Provide a Descriptor Model to Improve the Effect of FeO in Raw Pellets with Data Mining Approach

Proporcionar un modelo descriptor para mejorar el efecto de FeO en pellets crudos

Fornecer um modelo de descritor para melhorar o efeito do FeO em pelotas brutas

Recibido: 10 de mayo de 2018. Aceptado: 11 de junio de 2018

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Abstract

Data mining is extraction the knowledge from a wide range of data. In this study, data mining is used to analyze a production system in the Golgohar Sirjan Company. The collected data is saved in the Excel file and then data cleaning and data preparation operations were done in order to use in the IBM SPSS Modeler software. FeO is one of the controlling parametersduring the production of the pellet. In this study, the classification method of C & R Tree is used to predict the effect of FeO in the raw pellet against 10 input variables included SiO2, Fetot, CaO, S, Al2O3, Mgo, P, Fe2O3, C.C.S, Temp (dry temperature). The variables that create the most sensitivity on the FeO in the raw pellet are evaluated and compared according to the accuracy of the models and also, practical suggestions are presented for the directors of industry to improve the quality of pellet.

Keywords: FeO, pelletizing, the quality of pellet, classification models, data mining.

Resumen

La minería de datos es la extracción del conocimiento de una amplia gama de datos. En este estudio, la minería de datos se utiliza para analizar un sistema de producción en la empresa Golgohar Sirjan. Los datos recopilados se guardan en el archivo Excel y luego se realizaron las operaciones de limpieza y preparación de datos para utilizarlos en el software IBM SPSS Modeler. El FeO es uno de los parámetros de control durante la producción del pellet. En este estudio, el método de clasificación de C & R Tree se usa para predecir el efecto de FeO en el pellet sin procesar contra 10 variables de entrada incluidas SiO2, Fetot, CaO, S, Al2O3, Mgo, P, Fe2O3, CCS, Temp (seco). temperatura). Las variables que crean la mayor sensibilidad en el FeO en el pellet sin procesar se evalúan y comparan de acuerdo con la precisión de los modelos y, además, se presentan sugerencias prácticas para los directores de la industria para mejorar la calidad del pellet.

Palabras claves: FeO, peletización, la calidad del pellet, modelos de clasificación, minería de datos.

Resumo

A mineração de dados é extrair o conhecimento de uma ampla gama de dados. Neste estudo, a mineração de dados é usada para analisar um sistema de produção na Golgohar Sirjan Company. Os dados coletados são salvos no arquivo do Excel e, em seguida, as operações de limpeza de dados e preparação de dados foram feitas para serem usadas no software IBM SPSS Modeler. O FeO é um dos parâmetros de controle durante a produção do pellet. Neste estudo, o método de classificação de C & R Tree é usado para prever o efeito do FeO no pellet cru contra 10 variáveis de entrada, incluindo SiO2, Fetot, CaO, S, Al2O3, Mgo, P, Fe2O3, CCS, Temp temperatura). As variáveis que criam mais sensibilidade no FeO no pelete bruto são avaliadas e comparadas de acordo com a precisão dos modelos e também, sugestões práticas são apresentadas para os diretores da indústria para melhorar a qualidade do pellet.

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Palavras-chave: FeO, pelotização, qualidade de pelotas, modelos de classificação, mineração de dados.

1- Introduction

In the industry of extraction and in the processing of iron ore, blast furnace should have the necessary permeability for the gas to flow uniformly and at high speed. The concentrate of iron ore produced in powder form is not suitable because it is compressed in vacant spaces and forms penetrating surfaces. Also, iron ore particles always come out in the form of dust with exhaust gases. Therefore, iron ore concentrate powder should be changed to larger agglomerates to increase the permeability of the furnace bed and to reduce the output of the furnace in the form of dust decreases. The most common method is agglomeration of pelletizing, which involves the production of raw pellet from iron ore concentrate powder and heating at high temperatures to harden and achieve optimal properties (Eisele T.C. & Kawatra S. K 2003). FeO is one of the main criteria for pellet in the blast furnace for metallurgical processes. Pellets with low FeO cannot tolerate the load of the blast furnace. The results show that increasing the production of fine particles reduces the permeability and high FeO causes the better pellet behavior in the furnace. The improvement of the FeO of the pellet reduces the production of fine particles during recovery and increases the production of iron production units. Many attempts have been made to model pellet production in order to predict the quality of the pellets. Complex mechanisms have been developed to establish strength, but none of them has been used from the numerical method (Perzyk et al., 2013 & Dalkilic 2009). To model these complex systems, the CART classification model is an appropriate technique. The model has the capability to obtain non-linear and complex relationships between the input and output parameters of the process. This model is a computational method and does not require prior knowledge of the modeling process. In this study, the relationship between FeO and ten process variables was investigated for predicting FeO using CART classification model and a predictive model was presented. To test the model, many data were obtained from an industrial unit.

