

METHOD, DEVICE AND SYSTEM FOR ANALYZING PRODUCTION ENVIRONMENT SAFETY

TECHNICAL FIELD

[0001] The disclosure relates to the field of safety supervision, in particular to a method, device and system for analyzing production environment safety.

BACKGROUND

[0002] In current management with respect to production and management activities, it is a very important item in production safety supervision to analyze production environment safety. For production and management activities in enterprises, in order to ensure safe production of the enterprises, improve preventive ability of the enterprises to provide safe production and management activities and provide a solid foundation for construction of a safe and preventive harmonious production environment, the State Administration of Work Safety (hereinafter referred to as "State Administration") and the Production Safety Supervision Administration of respective provinces, cities and counties (hereinafter referred to as "Safety Supervision Administration" and other administrative departments not only need to conduct safety inspections of enterprises in their own jurisdiction, but also need to analyze and evaluate overall production safety environment to ensure smooth operation of production and management activities.

[0003] At present, there are many production safety indicators for measuring production safety environment and relationship between the indicators is complex, so it is difficult to provide reasonable optimized and improved measurements for the production safety environment, making it difficult to measure the production safety environment and in turn become a problem for supervisors.

[0004] In addition, a city is a highly concentrated area of population, social resources and wealth of the modern society, for example. It is also an area where all kinds of industrial accidents occur frequently. In order to further protect safety of the city, it is necessary to make a comprehensive analysis of situation of urban production safety.

SUMMARY

[0005] Embodiments of the disclosure provide a method, device and system for analyzing production environment safety, which enables analysis on production environment safety.

[0006] According to an aspect of embodiments of the disclosure, a method for analyzing production environment safety is provided. The method includes: acquiring a plurality of levels of an indication system affecting production environment safety and a production safety indicator of each of the plurality of levels, wherein the plurality of levels at least comprise a lowest level, at least one intermediate level and a highest level; calculating weight values of production safety indicators for the lowest level and the intermediate level by using an analytic hierarchy process; acquiring history data of a production safety indicator of a lowest level for each of a plurality of objects during a predetermined time period, wherein the history data of the production safety indicator of the lowest level comprises history data of a positive production safety indicator and history data of a negative production safety indicator, and wherein the positive production safety indicator is a production safety indicator that has a positive impact on the production environment safety and the negative production safety indicator is a production safety indicator that has a negative impact on the production environment safety; performing a standardization process on acquired history data of respective production safety indicators based on all history data of the same production safety indicator for the plurality of objects during the predetermined time period; and calculating, according to the history data of the production safety indicators of the lowest levels after the standardization process and the weight values of the production safety indicators for the lowest level and the intermediate level, the production safety indicator for the highest level.

[0007] According to another aspect of embodiments of the disclosure, an apparatus for analyzing production environment safety is provided. The apparatus includes: an indicator acquisition module configured to acquire a plurality of levels of an indication system affecting production environment safety and a production safety indicators of each of the plurality of levels, wherein the plurality of levels at least comprise a lowest level, at least one intermediate level and a highest level; a weight calculation module configured to calculate weight values of production safety indicators for the lowest level and the intermediate level by using an analytic hierarchy process; a data acquisition module configured to acquire history data of a production

safety indicator of a lowest level for each of a plurality of objects during a predetermined time period, wherein the history data of the production safety indicator of the lowest level comprises history data of a positive production safety indicator and history data of a negative production safety indicator, and wherein the positive production safety indicator is a production safety indicator that has a positive impact on the production environment safety and the negative production safety indicator is a production safety indicator that has a negative impact on the production environment safety; a standardization module configured to perform a standardization process on the acquired history data of respective production safety indicators based on all history data of the same production safety indicator for the plurality of objects during the predetermined time period; and a production safety indicator calculation module configured to calculate, according to the history data of the production safety indicators of the lowest levels after the standardization process and the weight values for the production safety indicators of the lowest level and the intermediate level, the production safety indicator for the highest level.

[0008] According to yet another aspect of embodiments of the disclosure, a system for analyzing production environment safety is provided. The system includes: a memory for storing a program; a processor for running the program stored in the memory to perform the following steps: acquiring a plurality of levels of an indication system affecting production environment safety and a production safety indicator of each of the plurality of levels, wherein the plurality of levels at least comprise a lowest level, at least one intermediate level and a highest level; calculating weight values of production safety indicators for the lowest level and the intermediate level by using an analytic hierarchy process; acquiring history data of a production safety indicator of a lowest level for each of a plurality of objects during a predetermined time period, wherein the history data of the production safety indicator of the lowest level comprises history data of a positive production safety indicator and history data of a negative production safety indicator, and wherein the positive production safety indicator is a production safety indicator that has a positive impact on the production environment safety and the negative production safety indicator is a production safety indicator that has a negative impact on the production environment safety; performing a standardization process on acquired history data of respective production safety indicators based on all history data of the same

production safety indicator for the plurality of objects during the predetermined time period; and calculating, according to the history data of the production safety indicators of the lowest levels after the standardization process and the weight values of the production safety indicators for the lowest level and the intermediate level, the production safety indicator for the highest level.

[0009] With the method, device and system for analyzing production environment safety according to embodiments of the disclosure, it is possible to make comparison on not only analysis results for different objects during the same time period but also analysis results for a same object during different time periods, and thus enable complete and reliable analysis of production environment safety.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] In order to more clearly illustrate technical solutions of embodiments of the disclosure, drawings used in embodiments of the disclosure will be briefly described below, and it is possible for a person skilled in the art to anticipate other drawings from these illustrated drawings without any inventive efforts.

