Integration of MACBETH and COPRAS methods to select air compressor for a textile company

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C H R O N I C L E	A B S T R A C T
	The selection of air compressor is a Multiple Criteria Decision Making (MCDM) problem including conflicting criteria and various alternatives. Selecting the appropriate air compressor is an important decision for the company as it affects the energy consumption and operating cost. To aid the decision making process in the companies, MCDM methods are proposed in the literature. In all MCDM methods, the main goal is to select the best alternative or to rank a set of given alternatives. In this paper, the air compressor is selected for a spinning mill of a textile company with an integrated approach based on MACBETH (**M**easuring **A**ttractiveness by a **C**ategorical **B**ased **E**valuation **T**ec**H**nique) and COPRAS (***CO**mplex **PR**oportional **AS**sessment*) methods. MACBETH method is utilized to determine the weights of the criteria. Then COPRAS method is used to determine the ranking of the alternatives and select the best one.

1. Introduction

Air compressors are widely used in industries to convert power using an electric motor, diesel or gasoline engine, etc. into potential energy stored in pressurized air. An air compressor forces more and more air into a storage tank by increasing the pressure. The energy contained in the compressed air can be used for a variety of applications. There are many types of air compressors, thus a proper selection is needed to fulfil the typical necessity of each company. Selection of an air compressor is a decision characterized by multiple criteria. In order to evaluate the overall efficiency of an air compressor it is necessary to identify selection criteria and to develop methods for evaluating the criteria and alternatives to meet the companies' needs. MCDM methods are proposed for the situations in which a decision maker has to choose among several alternatives by considering a common set of criteria. In the literature there are studies that apply different MCDM methods to the selection problems of textile companies. For instance, Ertuğrul and Karakaşoğlu (2008) selected a facility location for a textile

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company with fuzzy AHP (Analytic Hierarch Process) and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) methods. Cebeci (2009) compared ERP (Enterprise Resource Planning) systems with fuzzy AHP for a textile company. Ilangkumaran and Kumanan (2009) proposed fuzzy AHP and TOPSIS for selecting the best maintenance strategy for a textile industry. Yayla et al. (2013) selected subcontractor for a textile company by using generalized Choquet integral methodology. Mokhtari et al. (2013) proposed fuzzy Delphi, fuzzy AHP and VIKOR (Vise Kriterijumska Optimizacija I Kompromisno Resenje) methods for supplier selection in textile industry. In this paper, different selection problem of a textile company is considered. Integrated approach based on MACBETH and COPRAS methods are proposed for the air compressor selection of a textile company. MACBETH method is used to determine the weights of the criteria. Then the ranking of the alternatives are determined with COPRAS method. The main contribution of this paper to the literature is to integrate MACBETH and COPRAS methods for the first time.

This paper is organized as follows: In the second section, the integrated method is introduced and also MACBETH and COPRAS methods are explained respectively. In the third section, application of the integrated method in a spinning mill of a textile company is given. Finally, result of the integrated method are discussed and suggestions for future research are offered in the last section.

