A Hybrid MCDM Approach Based on ANP and TOPSIS for Facility Layout Selection

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Abstract: Facility layout selection is a multi-criteria decision making (MCDM) problem, since it has a strategic impact on the efficiency of manufacturing system. In view of the interdependency among selection criteria, analytic network process (ANP) is proposed to analyze the structure of the facility layout selection problem and determine the weights for each criterion. A network structure is constructed that shows all elements and clusters and their interactions. Limit priorities are also calculated which help decision maker evaluate the relative importance among criterion in the alternative selection process. Moreover, a hybrid MCDM approach that employs ANP and technique for order preference by similarity to an ideal solution (TOPSIS) method to rank the optimal facility layout alternatives. Finally, an application of a new aeronautic component assembly workshop facility layout selection is conducted. To further illustrate the advantage of the proposed approach, the difference between ANP-TOPSIS and AHP-TOPSIS methods are compared and discussed. Results have demonstrated the effectiveness and feasibility of the proposed method.

Key words: facility layout selection; multi-criteria decision making (MCDM); analytic network process; AHP; TOPSIS

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0 Introduction

Facility layout problem (FLP) involves in the optimal arrangements of a given number of non-overlapping facilities such as workstations, machines, utilities, et al.[1,2]. The facility layout selection should be considered from a strategic and comprehensive perspective as its tremendous impact upon the efficiency of manufacturing system[3]. A reasonable facility layout may decrease 10%—30% operational cost[4]. Moreover, possible consequences are caused by poor facility layout, such as heavier manufacturing costs, longer lead time, more inventory backlog etc. Therefore, selection of an optimal facility layout alternative is critical important for manufacturing system.

Facility layout selection involves both qualitative and quantitative criteria with different units and conflicting features[5]. In most literatures many multi-criteria decision making (MCDM) methodologies have been applied in the selection procedure that generally include establishing alternative layouts, determining selection criteria, and evaluating alternatives[6,7]. In many of these methodologies, each evaluation criterion was assumed to be independent. For instance, analytic hierarchy process (AHP) method was used to assign the weight of qualitative layout evaluation criteria[8], which also integrated with other MCDM methods to evaluate facility layout alternatives such as data envelopment analysis (DEA)[9], preference ranking organization methods for enrichment evaluation (PROMETHEE)[5], Vlsekriterijumska Optimizacija Kompromisno Resenje (VIKOR)[10], et al. The latent

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assumption in AHP is that each criterion is assumed to be independent. The criteria can be established in a hierarchy way so as to help decision-maker understand the problem clearly.

In real application, many decision making problems cannot be established in a hierarchy structure due to interactions and dependencies between criteria. The above mentioned assumption is imprecise in such case and may result in unreasonable decisions[3]. So the MCDM problem should be established in a network structure. Analytic network process (ANP) is an improved version of AHP and good at solving decision making problems with complicated system and dependence in feedback systematically. ANP method can provide more accurate weight of criteria, since it enables consideration of the interactions and dependencies between criterion. Therefore, ANP method has received more and more attention from researchers in the fields of marketing, resource assignment, industry, et al. For example, an ANP network model was proposed to evaluate suitable water treatment technology[11]. Moreover, it was compares with AHP hierarchy model to discuss their difference. Also, AHP and ANP methods were proposed to select a manufacturing system in wafer fabricating industry[12]. Unfortunately, AHP/ANP method requires many pairwise comparisons among the number of factors and possible alternatives. The shortcoming of AHP/ANP method can overcomed via the use of technique for order preference by similarity to an ideal solution (TOPSIS) method[13]. Therefore, this paper proposes a novel hybrid analytic approach based on AHP/ANP and TOPSIS to assist in facility layout decision.

1 Literature Review

The facility layout selection can be solved by a variety of MCDM methods. In the following section, literatures review on AHP, ANP, TOPSIS, respectively.

AHP method generally contains several levels: Top level represents main objective, intermediate level represents criteria and its corresponding sub-criteria, and bottom level usually represents several alternatives. Based on the above criteria, the optimal alternative was selected with respect to main objective[14]. Yang and Kuo integrated AHP and DEA method for solving facility layout design problem[9]. AHP and PROMETHEE were used to solve facility layout problem[5]. AHP and VIKOR methods were proposed to solve the facility layout problem[10]. However, the central premise of AHP method is that the criterion in the above methodologies is independent. Thus, the hierarchy structure cannot be applied in such a case that the interactions within or between different levels exist.