[0011] Fig.1 is a flow chart illustrating a method for analyzing production environment safety according to an embodiment of the disclosure;

[0012] Fig.2 is a detailed flow chart illustrating the calculating weight values of the production safety indicators for the lowest level and the intermediate level in Fig. 1;

[0013] Fig.3 is a detailed flow chart illustrating the performing a standardization process on history data of respective production safety indicators in Fig. 1;

[0014] Fig.4 is a schematic structural view of an apparatus for analyzing production environment safety according to an embodiment of the disclosure;

[0015] Fig.5 is a detailed structural diagram of a standardization module;

[0016] Fig.6 is a block diagram showing an exemplary hardware architecture of a system for analyzing production environment safety that is capable of enabling implement of the method and apparatus for analyzing production environment safety in accordance with embodiments of the disclosure.

DETAILED DESCRIPTION

[0017] Features and exemplary embodiments of various aspects of the disclosure will be described in detail below. The disclosure will be described in detail below with reference to the accompanying drawings and embodiments in order to make purposes, technical solutions and advantages of embodiments of the disclosure clear. It is to be understood that the specific embodiments described herein are only to be construed as illustrative and not limiting. The embodiments of the disclosure may be practiced without some of the details of these specific details. The following description of embodiments is merely intended to provide a better understanding of embodiments of the disclosure.

[0018] It is to be understood that the term "comprises", "comprising" or any other variations thereof is intended to encompass a non-exclusive inclusion, such that a process, method, article or device that comprises a series of elements also includes other elements that are not explicitly listed, or elements that are inherent to such a process, method, article or device. An element that is defined by the phrase "comprising" with not further limitation does not exclude presence of additional elements in the process, method, article or device.

[0019] A method, apparatus and system for analyzing production safety environment according to embodiments of the disclosure will be described in detail below with reference to the accompanying drawings. It should be noted that these embodiments are not intended to limit scope of the disclosure.

[0020] Fig.1 is a flow chart illustrating a method for analyzing production safety environment according to an embodiment of the disclosure. As shown in Fig. 1, the method 100 for analyzing production safety environment 100 in the embodiment includes the following steps S110-S150.

[0021] At Step S110, a plurality of levels of an indication system affecting production environment safety and production safety indicators of the levels are acquired. The plurality of levels at least include a lowest level, at least one intermediate level and a highest level.

[0022] At Step S120: weight values for the production safety indicators of the lowest level and the intermediate level are calculated by using an analytic hierarchy process.

[0023] At Step S130, history data of production safety indicators of the lowest level during a predetermined time period is acquired for each of a plurality of objects. The history data of the

production safety indicator of the lowest level includes history data of a positive production safety indicator and history data of a negative production safety indicator. The positive production safety indicator is a production safety indicator that has a positive impact on the production environment safety. The negative production safety indicator is a production safety indicator that has a negative impact on the production environment safety.

[0024] At Step S140, a standardization process is performed on history data of respective production safety indicators of the plurality of objects based on all history data of the same production safety indicator during the predetermined time period.

[0025] At Step S150, according to the history data of the production safety indicators of the lowest levels after the standardization process and the weight values for the production safety indicators of the lowest level and the intermediate level, a weight value for the production safety indicator of the highest level is calculated.

[0026] In embodiments of the disclosure, establishment of the indication system (IS) is a premise and basis for analyzing a research object. The indication system can decompose an abstract research object into a concrete and operable structure. By establishing the indication system for production environment safety, it is possible to analyze production safety indicators so as to enable overall analysis on production environment safety and thereby prediction of industrial accidents.

[0027] In analysis of the production safety indicators, contributions of respective indicators in the overall evaluation and analysis are often different and the analysis of production environment safety may involve multiple indicators, so the amount of data may be large and relationship between the indicators may be complex. Therefore, it is inappropriate to determine weights of respective indicators simply from the perspective of data information. In order to make the evaluation and analysis clearer and more explicit, it is necessary to determine the indication system for the evaluation or analysis and construct an architecture of the indication system in the embodiments of the disclosure. The Analytic Hierarchy Process (AHP) may be used as a method to determine weights of respective production safety indicators for each of levels.

[0028] In step S110, the indication system for production environment safety may have three or more levels.

[0029] Specifically, in the case where there are three levels, the three levels include a lowest level, an intermediate level and a highest level. In the case where there are more than three levels, the more than three levels include a lowest level, more than one intermediate levels and a highest level.

[0030] As an optional embodiment, Fig.2 is a detailed flow chart illustrating the calculating weight values of the production safety indicators for the lowest level and the intermediate level in Fig. 1. As shown in Fig. 2, step S120 may specifically include the following steps S121-S123.

[0031] At step S121, importance scores of the production safety indicators for each of the lowest level and the intermediate level are acquired.

[0032] In the above step S121, the importance scores are acquired by scoring importance of respective production safety indicators for each of the lowest level and the intermediate level according to a preset indicator importance level scoring standard.

[0033] At Step S122, based on the importance scores of the production safety indicators for each of the lowest level and the intermediate level, an indicator weight judgment matrix for each of the lowest level and the intermediate level is constructed.

[0034] At step S123, weights of the production safety indicators in the indicator weight judgment matrix for each of the lowest level and the intermediate level is calculated.

[0035] Through the above steps S121-S123, production safety indicators for each of the levels are scored, a judgment matrix is constructed, and weight values of respective production safety indicators in the constructed judgment matrix are calculated.