2- Literature review

In 1989 and 1991, workshops of discovery of knowledge from databases were held by Piatetsky and his colleagues, and between 1991 and 1994, the workshops were held by Fayyad and Piatetsky and others. Formally, the term data mining was first introduced by Fayyaz at the first international conference "knowledge discovery and data mining" in 1995 and established a scientific organization named ACM-SIGKD (Nezhad 2009). The complexity of heat transfers and mass transfer along with solid-solid and solid-gas reactions and the burning process all make pelletizing modeling very difficult. Butteran (1986) stated a formulation that predicted compressive strength using a decreasing core model. He also extracted the relationship between contraction and strength (Das, S 2009).

3- Concept of data mining

Data mining is the extraction of information and knowledge and the discovery of hidden patterns from a very large database, in which these patterns and knowledge are usually hidden in data (Chan, C & Lewis, B 2002). Data mining can be used to perform tasks such as classification, prediction, estimation, clustering of data. To do this works, techniques have been developed that, with the development of computers and this science, on the number and quality of this techniques are added every day. Some the most famous of these techniques are clustering algorithms, neural networks, genetic algorithms, nearest neighboring, and decision trees.

5. Data mining techniques:

Classification is one of the most popular methods used by statisticians and machine-learning researchers.
According to the general definition, the technology of classification, separation, or placement of components or objects in a number of classes that exist in the classification of these classes, and objects based on their characteristics are placed in these classes (Tan, P & Steinbach, M 2006).

4- The process of raw pelletizing

Production Iron ore Oxide Pellets from Iron Ore Particles include various operations such as drying to remove moisture and melting to reach the proper gradation.

After mixing powdered iron ore with other additives such as lime, sludge and iron ore slurry, raw pellets are produced using pelletizing discs. In this area, there are 9 discs with the same characters. The dough produced in the dough area is transmitted by the conveyors to the tanks on the discs. The dough in the disk is converted to the form of pellets called raw pellets due to circulating discs and under various parameters. This part includes the following systems.

- A Plough Scraper (a device is placed on each conveyorsto direct the mixed material into the disc tanks and is in the form of a tip of the arrow and moves downward or upwards by the motor).
- A storage tank for mixed materials
- A feeder pours a certain amount of material into the disk with the control system.
- A feeding chute with a fluffer (By fluffer the lump-shaped material and returned pelletsthrown in the disk with rotational motion)
- A rotating risk to produce the pellet
- A water spray system
- A reciprocating conveyor (http://geg.ir/Modules/CMS/CMSPages/ShowPage.aspx?MItemID=vneHvjik.).

5- Methodology

6-1 Investigation of the relationship between input variables with FeO

First, the relationship between input variables and FeO was investigated. Using linear models as shown in figure 2, this relation has a very low linear correlation coefficient that is not suitable for this situation, therefore, the CART classification model, which is very capable in modeling nonlinear and complex relationships, has used (Berry, M. & Berry G. 2006).

Table 1 Investigation of the relationship between input variables with FeO

Term	coef	SE coef	T	p
constant	5.5920	6.48056	0.8629	0.389
c.c.s(kg/p)	-0.0038	0.00168	-2.235	0.026
fetot(%)	-0.0565	0.09535	-0.592	0.554
p(%)	14.6817	5.63649	2.6048	0.010
s(%)	5.5211	9.12934	0.6048	0.546
sio2(%)	-0.3962	0.17236	-2.299	0.023
Al2o3(%)	1.8057	0.94459	1.9116	0.057
cao(%)	-0.4107	0.37025	-1.109	0.269
mgo(%)	-0.2459	0.1257	-1.957	0.052
Fe2o3(%)	-0.2365	0.1211	-1.94	0.045
temp. °C	1.7053	0.32236	1.8115	0.046
summary of model				
S = 0.323391 R-Sq = 11.74% R-Sq(adj) = 8.28%				
PRESS = 23.2294 R-Sq(pred) = 3.90%				

