Analysis responses to the implementation of nuclear installations safety culture using AHP-TOPSIS

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Abstract. An analysis of responses to the implementation of nuclear installations safety culture has been done using AHP (Analytic Hierarchy Process) - TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution). Safety culture is considered as collective commitments of the decision-making level, management level, and individual level. Thus each level will provide a subjective perspective as an alternative approach to implementation. Furthermore safety culture is considered by the statement of five characteristics which in more detail form consist of 37 attributes, and therefore can be expressed as multi-attribute state. Those characteristics and or attributes will be a criterion and its value is difficult to determine. Those criteria of course, will determine and strongly influence the implementation of the corresponding safety culture. To determine the pattern and magnitude of the influence is done by using a TOPSIS that is based on decision matrix approach and is composed of alternatives and criteria. The weight of each criterion is determined by AHP technique. The data used are data collected through questionnaires at the workshop on safety and health in 2015. Reliability test of data gives Cronbach Alpha value of 95.5% which according to the criteria is stated reliable. Validity test using bivariate correlation analysis technique between each attribute give Pearson correlation for all attribute is significant at level 0.01. Using confirmatory factor analysis gives Kaiser-Meyer-Olkin of sampling Adequacy (KMO) is 0.719 and it is greater than the acceptance criterion 0.5 as well as the 0.000 significance level much smaller than 0.05 and stated that further analysis could be performed. As a result of the analysis it is found that responses from the level of decision maker (second echelon) dominate the best order preference rank to be the best solution in strengthening the nuclear installation safety culture, except for the first characteristics, safety is a clearly recognized value. The rank of preference order is obtained sequentially according to the level of policy maker, management and individual or staff.

Keywords: Safety Culture, AHP, TOPSIS

1. Introduction
A variety of ways can be undertaken to evaluate the implementation of safety culture in an organization. Considering that a safety culture is a collection of attributes that characterize the attitudes and behaviors of the worker and organization to safety implementations within the organization. Decision-making on the set of attributes as an alternative can be done by applying multi-
attribute or multi-criteria decision-making techniques. The particular emphasis that is expected for the purpose of achieving organizational objectives and/or will be influenced by the organizational culture of the organization, such that there will be a difference between one organization to another, including within the organization itself as between sub-organization. In more detail, there may be certain attributes appear more dominant if compared to the other attributes within the organization. The weight of a criterion predicted will also affect how a criterion will contribute to the implementation or implementation.

Taking into account the different perspectives and concerns by each level of the organization, it is necessary to know which level is expected to be an approach that has given the best response to the implementation that has been done. By these ways, the approach to safety culture can be done by using multi attributes or multi criteria consisting of several characteristics and/or attributes, and then some indicators at a more detailed level. Each of these characteristics and/or attributes, as well as indicators, will indicate their influence in the implementation of the safety culture corresponding individually or collectively. Similarly, therefore, the selection of characteristics and/or attributes and indicators that will be used as the most effective factor subject to treatment to obtain a strong safety culture becomes important.

In this paper, the selection of characteristics and/or attributes or indicators in the rank of preference order indicates the best alternative solution to obtain a strong safety culture by using TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution). TOPSIS is one of the numerical methods of multi-criteria decision making composed in the form of a decision matrix of alternatives and criteria. For estimation of weight of each criterion will be used technique of AHP (Analytic Hierarchy Process).

As a result, the corresponding responses to the expected implementation of a safety culture will be adopted, based on one of the available alternatives as the best solution. The overall result of the best alternative is based on the overall characteristics. As a result for each characteristic can also be obtained and of course based on all the attributes associated with it.

2. Methodology
TOPSIS was originally developed by Hwang and Yoon in 1981 and developed further by Yoon in 1987 later by Hwang, Lai, and Liu in 1993 [1]. The basic concept of TOPSIS is an alternative selection performed on alternatives with the shortest geometric distance from the ideal positive solution and the furthest geometric distance from the ideal solution of negative compensation-based aggregation that compares a set of alternatives by identifying the weight of each criterion. The assumption used in TOPSIS is that the increase or decrease in the meaning of criteria is monotonic[1-3].

The work steps used are[1, 4, 5]:

1. Establish a decision matrix consisting of m alternatives and n criteria, expressed by $x_{ij}$.

Composing the decision matrix as an evaluation matrix consisting of the m alternatives and n criteria as the matrix ($x_{ij}$) of size m x n.