[0036] An important feature of the Analytic Hierarchy Process is use of a ratio of importance of a production safety indicator for a level with respect to importance of everyone of remaining production safety indicators for the same level to indicate importance degrees, i.e. weights of production safety indicators. In a usual practice, it is possible for a particular user to use the analysis scale of the analytic hierarchy process to compare production safety indicators of respective levels by pairwise comparison and scoring according to their importance.

[0037] For ease of understanding, Table 1 below exemplarily shows pairwise comparison and scoring of analysis standards of the conventional AHP and their meanings.

Table 1 Analysis Standards of Conventional AHP

pairwise comparison and scoring	meanings
1	Two indicators have the same importance
3	A former indicator is slightly important than a later indicator
5	A former indicator is quite important than a later indicator
7	A former indicator is obviously important than a later indicator
9	A former indicator is absolutely important than a later indicator
2、4、6、8	compromise among the above meanings
Inverse of the above numerals	If an importance score of an indicator A with respect to an indicator B is “a”, then an importance score of the indicator B with respect to an indicator A is “1/a”

[0038] According to the analysis standards in Table 1 above, a matrix formed by results of comparison between respective production safety indicators and remaining production safety indicators for a specified level may be used as a judgment matrix.

[0039] In embodiment of the disclosure, if everyone of a large number of production safety indicators is compared with remaining production safety indicators, since the number of production safety indicators is large, a tedious comparison is required and will have a greater impact on correct judgment of a user when the comparison process proceeds later stage thereof, which affecting scientificity and consistency of results of scoring.

[0040] In embodiments of the disclosure, in order to simplify the method for analyzing importance of safety production indicators and improve scientificity and consistency of results of scoring, an improved method for constructing an indicator weight judgment matrix is provided.

[0041] Specifically, at step S121, importance of respective production safety indicator for a specified level is directly scored according to a preset indicator importance degree scoring standard.

[0042] For ease of understanding, Table 2 below exemplarily shows definition of importance degree and corresponding scores for production safety indicators in a scoring standard of the analytic hierarchy process according to an embodiment of the disclosure. The examples in Table 2 should not be construed as limitation of a scoring standard of the AHP.

Table 2 Scoring Standard of AHP

Importance degree	score
unimportant	1
Slight important	3
Quite important	5
Obvious important	7
Absolute important	9
Between the above importance degrees	2、4、6、8

[0043] According to the example in Table 2 above, importance of respective production safety indicator for a specified level is scored according to a preset indicator importance degree scoring standard, and an indicator weight judgment matrix of the level is determined according to importance scores of respective production safety indicators.

[0044] As an optional embodiment, the step S122 may specifically include: calculating, based on the importance scores, an average score of importance scores of the production safety indicators for each of the lowest level and the intermediate level; and constructing the indicator weight judgment matrix for each of the lowest level and the intermediate level based on calculated averages of the importance scores, wherein a value of an element in the indicator weight judgment matrix is a ratio of an average of importance scores of indicators corresponding to a column in which the element is located with respect to an average of importance scores of indicators corresponding to a row in which the element is located.

[0045] For ease of understanding, construction of the indicator weight judgment matrix is described below by a specific example. In this example, accident consequence is a hierarchical indicator including the following indicators such as: D1, the number of deaths in industrial accidents; D2, the number of deaths in fire accidents; D3, the number of deaths in traffic accidents.

[0046] First, a specific user, such as an expert or any other designated assessor, scores importance of the indicators D1, D2, and D3 according to the scoring standard of the AHP shown in Table 2 based on professional knowledge. As an example, Table 3 below schematically shows results of scoring performed by three specific users on importance of the hierarchical indicator.

Table 3 Importance Score for Hierarchical Indicator

Specific user	Indicator Number	Importance Score
Specific user 1	D1	7
Specific user 1	D2	7
Specific user 1	D3	0
Specific user 2	D1	5
Specific user 2	D2	5
Specific user 2	D3	5
Specific user 3	D1	0
Specific user 3	D2	9
Specific user 3	D3	9

[0047] As shown in Table 3, importance scores of the indicator D1 are 7, 5, and 0; importance scores of the indicator D2 are 7, 5, and 9; and importance scores of the indicator D3 are 0, 5, and 9.

[0048] Secondly, an average of the importance scores of each of the indicators is calculated as a ratio of a sum of the importance scores of each of the indicators with respect to the number of specific users participating in the scoring.

[0049] Specifically, the average of the importance scores of the indicator D1 is 4; the average of the importance scores of the indicator D2 is 7; and the average of the importance scores of the indicator D3 is 4.667.

[0050] Next, based on the calculated average of the importance scores of each of the indicators, the indicator weight judgment matrix for each of the lowest level and the intermediate level is constructed.

[0051] Table 4 below schematically shows an indicator weight judgment matrix constructed based on the average of importance scores of each of the indicators and a ratios of pairwise comparison between the indicators.

Table 4 Element Value of Indicator Weight Judgment Matrix

	D1	D2	D3
D1	1	1.75	1.16675
D2	0.57143	1	0.66671

D3	0.85708	1.49989	1
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[0052] In Table 4 above, ratios of pairwise comparison of the average of the importance scores of respective indicators D1, D2, and D3 forms 3×3 position points:

$$\begin{aligned} & (D1, D1), (D1, D2), (D1, D3), \\ & (D2, D1), (D2, D2), (D2, D3), \\ & (D3, D1), (D3, D2), (D3, D3). \end{aligned}$$

[0053] The value of each position point in the indicator weight judgment matrix is a ratio of the average of the importance scores of the later indicator in the position point with respect to the average of the importance scores of the former indicator.