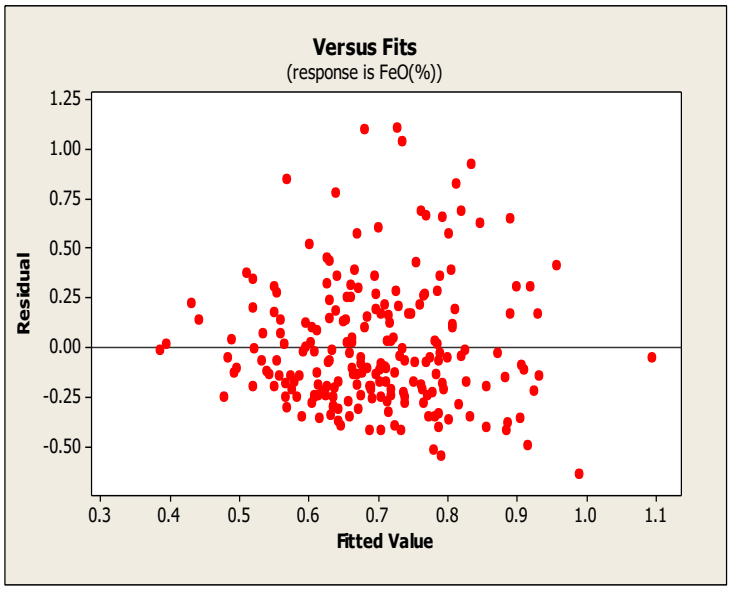


Figure 1 Forward selection

6-2- CART classification model

In the SPSS Modeler IBM software, the CART model was used for this research which is the most advanced and most used tool in the field of data mining. Designing user interface of this software has caused that the users communicate with the software easily. In order to understand the dominant parameters that have the greatest effect on FeO in raw pellet, the CART model was developed.

6-3- Assessment of the model

According to the operational experience, the variables in the table 1 were selected (V. Niiniskorpi: 2002). In order to model the operational data, 213 data were selected according to data that have been achieved in the stable operating mode and after normalization of data and identification of outlier data.

Results for output field FeO(%)

Comparing $R-FeO(%) with FeO(%)

Minimum Error	-0.585
Maximum Error	0.975
Mean Error	-0.0
Mean Absolute Error	0.183
Standard Deviation	0.25
Linear Correlation	0.674
Occurrences	213

Table 2. Analysis of Mean Absolute Error

6-4-Results of CART model for FeO (%)

The mean absolute error (MAE) is 0.183% of the prediction of FeO.

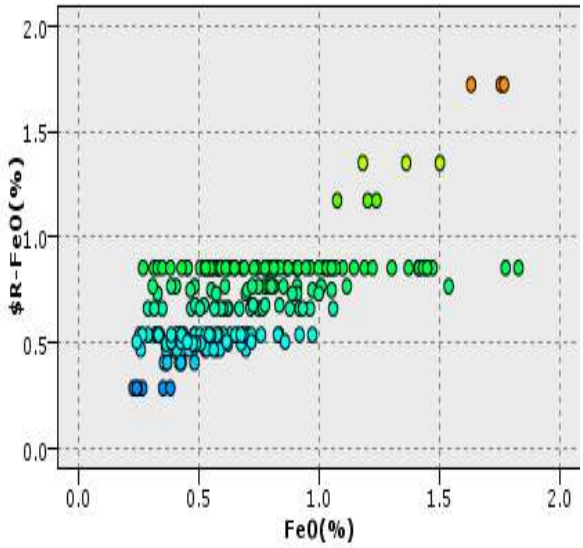


Figure 3 Results from testing the CART model for FeO

6-5- The effect of the input variables on FeO

The effect of the input variables on FeO is studied for all input variables that have been shown in figure 3. As it can be observed in Figure 3, the variable of Fe2O3 in the raw pellet has the most important in FeO.