2. Normalize the decision matrix, using:

$$r_{ij} = x_{ij} \left( \sum_{i=1}^{m} x_{ij}^2 \right)^{-1/2}$$

(1)
3. Calculate a weighted normalized decision matrix. Weight calculation is done by AHP calculation with the attribute weights of $j$ are $w_j$ and $\sum_{j=1}^{n} w_j = 1$. The weighted normalized decision matrix is determined as follows:

$$v_{ij} = (w_j) r_{ij}$$

(2)

4. Determine the best and worst alternative. Ideal solutions $A^+$ and Ideal Negative Solutions $A^-$ each corresponding to

$$A^+ = \left\{ \left( \max_i v_{ij} \right) \left| j \in J \right\} \left( \min_i v_{ij} \right) \left| j \in J' \right\} \right\} i = 1,2,...,m = \left\{ v_{1+}^+, v_{2+}^+, ..., v_{n+}^+ \right\}$$

$$A^- = \left\{ \left( \min_i v_{ij} \right) \left| j \in J \right\} \left( \max_i v_{ij} \right) \left| j \in J' \right\} \right\} i = 1,2,...,m = \left\{ v_{1-}^-, v_{2-}^-, ..., v_{n-}^- \right\}$$

(3)

with:

$J = \{ j = 1,2,..., n \}$

$J' = \{ j = 1,2,..., n \}$

5. Calculate the distance to the worst and best state

$$S_{ij}^+ = \sqrt{\sum_{j=1}^{n} \left( v_{ij} - v_{ij}^+ \right)^2}, i = 1,2,...,m$$

$$S_{ij}^- = \sqrt{\sum_{j=1}^{n} \left( v_{ij} - v_{ij}^- \right)^2}, i = 1,2,...,m$$

(4)

6. Calculate the similarity against the worst

$$C_{ij} = \frac{S_{ij}^-}{(S_{ij}^+ + S_{ij}^-)}, \quad 0 < C_{ij} \leq 1, \quad i = 1, 2, ..., m$$

$$C_{ij} = 1 \quad \text{if} \quad A_j = A^+$$

$$C_{ij} = 0 \quad \text{if} \quad A_j = A^-$$

(5)

7. Establish an alternative sequence in accordance with the similarity corresponding to $C_{ij}^*$

The decision matrix in the analysis of responses to the implementation of safety culture using AHP-TOPSIS is based on the consideration that safety culture as a set of attitudes of individuals and organizations that safety is a priority beyond others and that safety should be considered as important. As an explanation it is considered that the characterization of safety culture into characteristic forms will illustrate how the safety culture can be made in the form of application. Furthermore, in more detailed form, these characteristics are described in the form of attributes, and the actual attributes can be broken down into more detailed indicators still. Thus, the safety culture can be stated as multi-attribute state.[6]

In any detailed implementation it was sometimes becomes a subjective consideration, both in terms of its importance and or its understanding. As an explanation of the collective commitment the emphasis on the determination of the significance of an indicator and or attribute is not the same for all
levels within the organization. At the policy-making level the commitment to the policy statement can be one of the characteristics, while at the management level clear and clear accountability can be a feature of commitment, while at the individual level one of the characteristics of its commitment is in the form of prudence. Accordingly, the clustering of echelons as policy makers, and management and staff management echoes may generally be distinguished by their response to ongoing implementation.

In keeping with the above explanation, responses to the implementation of safety culture by individuals at all levels of the organization will not always be the same. It was not only because of the very different their competency, but it can also be due to the possibility of differences in perception of the definition of safety culture including its implementation. In accordance with the survey results that suppress the demographics of respondents based only on echelon, the criteria grouping is applied to echelon II, echelon III / IV and Staff.[7, 8]

In accordance with the above explanation, the matrix of decisions in the form of a matrix consisting of m alternatives and n attributes (or criteria) can be arranged on the basis of the characteristics / attributes of safety culture as criteria and groups of echelon or staff as alternatives, Eq. 6

$$A = \begin{bmatrix}
A_1 & A_2 & A_3 & A_4 \\
\begin{bmatrix} x_{11} & x_{12} & x_{13} & \ldots & x_{1n} \\
  x_{21} & x_{22} & x_{23} & \ldots & x_{2n} \\
  x_{31} & x_{32} & x_{33} & \ldots & x_{3n} \\
  x_{m1} & x_{m2} & x_{m3} & \ldots & x_{mn}
\end{bmatrix}
\end{bmatrix}
$$

The decision matrix is composed of 3 alternatives and its criteria are the number of characteristics and or the number of attributes of corresponding characteristics. The criteria are subject to normalization, in order to consider unequal dimensions of the attributes under consideration. The normalization method that is used is the normalization method of the vector according to Eq. 1 to consider the non-linear spacing between the core and the ratio of a single dimension will produce results that more smoothly. In this case, linear normalization is not considered appropriate for the inconsistent dimension of the criterion.