[0054] That is to say, a value of an element in the indicator weight judgment matrix is a ratio of an average of the importance scores of an indicator corresponding to a column of the matrix in which the element is located with respect to an average of the importance scores of an indicator corresponding to a row of the matrix in which the element is located.

[0055] The indicator weight judgment matrix is representation of degree of association between the indicators, and the degree of association is determined by score of all indicators made by all specific users.

[0056] In embodiments of the disclosure, it is possible to determine weights of respective production safety indications for a specified level by constructing the indicator weight judgment matrix of the specified level.

[0057] The following continues to refer to the indicator weight judgment matrix in Table 4 above to describe details about how to calculate weight of each of the indicators in the indicator weight judgment matrix.

[0058] Table 5 below schematically shows summation of values for every rows in the matrix and summation of all values according to the indicator weight judgment matrix in Table 4.

Table 5: Summation of Values for Every Rows and Summation of All Values of Indicator Weight Judgment Matrix

	D1	D2	D3	Summation of Values of Every Rows of Position Points
D1	1	1.75	1.16675	$\sum_1 = 1 + 1.75 + 1.16675 = 4.4175$

D2	0.57143	1	0.66671	$\Sigma_2 = 0.57143 + 1 + 0.66671 = 2.23814$
D3	0.85708	1.49989	1	$\Sigma_3 = 0.85708 + 1.49989 + 1 = 3.35697$
	Summation of All Values			$\Sigma = \Sigma_1 + \Sigma_2 + \Sigma_3 =$ $4.4175 + 2.23814 + 3.35697 = 10.01261$

[0059] As shown in Table 5, firstly, summation of values of every rows of position points in the index weight judgment matrix is calculated. Specifically, summation of values of the first row of position points is 4.4175, summation of values of the second row of position points is 2.23814, and summation of values of the third row of position points is 3.35697.

[0060] Secondly, the summations of values of respective rows of position points are further summed to obtain summation of values of all the position points in the indicator weight judgment matrix, that is, 10.01261.

[0061] Then, the weight of the indicator D1 is represented as ω_1 , the weight of the indicator D2 is represented as ω_2 , and the weight of the indicator D3 is represented as ω_3 . The value of ω_1 is a ratio of the summation of values of the first row of position points with respect to the summation of values of all the position points, that is, $\omega_1 = \frac{4.4175}{10.01261} \cong 0.44119$. Likely, $\omega_2 = \frac{2.23814}{10.01261} \cong 0.22353$ and $\omega_3 = \frac{3.35697}{10.01261} = 0.33527$.

[0062] In some embodiments, for the calculated weight values, a rounding operation may be further performed to quantize each of the weight values to two digits after the decimal point. That is, the weight values corresponding to the indicators D1, D2 and D3 in the indicator weight judgment matrix are $\omega_1 = 0.44$, $\omega_2 = 0.22$, $\omega_3 = 0.34$, respectively.

[0063] In practical applications, there are many methods for calculating weight values of the indicators based on the indicator weight judgment matrix, which is not described here.

[0064] It should be understood that the method for calculating weight values of the indicators based on the constructed indicator weight judgment matrix described in embodiment of the disclosure should not be construed as limiting of a method for calculating a weight value in embodiments of the disclosure. That is to say, in embodiments of disclosure, the method for calculating weight values of respective production safety indicator based on the constructed indicator weight judgment matrix may be selected according to actual calculation requirement.

[0065] In some embodiments, since the analysis of the production environment safety may

involves a large number of production safety indicators and is susceptible to other human factors, the constructed indicator weight judgment matrix may have a consistency problem. In order to improve accuracy of data in the indicator weight judgment matrix, as an optional embodiment, the step S123 may further include: performing consistency check on the indicator weight judgment matrix for each of the lowest level and the intermediate level to determine whether the indicator weight judgment matrixes for the lowest level and the intermediate level has consistency; and calculating, in the case where the indicator weight judgment matrixes for the lowest level and the intermediate level has consistency, weights of respective indicators of the lowest level and the intermediate level.

[0066] In embodiments of the disclosure, with the consistency check, it can be determined whether the indicator weight judgment matrixes for the lowest level and the intermediate level has consistency, and thereby it enables overall analysis and improvement of accuracy and validity of analysis results after through the consistency check of the indicator weight judgment matrixes.

[0067] If the constructed indicator weight judgment matrix cannot pass the consistency check, importance of each of production safety indicators of the level should be re-scored so as to construct an indicator weight judgment matrix.

[0068] As an optional embodiment, at step S130, when it is necessary to perform evaluation and analysis on a plurality of analysis objects, history data of the production safety indicators for the lowest level at different time sections during a predetermined time period is acquired for each analysis object. For example, history data of the production safety indicators for the lowest level every month during last five years is acquired for respective objects A, B and C. Since the production safety indicators may include a positive production safety indicator that has a positive impact on the production environment safety and a negative production safety indicator that has a negative impact on the production environment safety, the history data of production safety indicators for the lowest level may include history data of a positive production safety indicator and history data of a negative production safety indicator.

[0069] In the analysis of the production environment safety, it is sometimes necessary to compare not only production safety indicators of multiple analysis objects at the same time period, but also production safety indicators of multiple analysis objects at different time

periods. Conventionally, due to inconsistent standards in conventional analysis process, it is difficult to compare production safety indicators at different time periods, or the comparison, even if it is made, is not accurate.

[0070] Therefore, at step S140, for each of the plurality of objects, a standardization process on history data of respective production safety indicators is performed based on all history data of the same production safety indicator during the predetermined time period.

[0071] Specifically, the step S140 may further include step S141, in which history data a normalization process is performed on each history data of respective production safety indicators based on all history data of the same production safety indicator.