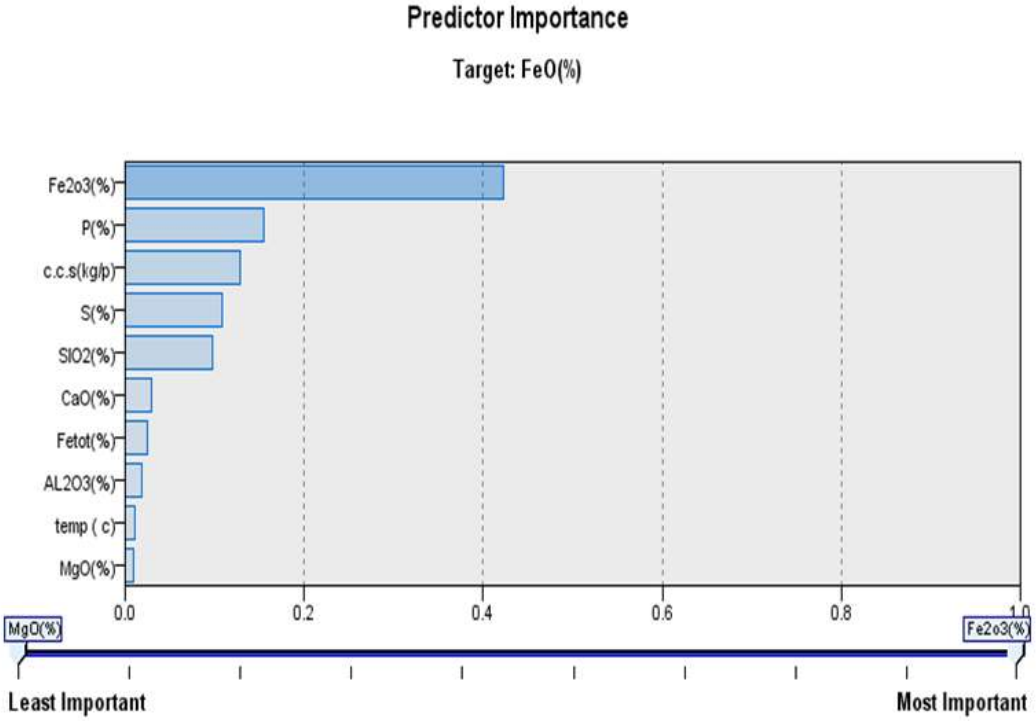
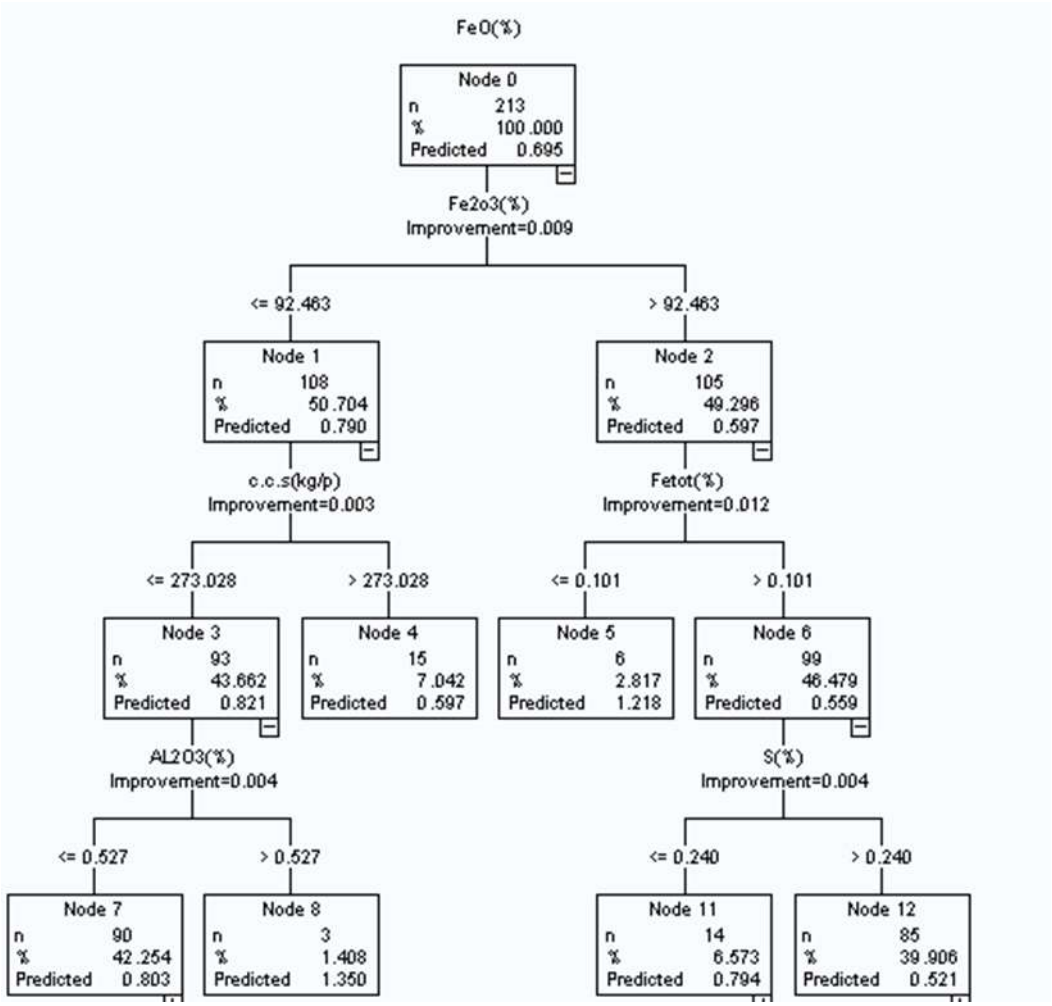