2. Integrated Method

In this section, MACBETH and COPRAS methods are integrated for selecting the best air compressor alternative for the spinning mill of a textile company. MACBETH method is used for determining the weights of the criteria and then with COPRAS method the ranking of the alternatives are determined. So, in this section firstly MACBETH method is introduced and then COPRAS method is explained. Flow chart of the integrated method can be seen in Fig. 1.
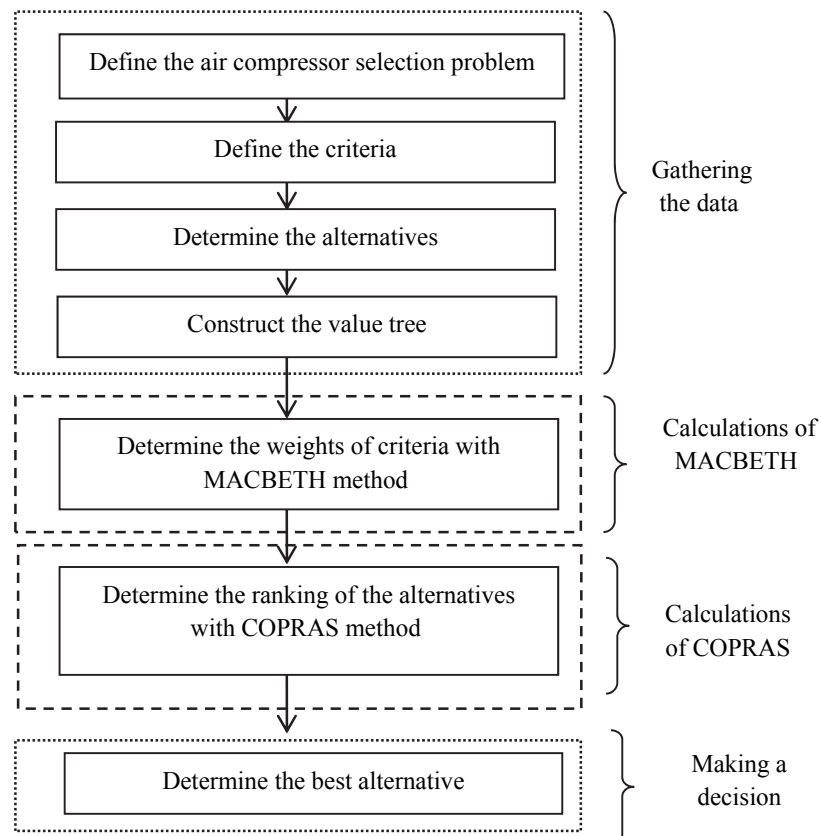
Fig. 1. Flow chart of the integrated method

2.1 MACBETH Method

MACBETH (**M**easuring **A**ttractiveness by a **C**ategorical **B**ased **E**valuation Tec**H**nique) is a MCDM method used to establish a quantitative model of values. It avoids decision makers to produce direct numerical representations of their preferences (Bana e Costa & Chagas, 2004) and helps for determining the ranking of the alternatives based on aggregated value of relative weighted attractiveness of alternatives with respect to decision criteria (Karande & Chakraborty, 2014).

MACBETH was firstly proposed by Bana e Costa, Vansnick and De Corte in 1990s. After introduced in the XIth International Conference on MCDM, this method was applied to various fields (Burgazoğlu, 2015). For instance, Bana e Costa et al. (1999) solved complex strategic problems of Santa Catarina textile industry by integrating several decision support systems. Bana e Costa et al. (2001) integrated MACBETH and disaggregation-aggregation approaches for conflict dissolution in the construction of a new railway link to the port of Lisbon. Bana e Costa (2001) used MACBETH method for analyzing spatial conflicts in the investment policy of new inter-municipal road-links. Bana e Costa & Oliveira (2002) determined the maintenance, repair and refurbishment priorities in managing a municipal housing stock. Bana e Costa et al. (2002a) used this method for the strategic town planning of Barcelos which was one of the medium sized Porteguese towns. Bana e Costa et al. (2002b) helped credit granting decisions in banking sector. Bana e Costa et al. (2002c) facilitated bid evaluation processes in public call for tenders. Bana e Costa & Chagas (2004) used MACBETH method and software to solve career choice problem. Roubens et al. (2006) determined stable governments by developing a model for coalition formation with MACBETH method. Cliville et al. (2007) used MACBETH method to determine the industrial performance expressions. Montignac et al. (2009) compared the technical performance of hydrogen storage technologies with MACBETH method. Fakhfakh et al. (2011) combined MACBETH method with workflow patterns aggregation rules for measuring the satisfaction degree of services orchestration. Karandea & Chakraborty (2013) used MACBETH method to solve supplier selection problems. Rodrigues (2014) proposed MACBETH method to build a multidimensional value-based population health indices. Karande and Chakraborty (2014) solved facility layout selection problems with MACBETH method. Lastly, Dhouib (2014) applied fuzzy MACBETH method to evaluate reverse logistics alternatives for the automobile tire wastes.