[0072] Optionally, a normalization method represented by the formula (2) may be employed, and the formula (1) represents a calculation method of a variation coefficient,

$$C.V. = \frac{\sigma}{\mu} \times 100\% \quad (1)$$

$$z = \frac{x}{\max(x) + C.V. \cdot \sigma} \quad (2)$$

where x represents history data of the production safety indicator, $\max(x)$ represents a maximum value of history data of the same production safety indicator of the plurality of objects during the predetermined time period, $C.V.$ represents the variation coefficient, σ represents a standard deviation of history data of the same production safety indicator of the plurality of objects during the predetermined time period, and μ represents an average of history data of the same production safety indicator of the plurality of objects during the predetermined time period, z represents history data of the production safety indicator after the normalization process.

[0073] The standardization process on history data of a positive production safety indicator may include only the normalization process. The standardization process on history data of a negative production safety indicator may not only include the normalization process but also a redirection process. That is, the step S140 may further include step S142, in which a redirection process represented by the formula (3) is performed after the normalization process on the history data of the negative production safety indicator:

$$z' = 1 - \frac{x}{\max(x) + C.V. \cdot \sigma} \quad (3)$$

where z' represents history data of the negative production safety indicator after the redirection

process.

[0074] By adopting the above-mentioned standardization process, influence of difference of the collected history data such as different dimensional quantities and different data sizes on data analysis can be eliminated and data precision can be improved in order to ensure standardization of the collected history data. In addition, by adopting the above-mentioned standardization process, history data of the same production safety indicators can be normalized by using the same standard as described above. In addition, in the above-mentioned standardization process, all history data of production safety indicators of all the analysis objects can be taken into consideration, and the production safety indicator is unified into a range of (0, 1). In addition, by adopting the above-mentioned standardization process, it is also take degree of dispersion of a group of data of the same production safety indicator (that is, a group of data composed of history data of the same production safety indicator of a plurality of analysis objects) into consideration so as to avoid conflict due to the same normalization result caused by same increase or decrease.

[0075] Next, at step S150, according to the history data of the production safety indicators of the lowest levels after the standardization process and the weight values of the production safety indicators for the lowest level and the intermediate level, a weight value of the production safety indicator of the highest level is calculated.

[0076] For the sake of easy understanding, taking the production safety indicators for the third level as an example, calculation of an indicator of the highest level may be performed by the following formula (4):

$$\begin{cases} \text{Inc} = \sum_{j=1}^m (\alpha_j \cdot \sum_{i=1}^n (\omega_i \cdot x_i)) \\ \text{IR} = \sum_{j=1}^m (\beta_j \cdot \sum_{i=1}^n (\omega_i \cdot y_i)) \\ \text{SafetySup} = \sum_{j=1}^m (\gamma_j \cdot \sum_{i=1}^n (\omega_i \cdot z_i)) \\ \text{SPI} = \text{nor}[\omega_1 \cdot \text{Inc} + \omega_2 \cdot \text{IR} - \omega_3 \cdot \text{SafetySup}] \end{cases} \quad (4)$$

[0077] In the above formula (4), SPI represents a production safety indicator, that is, indicator for the highest level, Inc represents an industrial accident indicator, IR represents an inherent risk indicator, SafetySup represents a safety supervision indicator, and Inc, IR and SafetySup represent intermediate indicators, i.e., the secondary indicators.

[0078] α_j represents weight of a secondary indicator, that is, the industrial accident indicator,

β_j represents weight of a secondary indicator, that is, the inherent risk indicator, γ_j represents weight of a secondary indicator, that is, the safety supervision indicator; m is the number of the secondary indicators; ω_i is weight of each third-level indicator under a corresponding secondary level; n is the number of third-level indicators under a corresponding secondary indicator, and $\text{nor}[]$ is a standardization process on calculated indicator data for the highest-level.

[0079] That is to say, in embodiments of the disclosure, a standardization process may be performed on calculated indicator data for the highest-level so as to improve accuracy of the data.

[0080] In the standardization process on production safety indicator for the highest level, Min-Max normalization (also known as Min-Max standardization), which is one of standardization process, may be used. The standardization process on the production safety indicators may be performed by utilizing linear transformation such that values of the standardized production safety indicators fall within the range of (0, 1).

[0081] In order to prevent the case where the normalized value of the production safety indicator for the highest level is 0 or 1, the embodiments of the disclosure provide the following Min-Max normalization method.

[0082] Specifically, the embodiments of the disclosure normalizes the production safety indicator for the highest level by using the following formula (5) and formula (6):

$$t = \frac{w - u_{\min}}{u_{\max} - u_{\min}} \quad (5)$$

$$\begin{cases} u_{\min} = w_{\min} - k_1 |w_{\min}| \\ u_{\max} = k_2 w_{\max} \\ 0 < k_1 < 1, \quad 1 < k_2 < 2 \end{cases} \quad (6)$$

where t represents the production safety indicator for the highest level after the normalization process, w represents production safety indicator for the highest level before the normalization process, $w_{\min}$ and $w_{\max}$ represent minimum and maximum values of production safety indicators of all highest levels of the plurality of objects during the predetermined time period, and k_1 and k_2 are constants.

[0083] Through the above formula (5) and formula (6), the production safety indicator for the highest level is standardized to enable accurate analysis.

[0084] As a specific example, k_1 may take a value of 0.1 and k_2 may take a value of 1.1.

[0085] By standardizing all production safety indicators for the highest level by using the above-described Min-Max normalization method, it is possible prevent the case where the normalized value of the production safety indicator for the highest level is 0 or 1, so that final evaluation and analysis results can be more comprehensive and accurate.

