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Selection of the Best Belt Conveyor using AHP

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ABSTRACT

There are various criteria which affect the performance of Belt Conveyor. The performance of Belt Conveyor in terms of Maintenance cost and Load capacity is an essential issue for Screening Creaser. Selection of Belt Conveyor is a Multi-Criteria Decision Making (MCDM) problem. In that respect there are many methods available for selection of Best Belt Conveyor, however, this paper targets to investigate the applicability of AHP to solve Best Belt Conveyor selection problem. AHP is a method that assists in choosing greatest alternatives by pair wise comparison of each other and their criteria articulated as a matrix. In the Analytic Hierarchy Process (AHP), decision maker primaries give linguistic pair wise comparisons and then obtain an arithmetical pair wise assessment by selecting a certain numerical scale to measure them. After that, each column of the substitutes is multiplied as per the priority of the corresponding criteria and lastly the ranks are calculated by adding each row. The pair wise comparison is made with the standard scale. On the basis of giving criteria, which conclude how much one alternative is more important than other? Finally derives a priority vector from the numerical pair wise comparisons.

Key words: Multi-Criteria Decision Making [MCDM], Belt Conveyor, Analytic Hierarchy Process [AHP]

INTRODUCTION

Convey is an important logistic action in the production systems influencing smoothness of the production process. Belt Conveyor conveys system play an important role in Timber Industry, mining, handling of bulk material, stone industry and many additional fields where large quantities of goods have to be conveyed [1-2]. The belt conveyor depends upon their presentation, no issue whether it is in metallurgical industry, in the mining industry or building industry. Selection of best belt conveyor assembly is a Multi-Criteria Decision Making (MCDM) problem [3-4]. Multi criteria decision making initiates decision-making troubles which the decisions are making effects, considered from the point of view of several criteria. As the decision making problems, it is compulsory to take into concern all elements, which influence the result of the investigation, the relation among them and the intensity by which they inter relate. One of the ways how to demonstrate these facts is the formation of a certain hierarchical structure.

An MCDM method, as its own name suggests, is for use in situations when more than one decisive factor must be considered (example Base Length, Load Capacity, Material Cost, Roller Cost etc.). Fundamentally, these methods work with the same fundamental tool decision matrix [5]. AHP method is flexible, intuitive appeal to the decision makers and it has an ability to check the consistency ratio. There are several MCDM methods [6-7], but in this paper AHP has been used [3, 8] because of its simplicity and applicability.

In this study, the different possible alternatives are the four different Belt conveyor of screening Creaser. In order to identify the criteria which, the AHP model will be based on, we take the supervision from the engineers of screening Creaser. The identified criteria were then validated by other screening creasers. In the end, the criteria of the AHP structure we have developed are Base Length (BL), Load Capacity (LC), Material Cost (MC), and Roller Cost (RC).

ANALYTIC HIERARCHY PROCESS [AHP]

The Conception and the Principles of AHP

AHP, which is a type of method of multi-objective decision and combine qualitative and quantitative analysis, was initially created by American scholar Saaty. The basic theory of AHP is that the multifaceted problem was decomposed into composing factors, which are grouped hierarchically according to their administrative affiliation. It has particular application in group decision making, and is used around the world in a spacious variety of decision situations, in fields such as government, business, industry, healthcare, shipbuilding and education.

The establishment of judgment matrix is the key of the application of AHP [9]. The characteristic feature of AHP in human factors analysis is a quantitative analysis of the qualitative problem and mathematic modelling of reviewers' put into effect Priority. So not much quantitative data are needed by AHP, but all the related factors and their inter-relation must be described, which is a matter that the ultimate answer is correct or not.

Methodology of AHP

AHP has been designed to explain complex problems involving multiple criteria [10-11]. It allows decision-makers denote their preferences using a status scale [12-13]. A representation flow chart describing the methodology adopted shown in fig 1.

