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Ranking and comparing of traditional and industrial coke making by TOPSIS technique in Shahrood Simin Coke Company

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Abstract

Various traditional and industrial coke making techniques were discussed based on their limitations and production capacities, and the criteria such as the quality and size of coke production, amount of coke crumb, amount of investment, amount of operational costs, labor force and mechanization. In this work, the rankings of various traditional and industrial coke making techniques were carried out using a multi-criteria decision making with technique for order preference by similarity to ideal solution (TOPSIS), in which, at first, industrial heat recovery coke oven, by product coke oven and non-recovery coke oven and then traditional bee-hive coke making was performed in Shahrood Simin Coke Company. The designed oven decreased both the environmental pollution and the amount of coke crumb, and increased the coke production and coke recovery qualities.

Keywords: *Coke Making, Decision Making, Traditional and Industrial Ovens*.

1. Introduction

It is believed that the coke-making history dates back to the thirteenth century in England. At that time, coal in fairly large sizes would be heated in particular ovens named black smith, and the semi-coal produced was rather large as well. Semi-coke would produce more heat than wood coal, and it would be applied for melting ironed minerals in ovens. Since the discovery of iron to the middle of the century, iron used to be obtained by wood coal. In 1841, coke was substituted for wood coal and anthracite, and was considered as an important fuel in the iron and steel industry worldwide [1].

In the past, the coke produced used to be obtained in the same way that wood coal is obtained now. In this method, coal is gathered like a pile, and then fired. In this case, a thin layer is burned but inside the pile is fairly carbonized. There is no control on this process, and the coke produced is not as good as the today's coke. For increasing the quality of the products, bricks are put under the pile to remove the gas produced around the bricks. In the eighteenth century, bee-hive ovens were used, and, in this system, the time required to heat all parts of the coal was about two days [2].

Not all kinds of coals could be used in such ovens. Based on experience, a vertical layer of coal with a thickness of 15-30 cm could be carbonized in less than 24 hours. In such an oven, coal enters from the top. Then it is heated and changed into coke, and finally gathered at the bottom. The hot coke becomes cool by air and, in some cases, by water first, and then it is broken into small sizes [3].

Based on Diez et al. 2001, studying some coal types and metallurgical coke qualities has been carried out [4]. In 2004, Magrita Segers expanded the researches regarding the non-recovery ovens [5]. In 2006, Loha reviewed the coke-making process carried out by the non-recovery method in India [6]. In 2010, Manjo Sharma published an introduction on coke production in the Tata India Steel Company [7]. In 2011, the American Sun-Coke company built the first coke-making unit by the heat recovery method in the Indiana city; regarding this, John F Quanci published a report on his investigation [8]. In 2012, a comparison was made by Pauls Towsey et al. between the by-product coke ovens and the recovery ovens [9]. In another case, Tivari et al. proposed a new way to evaluate the mixed coal to see if it could be changed to coke for use in the non-recovery ovens [10].

For the purpose of ranking various coke-making methods, the TOPSIS method has been applied. TOPSIS is one of the multi-evaluation decision-making methods, which has been presented by Tuan and Howang in 1981. Two concepts, ideal solution and similarity to ideal solution, taken from the math rules, were used in this method. The results obtained from the application of this method is quantified, and it both identifies the top case and expresses the ranking of other cases in digit. [11].

1.1. Coke applications

Coke is a solid mass that is obtained from cook coal which is destroyed at 850-1050 ^{o}C in the absence of oxygen. This process is called “cooling” as well, in which some materials are released in the gas form, and then a black and hard material is produced, referred to as coke. Coke is produced by carbon and hydrogen in the presence of oxygen, nitrogen, and sulfur [2]. The most significant application of coke is in a high temperature oven, which is used to produce melted raw iron. Coke is used in the mould industry and Koopl ovens as well. It is also used in other fields such as gas generators, electrode and carbid calcium production, steam pots, building heaters, and as a basic material in the chemical industries [1].