Steps of the MACBETH method can be summarized as follows:

Step 1. Decision criteria are defined and expressed in the form of a value tree.

Step 2. Then alternatives and the ordinal performance levels of them with respect to each criterion are defined. Minimum two reference levels are required to be identified as upper reference (good) level and lower reference (neutral) level. The upper reference level denotes the score of 100 while lower reference level denotes the score of 0 on MACBETH scale. But 100 does not always show the best performance and also 0 does not indicate the worst performance of an alternative (Karande & Chakraborty, 2013).

Step 3. The alternatives are arranged in an *m*x*m* matrix form from left to right according to their importance to quantify the qualitative performance levels or convert quantitative performance levels into proportionate MACBETH scale. Here *m* indicates the number of alternatives selected for that criterion. Also the same procedure is applied for the criteria.

Step 4. Pairwise comparisons are made for the criteria and alternatives based on difference of attractiveness. MACBETH method uses a semantic scale set with seven categories to indicate the difference of attractiveness. The equivalent numerical scales and significances of these semantic scales can be seen in Table 1 (Karande & Chakraborty, 2013; Bana e Costa &Chagas, 2004).

Table 1
Semantic scale of MACBETH

Semantic Scale	Equivalent Numerical Scale	Significance
Null	0	Indifference between alternatives
Very Weak	1	An alternative is very weakly attractive over another
Weak	2	An alternative is weakly attractive over another
Moderate	3	An alternative is moderately attractive over another
Strong	4	An alternative is strongly attractive over another
Very Strong	5	An alternative is very strongly attractive over another
Extreme	6	An alternative is extremely attractive over another

Step 5. The consistency of the decision makers' judgments are checked. If the judgments are inconsistent, M-MACBETH software recommends possible changes to make the judgments consistent (Bana e Costa & Oliveira, 2002).

Step 6. The consistent judgments are transformed into a suitable numerical scale, identified as the MACBETH scale based on linear programming models.

Step 7. Finally, the weighted global scores representing the overall attractiveness of the considered alternatives are computed using an additive aggregation model to rank the alternatives.

In order to obtain quantified MACBETH scores of qualitative performance levels, the following procedure is adopted (Karande & Chakraborty, 2013; 2014; Fakhfakh et al., 2011).

Firstly, decision maker is asked about his/her preferences between pairs of alternatives under each criterion. If the decision maker prefers alternative A_i to $A_{i'}$ for a criterion j, this is noted as follows:

$$A_i > A_{i'} \tag{1}$$

Secondly, the decision maker expresses his/her strengths of preference about the alternatives. The strengths of preference are characterized with semantic scale in Table 1. If the decision maker cannot give his/her strengths of preference but only his/her preferences, this is noted by positive or more shortly P. The decision maker prefers the alternative A_i to $A_{i'}$ with strength $h \in \{0,1,2,3,4,5,6\}$ for a criterion j,

$$A_i \succ^h A_{i'} \tag{2}$$

This is equivalent to:

$$A_i - A_{i'} = h\alpha \tag{3}$$

Here α is a coefficient necessary to meet condition A_i and $A_{i'} \in [0,100]$. Consider an example with four alternatives and their preference for importance for the jth criterion are as $A_4 > A_1 > A_3 > A_2$. If $v_j(A_4)$, $v_j(A_1)$, $v_j(A_3)$ and $v_j(A_2)$ are MACBETH scores for A_4, A_1, A_3, A_2 respectively, then $v_j(A_4)=100$, $v_j(A_2)=0$ and $v_j(A_4) > v_j(A_1) > v_j(A_3) > v_j(A_2)$. Then, decision maker expresses his/her strengths of preferences for alternatives using seven semantic scale in Table 1. These preference strengths of alternatives for j^{th} criterion are given in Table 2.