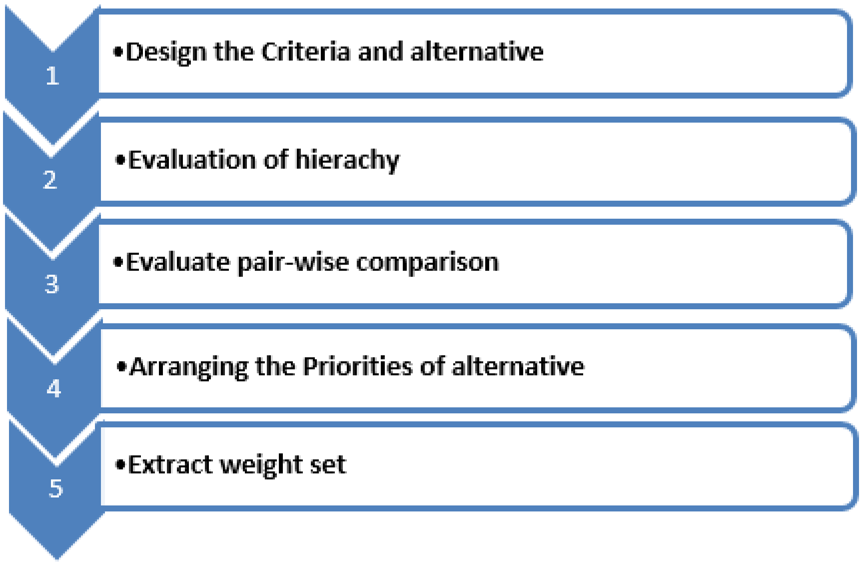

Fig. 1 Schematic Flow Chart Describing the Methodology

The analysis and basic steps of AHP

Recognize the Problem

Recognize the scope of problem and the relations between the factors. This thread is not only the basis of the approach for AHP, but also the key point of the entire process. The correctness of the logical relations among factors in a straight line relates to the reliability of the final result.

Originate Pairwise Comparison Matrices

In this step decision maker have to originate a pairwise comparison matrix of elements at each level in the hierarchy, virtual to each element at the next level. At AHP, if M is the alternative and N is the criteria, then the decision maker has to construct N judgment matrices of alternative of M x M order and an M judgment matrix of criteria of N x N order. Lastly, the decision matrix of M x N order is formed by using relative scores of the alternative with respect to each criterion. At AHP, Saaty's scale of the real number from 1-9 and their reciprocals are used to assign importance in a systematic manner. Relational scale proposed by Saaty's [3, 8, 11, and 13] is shown in Table -1.

Table -1 Fundamentals of Saaty's Scale

Intensity of Importance	Definition
1	Equal Importance
3	Moderate Importance
5	Strong Importance
7	Very strong or Demonstrated Importance
9	Extreme Importance
2,4,6,8	For compromise between the above value
Reciprocal	If activity, I have one of the above number assigned to it when compared with activity j, then j has the reciprocal value when compared with I.

The Relative Importance of Different Criteria

In this step, the relative importance of different criteria with respect to the goal of the problem and the alternative score with respect to each of the criteria is determined [14]. For N criteria the size of the comparison matrix (C_1) will be N x N and cij will denote the relative importance of criteria i with respect to the criteria j.

In the matrix, c_{ij} = 1 only when i = j and $ij = \frac{1}{c_{ij}}$.

The relative importance of the i^{th} criteria (W_i) is determined by calculating the geometric mean of the i^{th} row and then normalizing the geometric means of the row from the above matrix. Then matrix C_3 and C_4 are calculated such that $C_3 = C_1 x C_2$ and$= \frac{C_3}{C_2}$ Where, $C_2 = [W1, W2…… W_N]$ T

$$c_{ij} = \begin{bmatrix} 1 & C_{12} & \cdots & C_{1N} \\ C_{21} & 1 & & C_{2N} \\ \cdots & & 1 & \cdots \\ C_{N1} & C_{N2} & \cdots & 1 \end{bmatrix}$$

Principal Eigenvector (λ_{max}) of the original pairwise comparison matrix (C1) is calculated from the average of matrix C4. To check the consistency in pairwise comparison, judgment, consistency index (CI) and consistency ratio (CR) are calculated.