Based on the fact that about 922 million tons of steel are produced a year by the high temperature oven technique, the restoration substances are required to restore iron ore and subsequently melting it. In 2007, 5600 million tons of coal were produced worldwide, and 906 million tons were exported to various areas around the world, 306 million tons of which composed of coking coal. Moreover, 202 million tons of it were exported by the see. China has produced 2523 million tons of coal annually. The total amount of coke that can be produced annually worldwide is estimated to be about 750 million tons.

Three countries including Australia, USA, and Canada, by exporting 138, 26, and 25 million tons of coke annually, have been ranked from the top. To the contrary, countries including Japan, EU, India, and South Korea are the biggest coal importers by 50.2, 64, 23, and 21 million tons a year. Regarding the increased cost iron production in China, pure coal export with a rate of 83 million tons in 2003 decreased by 2 million tons in 2007 [6].

The total amount of coke exported worldwide last year was 31 million tons. China has reached the first place by exporting 15.3 million tons a year, and Poland has the second place by the annual export of 6.43 million tons. 25 million tons of coke was exported annually by the sea, and 6 million tons by land. It should be noted that in high temperature ovens in Germany, 351 kg coke, 107 kg coal puree, and 20 kg mazut are applied for the production of one ton of cost iron. In this situation, Germany has annually imported 4.13 million tons of coke and 10.3 million tons of cokeable coal. The German coke raw materials were provided by Poland (34.5%), Spain (21.7%), France (19.1%), China (17.6%), and some other countries. Iran has imported 6 million tons of coking coal and coke from Australia and 25 million tons from China. In 2007, 3006 million tons of raw materials were exported around the world by the sea, 1566 million tons of which were related to the steel industry applications [4].

2. Traditional coke making ovens

Coke-making ovens can generally be divided into the traditional and industrial ones.

2.1. Mazghali ovens

Mazghali ovens were used in the 16th century. At the beginning, such ovens, similar to producing wood coals, used to be built in pits in the way that the ground would be dug out and the inside would be filled by coking coal and then would be fired. After finishing the flames, the reminder was used as coke. After this kind of oven, tunnel ovens were built. Because of the unsuitable coke production, the Mazghali ovens were built. In Iran, this type of oven was probably built before 1340s in Qazvin. For the first time, this kind of oven was called Mazghali in Iran due to chimneys and tunnels on the coal inside the oven. Figure 1 shows a Mazghali oven [12].

2.2. Bee-hive ovens

Bee-hive ovens were built in Iran after the Mazghali ovens because of quality of produced coke. However, it was not applied anymore because of its building difficulty as well as its high cost production. This type of oven was used in 1340s by the Mashhad cement company for the need for coke, which was produced in the Gheshlagh coal mine. A comparison between the Mazghli and bee-hive ovens is presented in Table 1 [13]. Figure 2 shows a Bee-hive oven.

Figure1. A view of Mazghali oven ready to use [12].

Figure2. Bee-hive oven ready to discharge [13].

3. Industrial coke-making ovens

3.1. By-product ovens

In today's ovens, the gas products are completely separated from the load. These ovens, called the coke-making cells are 12-15 m in length, 3.5-5 m in height, and 40-60 cm in width. The complete series of the cells is named coke-making battery, which is represented in Figure 3. The cell container is trapezoid, in which a piston from the less width side sends the coke out of the more width side. [14-16].

Table 1. Comparison between Mazghali and bee-hive ovens.

Oven type / Criteria	Mazghali	bee-hive
Practical efficiency	60-70%	65-70%
Investment	Low	Average
Regular expenses	High	Low
Labor force	Average	Average
Mechanization capability	Very low	Low
Produced coke quality	Average	High
Pollution	Very high	Average
Produced coke sizes	Big	Suitable
Coke crumb	High	Low

3.2. Non-recovery ovens

As mentioned earlier, this kind of oven was used many years ago. After creation of the cell ovens, they were applied because of their simple structure and low cost. A number of companies used this technology to produce coke. As an example, JSW Co. in India exclusively owns the sizes as well as constructing methods of such ovens. To reach a better understanding of the oven building process by JSW Co., their technical features have been investigated [7].