Each criterion on the decision matrix expresses the weakness or strength of the implementation of safety culture and it is considered in monotonically way. The characteristics and or attributes will be used as criteria on the decision matrix. Strengthening or weakening that is considered coming from any characteristic and or any attribute will not necessarily be the same. Likewise the magnitude of the influence of each characteristic and / or corresponding attribute expressed as the weight of each criterion, will also be different for each characteristic and or attribute. The approximate weight of the weights is obtained by using the AHP approach which corresponds to the value of each attribute, and the comparison of each other can be regarded as pairwise. By using the AHP approach a set of weights for the criterion can be obtained.[6, 9]

The calculated weights for each criterion that is based on each characteristic and or each attribute of corresponding characteristic, the weighted normalized decision matrix can be determined, Eq. 7.
Using a weighted normalized decision matrix Eq. 7 positive and negative ideal solutions can be
determined by calculating the relative closeness to ideal solution using Eq. 4 and Eq. 5. While the
closest relative distance to the ideal solution is determined by comparison of the distance to the
average negative solution with the distance to the positive and negative solutions, Eq. 6. By ranking
the relative distance, it can be obtained the rank of preference order which states that the largest as the
best solution approach and smallest as the worst solution approach.

3. Results and discussion
The data used are data collected through questionnaires at the annual workshop on safety and health in
2015. Data respondens are 13 Echelon II (noted as \( \sum \)Es2), 9 Echelon III / IV (noted as \( \sum \)Es34), and 40
staffs (noted as \( \sum \)Staf), and resulted in 3,8871 positive Likert scales from 1 to 5. Reliability test of data
gives Cronbah Alpha value of 95.5% which according to the criteria is stated reliable. Validity test
using bivariate correlation analysis technique between each attribute give Pearson correlation for all
attribute is significant at level 0.01. Using confirmatory factor analysis gives Kaise-Meyer-Olkin of
sampling Adequacy (KMO) that can be seen in Table 1.

| Table 1. Significance test results |
|-----------------------------------|
| KMO and Bartlett's Test*           |
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | 0.719 |
| Bartlett's Test of Sphericity     | Approx. Chi-Square | 1726.064 |
| df                               | 666 |
| Sig.                             | 0.000 |
| a. Based on correlations          |

Thus, since the KMO is greater than 0.5 with a degrees of freedom of 666 and a significance
level of 0.000, the obtained data can be further processed [10]. Initial information that can be obtained
directly through the used Likert scale as the measurement scale states that the highest Likert Scale
value between each level is not always at the same level, although overall it is dominated by the
echelon 2 level. It can be interpreted that the level associated with the safety policy within collective
commitment is decision making level more committed than others, Table 2. Table 2 also can be
showed that the first characteristic, i.e. safety is as a clear recognized value, has the highest value that
is given by Echelon III/IV or management level, while for almost of the characteristics staff gives the
lowest value except for characteristics of accountability. The accountability that shows the ownership
of safety at the staff level goes beyond the management level.

As a whole it can be stated that on the consideration of decision-level or echelon 2 provides a
better response to the strengthening of safety culture followed by echelon 3 & 4 and then staff, i.e.
based on the ranks of preferences order 0.8651, 0.5440, and 0.0389 respectively, Table 2. This table
shows that Echelon 2 has shown a very positive response to the presence of a strong safety culture,
although gave not the best response to the characteristics of safety is as a clear recognized value,
instead on this characteristic can be stated ugliest response approach among the three groups of
responders. For each characteristic, it can be stated that the best response approach, the majority is
given by echelon two or decision making level, but not always.

| Table 2. Ranking of preference order |
|-------------------------------------|
| Characteristics | Overall | A-Char | B-Char | C-Char | D-Char | E-Char |
| \( \sum \)Es2     | 0.8651  | 0.4130  | 0.9920  | 0.6506  | 0.6651  | 0.7055  |
| \( \sum \)Es34    | 0.5440  | 0.6788  | 0.4544  | 0.4278  | 0.6180  | 0.6380  |
| \( \sum \)Staf    | 0.0389  | 0.4340  | 0.2665  | 0.4962  | 0.2641  | 0.0061  |
To further examine the effect of each characteristic can be done by considering the Likert scale. On the first characteristic, i.e. safety is as a clear recognized value. the smallest result is not give by decision-making level but by staff level. The smallest result is on the staff level and the highest is the management level. When compared to the rank of preference order that placing responses from policy-making levels as a best alternative. it shows that expectations of safety as a higher value in policy making level while management level more focus on determining how to implementation of safety.