Table 2
Preference strengths of alternatives for j^{th} criterion

Alternatives	A_4	A_1	A_3	A_2
A_4 (good)	No	Very Strong	P	P
A_1		No	Strong	P
A_3			No	Very Weak
A_2 (neutral)				No

From the data provided from Table 2, these equation systems can be extracted;

$$v_j(A_4) - v_j(A_1) = 5\alpha \tag{4}$$

$$v_j(A_1) - v_j(A_3) = 4\alpha \tag{5}$$

$$v_j(A_3) - v_j(A_2) = \alpha \tag{6}$$

As mentioned before, $v_j(A_4)=100$ (good) and $v_j(A_2)=0$ (neutral). By solving equations (4) - (6) the obtained solutions are $\alpha = 10$, $v_j(A_1)=50$ and $v_j(A_3)=10$.

The quantification of alternatives for all the remaining criteria as well as the corresponding criteria weights can be obtained adopting the same procedure. Then the MACBETH scores are multiplied with the criteria weights and added for finding the overall scores of alternatives. The final overall score is obtained using the following additive value model (Karande & Chakraborty, 2014; Bana e Costa el al., 2002b):

$$V(A_i) = \sum_{j=1}^{n} w_j(v_j(A_i)) \tag{7}$$

$$\sum_{j=1}^{n} w_j = 1, \quad w_j > 0 \quad and \quad \begin{cases} v_j(A_i^{good}) = 100 \\ v_j(A_i^{neutral}) = 0 \end{cases} \tag{8}$$

Here w_j indicates weight of the jth criterion. The final ranking of the alternatives is determined based on the $V(A_i)$ values. This method is also supported by M-MACBETH software (http://www.m-macbeth.com/en/downloads.html) developed using algorithm based on linear programming models (Karande and Chakraborty, 2013). In this paper, M-MACBETH software is used while determining the weights of the criteria.

2.2 COPRAS Method

The COPRAS (**CO**mplex **PR**oportional **AS**sessment) method was first introduced by Zavadskas, Kaklauskas and Sarka in 1994. This method compares the alternatives and determines their priorities under the conflicting criteria by taking into account the criteria weights (Zavadskas et al., 2009). It assumes direct and proportional dependences of the significance and utility degree (priority) of the alternatives. This method selects the best alternative considering both the ideal and the ideal-worst solutions (Chatterjee & Chakraborty, 2014).

COPRAS method due to its simplicity was applied to the various problems in different fields like construction, property management, economics etc. Zavadskas et al. (2001) proposed COPRAS method for assessing building life cycles to select the best alternative. Vilutienė and Zavadskas (2003) determined the effective variant of a dwelling maintenance work and performance with this method. Zavadskas et al. (2004) used COPRAS method for developing a housing credit access model. Zavadskas and Vilutiene (2004) determined the appropriate maintenance contractors for apartment blocks. Kaklauskas et al. (2005) proposed COPRAS method for designing and refurbishment of building. Andruškevicius (2005) used this method for selecting the best contractor for the construction of a trade and entertainment center. Kaklauskas et al. (2006) evaluated contractors for the replacement of windows in Vilnius Gediminas Technical University main building. Kaklauskas et al. (2007a) selected the best construction alternative with COPRAS method. Kaklauskas et al. (2007b) determined the market value of real estate with help of COPRAS method. Zavadskas et al. (2007) proposed to use COPRAS method for evaluating road design alternatives. Viteikienė and Zavadskas (2007) used COPRAS method for evaluating the sustainability of residential areas in Vilnius City. Zagorskas et al.