[0086] In the embodiments, if the indication system for indicating production safety includes more than three layers, that is, it includes more than one intermediate level, it is possible to calculate production safety indicators for a higher level based on indicators of a current level and weights of respective production safety indicators for the higher level, and in turn to calculate production safety indicators for the highest level through derivation on basis of levels.

[0087] In summary, in embodiments of the disclosure, a method for analyzing production environment safety is provided. The method acquires indicators of an indication system, constructs a judgment matrix for the indications of various levels of production environment by using an analytic hierarchy process, calculates weight values of respective production safety indicators, performs a standardization process on the collected history data and calculates a weight value of the production safety indicator for the highest level through derivation on basis of levels in order to enable analysis of production environment safety. With the method for analyzing production environment safety described above, it is possible to make comparison on not only analysis results for different objects during the same time period but also analysis results for a same object during different time periods, and thus enable complete and reliable analysis of production environment safety.

[0088] The apparatus for analyzing production environment safety according to embodiments of the disclosure will be described in detail below with reference to Figs. 4 to 5.

[0089] Fig. 4 is a block diagram showing structure of an apparatus for analyzing production environment safety according to an embodiment of the disclosure. As shown in Fig. 4, the apparatus for analyzing production environment safety according to an embodiment of the disclosure includes modules 210-250.

[0090] The indicator acquisition module 210 is configured to acquire a plurality of levels of an indication system affecting production environment safety and production safety indicators of the levels, wherein the plurality of levels at least comprise a lowest level, at least one intermediate level and a highest level.

[0091] The weight calculation module 220 is configured to calculate weight values for the production safety indicators of the lowest level and the intermediate level by using an analytic hierarchy process.

[0092] The a data acquisition module 230 is configured to acquire history data of production safety indicators of lowest levels of a plurality of objects during a predetermined time period, wherein the history data of the production safety indicator of the lowest level comprises history data of a positive production safety indicator and history data of a negative production safety indicator.

[0093] The standardization module 240 is configured to perform a standardization process on history data of respective production safety indicators of the plurality of objects based on all history data of the same production safety indicator during the predetermined time period.

[0094] The production safety indicator calculation module 250 is configured to calculate, according to the history data of the production safety indicators of the lowest levels after the standardization process and the weight values for the production safety indicators of the lowest level and the intermediate level, a weight value for the production safety indicator of the highest level.

[0095] In the apparatus for analyzing production environment safety according to the embodiment of the disclosure, a plurality of levels of an indication system affecting production environment safety is acquired, weight values for the production safety indicators of the respective levels are calculated, a standardization process is performed on history data of acquired production safety indicators, and a weight value for the production safety indicator of the highest level is acquired so as to analyze production environment safety.

[0096] In some embodiments, the weight calculation module may further include: an importance scoring unit configured to acquire importance scores of the production safety indicators for each of the lowest level and the intermediate level; and a judgment matrix construction unit configured to construct, based on the importance scores of the production

safety indicators for each of the lowest level and the intermediate level, an indicator weight judgment matrix for each of the lowest level and the intermediate level; and a weight calculation unit configured to calculate weights of the production safety indicators in the indicator weight judgment matrix for each of the lowest level and the intermediate level.

[0097] In an optional embodiment, the judgment matrix construction unit may be specifically configured to: calculate, based on the importance scores, an average score of importance scores of the production safety indicators for each of the lowest level and the intermediate level; and construct the indicator weight judgment matrix for each of the lowest level and the intermediate level, wherein a value of an element in the indicator weight judgment matrix is a ratio of an average of importance scores of an indicator corresponding to a column in which the element is located with respect to an average of importance scores of an indicator corresponding to a row in which the element is located.

[0098] In some embodiments, the weight calculation module may further include a consistency checking unit configured to perform consistency check on the indicator weight judgment matrix for each of the lowest level and the intermediate level to determine whether the indicator weight judgment matrixes for the lowest level and the intermediate level has consistency.

[0099] The weight value calculation unit calculates weights of respective indicators of the lowest level and the intermediate level in the case where the indicator weight judgment matrixes for the lowest level and the intermediate level has consistency.

[00100] With the consistency check, it can be determined whether the indicator weight judgment matrixes for the lowest level and the intermediate level has consistency, and thereby it enables overall analysis and improvement of accuracy and validity of analysis results after through the consistency check of the indicator weight judgment matrixes.

[00101] Fig.5 is a detailed structural diagram of a standardization module. The standardization module 240 in Fig. 5 includes a normalization unit 241 and a redirection unit 242. The normalization unit 241 is configured to perform a normalization process on history data of respective production safety indicators of the plurality of objects based on all history data of the same production safety indicator. The redirection unit 242 is configured to perform, if the normalization process is performed on history data of a negative production safety indicator, a redirection process after the normalization process. The normalization unit 241 and the

redirection unit 242 utilize the same method as that method for analyzing production environment safety described above.

[00102] Other details of the apparatus for analyzing production environment security according to embodiments of the disclosure are similar as those for the method for analyzing production environment security according to embodiments of the disclosure described above, and will not be described herein again.