RCI is a Random Consistency Index and its value could be found out from Table -2. The value of CR should be equal to or less than 0.1 for considering the judgment is consistent or acceptable. Otherwise the judgment will be inconsistent and unacceptable. In this situation decision maker has to add some change in the pairwise comparison matrix.

Similarly, N numbers of pairwise comparison matrices, one for each criteria of M x M order are formed where each alternative is used against all of its competitors and then the pairwise comparison is made with respect to each for the decision criterion. The eigenvector of each of these 'N' matrices represents another performance score in the corresponding criteria and a column of the final decision matrix is formed [15-16]. The decision matrix (Table -3) resembles the following:

$$\sum_{i=1}^{M} a_{ij} = 1 \quad (1)$$

Determine the Final Priority of All the Alternatives

In this step, determine the final priority of all the alternatives [17-18], considering the alternative scares (aij) in each criteria and (Wj) weight of the corresponding criteria using the following equation [19-20]

$$A_{AHP} = \max \text{ For } i=1, 2, 3…… M \quad (2)$$

Table -2 Random Consistency Index (RCI) Value

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.4	1.45	1.49	1.51	1.54	1.56	1.57	1.59

Table -3 Decision Matrix of AHP

				Criteria			
Alternatives	*C1*	*C2*	*C3*	*C4*	...	...	*CN*
	W1	*W2*	*W3*	*W4*	...	...	*WN*
A1	*a11*	*a12*	*a13*	*a14*	...	...	*a1N*
A2	*a21*	*a22*	*a23*	*a24*	...	...	*A2N*
...	...	...	...	...	...	...	...
AM	aM1	aM2	aM3	…	…	…	aMN

RESULT AND DISCUSSION

The belt Conveyor problem is decomposed into a hierarchy as shown in fig. To do this, first level is the goal, next level is the criteria and the level is the five alternatives (belt conveyor) which are to be evaluated. Criteria to the Belt Conveyor are: Base Length (BL) 2. Load Capacity (LC) 3. Material Cost (MC) and 4. Roller Cost (RC). Table -4 shows the pairwise comparison of matrix of the criteria in case of the Performance of Belt Conveyor. Table -6 established the global priority of the Belt Conveyor for Performance. Final ranking score of alternatives on the basis of Performance are as shown in Fig. 4. In this figure it can be seen that Belt Conveyor 1 is the best Conveyor.

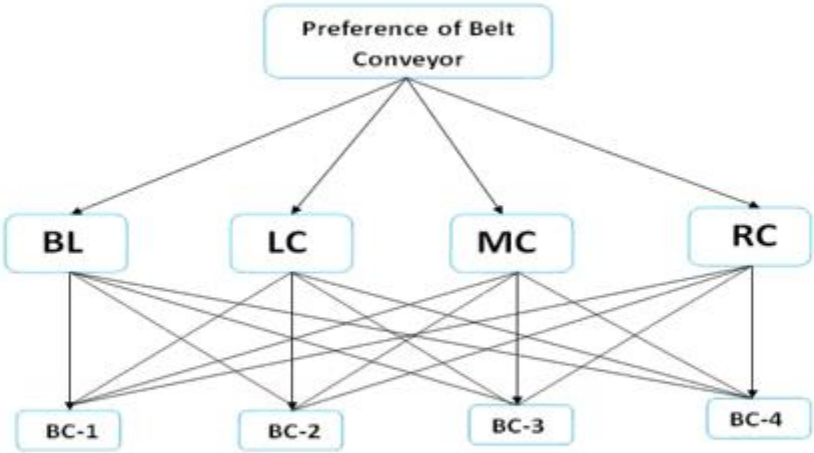

Fig. 2 Decomposition of Belt Conveyor Problem into a Hierarchy for Performance

Table -4 Pair-Wise Comparison Matrix

Performance	BL	LC	MC	RC	Priority
BL	1	0.16	0.11	0.33	0.05
LC	6	1	0.33	2	0.22
MC	9	3	1	3	0.53
RC	3	0.05	0.33	1	0.16
λ_{max} = 4.09, CI = 0.03 and CR = 0.033					