Table 3. Weight and Likert Scale of Safety Culture Characteristics

| Weight-Char. | 0.1986 | 0.1969 | 0.1987 | 0.2041 | 0.2016 |
|--------------|--------|--------|--------|--------|--------|
| ∑Es2         | 3.8846 | 4.1231 | 3.9077 | 3.8120 | 4.0220 |
| ∑Es34        | 3.9444 | 3.9111 | 3.8444 | 3.7901 | 4.0000 |
| ∑Staf        | 3.8750 | 3.8575 | 3.8600 | 3.7000 | 3.7750 |
| Likert Scale. Av. | 3.9014 | 3.9639 | 3.8707 | 3.7674 | 3.9323 |

Figure 1. Likert Scale of Characteristics

Figure 2. Likert Scale of A Characteristic

Further consideration is imposed on each characteristic. such that can be knew and or understood the shape of the influence of each attribute in each corresponding characteristic. The five characteristics that shall be considered are characteristics of safety is as a clear recognized value represented by characteristic A. the characteristic of leadership for safety is clear and is expressed by B characteristic. the characteristic of accountability for safety is clear and is expressed by the C characteristic. the characteristic of the integrity of safety into all activity is expressed by the D characteristic and the characteristic of safety is the learning driven of is expressed by the characteristics of E.

The results of the response analysis on characteristic of safety is as a clear recognized values are given in Table 4 and Figure 2. The ranks of preference order for this characteristic are for Echelon II. Echelon III/IV. and successive staff are 0.4130, 0.6788. and 0.4340. These results illustrate that the best solution lies on the management level and the worst at the decision-making level. Considering the value of the Likert scale of magnitude of 3.8308, 3.9333. and 3.8250 respectively can be said that the
The greatest value lies on the management level that may be illustrate to consider more detail the attribute of A proactive and long term approach to safety issues is shown in decision making.

**Table 4. Weight and Likert Scale of A Characteristic**

| Weight-A | 0.1580 | 0.1611 | 0.1694 | 0.1702 | 0.1713 | 0.1699 |
|----------|--------|--------|--------|--------|--------|--------|
| ∑Es2     | 4.1538 | 3.8462 | 4.0000 | 3.7692 | 4.0000 | 3.5385 |
| ∑ES34    | 4.0000 | 3.6667 | 3.7778 | 4.0000 | 4.1111 | 4.1111 |
| ∑Staf    | 4.1250 | 3.9250 | 3.9000 | 3.7750 | 3.6750 | 3.8500 |
| Likert Scale, Av | 4.0929 | 3.8126 | 3.8926 | 3.8481 | 3.9287 | 3.8332 |

The result of the response analysis on the characteristics of safety leadership (B characteristic) is expressed in Table 5 and Figure 3. The rank of the preference order for these characteristics for Echelon II, Echelon III/IV, and consecutive the Staff are 0.9920, 0.4544, and 0.2665 respectively. These results illustrate that the best solution lies on the policy level and the worst at the staff level. The average value of the liker scale of magnitude is 4.1231, 3.9111 and 3.8575 respectively. Indicate that the greatest value lies on the policy-making level corresponding to the rank order of preference values so that it can be said that. The attribute of Leadership skills are systematically developed and the attribute of Management has the ability to resolve conflicts as necessary or the 4th and 9th attributes; must be more considered to be developed.