Figure 4 represents the coke production stages, and shows a view of a non-recovery oven activated by the vibro-compacting method.

Figure 3. A view of a coke-making battery [15].

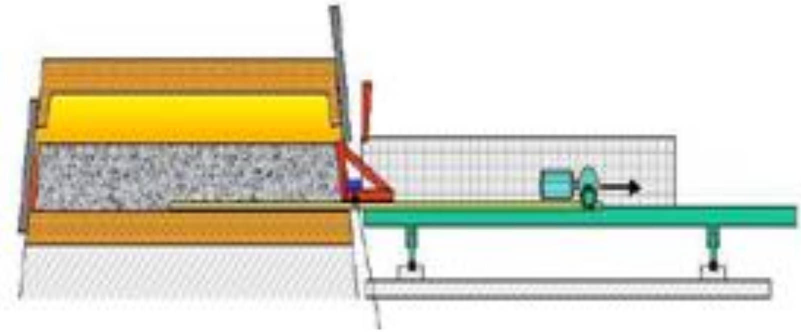

Figure 4. A view of a non-recovery oven activated by vibro compacting method [7].

3.3. Heat recovery ovens

This kind of coke-making oven is the newest one, a large number of which has been built in the USA. The most professional company that builds such ovens is the American sun-coke Co. In 1960, this company structured the first horizontal heat recovery oven, and then, later in 1970, presented a more modern model. In 1980, the company carried out investigations on the coke-making model to produce a more suitable coke in the USA. In 1990, the first coke-making unit was built in Indiana, USA. It was the first coke-making unit built worldwide based on the heat recovery method. Figure 5 presents a view of the sun-coke coke-making Co. in the Indiana city. Until 2008, the company built 562 ovens by this method in the Middletown and Haverhill states.

Figure 5. A view of sun-coke coke-making Company in Indiana, US [8].

3.4. Comparing industrial ovens

A general comparison is presented between the industrial coke-making ovens in Table 2. According to this table, the most efficient oven is the heat-recovery one. Considering the produced coke sizes, the by-product and heat recovery ovens are more suitable because of the charging type and coke-making process; also they are low-cost to be granulated. The mechanization capability is in direct relation to all parameters. This means that the more mechanization capability is the lower expense one, and accordingly, the quality is higher and coke crumbs are lower [14].

Table 2. A comparison between industrial coke-making ovens.

Oven type Criteria	by-product	non-recovery	heat recovery
Practical efficiency	68-75%	65-75%	75-78%
Investment	Very high	High	High
Regular expenses	High	High	High
Labor force	Low	Average	Low
Mechanization capability	Very high	High	Very high
Produced coke quality	Very suitable	Suitable	Very suitable
Pollution	Very low	Low	Very low
Produced coke sizes	Very suitable	Fairy suitable	Very suitable
Coke crumb	Very low	Low	Very low

4. Decision-making method of multi-criterion TOPSIS

If there are n criteria and m cases in a multi-criterion problem, to choose the best case by the TOPSIS method, seven steps exist, as follow [11].

4.1. Decision matrix formation

Considering the number of criteria and options, and evaluating all options for the various criteria, the decision matrix is formed as follows:

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \tag{1}$$

in which, x has been resulted from the option i (1, 2 … m) in relation to the criterion j (1=1, 2,…, m).

4.2. Decision matrix scaleless

At this stage, there is an attempt to change the criteria having various dimensions to the dimensionless criteria. The matrix R is defined as follows:

$$R = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix} \tag{2}$$

There are several ways to scaleless but TOPSIS uses the following relation:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{3}$$

4.3. Vector identification of criteria weight

At this stage, being based upon the effects of various criteria on decision, the criteria weight vector is analyzed as stated below, in which the vector elements are the related criteria significance.