Table -5 Shows Pair-Wise Comparison Judgment of Belt Conveyor of Alternative

BL	BC-1	BC-2	BC-3	BC-4	Priority
BC-1	1	0.2	0.33	3	0.132
BC-2	5	1	3	7	0.562
BC-3	3	0.33	1	5	0.262
BC-4	0.33	0.14	0.2	1	0.052
λ_{max} = 4.14, CI =0.040, CR =0.044					

LC	BC-1	BC-2	BC-3	BC-4	Priority
BC-1	1	0.14	0.25	0.11	0.042
BC-2	7	1	3	0.33	0.252
BC-3	4	0.33	1	0.14	0.105
BC-4	9	3	7	1	0.588
λ_{max} = 4.13, CI =0.045, CR =0.0505					

MC	BC-1	BC-2	BC-3	BC-4	Priority
BC-1	1	2	5	8	0.529
BC-2	0.5	1	2	7	0.289
BC-3	0.2	0.5	1	3	0.130
BC-4	0.12	0.14	0.33	1	0.048
λ_{max} = 16.092, CI =0.0076, CR = 0.0086					

RC	BC-1	BC-2	BC-3	BC-4	Priority
BC-1	1	7	4	9	0.648
BC-2	0.14	1	0.33	3	0.103
BC-3	0.25	3	1	5	0.228
BC-4	0.11	0.33	0.2	1	0.049
λ_{max} = 4.1075, CI =0.0358, CR = 0.0402					

Table -6 Local and Global Priorities

Performance	BC	LC	MC	RC	Score
BC-1	0.132	0.042	0.529	0.648	**0.399**
BC-2	0.562	0.252	0.289	0.103	0.253
BC-3	0.262	0.105	0.130	0.228	0.141
BC-4	0.052	0.588	0.048	0.049	0.165

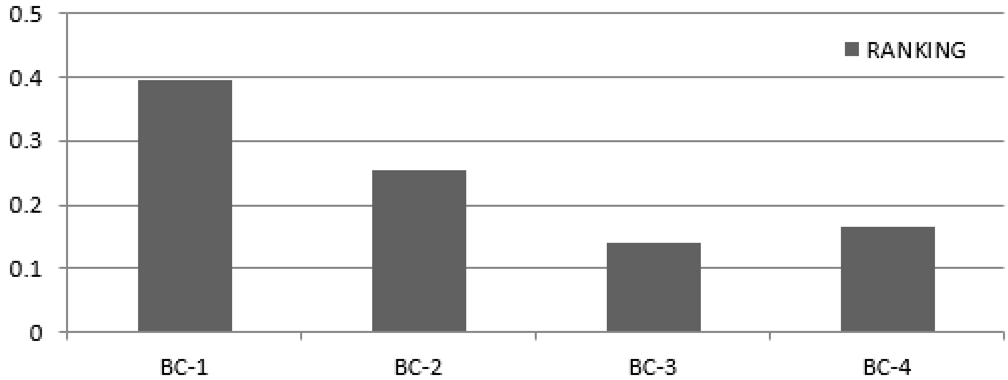

Fig. 3 Score of Belt Conveyor for Performance

CONCLUSION

The main goal of the application of multi criteria decision-making methods is that all obstacles the decision-maker has solved of the decision-making problem were constantly managed. In practice the emphasis is often put on the selection of the best option, the best solution at the large amount of information. Analytical hierarchical process (AHP) belongs to frequently used multi criteria, methods, which are used in more complex decision-making tasks. The method can be used not only for the situation of preferences among criteria, but also among variants.

In this Paper, a case study was performed to choose the best belt conveyor assembly. The importance of the dimensions was evaluated by industry experts. In our study AHP method is used. Belt Conveyor-1 was found to be the suitable Belt Conveyor among the given four alternatives. The results point out that this optimization method heavily depends on global priorities of the criteria and the alternatives of the problem. One of the advantages of the proposed method is its ability and flexibility with the different applications.

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