In practical application, a MCDM problem cannot always be solved by a hierarchy structure because of the existence of interdependencies between criteria. For example, the alternatives may affect the importance of the criteria reversely, even these criteria may be used to evaluate the alternatives[15]. Instead of a hierarchical structure as in AHP, the ANP method is a network structure with potential interactions, feedback and interdependence. Due to its advantage in solving the MCDM problem with its interrelationships among the decision levels and elements, ANP method has been applied in many fields. For example, an ANP network model was formed to select the best supplier in IC packaging[16]. ANP method along with cost analysis were used in the selection of R&D project[17]. ANP method was proposed to select the facility location[3]. However, it needs many pairwise comparisons among the number of criteria. Therefore, TOPSIS method is introduced to avoid a large number of pairwise comparisons.

TOPSIS method has been widely used in facility layout selection because of easy implementation and rational logic. It should be noted that the TOPSIS method requires an effective tool to attain the weight of criteria. Therefore, it is always combined with other MCDM methods in facility layout selection. For example, AHP was combined with TOPSIS to rank the alternatives[18]. TOPSIS was integrated with DEA to select the optimal flexible bay structure layout[14]. TOPSIS was also integrated with simulated annealing algorithm and DEA for evaluation dynamic facility layout alternatives[19]. However, all the evaluation criteria lack feedback and interactions between criteria still exist. In this paper, ANP is integrated with TOPSIS for selecting optimal facility layout alternatives.

2 Methodologies

2.1 AHP method

Due to its simplicity, ease of implement, and great flexibility, AHP is proved to be a useful logic approach for solving various type of MCDM problem in many fields of technology and science. The main advantage of AHP is that it is capable of incorporating tangible factors as well as nontangible factors, especially decision process involving subjective judgments[20,21]. AHP method is generally divided into three steps as follows:

Step 1 Determine the evaluation criteria of the hierarchy model. AHP initially decomposes a complex multi-criteria decision problem into many subproblems, including criteria, sub-criteria, alternatives, etc.[22,23]. Construct the control hierarchy and define the evaluation criteria according to literature search and expert suggestions.

Step 2 Construct the pairwise comparison of the criteria. In order to determine the relative importance of the criteria with respect to the objective, the comparison matrix is formulated on the basis of standardized comparison scales (1—9). The pairwise comparison matrix $\boldsymbol{A}_k$ for expert k is described as

$$\boldsymbol{A}_k=\begin{bmatrix} 1 & a_{12k} & \cdots & a_{1nk} \\ \frac{1}{a_{12k}} & 1 & \cdots & a_{2nk} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{a_{1nk}} & \frac{1}{a_{2nk}} & \cdots & 1 \end{bmatrix} \tag{1}$$

where a_{ij} denotes the relative importance of the component i against the component j, where $i=1, 2,\cdots,m$ and $j=1,2,\cdots,n$.

Step 3 Check the consistency property of the comparison matrix.

The quality of output of the AHP process is related to the consistence property of the comparison matrix. The consistency index CI and consistency ratio CR are defined as

$$\mathrm{CI}=\frac{\lambda_{\max}-n}{n-1} \tag{2}$$

$$\mathrm{CR}=\frac{\mathrm{CI}}{\mathrm{RI}} \tag{3}$$

where $\lambda_{\max}$ denotes the largest eigenvalue of the matrix, n the number of items being compared in the matrix, and RI the random index. CR should be less than 0.1, and the comparisons are acceptable, otherwise, the compassion matrix need to be revised.

2.2 ANP method

Compared with AHP, ANP method takes account of more complex interrelationships among different decision levels. The ANP method is able to solve interdependence among elements by obtaining the relative importance of different criteria. Instead of a hierarchy structure, ANP method forms a network structure, which not only includes the clusters with others, but also contains clusters' internal connection. Each cluster contains many elements with resemblance functions. Moreover, elements may affect its corresponding criteria, even other criteria. Therefore, the interaction between clusters or elements forms the network. The ANP method is generally divided into six steps as follows:

Step 1 Evaluate criteria and construct a network model. The complex system breaks down into a rational system as a network. Collect the evaluation criteria according to expert suggestions and literature search. Analyze the interdependencies among criteria and construct a network structure.