(2007) determined sustainable city compactness by using COPRAS method. Banaitiene et al. (2008) used COPRAS method to select a building's life cycle. Kaklauskas et al. (2010) evaluated intelligent built environment alternatives in industrialized countries. Kanapeckiene et al. (2010) proposed Knowledge Based Decision Support System for Construction Projects Management (KDSS-CPM) to select a land parcel from the alternatives. Das et al. (2012) applied COPRAS method to measure relative performance of Indian technical institutions. Mulliner et al. (2013) evaluated the affordability of different housing locations by considering economic, environmental and social criteria. Chatterjee and Chakraborty (2014) used COPRAS method to select the most appropriate Flexible Manufacturing System (FMS) for a manufacturing firm. Also, COPRAS-G method was used for the selection of investment project (Popovic et al., 2012), the effective dwelling house walls (Zavadskas et al., 2008a), construction project manager (Zavadskas et al., 2008b), contractor (Zavadskas et al., 2008c), best web site (Bindu Madhuri et al., 2010) and material (Chatterjee & Chakraborty (2012); Maity et al. (2012))

The procedure of the COPRAS method consists of the steps as below (Chatterjee & Chakraborty, 2014):

Step 1: The decision matrix is normalized with linear normalization procedure using the following formula (Kaklauskas et al., 2006):

$$x_{ij}^* = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad (i = 1,2,\ldots,m; j = 1,2,\ldots,n) \tag{9}$$

where x_{ij} is the performance of the ith alternative with respect to the jth criterion, x_{ij}^* is its normalized value, and m is number of alternatives. When performing multiple criteria evaluation of the alternatives, the values of the criteria describing them should be normalized. This provides a possibility to compare the values of the criteria having different units of measurement (Zavadskas et al., 2009).

Step 2: Weighted normalized decision making matrix (D) is formed as,

$$D = [d_{ij}]_{mxn} = x_{ij}^*.w_j \tag{10}$$

where w_j represents the importance weight of criterion C_j.

Step 3: The sums of weighted normalized values are calculated for both beneficial and non-beneficial criteria as:

$$S_{+i} = \sum_{j=1}^{n} d_{+ij} \tag{11}$$

$$S_{-i} = \sum_{j=1}^{n} d_{-ij} \tag{12}$$

where d_{+ij} and d_{-ij} are the weighted normalized values for the beneficial and non-beneficial criteria respectively. The greater the value of S_{+i}, the better is the alternative; and the lower the value of S_{-i}, the better is the alternative. The S_{+i} and S_{-i} values express the degree of goals attained by each alternative. In any case, the sums of S_{+i} and the sums of S_{-i} are equal to the weighted sums for the beneficial and non-beneficial criteria as expressed by the following equations:

$$\sum_{i=1}^{m} S_{+i} = \sum_{i=1}^{m} \sum_{j=1}^{n} d_{+ij} \tag{13}$$

$$\sum_{i=1}^{m} S_{-i} = \sum_{i=1}^{m} \sum_{j=1}^{n} d_{-ij} \tag{14}$$

Step 4: The relative significances or priorities (Q_i) of each alternative are determined using the following formula:

$$Q_i = S_{+i} + \frac{S_{-\min}\sum_{i=1}^{m} S_{-i}}{S_{-i}\sum_{i=1}^{m}(S_{-\min}/S_{-i})} = S_{+i} + \frac{\sum_{i=1}^{m} S_{-i}}{S_{-i}\sum_{i=1}^{m}(1/S_{-i})} \qquad (i=1,2,\ldots,m) \tag{15}$$

where S_{-min} is the minimum value of S_{-i}. The greater the value of Q_i, the higher is the priority of the alternative. The relative significance value of an alternative shows the degree of satisfaction attained by that alternative. The alternative with the highest relative significance value (Q_{max}) is the best choice among the alternatives.

Step 5: The quantitative utility (U_i) for each alternative is calculated. The degree of an alternative's utility which leads to a complete ranking of the alternatives, is determined by comparing the priorities of all the alternatives with the most efficient one and can be denoted as below:

$$U_i = \left[\frac{Q_i}{Q_{\max}}\right] x100\% \tag{16}$$

where Q_{max} is the maximum relative significance value. These utility values of the alternatives range from 0 % to 100 %.

