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Evaluating the Best Belt Conveyor Assembly Using TOPSIS Approach

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Abstract

This article presents a new approach for the selection of Belt Conveyor of screening creaser on the basis of their performance. This article includes the effective factors like angle of response, load capacity of motor, raw material load capacity, raw material dimension. These all important factors affect the performance of Belt Conveyor Assembly. Therefore, determination of the best Belt Conveyor is basically a Multi-Attribute Decision Making (MADM) problem. Our aim is to explore the applicability of an integrated AHP, TOPSIS and DOE method for selecting best Belt Conveyor Assembly. In this paper, AHP methods are used to determining weight sets, TOPSIS and Design of Experiment (DOE) methods are used together to identify critical selection attributes. Then interactions of each alternative are evaluated, using Minitab-16 for the empirical data suited to a polynomial in a multiple linear regression analysis. Finally Belt Conveyor Assembly has been graded and selected on basis of our methodology method.

***Keywords**: TOPSIS, AHP, DOE, geometric modeling (belt conveyor assembly)*

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INTRODUCTION

Transport is an important logistic activity in the production system influencing fluency of the production system. The Belt transport system belongs to high-efficient and economical, as well as energy undemanding continual transport system. Belt transport has very wide use nowadays [1]. Belt conveyors are used to economically carry a greater diversity of bulk material at higher capacities and for longer distances than any other kind continuously operating mechanical conveyor. Belt conveyor has high load carrying capacity, simple design, easy maintenance and high reliability of operation [2]. There are varieties of option available for running conveying system, including the hydraulic, mechanical and fully automated systems which are equipped to fit individual needs. Belt Conveyor Manufacturers seek to improve Belt Conveyor Assembly Performance in order to improve Screening Creaser comfort. The essential part of Belt Conveyor Assembly is conveying roller, return rollers, impact rollers and drum pulley. There are many methods for solving multi attribute decision making problems such as technique for order preference by similarity to ideal solution (TOPSIS) [3], Analytical Hierarchy Process (AHP)[4], Simple Additive Weighting (SAW) [3], Data Envelopment Analysis (DEA) [5], Vlse Kriterijumska Optimizacija Kompromisno Rzesenje (VIKOR) [6], Grey Relational Analysis (GRA) [7], Elimination and Et Choice Translating Reality (ELECTRE) [6], PROMETHEE [8] and Multi-objective optimization on the basis of Ratio Analysis (MOORA) [9]. Among the aforementioned methods, one of the ways to choose the best conveyor belt system is TOPSIS and AHP. These two methods of subsets multi-criteria decision making methods are able to solve complex and multi-criteria problems.

The article tries to prioritize system for best suitable conveyor belt by using TOPSIS method. So AHP method is used in a bid to measure the weight of criteria. Aiming to reach the objective four criteria has been applied to prioritize the best suitable conveyor belt. In this paper, 3D model of the Belt

Conveyor Assembly as well as basic elements of the belt conveyor, modeled in the CATIA software is presented as shown in Figure 1. In CATIA software, good feature is that any change made to the external data is notified to user and the model can be updated quickly.

MULTI-ATTRIBUTE DECISION MAKING (MADM)

MADM methods introduce decision-making problems, at which the decision-making effects are considered from the point of view of several criteria [10] as shown in Figure 2. At MADM problems it is necessary to take into consideration all elements, which influence the result of the analysis, the relation among them and the intensity by which they interact. MADM models are widely used in belt conveyor assembly selection problem in industrials application. MADM provides the best alternative by giving set of selection attributes and alternative [11]. MADM models rank the alternative and the highest ranked one is recommended as the best alternative to the decision maker [12].