Step 2 Construct pairwise comparison matrices of interdependencies. Similar to AHP, pairwise comparisons of the elements in each level and clusters are conducted with respect to their relative importance toward different clusters.

Step 3 Check the consistency property of the comparison matrix. Similar to AHP, consistency property CI and CR of the comparison matrix have an important influence on the effectiveness of evaluation.

Step 4 Form an un-weighted super matrix. The un-weighted super matrix is a partitioned matrix, where each sub-matrix consists of a set of relationships between clusters. The derived vectors that result from the pairwise comparisons are composed of each sub-matrix. However, an un-weighted super matrix contains only the indirect influence and does not contains intermediate elements that carry the influence between a pair of elements. This influence can be formed by next step.

Step 5 Construct a weighted super matrix. Different weights are assigned to blocks in the same column, which sum to unity. According to the weight calculation, weights of clusters can be obtained by cluster comparison. The weighted super matrix is completed after multiplying all elements in the cluster matrix by the corresponding blocks in the un-weighted super matrix.

Step 6 Calculate the limit super matrix. In order to achieve a convergence on the importance weights and obtain a steady-state outcome, the weighted super matrix is calculated with limiting power until it reaches stability.

2.3 TOPSIS method

After the weight of each criterion obtaining by ANP limit matrix, TOPSIS methods is used to rank the alternatives.

Step 1 The normalized value r_{ij} can be calculated as

$$r_{ij} = f_{ij} \Big/ \sqrt{\sum_{j=1}^{n} f_{ij}^2} \quad i=1,2,\cdots,m;\ j=1,2,\cdots,n \tag{4}$$

Step 2 Build weighted decision matrix. In view of the different importance of each criterion, the weighted normalized value v_{ij} can be calculated as

$$v_{ij} = w_{ij} r_{ij} \tag{5}$$

where w_{ij} is the weight for the criterion and can be obtained from ANP limit super matrix.

Step 3 Calculate the distance from given alternatives to positive and negative ideal reference points respectively. The range of each element in weighted decision matrix belongs to interval [0, 1]. The detail distances are described as follows

$$d_i^+ = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^+) \quad i=1,2,\cdots,m \tag{6}$$

$$d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^-) \quad i=1,2,\cdots,m \tag{7}$$

where $\tilde{v}_j^+ = (1,1,1)$ and $\tilde{v}_j^- = (0,0,0)$, d_i^+ denotes the distance between the given alternative i and the positive ideal point and d_i^- the distance between the given alternative i and the negative ideal point.

Step 4 Calculate the rank index. The relative closeness to the ideal solution for each given alternative is described as follows

$$C_i^* = \frac{d_i^-}{d_i^- + d_i^+} \tag{8}$$

The higher rank index C_i^* means the given alternatives are closer to the positive ideal solution and farther from the negative ideal solution. Therefore, the ranking order for all alternatives is determined and the best solution can be obtained among a set of feasible alternatives.

3 Case Study and Result Discussion

After presenting the hybrid MCDM method for facility layout selection, this section employs a case of a new aeronautic component assembly workshop to demonstrate the proposed method. The production of aeronautic component involves various batch production, multiple process plan, various components and frequent delivery etc. The production line consists by five assemble stations. According to production planning, each station is assigned with assembling different components but it should keep the same and adaptable production cycle, even in case of urgent demand. Therefore, the optimal facility layout alternative is dedicated to stress on improve material handling flexibility and makes the workshop more responsive to products and demands variations.