Figure 4. The importance of input variables

6-6- Tree Analysis



6-6-1-The results of tree analysis

In the created model, Fe2O3is placed in the root of tree because of its importance. The predicted mean of all 213 data is equal with 0. 695.After that, two main branches have been created that effect of reduction of Fe2O3 have been calculated in one of branches and effect of increasing of Fe2O3 have been calculated in another branch. Since Fe2O3 has a direct relation with the improvement of oxide iron of pellet, the increase and reduction in raw pellet is considered as an effective factor. So if Fe2o3 is more than 92.46, the number of classified data in this section is 105 data that is equal with 49.29% of the total available data with an average improvement of 0.59%. An important factor, which affects the improvement of Feo's raw pellet, is Fetot. In this case, the tree again is split into two sub-branches. If Fetot is more than 0.1, which contains 99 data, that is, 46.47% of all data, the mean prediction value is 0.55%, and in the next branch if the Fetot is less than 0.1, which contains 6 data, about 2.81% of the total data, the mean prediction value is 1.21%.Since the greatest improvement in the Feo of the raw pellet in this branch is the same number, this branch is cut off here. But if the Fe2o3 is less or equal to 92.46, with 108 data that contains 50.7% of the total data, the mean prediction value is 0.79%, that C.C.S is the effective factor on Feo in this section. If the CCS is more than 273, the improvement would be 0.59%, and if it is less than this amount, the improvement amount would reach 0.82%, in which case AL2O3 would be an effective factor on FeO. If the amount of aluminum oxide is more than 0.52, the improvement amount would be 1.35% and if the amount of aluminum oxide is less than 0.52, the improvement amount would be 0.803%.

6. Conclusion

7.1. Quantitative Conclusion

The prediction of the effect of Feo in raw pellets by the CART model can be used as an effective tool in the industry and also for world-class training.

The results of the analytical analysis are as follows:

1. The increase in C.C.S (cold crushing strength) causes the reduction in the amount of FeO of the raw pellet.
2. Increasing Fetot reduces the amount of FeO of the raw pellet.
3. Reducing S causes the increase in the amount of FeO of the raw pellet.
4. The increase in the amount of Al2O3 causes the increase in the amount of FeO of the raw pellet.
5. The reduction in the amount of Fe2O3increases the amount of FeO of the raw pellet.

7.2 Conceptual Conclusion

In this study, the model of CART is used according to data and the analyses show that mean absolute error equals 0.18 percent. The output audit data, the difference between the minimum and the maximum amount ofmean error and also the standard deviation between the output of the model and the real output show that there is less difference compared to other models used in this study.

Therefore, based on this model, the factor of Fe2O3is the effective factor in the improvement of FeO in the raw pellet and the other effective parameters are P,C.C.S,S,Sio2, respectively.

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