**Table 5. Weight and Likert Scale of B Characteristic**

| Weight-B | 0.0951 | 0.1022 | 0.0994 | 0.0989 | 0.1009 | 0.0965 | 0.1014 | 0.0950 | 0.1075 | 0.1031 |
|----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| ∑Es2     | 4.3077 | 3.9231 | 4.1538 | 4.0000 | 4.3077 | 4.0769 | 4.3077 | 4.3077 | 3.7692 | 4.0769 |
| ∑Es34    | 3.8889 | 3.8889 | 3.8889 | 3.8889 | 4.1111 | 4.0000 | 3.8889 | 3.8889 | 3.7778 | 3.8889 |
| ∑Staf    | 4.2750 | 3.8250 | 3.9000 | 4.0000 | 3.7250 | 4.0500 | 3.7000 | 4.0750 | 3.4500 | 3.5750 |
| Likert Scale. Av | 4.1572 | 3.8790 | 3.9809 | 3.9630 | 4.0479 | 4.0423 | 3.9655 | 4.0905 | 3.6657 | 3.8469 |

![Figure 3. Likert Scale of B Characteristic](image1)

![Figure 4. Likert Scale of C Characteristic](image2)
The results of the response analysis on the safety accountability characteristics are given in Table 6 and Figure 4. The rank of preference order sequences of this characteristic for echelon II, Echelon III/IV and successive the Staff are 0.6506; 0.4278, and 0.4962. The best solution pattern lies on response of the decision-making level and the worst on the management level. The average value of the Likert scale on this characteristic are 3.9077; 3.8444, and 3.8600 respectively. The greatest value is lies on the management level. It can illustrates the consistency of the implementation of the safety to the results that will be obtained. It can be pointed out that the rank of preference order value consistent with the Likert scale value. and then can be said that the fulfillment of requirements on the provision of safety need more attention to attributes of 1, 2 and 3.

### Table 6. Weight and Likert Scale of C Characteristic

| Weight-C | 0.1972 | 0.1963 | 0.2100 | 0.1977 | 0.1989 |
|----------|--------|--------|--------|--------|--------|
| ∑Es2     | 4.0000 | 4.1538 | 3.6923 | 4.0000 | 3.6923 |
| ∑Es34    | 3.7778 | 3.8889 | 3.6667 | 4.0000 | 3.8889 |
| ∑Staf    | 4.0250 | 3.9250 | 3.7000 | 3.8250 | 3.8250 |
| Likert Scale. Av | 3.9343 | 3.9892 | 3.6863 | 3.9417 | 3.8021 |

### Table 7. Weight and Likert Scale of D Characteristic

| Weight-D | 0.1142 | 0.1118 | 0.1077 | 0.1126 | 0.1104 | 0.1104 | 0.1107 | 0.1094 |
|----------|--------|--------|--------|--------|--------|--------|--------|--------|
| ∑Es2     | 3.7692 | 3.8462 | 3.8462 | 3.8462 | 3.6923 | 3.6923 | 4.0000 | 3.9231 |
| ∑Es34    | 4.0000 | 3.5556 | 4.0000 | 3.6667 | 3.6667 | 3.6667 | 3.8889 | 4.0000 |
| ∑Staf    | 3.5750 | 3.7500 | 3.8500 | 3.6750 | 3.8000 | 3.6500 | 3.6250 | 3.6000 |
| Likert Scale. Av | 3.7814 | 3.7172 | 3.8987 | 3.7293 | 3.7197 | 3.6697 | 3.8380 | 3.8410 |

The results of the response analysis on the characteristics of safety integrity can be expressed in Table 7 and Figure 5. The rank values of preference sequences for these characteristics for Echelon III,
Echelon III/IV, and successive the staff are 0.6651, 0.6180, and 0.2641. For this characteristics the best solution lies at the policy-making level and worst at the staff level. Likert scale values of magnitude are 3.8120; 3.7901, and 3.7000 respectively. The greatest value lies on the policy-making level and consistent with the rank of preference order. However, Figure 5 illustrates the inconsistency of safety practices specifically at the management level as the organizer in attributes of 2, 4, 5 and 6 still need to strengthen the implementation.

The result of the response analysis on safety characteristics as the driving force for safety learning is given in Table 8 and Figure 6. The rank ratings of the preference sequences for these characteristics for echelon II, Echelon III/IV, and successive the Staff are 0.7055, 0.6380, and 0.0061. The best solution lies on the policy making level of and the worst lies on the staff level. The magnitude of the average value of the Likert scale are 4.0220; 4.0000, and 3.7750 respectively. It is show the consistency with the value of the rank preference order. In this case shall be paid more attention to every attribute that exists in this characteristics, and it can be said that in general the prudence and motivation of staff still need to be improved. Especially the emphasis on attributes 1 and 4. see Figure 6 will be usefully.