3.1 Criteria for facility layout selection

Criteria selection initially involves gathering all factors that affect the rationality and effectiveness of a facility layout. An expert's team including three senior aeronautic industry researchers, three senior engineers in planning, logistic, and manufacturing are formed to determine the criteria of facility layout selection of a new aeronautic component assembly workshop. According to a standard scales (1—9), experts fill out the questionnaire on the basis of experience. The decision goal, the set of evaluation criteria and alternatives have been determined. Finally, There are four feasible alternatives (A_1, A_2, A_3, A_4), which are built by experts team in the aeronautic industry. And also five criteria(AD, FF, RF, VV, FE)and its twelve elements ($C_1, C_2, \cdots, C_{12}$) for facility layout selection are determined, as shown in Table 1.

Table 1 Criteria for the most effective alternative facility layout

Criteria	Elements	Explanation	Reference
Adjacency distance (AD)	• Distance between facilities in different apartments	Facilities adjacency should be considered	[7]
	• Distance of material handling transportation	Material transportation rectilinear distance between the centroids of two facilities	
Facility features (FF)	• Shape factors	Facilities regular shapes and material I/O port	[24]
	• Accessible area utilization	Including value adding area utilization and non-value adding area utilization	
Routing flexibility (RF)	• Average number of alternate routes	The number of options to produce or assemble components	[3]
	• Accessibility of alternate routes	The ease to rerouting process in terms with material transportation or machines setup changes	
	• Material handling flexibility	The ability of a material handling transportation use multiple paths between facilities with different type of parts	[25]
Volume variation (VV)	• Demand volume variation	Due to the rapid market change or factory keep producing in profitable manner	[3]
	• Variation in material handling cost	The variation in material handling costs with a range of demand volume and transportation frequency	
Facility environment (FE)	• Worker safety	The safety distance for employee, machines, material storage etc	
	• Ease of facilities maintenance	According to the effort and time for facilities maintenance	
	• Accessibility workspace	The required space for maintenance engineer or tool movement	

3.2 Assigning criteria weights by AHP and ANP

3.2.1 Assigning criteria weights by AHP

In contrast with ANP method, an AHP model is constructed to select the optimal facility layout alternatives. After determining the criteria for the facility layout selection, the expert panel is gathered to construct the AHP hierarchy structure, as shown in Fig. 1. It is important to emphasize that no interdependencies exist within all involved criteria in AHP hierarchy structure. The pairwise comparison with different levels is performed by super decision software. The expert's opinions need to be asked to describe the relative importance between different levels through all the pairwise process. According to the pairwise results gathering from experts, the pairwise matrix can be obtained. For example, the pairwise comparison matrix of criteria towards goal based on the first expert opinion is shown in Table 2. Through this step, the consistency of questionnaire results needs to be tested. In the above case, the consistency ratio is CR = 0.060. Since the pairwise matrix is consistent, otherwise, the part of questionnaire needs to be filled out again. After completing all the pairwise comparison with different level, the overall weights can be calculated by super decision software. Table 3 shows overall weights in this case.

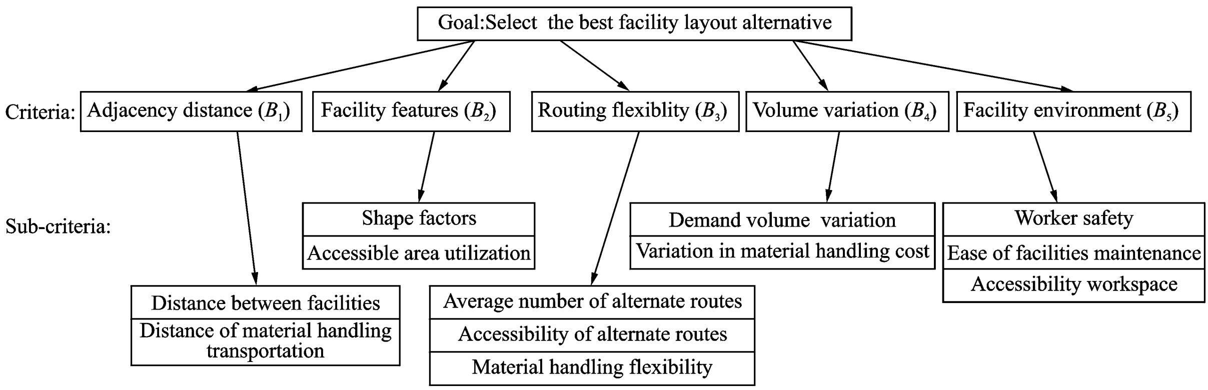

Fig. 1 Hierarchy structure for selecting the best facility layout alternative

Table 2 Pairwise comparison matrix of criteria towards goal

Criteria	AD	FE	FF	RF	VV
AD	1.000	5.000	3.000	3.000	3.000
FE	0.200	1.000	0.333	0.200	0.143
FF	0.333	3.000	1.000	0.333	0.333
RF	0.333	5.000	3.000	1.000	1.000
VV	0.333	7.000	3.000	1.000	1.000

