silicon content of a BF [4]. There have been other studies about the use of artificial intelligence in the sintering process. A simulated annealing algorithm [5], an evolutionary algorithm, a particle swarm optimization (PSO) algorithm or an ant colony algorithm, etc. using intelligent optimum proportioning methods have been developed [6]. As a result, the added rates of chemical alloys added to liquid steel should not be less or more than they should be, in terms of both material and quality standards. Because the mentioned alloys are serious cost items when purchased in dollars and spread over a long term. For this reason, the rates must be adjusted very accurately. In the examinations made, it is seen that an average of 4 rehearsals were made in a casting. These periods cause serious waste of time. Therefore, the time of the next casting has to be started later than the planned time. Today, with the advancement of technology, the use of artificial intelligence in the iron and steel industry will be a mandatory approach to minimize the loss of material and temporal labor by minimizing the number of proofs.

II. MATERIALS AND METHODS

A. Production Processes

Liquid steel is poured into molds in continuous casting facilities, solidified in desired sizes and turned into semi-products, slab or billet.

The formed steel is sent to the rolling mill. Rolling is a metal forming process in which steel is passed through one or more rolls to reduce its thickness and make the thickness even.

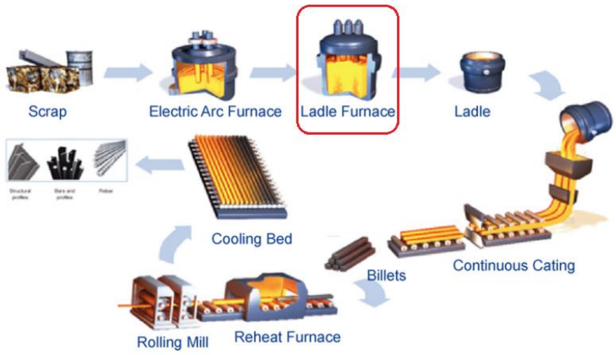

Figure 1. Production line flow chart

The proportions of chemicals in steel are very important for shaping and durability. While in the liquid steel ladle furnace, each alloy added has a chemical that acts. For example; If it is desired to change the aluminum ratio of liquid steel, AltelPOTP alloy is added. In the analysis results, it is observed that the aluminum ratios have changed. According to the examinations made, the alloys to be added to the liquid steel in the ladle furnace (FeSiMnPOTP, AltelPOTP, GrnKrbnPOTP, FeMnOrtCPOTP, KirecPOTP, FeSiPOTP, AlPOTP, FlşptPOTP, etc.) It is seen to be repeated up to 6 times. Taking samples from the liquid steel in the ladle furnace, sending the sample for chemical analysis, obtaining the chemical analysis result and obtaining the desired quality standards, repeating these processes is an average of 45 minutes. These periods cause serious waste of time. Therefore, the time of the next casting has to be started later than the planned time. This causes delay in subsequent processes (pouring liquid steel into molds in continuous casting, forming in the rolling mill, passing quality tests, etc.)

B. Production Line Analysis

In the examinations made in order to obtain the desired quality in each casting, it was seen that the analysis was made by rehearsing at least 2, at most 6 times. This is quite a lot of time for the steel mill process. The aim is to produce liquid steel of the desired quality as soon as possible and move on to the next casting. As a result of the analysis in the proofs made in a casting, the change rates of the chemical substances will be analyzed according to the amount of alloy added. There are 3 different processes in steel production;

- Low carbon,
- Medium carbon,
- High carbon steel production.

Carbon ratios are checked with chemical analysis. At the same time, other most important elements are Si (silicon) and Mn (manganese). The mechanical strength of steel depends on these elements. It is very important to have the silicon and manganese values at the required rate in order to pass the yield tensile tests successfully. Since P (phosphorus) increases the brittleness of steel, phosphorus should be at low values. In chemical analysis, the proportions of these elements are checked according to the alloys added and the rehearsals are continued until the ratio in the target quality is reached. In this study, the change graphs of the relevant elements according to the added alloys are based on.

In the process follow-up report, the total of alloys added to the total liquid steel in a casting is monitored in kg. In the process follow-up detail report, the changes of the elements affected as a result of the added alloys are monitored according to the proofs. In this report, there are analysis results of 4 proofs taken from a casting in order to achieve the desired ratios in a casting. The number of tons of solid steel obtained from liquid steel, how much of it consists of HBI (scrap type used) scrap, how many kilograms of alloys are used can be followed from the process follow-up report. The details of the effect of the alloys on which elements and at what rate are followed from the detail report. For example; If it is desired to play with Mn (manganese) value, FeMnOrtCPOTP is added to liquid steel. If you want to play with the Si (silicon) value, FeSiPOTP is added.