Table 8. Weight and Likert Scale of E Characteristic

| Weight-E  | 0.1455 | 0.1533 | 0.1338 | 0.1399 | 0.1438 | 0.1397 | 0.1440 |
|-----------|--------|--------|--------|--------|--------|--------|--------|
| ∑Es2      | 3.7692 | 4.0769 | 4.3077 | 3.9231 | 3.9231 | 4.0769 | 4.0769 |
| ∑Es34     | 4.1111 | 3.7778 | 4.1111 | 4.0000 | 4.0000 | 4.0000 | 4.0000 |
| ∑Staf     | 3.7750 | 3.4750 | 4.0500 | 3.9000 | 3.7250 | 3.8500 | 3.6500 |
| Likert Scale. Av | 3.8851 | 3.7766 | 4.1563 | 3.9410 | 3.8827 | 3.9756 | 3.9090 |

4. Conclusion
The AHP -TOPSIS method for ranking sequence preferences can be used practically in such a way that the best and worst solutions of available alternative options can be made. TOPSIS based on decision matrix that composed of alternatives and criteria on multi-criteria decision system. The approach to alternatives is based on levels in the collective commitment to declare safety culture. ie. policy making, management, and staff. While the approach is intended as a criterion is the characteristics and or attributes of safety culture. The magnitude of influence in the form of weights contained in each criterion is estimated by AHP technique. Alternative can be expressed as a pattern of how the safety culture is implemented with the particular treatment imposed on every characteristic and or attribute of safety culture. Using of data which derived from questionnaires at a workshop on occupational health and safety 2015. the decision matrix was prepared with Echelon II, Echelon III/IV, and staff as alternatives. and five characteristics and or 37 safety culture attributes were used to be criteria. As a result, there is consistency of Likert scale value in questionnaire with rank of preference order value as available alternative option. Estimated sequence of ranks obtained are 0.8651, 0.5440, and 0.0389 respectively for decision making level, management level and staff level. The best alternatives option exist at the policy-making level or responses of the Echelon II followed by the management level or responses of the Echelons III/IV and the worst is at the staff level or responses from Staff. Considering the attributes contained in the corresponding characteristics. the best alternative as a response is obtained from the policy making level except on the characteristic of safety is as a clear recognized value. Response patterns as the best successive alternatives of decision-making, management, and staff levels are not always for the overall considered characteristics. and hence to get a more detailed picture it is necessary to consider the elements of the criteria group of the characteristics and or attributes in the corresponding characteristics. Likert scale that provides information about the criteria can be use to establish the influence the corresponding characteristics and or attributes.
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References

[1] Pavić Z. and V. Novoselac 2013 Notes on TOPSIS method. International Journal of Research in Engineering and Science (2) p. 5-12.
[2] Liu P. 2011 An Extended TOPSIS Method for Multiple Attribute Group Decision Making Based on Generalized Interval-valued Trapezoidal Fuzzy Numbers. Informatica (03505596). 35(2).
[3] Ozturk D. and F. Batuk 2011 Technique for order preference by similarity to ideal solution (TOPSIS) for spatial decision problems. in Proceedings ISPRS.
[4] Athawale V.M. and S. Chakraborty 2010A TOPSIS method-based approach to machine tool selection, in International Conference on Industrial Engineering and Operations Management. Dhaka, Bangladesh.
[5] Chi P. and P. Liu 2013An extended TOPSIS method for the multiple attribute decision making problems based on interval neutrosophic set. Neutrosophic Sets and Systems. 1(1) p. 63-70.
[6] Bhattia P.W. and R. Phipon 2012 Application of AHP and TOPSIS method for supplier selection problem. IOSR Journal of Engineering. 2(10) p. 43-50.
[7] Situmorang J.2016 Evaluation of influence factors within implementing of nuclear safety culture in embarking countries International Conference on Human and Organizational Aspects of Assuring Nuclear Safety IAEA p214-215
[8] Situmorang J 2014 EVALUASI BUDAYA KESELAMATAN UNTUK PRIORITISASI PENTINGNYA KARAKTERISTIK/ATRIBUT PADA INSTALASI NUKLIR DENGAN TEKNIK AHP (ANALYTIC HIERARCHY PROCESS). Jurnal Teknologi Pengelolaan Limbah.: 16(1).
[9] Kallas Z 2011 Butchers’ preferences for rabbit meat; AHP Pairwise comparisons versus a LIKERT scale valuation. in Proceedings of the 11st International Symposium on the Analytic Hierarchy Process and Analytic Network Process [ISAHP 2011].
[10] Ghozali Imam H. 2005 “Aplikasi Analysis Multivariate dengan program SPSS”. edisi 3. Badan Penerbit Universitas Diponegoro. Januari. Semarang