Table 3 Overall weight for facility layout alternatives selection (AHP)

Element	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
Weight	0.128	0.114	0.082	0.042	0.051	0.067	0.041	0.103	0.129	0.107	0.094	0.042

3.2.2 Assigning criteria weights by ANP

After determining the criteria for the facility layout selection, the expert panel is gathered to construct the ANP model. Since the pairwise comparison process can be implemented by super decision software, the dependence and feedback between involved criteria need to be analyzed by expert's team. Then, an ANP network structure is constructed on the basis of the pairwise comparison, as shown in Fig. 2. According to the pairwise results gathering from experts, the pairwise matrix can be obtained. For example, the pairwise comparison matrix of criteria towards criterion AD based on the first expert opinion is shown in Table 4. Through this step, the consistency of questionnaire results needs to be tested. As mentioned method, the consistency ratio can be obtained as CR = 0.009 37. Since CR < 0.1, the pairwise matrix is consistent, otherwise, the part of questionnaire needs to be filled out again. Through this step, ANP process runs automatically in super decision software, in which super matrix can be obtained. Table 5 shows the weighted super matrix in this case. The cumulative influence that elements interact with each other can be obtained. Then the weighted super matrix is raised to powers to obtain a stable outcome that the final weights from limit super matrix are shown in Table 6. These overall weights are used in the TOPSIS method later. It can be seen that the top three most important criteria in the experts questionnaire are "material handling flexibility (20.3%)" "accessibility of alternate route (16.6%)", and "average number of alternate route (14.3%)". The above three criteria occupy 51.2% importance of all criteria.

Table 4 Pairwise comparison matrix of criteria towards AD clusters

Criteria	AD	FE	FF	RF	VV
AD	1.000	5.000	3.000	1.000	1.000
FE	0.200	1.000	1.000	0.200	0.333
FF	0.333	1.000	1.000	0.333	0.333
RF	1.000	5.000	3.000	1.000	1.000
VV	1.000	3.000	3.000	1.000	1.000

3.3 Evaluation of the alternatives by TOPSIS

In this section, normalizing the decision matrix based on the response of the six experts, the