4.4. Identification of weight unscaled decision matrix

The weight unscaled decision matrix is obtained using the multiple of the scaled decision matrix and criteria weight vector:

$$v_{ij} = w_i r_{ij} \quad j = 1, \dots, n\,; i = 1, \dots, m \tag{4}$$

4.5. Ideal and anti-ideal discovery

If the ideal solution is shown by A* and the anti-ideal solution by A-, we will have:

$$A^* = \{v_1^*, v_2^*, \dots, v_j^*, \dots, v_n^*\} \tag{5}$$

$$A^- = \{v_1^-, v_2^-, \dots, v_j^-, \dots, v_n^-\} \tag{6}$$

In this case, v*j is the best criterion amount of j, and v*j is the worst criterion amount of the whole options.

The options located in A^* and A^- represent the best and worst options, respectively.

4.6. Distance calculation by ideal and anti-ideal solutions

At this stage, for each distance option from the ideal and anti-ideal solutions, the following relations were analyzed:

$$S_i^* = \sqrt{\sum_{j=1}^{n} \left(V_{ij} - V_j^*\right)^2} \tag{7}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} \left(V_{ij} - V_j^-\right)^2} \tag{8}$$

In these relations, the j index represents the interested criterion, and the I index represents the interested option.

4.7. Similarity index calculation

At the last stage, the similarity index is calculated using the following formula:

$$C_i^* = \frac{S_i^-}{S_i^* + S_i^-} \tag{9}$$

The amount of similarity index is changeable between 1 and 0. When the interested option is more similar to ideal, the amount of similarity index is closer to one. Thus ranking the options is based upon the amount of similarity index. The one with the highest similarity index is placed first, and the one with the lowest similarity index is the last.

5. Ranking industrial and traditional coke-making methods

5.1. Decision matrix organization

The decision matrix was represented in Table 3. The C1- C16 criteria include the practical efficiency, amount of investment, regular expenses, the required labor force, rate of mechanization, produced coke quality, pollution, produced coke sizes, amount of remained coke crumbs, percentage of the volatile matter, self-burning of the coke inside the oven, time of being in the oven, the added ash to the coke, flexibility in choosing the entering coal, and heat recovery capability. The elements C2, C3, C4, C7, C8, C9, C10, C11, and C12 are negative, and C1, C5, C6, C14, C15, and C16 are positive. The options A1 and A5 include the Mazghali, bee-hive, by-product, non-recovery, and heat recovery ovens.

5.2. Quantifying decision matrix

According to the positive and negative criteria, the decision matrix was quantified in Table 4.

5.3. Deforming decision matrix

To deform the decision matrix, the following formula is applied. Thus for the first option, we have:

$$r_{11} = \frac{65}{\sqrt{65^2 + 67.5^2 + 71.5^2 + 70^2 + 76.5^2}} = 0.414040036 \tag{10}$$

For the other parameters, we use of this method, and the results obtained are shown in Table 5.

5.4. Weighting decision matrix

Interviewing three experts (a university faculty member, a 25-year experienced person in coke-making, and a 10-year experienced person), the researcher obtained the weights of the elements as are shown in Table 6. The weighted deformed matrix is obtained in Table 7.

Table 3. Decision matrix organization.

C4	C3	C2	C1	
Average-high	Average-high	Average	60-70%	**A1**
Average	Low	Average	65-70%	**A2**
Low	High	High	68-75%	**A3**
Average	High	Average	65-75%	**A4**
Low	High	High	75-78%	**A5**

C8	C7	C6	C5	
Very big	Very high	Low	Very low	**A1**
Average	High	High	low	**A2**
Good	Very low	High	Very high	**A3**
Average	Low	High	Very high	**A4**
Good	Very low	Very high	Very high	**A5**

C12	C11	C10	C9	
312	Average	Low	Very high	**A1**
24	Average	Very low	Low	**A2**
18	Very low	Very low	Very low	**A3**
48	Very low	Very low	low	**A4**
48	Very low	Very low	Very low	**A5**

C16	C15	C14	C13	
Very low	Very low	Very low	High	**A1**
Very low	Low	Low	Very low	**A2**
Very high	High	Low	Very low	**A3**
Very low	Average	Low	Very low	**A4**

Table 4. Quantifying decision matrix.