3. Application

The main objective of this paper is to select the best air compressor for a spinning mill of a textile company. This textile company established in Denizli and it is a fully integrated facility which performs production of spinning, weaving, knitting, dying and confection. Their major product range includes all kinds of towels & bathrobes, kitchen home textile products, home wear and beach wear products. The textile company decides to buy an air compressor for using in its spinning mill. They need screw air compressor driven by inverter motor. This kind of air compressor which is to be used in spinning mill that has variable air requirements, provides energy saving and improves the air compressor's service life. There are many air compressor alternatives in the market and conflicting criteria to be considered, so the air compressor selection is a crucial and difficult decision for the company. For selecting the best air compressor for this textile company an integrated method based on MACBETH and COPRAS methods are proposed. The weights of the decision criteria are determined with MACBETH method and then the ranking of the alternatives is determined by COPRAS method.

First of all, decision criteria are defined and expressed in the form of a value tree as seen in Figure 2. These criteria are; C_1 Energy consumption (kw/hour per day), C_2 Maintenance cost (Euro per year), C_3 Price (Euro), C_4 Physical life of the compressor (year), C_5 Maximum flow rate (m^3/min), C_6 Minimum flow rate (m^3/min), C_7 Brand reliability, C_8 Service quality and C_9 Scrap value of the compressor (Euro).

In order to determine the weights of the criteria with MACBETH method, criteria are entered into M-MACBETH software in descending order of their importance from left to right and top to bottom in the weighting matrix, as shown in Table 3.
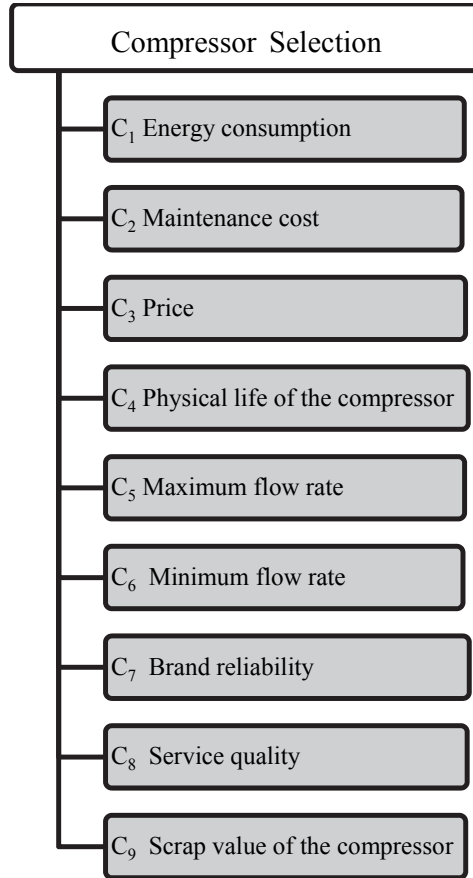
Figure 2. MACBETH value tree for air compressor selection problem

Table 3
Comparison of the criteria

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	Current Scale
C_1	no	very weak	weak	moderate	strong	strong	v.strong	extreme	extreme	20.27
C_2		no	very weak	weak	moderate	moderate	strong	v.strong	extreme	17.57
C_3			no	very weak	weak	moderate	strong	v.strong	extreme	16.22
C_4				no	very weak	weak	moderate	strong	v.strong	13.51
C_5					no	very weak	weak	moderate	strong	10.81
C_6						no	very weak	weak	moderate	9.46
C_7							no	very weak	weak	6.76
C_8								no	very weak	4.05
C_9									no	1.35

In order to convert the performance levels for all criteria into proportionate quantitative MACBETH scores, they are pair-wise compared with the help of a seven point semantic scale. M-MACBETH software checked the consistency of these judgments and it is found that the entered judgments are

entirely consistent. Further, based on the provided differences of attractiveness, M-MACBETH software converts the ordinal performance levels into proportionate cardinal MACBETH scale using appropriate linear programming models. This MACBETH scale can be seen in the last column of the Table 3 and these values show the weights of the criteria. The weights of the criteria obtained with the MACBETH method can be summarized as in Table 4.