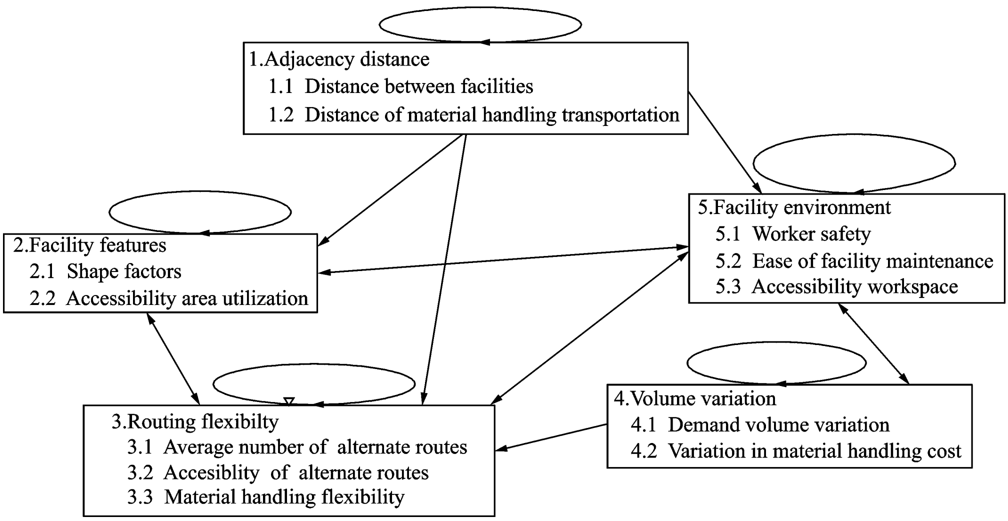

Fig. 2 Network structure for selecting the best facility layout alternative

Table 5 Weighted super matrix of facility layout alternatives selection

Element	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
C_1	0.000	0.290	0.000	0.000	0.000	0.000	0.287	0.000	0.000	0.131	0.071	0.063
C_2	0.290	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.131	0.071	0.188
C_3	0.072	0.072	0.000	0.106	0.750	0.100	0.096	0.118	0.092	0.116	0.000	0.000
C_4	0.000	0.000	0.000	0.000	0.250	0.000	0.000	0.000	0.044	0.000	0.000	0.000
C_5	0.000	0.000	0.105	0.035	0.000	0.034	0.000	0.039	0.021	0.000	0.000	0.000
C_6	0.044	0.044	0.000	0.000	0.000	0.000	0.394	0.067	0.134	0.099	0.000	0.000
C_7	0.044	0.044	0.258	0.000	0.000	0.553	0.000	0.067	0.000	0.000	0.000	0.000
C_8	0.058	0.174	0.212	0.172	0.000	0.000	0.000	0.000	0.532	0.261	0.000	0.000
C_9	0.058	0.058	0.212	0.172	0.000	0.000	0.000	0.355	0.000	0.261	0.000	0.000
C_{10}	0.174	0.058	0.212	0.515	0.000	0.313	0.223	0.355	0.177	0.000	0.429	0.750
C_{11}	0.000	0.196	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C_{12}	0.261	0.065	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.429	0.000

Table 6 Limit super matrix of facility layout selection for a new aeronautic workshop

Element	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
C_1	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071
C_2	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053
C_3	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103
C_4	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
C_5	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
C_6	0.093	0.093	0.093	0.093	0.093	0.093	0.093	0.093	0.093	0.093	0.093	0.093
C_7	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095
C_8	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.166	0.166
C_9	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143
C_{10}	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203
C_{11}	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
C_{12}	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027

initial value from experts for given alternatives is presented in Table 7. Then the weighted matrix can be constructed on the basis of overall weights obtained from AHP and ANP models, respectively. The next step is to calculate the distance from given alternatives to the positive ideal reference point and the negative ideal reference point, respectively. Under this circumstance, the positive distance and negative distance of the facility layout alternatives selection are shown respectively in Table 8 (ANP-TOPSIS), Table 9 (ANP-TOPSIS), Table 10 (AHP-TOPSIS), and Table 11 (AHP-TOPSIS).

3.4 Results and discussion

Table 12 shows the final ranking index for the optimal facility layout alternative obtained from AHP-TOPSIS and ANP-TOPSIS methods, respectively. The ranking order of the alternatives with ANP-TOPSIS methods is $A_3 > A_2 > A_4 > A_1$, while in AHP-TOPSIS method the ranking order is $A_2 > A_3 > A_4 > A_1$. It can be observed from Table 12 that in both methods alternative 1 obtains the worst results, especially the least rank index in AHP-TOPSIS method with a score of 0.169, while alternative 1 in ANP-TOPSIS method with a score of 0.175.

It is shown that the consideration of inter-dependencies in the ANP model affects the final alternative selection. A_2 is the best alternative in AHP method while A_3 is the best alternative in ANP method. In this case, AHP method cannot suite for decision making problems, which include multiple criteria interacting with each other such as variation in material handling cost and distance between facilities, AD criterion and FF criterion, AD criterion and RF criterion etc. For example, the longer distance between facilities, the more cost of material delivery. However, ANP method has advantage of considering interaction with each criteria or element. Therefore, it can be concluded that the ANP method is more closer to reality than the AHP in such case, which can provide a more reasonable alternative for decision maker. Moreover, ANP and TOPSIS methods proposed for facility layout selection have significantly eased the procedure burden on decision-making process.