C4	C3	C2	C1	
4	4	5	65	**A1**
5	7	5	67.5	**A2**
7	3	3	71.5	**A3**
5	3	5	70	**A4**
7	3	3	76.5	**A5**

C8	C7	C6	C5	
1	1	3	1	**A1**
5	3	7	3	**A2**
7	9	7	9	**A3**
5	7	7	9	**A4**
7	9	9	9	**A5**

C12	C11	C10	C9	
312	5	7	1	**A1**
24	5	9	7	**A2**
18	9	9	9	**A3**
48	9	9	7	**A4**
48	9484	9	9	**A5**

C16	C15	C14	C13	
1	1	1	3	**A1**
1	3	3	9	**A2**
9	7	3	9	**A3**
1	5	3	9	**A4**
1	9	9	9	**A5**

Table 5. Deforming decision matrix.

C4	C3	C2	C1	
0.31235	0.41703	0.51864	0.41404	**A1**
0.39143	0.72980	0.51848	0.42996	**A2**
0.54661	0.31277	0.31109	0.45544	**A3**
0.39043	0.31277	0.51848	0.44589	**A4**
0.54661	0.31277	0.31109	0.48729	**A5**

C8	C7	C6	C5	
0.08192	0.06727	0.19487	0.06287	**A1**
0.40962	0.20180	0.45470	0.18861	**A2**
0.57346	0.60541	0.45470	0.56583	**A3**
0.40962	0.47087	0.45470	0.56583	**A4**
0.57346	0.60541	0.58461	0.56583	**A5**

C12	C11	C10	C9	
0.97286	0.29210	0.36245	0.06190	**A1**
0.07484	0.29210	0.46600	0.43329	**A2**
0.05613	0.52579	0.46600	0.55709	**A3**
0.14967	0.52579	0.46600	0.43329	**A4**
0.14967	0.52579	0.46600	0.55709	**A5**

C16	C15	C14	C13	
0.10847	0.07785	0.09587	0.16440	**A1**
0.10847	0.23355	0.28735	0.49320	**A2**
0.97619	0.54495	0.28735	0.49320	**A3**
0.10847	0.38925	0.28735	0.49320	**A4**
0.10847	0.70065	0.86204	0.49320	**A5**

Table 6. Weight matrix.

C_1=0.11	C_2=0.04	C_3=0.06	C_4=0.05
C_5=0.07	C_6=0.135	C_7=0.35	C_8=0.085
C_9=0.08	C_{10}=0.03	C_{11}=0.04	C_{12}=0.02
C_{13}=0.03	C_{14}=0.135	C_{15}=0.05	C_{16}=0.03

Table 7. Weighted deformed matrix.

C4	C3	C2	C1	
0.01562	0.02502	0.02074	0.04554	**A1**
0.01952	0.04379	0.02074	0.04730	**A2**
0.02733	0.01877	0.01244	0.05010	**A3**
0.01952	0.01877	0.02074	0.04905	**A4**
0.02733	0.01877	0.01244	0.05360	**A5**

C8	C7	C6	C5	
0.00696	0.00235	0.02631	0.00440	**A1**
0.03482	0.00706	0.06138	0.01320	**A2**
0.04874	0.02119	0.06138	0.03961	**A3**
0.03482	0.01648	0.06138	0.03961	**A4**
0.04874	0.02119	0.07892	0.03961	**A5**

C12	C11	C10	C9	
0.01946	0.01168	0.01087	0.00495	**A1**
0.00150	0.01168	0.01398	0.03466	**A2**
0.00112	0.02103	0.01398	0.04457	**A3**
0.00299	0.02103	0.01398	0.03466	**A4**
0.00299	0.02103	0.01398	0.04457	**A5**

C16	C15	C14	C13	
0.00325	0.00389	0.01293	0.00493	**A1**
0.00325	0.01168	0.03879	0.01480	**A2**
0.02929	0.02725	0.03879	0.01480	**A3**
0.00325	0.01946	0.03879	0.01480	**A4**
0.00325	0.03503	0.11638	0.01480	**A5**

5.5. Discovering ideal and anti-ideal solutions

If the ideal solution is shown by A*, and the anti-ideal one by A^{-}, we have:

$\mathbf{A}^{+}$ = {0.05360, 0.01244, 0.01877, 0.01562, 0.03961, 0.07892, 0.00235, 0.00696, 0.004595, 0.01087, 0.01168, 0.00112, 0.00493, 0.11638, 0.03503 and 0.02929}

$\mathbf{A}^{-}$ = {0.04554, 0.02074, 0.04379, 0.02733, 0.00440, 0.02631, 0.02119, 0.04874, 0.04457, 0.01398, 0.02103, 0.01946, 0.01480, 0.01293, 0.00389 and 0.002325}

5.6. Ideal and anti-ideal solution distance calculations

According to the relationship between the Formulas 7 and 8 for the distance of the option A1 about the ideal solution, we have:

$$S_1^* = \sqrt{\begin{array}{c}(0.04554-0.05360)^2+(0.02074-0.01244)^2+\\(0.02502-0.01877)^2+(0.01562-0.01562)^2+\\(0.00440-0.03961)^2+(0.02631-0.07892)^2+\\(0.00235-0.00235)^2+(0.00696-0.00696)^2+\\(0.00493-0.00493)^2+(0.01087-0.01087)^2+\\(0.01168-0.01168)^2+(0.01946-0.00112)^2+\\(0.000493-0.00493)^2+(0.01293-0.11638)^2+\\(0.00389-0.03503)^2+(0.00325-0.02929)^2\end{array}} = 0.12987$$

Then for the other options in order we have:

$$s_2^* = 0.10385 \qquad s_3^* = 0.10199$$

$$s_4^* = 0.09699 \qquad s_5^* = 0.06843$$

Also the distance from the anti-ideal solution is based upon the following formulas:

$$s_1^- = 0.06598 \qquad s_2^- = 0.05480$$

$$s_3^- = 0.07358 \qquad s_4^- = 0.06831$$

$$s_5^- = 0.12926$$

5.7. Similarity index calculation

According to Formula 7 for the options, we have:

$$\mathrm{C}_1^* = 0.33690 \qquad \mathrm{C}_2^* = 0.34541$$

$$\mathrm{C}_3^* = 0.41909 \qquad \mathrm{C}_4^* = 0.41323$$

$$\mathrm{C}_5^* = 0.65387$$

Thus the option prioritization is like this:

$$A_5 > A_3 > A_4 > A_2 > A_1$$

Based on the achieved ranking, it can be observed that coke-making by the industrial methods is prioritized, and, in this case, the heat recovery coke-making has the first place with a significant difficulty from the others. For the time being, the only method that is allowed to be active in USA is heat recovery coke-making, and Sun-Coke Company has the first rank for designing and building such ovens. As it can be observed, the by-product and non-recovery methods are ranked with a small difference.

Nowadays, there is a rising tendency worldwide to recover heat from coal distillation rather than recovering gas, and the producing countries are more interested in using the energy produced by burning coal.

6. Case study: Shahrood Simin Coke Company

Shahrood Simin Coke Company started its activity in Iran in 2011 with the aim of industrialization of coke production. According to the demand for the production of metallurgical coke that is needed for the iron melting industry, and the fact that metallurgical coke is produced just in Isfahan by an industrial method, and by doing extensive research works, and with half of the technology used in coke-producing countries, this company has started building non-recovery industrial coke-making in a new and innovative way. Based on the modern technology being used around the world and applying expert staff, the Iranian coke-making ovens are built in the country, which are competing with other structures in the other countries well-known in this field [14].

Besides constructing such ovens, off-loading and oven charging machines which continuously perform charging and off-loading operation, are designed and have been employed. By the aim of this innovation, the off-loading and recharging of each oven in this company has been reduced to 15 minutes because the off-loading jack speed is high, and the doors are greatly mechanized [14].

6.1. Coke making process

The diagram of producing process (FPC) represents the production process and that is a picture of all the operations including production, transportation, burning, inspecting, and the delays that take place in the coke-making process are identified. The diagram is shown in Table 8 [14].