Table 4
Weights of the criteria

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
Weights	0.2027	0.1757	0.1622	0.1351	0.1081	0.0946	0.0676	0.0405	0.0135

After determining the weights of the criteria with MACBETH method, COPRAS method is used to determine the ranking of the air compressor alternatives. After a preliminary research, mechanical engineer of the textile company determined six possible air compressor alternatives. In COPRAS method firstly decision matrix is formed as seen in Table 5. In this table, quantitative data for performance evaluation of alternatives are summarized. The data for C_1, C_2, C_3, C_4, C_5, C_6 and C_9 are quantitative data whereas data for the C_7 and C_8 are qualitative data and while obtaining these values decision maker evaluated the alternatives by using 5 point scale (5=Excellent, 4=Very good, 3=Good, 2=Fair, 1=Poor). Compressor selection criteria can be categorized as beneficial and non-beneficial. Among these nine criteria C_4, C_5, C_7, C_8 and C_9 are beneficial where higher values are desirable; C_1, C_2, C_3 and C_6 are non-beneficial where smaller value is always preferred. Beneficial criteria are maximized whereas non-beneficial criteria are minimized.

Table 5
Quantitative data for performance evaluation of alternatives

Optimization direction	min	min	min	max	max	min	max	max	max
Alternatives	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
A_1	1543	2000	39000	15	13.76	3.86	5	3	5000
A_2	1496	3600	43000	14	14	2.5	4	4	4000
A_3	1584	3100	24500	10	13.1	3.7	2	2	3500
A_4	1560	2700	36000	12	13.2	3.2	3	3	3500
A_5	1572	2500	31500	13	13.3	3.4	3	2	3500
A_6	1580	2400	20000	12	12.8	3.9	2	2	3000
Total	9335	16300	194000	76	80.16	20.56	19	16	22500

After forming the decision matrix, this matrix is normalized by using Eq. (9) as shown in Table 6.

Table 6
Normalized decision matrix

Alternatives	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
A_1	0.1653	0.1227	0.2010	0.1974	0.1717	0.1877	0.2632	0.1875	0.2222
A_2	0.1603	0.2209	0.2216	0.1842	0.1747	0.1216	0.2105	0.2500	0.1778
A_3	0.1697	0.1902	0.1263	0.1316	0.1634	0.1800	0.1053	0.1250	0.1556
A_4	0.1671	0.1656	0.1856	0.1579	0.1647	0.1556	0.1579	0.1875	0.1556
A_5	0.1684	0.1534	0.1624	0.1711	0.1659	0.1654	0.1579	0.1250	0.1556
A_6	0.1693	0.1472	0.1031	0.1579	0.1597	0.1897	0.1053	0.1250	0.1333

Then, the corresponding weighted normalized decision matrix is developed by using Eq. (10) as shown in Table 7.

Table 7
Weighted normalized decision matrix

Alternatives	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
A_1	0.0335	0.0216	0.0326	0.0267	0.0186	0.0178	0.0178	0.0076	0.0030
A_2	0.0325	0.0388	0.0360	0.0249	0.0189	0.0115	0.0142	0.0101	0.0024
A_3	0.0344	0.0334	0.0205	0.0178	0.0177	0.0170	0.0071	0.0051	0.0021
A_4	0.0339	0.0291	0.0301	0.0213	0.0178	0.0147	0.0107	0.0076	0.0021
A_5	0.0341	0.0269	0.0263	0.0231	0.0179	0.0156	0.0107	0.0051	0.0021
A_6	0.0343	0.0259	0.0167	0.0213	0.0173	0.0179	0.0071	0.0051	0.0018

The sums of the weighted normalized values for the beneficial criteria (S_{+i}) and for the non-beneficial criteria (S_{-i}) are calculated based on Eq. (11) and Eq. (12) as shown in Table 8.