Table 7 The initial value from experts for given alternatives

Alternative	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
A_1	2.10	1.20	2.50	1.50	2.42	1.62	1.57	1.21	1.43	1.70	1.92	1.43
A_2	3.08	0.83	0.91	1.20	1.73	2.02	2.01	1.45	1.90	1.82	2.42	2.20
A_3	3.10	0.72	0.81	1.16	1.75	2.12	1.92	1.42	1.70	1.92	2.40	2.20
A_4	2.62	2.90	1.96	1.70	2.72	1.28	1.20	1.76	2.92	1.56	1.42	2.28

Table 8 Positive distance of the alternatives with respect each criterion (ANP)

Alternative	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
A_1	0.071	0.083	0.083	0.083	0.083	0.100	0.112	0.201	0.246	0.276	0.276	0.277
A_2	0.001	0.050	0.109	0.110	0.112	0.113	0.113	0.147	0.176	0.185	0.185	0.185
A_3	0.000	0.053	0.116	0.116	0.119	0.119	0.119	0.157	0.196	0.196	0.196	0.196
A_4	0.034	0.034	0.047	0.047	0.047	0.104	0.141	0.141	0.141	0.247	0.247	0.247

Table 9 Negative distance of the alternatives with respect each criterion (ANP)

Alternative	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
A_1	0.000	0.012	0.103	0.104	0.105	0.112	0.120	0.120	0.120	0.143	0.143	0.143
A_2	0.070	0.070	0.070	0.070	0.070	0.108	0.144	0.161	0.167	0.222	0.222	0.224
A_3	0.071	0.071	0.071	0.071	0.071	0.117	0.144	0.158	0.160	0.258	0.258	0.259
A_4	0.037	0.065	0.095	0.096	0.099	0.099	0.099	0.194	0.241	0.241	0.241	0.242

Table 10 Positive distance of the alternatives with respect each criterion (AHP)

Alternative	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
A_1	0.128	0.156	0.156	0.159	0.161	0.166	0.169	0.197	0.236	0.244	0.249	0.252
A_2	0.036	0.088	0.106	0.106	0.118	0.122	0.122	0.122	0.151	0.154	0.161	0.161
A_3	0.000	0.114	0.140	0.147	0.154	0.154	0.156	0.181	0.209	0.209	0.209	0.209
A_4	0.061	0.061	0.074	0.080	0.080	0.104	0.112	0.152	0.152	0.186	0.208	0.208

Table 11 Negative distance of the alternatives with respect to each criterion (AHP)

Alternative	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
A_1	0.000	0.025	0.086	0.086	0.090	0.094	0.095	0.095	0.095	0.104	0.114	0.114
A_2	0.092	0.098	0.101	0.109	0.109	0.114	0.121	0.159	0.164	0.181	0.188	0.191
A_3	0.128	0.128	0.128	0.128	0.128	0.145	0.145	0.146	0.148	0.182	0.205	0.209
A_4	0.067	0.132	0.138	0.139	0.148	0.148	0.148	0.148	0.196	0.196	0.196	0.201

Table 12 Rank index of facility layout alternative

Alternative	ANP-TOPSIS Rank index	AHP-TOPSIS Rank index
A_1	0.175	0.169
A_2	0.280	0.294
A_3	0.291	0.271
A_4	0.254	0.266

4 Conclusions

A hybrid method of integrating ANP and TOPSIS methods is proposed to evaluate facility layout selection. The ANP model is constructed on the basis of selection criteria collected from the literatures and industry. A new aeronautic component workshop is selected as an application model, which shows the ANP can easily solve the complex multi-criteria decision problem such as handling independencies between criteria. ANP has advantage of covering feedback loops and cycles in its network structure. For a contrast purpose, this paper introduced an AHP hierarchy model, and also combined with TOPSIS method to evaluate facility layout selection with same evaluation criteria but ignoring interdependencies between criteria. The results show the difference between above two hybrid methods. It is worth noting that the existence of all criteria independencies may affect final alternative selection and future improvement factors. The alternatives with higher rank indices and factors with higher priorities and impacts are considered to be more invested. It is observed that ANP-TOPSIS method is a flexible, precise and convenient ranking method. In the future work, fuzzy logic with ANP, AHP, TOPSIS are supposed to be taken into consideration as well. It will help decision maker deal with vagueness and fuzziness linguistic assessment.

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