[00103] The method and apparatus for analyzing production environment safety according to embodiments of the disclosure described in conjunction with Figs. 1 to 5 may be implemented by a system for analyzing production environment safety according to embodiments of the disclosure. Fig.6 is a block diagram showing an exemplary hardware architecture of a system for analyzing production environment safety that is capable of enabling implement of the method and apparatus for analyzing production environment safety in accordance with embodiments of the disclosure. As shown in Fig. 6, the system 600 for analyzing production environment safety includes an input device 601, an input interface 602, a central processing unit (CPU) 603, a memory 604, an output interface 605, and an output device 606. The input interface 602, the central processing unit 603, the memory 604, and the output interface 605 are connected to each other through a bus 610. The input device 601 and the output device 606 are respectively connected to the bus 610 through the input interface 602 and the output interface 605, so as to be connected to other components of the system 600 for analyzing production environment safety. Specifically, the input device 601 receives input information from outside and transmits the input information to the central processing unit 603 via the input interface 602; the central processing unit 603 processes the input information based on computer executable instructions stored in the memory 604 to generate output information, stores the output information in the memory 604 temporarily or permanently, and transmits the output information to the output device 606 (e.g., a display, etc.) via the output interface 605; the output device 606 outputs the output information to outside of the system 600 for analyzing production environment safety for use by a user.

[00104] That is, the system for analyzing production environment safety shown in Fig. 6 may include: a memory for storing computer-executable instructions; and a processor for executing the computer-executable instructions to implement a method and apparatus for analyzing

production environment safety described in conjunction with Fig.1 to Fig. 5. Here, the processor may communicate with an external device to acquire various production safety indicators so as to execute computer-executable instructions based on the acquired information from the external device, thereby implementing the method and apparatus for analyzing production environment safety described in conjunction with Fig.1 to Fig. 5.

[00105] In an embodiment, the system 600 for analyzing production environment safety shown in Fig. 6 may be implemented to include: a memory for storing a program; and a processor for executing the program stored in the memory to perform the following steps: acquire a plurality of levels of an indication system affecting production environment safety and production safety indicators of the levels, wherein the plurality of levels at least comprise a lowest level, at least one intermediate level and a highest level; calculate weight values for the production safety indicators of the lowest level and the intermediate level by using an analytic hierarchy process; acquire history data of production safety indicators of lowest levels of a plurality of objects during a predetermined time period, wherein the history data of the production safety indicator of the lowest level comprises history data of a positive production safety indicator and history data of a negative production safety indicator, and wherein the positive production safety indicator is a production safety indicator that has a positive impact on the production environment safety and the negative production safety indicator is a production safety indicator that has a negative impact on the production environment safety; perform a standardization process on history data of respective production safety indicators of the plurality of objects based on all history data of the same production safety indicator during the predetermined time period; and calculate, according to the history data of the production safety indicators of the lowest levels after the standardization process and the weight values for the production safety indicators of the lowest level and the intermediate level, a weight value for the production safety indicator of the highest level.

[00106] It should be understood that the disclosure is not limited to the specific configurations and processes described above and illustrated in the drawings. For the sake of brevity, a detailed description of known methods is omitted here. In the above embodiments, several specific steps have been described and illustrated as examples. However, the method of the disclosure is not limited to the specific steps described and illustrated, and a person skilled in the art can make

various changes, modifications and additions, or change the order between the steps under spirit of the disclosure.

[00107] The functional blocks shown in the block diagrams described above may be implemented as hardware, software, firmware, or a combination thereof. When implemented in hardware, it may be, for example, an electronic circuit, an application specific integrated circuit (ASIC), suitable firmware, plug-ins, function cards, and the like. When implemented in software, the elements of the disclosure may be programs or code segments that can be used to perform required tasks. The program or code segments may be stored in a machine readable medium or transmitted over a transmission medium or communication link through a data signal carried in carriers. A "machine-readable medium" may include any medium that can store or transfer information. Examples of machine-readable media may include electronic circuits, semiconductor memory devices, ROM, flash memory, erasable ROM (EROM), floppy disks, CD-ROMs, optical disks, hard disks, optical fiber media, radio frequency (RF) links, and the like. The code segments may be downloaded via a computer network such as the Internet, an intranet, and the like.

[00108] It should also be noted that the exemplary embodiments in the disclosure describe some methods or systems based on a series of steps or devices. However, the disclosure is not limited to the order of the steps, that is, the steps may be performed in the same order as described, or in different order from the described order, or several steps may be simultaneously performed.

[00109] The foregoing descriptions are only specific embodiments of the disclosure, and a person skilled in the art can clearly understand that for convenience and brevity of the description, specific operations of systems, modules and units described above may refer to those described with respect for the method embodiments, and will not be repeated here. It should be understood that the scope of the disclosure is not limited thereto, and a person skilled in the art can easily conceive various equivalent modifications or substitutions without departing from the scope of the disclosure, which are fallen within the scope of the disclosure.

CLAIMS:

1. A method for analyzing production environment safety, comprising:

acquiring a plurality of levels of an indication system affecting production environment safety and a production safety indicator of each of the plurality of levels, wherein the plurality of levels at least comprise a lowest level, at least one intermediate level and a highest level;

calculating weight values of production safety indicators for the lowest level and the intermediate level by using an analytic hierarchy process;

acquiring history data of a production safety indicator of a lowest level for each of a plurality of objects during a predetermined time period, wherein the history data of the production safety indicator of the lowest level comprises history data of a positive production safety indicator and history data of a negative production safety indicator, and wherein the positive production safety indicator is a production safety indicator that has a positive impact on the production environment safety and the negative production safety indicator is a production safety indicator that has a negative impact on the production environment safety;

performing a standardization process on acquired history data of respective production safety indicators based on all history data of the same production safety indicator for the plurality of objects during the predetermined time period; and

calculating, according to the history data of the production safety indicators of the lowest levels after the standardization process and the weight values of the production safety indicators for the lowest level and the intermediate level, the production safety indicator for the highest level.