Table 8
S_{+i} and S_{-i} values

Alternatives	S_{+i}	S_{-i}
A_1	0.0736	0.1054
A_2	0.0705	0.1187
A_3	0.0497	0.1053
A_4	0.0595	0.1078
A_5	0.0589	0.1031
A_6	0.0526	0.0948

Then the relative significance or priority value (Q_i) and the quantitative utility (U_i) for each alternative are computed by applying Eq. (15) and Eq. (16) as shown in Table 9.

Table 9
Qi and Ui values

Alternatives	Q_i	U_i	Rank
A_1	0.1794	100,0000	1
A_2	0.1645	91,6705	4
A_3	0.1557	86,7531	6
A_4	0.1630	90,8437	5
A_5	0.1672	93,1505	3
A_6	0.1702	94,8626	2

According to the calculation results, the complete ranking of the alternatives is obtained as $A_1>A_6>A_5>A_2>A_4>A_3$. A_1 is the best alternative with 100% utility degree.

4. Conclusion

In this paper, an integrated approach based on MACBETH and COPRAS methods is proposed for the first time and its applicability is illustrated with a real life problem of a textile company. Air compressor selection problem is considered where the decision criteria are energy consumption, maintenance cost, price, physical life of the compressor, maximum flow rate, minimum flow rate, brand reliability, service quality and scrap value of the compressor. These criteria are evaluated to determine the ranking of the air compressor alternatives to select the most appropriate for the spinning mill of the textile company. MACBETH method is utilized for determining the criteria weights and then ranking of the alternatives are determined with COPRAS method. The ranking of the six alternatives has been determined as $A_1>A_6>A_5>A_2>A_4>A_3$. According to the results, it is advised to the textile company to choose the A_1

air compressor for its spinning mill. The company management found the results satisfactory and decided to buy A_1 air compressor. Consequently, in this paper a scientific and integrated approach is proposed to the company that determines the best alternative intuitively by the help of experiences before.

The proposed integrated approach consists of two MCDM methods; MACBETH and COPRAS. These methods are chosen because they have some advantages over other MCDM methods. The weights of the criteria are determined with a relatively new method MACBETH. Also these weights can be determined with Analytic Hierarch Process (AHP). Although there are similarities between these two methods, there are differences in the manner within the phases must be conducted. In the phase of evaluation, there are also pairwise judgment as in the AHP with the use of a decision matrix. The main differences are in the scale to be used in the judgments and in the validation of these judgments. In the MACBETH the validation of judgments may also be obtained by the theoretical consistency checking and by the semantic consistency checking (Salomon & Montevechi, 2001).

MACBETH has advantage over other MCDM methods is that only requires qualitative judgements to score alternatives and to weight the criteria. Furthermore, the MACBETH provides a visual preliminary consistency checking: in the judgment matrixes the attractiveness difference must increase from left to right and from bottom to up, given a necessary judgment sorting (Salomon & Montevechi, 2001). On the other hand, the support of M-MACBETH software also improves the usefulness of this method in solving complex decision-making problems having performance of the alternatives expressed in ordinal scale (Karande & Chakraborty, 2013).

COPRAS method has the potential to be popular, widely acceptable because it does not contain complex calculations and easy to apply to real life problems. Also COPRAS method is very useful when the number of alternatives and criteria are very high, because it does not need pair-wise comparison like PROMETHEE or ELECTRE methods. This method can provide a complete ranking of alternatives and deal with both quantitative and qualitative criteria within one assesment. It has the ability to account for both positive and negative evaluation criteria, which can be assessed separately within the evaluation process. An important feature that makes the COPRAS method superior to other available MCDM methods is that it may be used to estimate the utility degree of alternatives, showing, as a percentage, the extent to which one alternative is better or worse than other alternatives taken for comparison (Mulliner et al., 2013)

In future studies, proposed approach can also be applied to other MCDM problems of the company. In air compressor selection problem, AHP can be used to determine the weights of the criteria and other MCDM methods like TOPSIS, ELECTRE, PROMETHEE, VIKOR and MOORA can be used to determine the ranking of the alternatives and also the obtained results can be compared.

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