In this chart, the operation order is reduced by applying some signs including:

1 ≅ Operation

2 ≅ Inspecting (based on quality control that is done in a lab)

3 ≅ Transportation (transporting coal or coke to suitable places)

4 ≅ Delay (the time that coal or coke wait for an answer ofanalysis from the lab)

5 ≅ Barn (the place for storing the coals)

7. Conclusions

Based on the researchers, the following results can be mentioned. The non-recovery heat ovens and heat recovery ovens are more efficient than the other ovens. The non-recovery ovens and by-product coke-making ovens are mostly ranked like each other. For coke-making methods, rankings of some criteria were chosen including practical efficiency, amount of the investment, ongoing expenses, required labor force, amount of mechanization, produced coke quality, pollution and the produced coke sizes, the produced coke crumbs, percentage of related substances, self-burning of coke inside the oven, duration of coke staying in the oven, added ash to the coke, flexibility in choosing the entering coal, capability of heat and gas recovery comparing various coke-making methods, and ranking them in TOPSIS basis, it was observed that coke-making by the industrial methods are prioritized, while coke-making by the heat recovery method has the first place with significant differences.

The by-product and non-recovery methods are ranked with a small difference. They produced coke quality in Shahrood Simin Coke Co is definitely higher than the one produced by various traditional methods in which the mount of coke crumb and the produced ash on the coke are less, but produced coke mechanical resistance is higher that is led to more efficient coke-making process.

Table 8. Coke making process in Shahrood Simin Coke Company.

Descriptions	5 ▽	4 D	3 □	2 ⇨	1 ○	Time (min)	distance (m)	amount (ton)	Description
----------	●								Coal delivery from the barn
----------					●				Coal sampling
----------				●			200		Sample transferring to the lab
----------			●			240			Coal analyze investigation
----------				●			50		Coal transfer to be mixed
Mix is done on required rate					●				Coal mixture making
----------		●				30			Mixed damped
A time of coal every 5min					●		10		Mixed barning
24 h waiting for oven charging		●				1440			Burning to change ovens
----------				●		10	20	3	Transforming to off-loading machine
----------					●	3		3	Oven charging
Process duration is 48h					●	2880			Coke making
----------					●	0.5		2.25	Coke off-loading by jack
By Wet					●	30		2.25	Coke cooling
----------		●				20	30		Coke damped
Various coke usage			●			240			Coke analyze investigation
Based on analysis				●			40		Transferring to loading unit

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رتبه‌بندی و مقایسه روش‌های کک‌سازی سنتی و صنعتی توسط روش شباهت به گزینه ایده‌آل- مطالعه موردی شرکت سیمین کک شاهرود

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چکیده:

کک به عنوان ماده احیاء کننده و تأمین‌کننده انرژی حرارتی لازم برای ذوب سنگ آهن در صنعت فولادسازی کاربرد دارد. روش‌های متنوع کک‌سازی سنتی و صنعتی بر اساس محدودیت‌ها و ظرفیت تولید و معیارهایی مانند کیفیت و ابعاد کک تولیدی، میزان نرمه کک، میزان سرمایه‌گذاری، هزینه‌های جاری، نیروی کاری و قابلیت مکانیزاسیون، انتخاب می‌شوند. در این مقاله، رتبه‌بندی انواع روش‌های کک‌سازی سنتی و صنعتی توسط روش تصمیم‌گیری چند معیاره شباهت به گزینه ایده‌آل (TOPSIS) انجام شده است به نحوی که به ترتیب، کوره‌های صنعتی با بازیابی حرارتی، با محصولات جنبی، و بدون بازیابی و کوره‌های سنتی کندویی و مزقلی، اولویت‌بندی شدند. همچنین به توسعه مدل کک‌سازی صنعتی در شرکت سیمین کک شاهرود پرداخته شد. کوره طراحی و ساخته شده، باعث افزایش بازیابی، کاهش آلودگی زیست‌محیطی، افزایش کیفیت کک تولیدی و کاهش میزان نرمه کک شده است.

کلمات کلیدی: کک‌سازی، تصمیم‌گیری، کوره‌های سنتی و صنعتی.