2. The method according to claim 1, wherein the standardization process comprises:

performing a normalization process on the acquired history data of respective production safety indicators based on all history data of the same production safety indicator for the plurality of objects, and

performing, if the normalization process is performed on history data of a negative production safety indicator, a redirection process after the normalization process.

3. The method according to claim 2, wherein the normalization process on history data of respective production safety indicators is performed based on the following formula:

$$C.V. = \frac{\sigma}{\mu} \times 100\%$$

$$z = \frac{x}{\max(x) + C.V. \cdot \sigma}$$

where x represents history data of the production safety indicator, $\max(x)$ represents a maximum value of history data of the same production safety indicator of the plurality of objects during the predetermined time period, $C.V.$ represents a variation coefficient, σ represents a standard deviation of history data of the same production safety indicator of the plurality of objects during the predetermined time period, μ represents an average of history data of the same production safety indicator of the plurality of objects during the predetermined time period, and z represents history data of the production safety indicator after the normalization process.

4. The method according to claim 3, wherein the redirection process on history data of the negative production safety indicator after the normalization process is preformed based on the following formula:

$$z' = 1 - \frac{x}{\max(x) + C.V. \cdot \sigma}$$

where z' represents history data of the negative production safety indicator after the redirection process.

5. The method according to claim 1, further comprising:

performing a normalization process on the calculated production safety indicator for the highest level based on the following formula:

$$t = \frac{w - u_{\min}}{u_{\max} - u_{\min}},$$

$$\begin{cases} u_{\min} = w_{\min} - k_1 |w_{\min}| \\ u_{\max} = k_2 w_{\max} \\ 0 < k_1 < 1, \quad 1 < k_2 < 2 \end{cases}$$

where t represents the production safety indicator for the highest level after the normalization process, w represents the production safety indicator for the highest level before the normalization process, $w_{\min}$ and $w_{\max}$ represent minimum and maximum values of

production safety indicators of all highest levels of the plurality of objects during the predetermined time period, and k_1 and k_2 are constants.

6. An apparatus for analyzing production environment safety, comprising:

an indicator acquisition module configured to acquire a plurality of levels of an indication system affecting production environment safety and a production safety indicators of each of the plurality of levels, wherein the plurality of levels at least comprise a lowest level, at least one intermediate level and a highest level;

a weight calculation module configured to calculate weight values of production safety indicators for the lowest level and the intermediate level by using an analytic hierarchy process;

a data acquisition module configured to acquire history data of a production safety indicator of a lowest level for each of a plurality of objects during a predetermined time period, wherein the history data of the production safety indicator of the lowest level comprises history data of a positive production safety indicator and history data of a negative production safety indicator, and wherein the positive production safety indicator is a production safety indicator that has a positive impact on the production environment safety and the negative production safety indicator is a production safety indicator that has a negative impact on the production environment safety;

a standardization module configured to perform a standardization process on the acquired history data of respective production safety indicators based on all history data of the same production safety indicator for the plurality of objects during the predetermined time period; and

a production safety indicator calculation module configured to calculate, according to the history data of the production safety indicators of the lowest levels after the standardization process and the weight values for the production safety indicators of the lowest level and the intermediate level, the production safety indicator for the highest level.

7. The apparatus according to claim 6, wherein the standardization module comprises:

a normalization unit configured to perform a normalization process on the acquired history data of respective production safety indicators based on all history data of the same production safety indicator for the plurality of objects; and

a redirection unit configured to perform, if the normalization process is performed on history data of a negative production safety indicator, a redirection process after the normalization process.

8. The apparatus according to claim 7, wherein the normalization process on history data of respective production safety indicators is performed based on the following formula:

$$C.V. = \frac{\sigma}{\mu} \times 100\%$$

$$z = \frac{x}{\max(x) + C.V. \cdot \sigma}$$

where x represents history data of the production safety indicator, $\max(x)$ represents a maximum value of history data of the same production safety indicator of the plurality of objects during the predetermined time period, $C.V.$ represents a variation coefficient, σ represents a standard deviation of history data of the same production safety indicator of the plurality of objects during the predetermined time period, μ represents an average of history data of the same production safety indicator of the plurality of objects during the predetermined time period, and z represents history data of the production safety indicator after the normalization process.

9. The apparatus according to claim 8, the redirection process on history data of the negative production safety indicator after the normalization process is performed based on the following formula:

$$z' = 1 - \frac{x}{\max(x) + C.V. \cdot \sigma}$$

where z' represents history data of the negative production safety indicator after the redirection process.

10. A system for analyzing production environment security, comprising:

a memory for storing a program;

a processor for executing the program stored in the memory to perform the following steps:

acquire a plurality of levels of an indication system affecting production environment safety and a production safety indicator of each of the plurality of levels, wherein the plurality of levels at least comprise a lowest level, at least one intermediate level and a highest level;

calculate weight values of production safety indicators for the lowest level and the

intermediate level by using an analytic hierarchy process;

acquire history data of a production safety indicator of a lowest level for each of a plurality of objects during a predetermined time period, wherein the history data of the production safety indicator of the lowest level comprises history data of a positive production safety indicator and history data of a negative production safety indicator, and wherein the positive production safety indicator is a production safety indicator that has a positive impact on the production environment safety and the negative production safety indicator is a production safety indicator that has a negative impact on the production environment safety;

perform a standardization process on the acquired history data of respective production safety indicators based on all history data of the same production safety indicator during the predetermined time period for the plurality of objects; and

calculate, according to the history data of the production safety indicators of the lowest levels after the standardization process and the weight values for the production safety indicators of the lowest level and the intermediate level, the production safety indicator for the highest level.