The change graph of the proportions of the elements according to the proofs in the process follow-up detail report is shown in Figure-2. In order to control the mechanical strength of the steel, the effect of different alloy values on the steel is controlled by equivalence values (copper, carbon, etc.). These values have formulas valid in the literature. According to those formulas, there are ranges where those values should be. As a result of the analysis, those intervals are also checked regularly. It is checked whether it is exceeded or not.

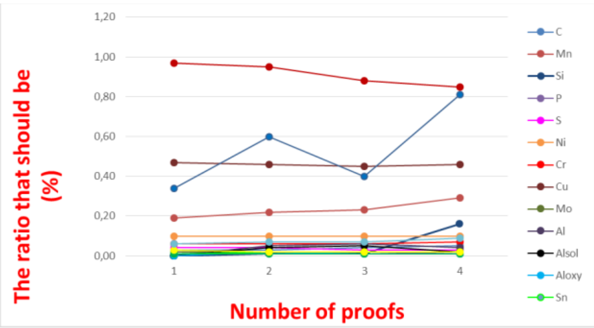

Figure 2. The change graph of the elements after the proofs according to the added alloys

The change graph of the proportions of the Mn (manganese) element according to the added alloys according to the proofs is shown in Figure-3.

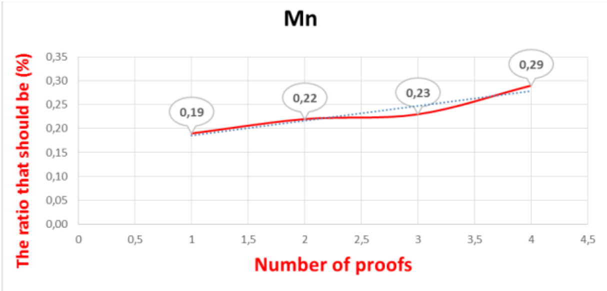

Figure 3. Graph of change of element Mn

The change graph of the proportions of the Si (silicon) element according to the added alloys according to the proofs is shown in Figure-4.

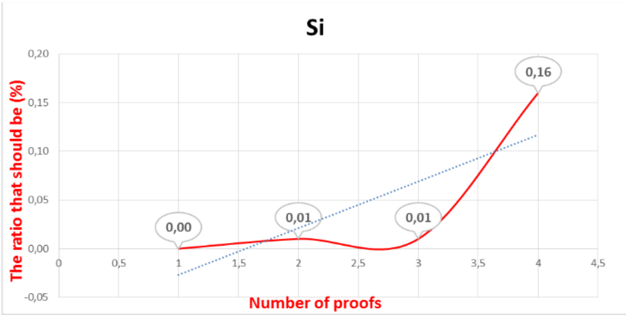

Figure 4. Graph of change of element Si

The change graph of the proportions of the Al (aluminum) element according to the added alloys according to the proofs is shown in Figure-5.

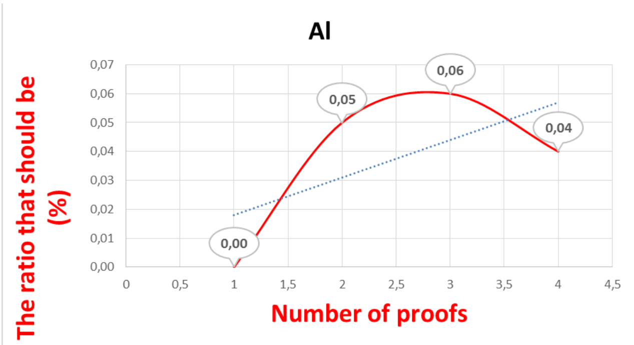

Figure 5. Graph of change of element Al

III. Results and Discussion

In this study, the first step is to estimate which elements are required with appropriate artificial intelligence algorithms according to the results in the first proof so that the liquid steel obtained by the melting of scraps in electric arc furnaces is in accordance with the desired reticle. Thus, steel of the desired quality can be produced in a single proof. In the second stage, a system will be designed to estimate the result of the 1st trial according to the content of the scrap and the recipe. Thus, excessive use of alloys will be prevented. Thus, costs due to overuse will be reduced. At the same time, the number of proofs will be reduced. Thus, time will be gained. The total time taken for the liquid steel to reach the desired standard while in the ladle furnace will be minimized.

Consequently, two approaches will be appropriate for this study;

In the first approach, estimating which elements are required according to the results in the first proof with appropriate artificial intelligence algorithms. Thus, to be able to produce the desired quality steel with a proof.

The second approach is to design a system that will predict the outcome of the 1st trial according to the content of the scrap and the recipe.

Thus, the alloys will be used at the required proportions. Overuse will be prevented. Thus, costs due to overuse will be reduced. At the same time, the number of rehearsals up to 6 times will be reduced. Thus, time will be gained. The total time taken for the liquid steel to reach the desired standards while in the ladle furnace will be minimized.

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