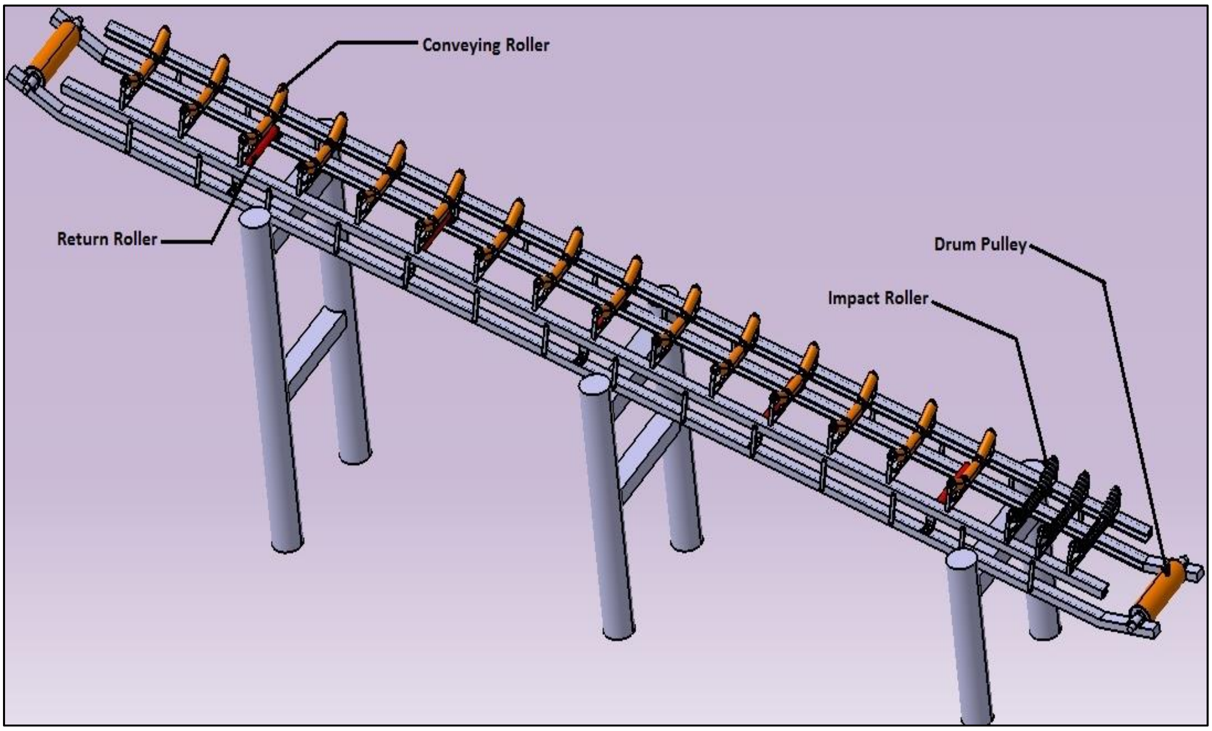

Fig. 1: *Geometric Modeling Using CATIA.*

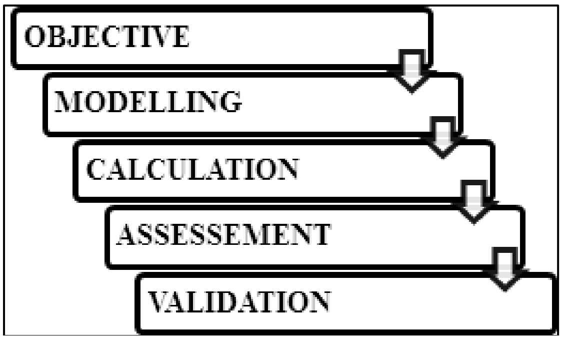

Fig. 2: *Effective Procedure of MADM.*

ANALYTIC HIERACY PROCESS (AHP)

AHP has been designed to solve complex problem involving multiple criteria.

A schematic flow chart describing the methodology adopted in this paper as shown in Figure 3.

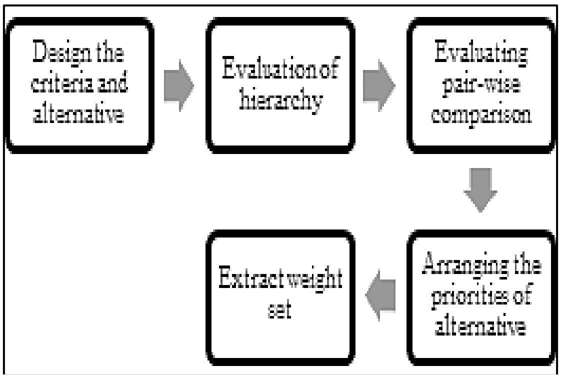

Fig. 3: *Flow Chart of AHP.*

Analytic Hierarchy Process (AHP), designed by Prof. Saaty in 1980 [13]. The AHP method uses the method of pair comparison by which the preference relations of the pairs of single criteria are detected [2–4, 7, 8]. AHP provides a vector of weights expressing the relative importance of selection factor alternative for each criterion [14]. AHP possesses several advantages like ability to check attributes, flexibility, and intuitive appeal to the decision makers. A pair comparison is performed by a recommended basic rating scale table (Table 1).

Table 1: *Saaty's Scale.*

Intensity of Importance	Characteristic
1	Criterions are equally importance
3	First criterion slightly more important than the other.
5	First criterion is rather more important than the other one.
7	First criterion demonstrably more important than the other one.
9	First criterion is absolutely more important than the other one.
2, 4, 6, 8	Finer distinction of the size of pair criteria preference.

In this article, data taken consist of four criteria and four belt conveyor assembly of a screening creaser. Four criteria taken in this article are Angle of response (AOR), Raw material dimension (RMD), Raw material load capacity (RMLC), Load capacity of motor (LCOM). Out of these four criteria, RMD is non-beneficial and other three criteria are beneficial. For beneficial alternative higher values are preferable while lower values were preferred for non-beneficial factors.

Table 2: *Attributes for Belt Conveyor Assembly Selection Problem.*

Belt Conveyor (BC)		AOR(L)	RMD (M)	RMLC (N)	LCOM (O)
BC-1		16	120	200	18
BC-2		20	120	100	11
BC-3		18	45	110	15
BC-4		12	5	10	11
Attribute level	**High**	20	120	200	18
	Low	12	5	10	11

Table 2 shows criteria for all four conveyor belt assembly. Angle of response (AOR) with minimum level 12 and maximum level 20. Raw material dimension (RMD) with minimum level 5 and maximum level 120. Raw material load capacity (RMLC) with minimum level 10 and maximum level 200. Load capacity of motor (LCOM) with minimum level 11 and maximum level 18 are used for determine factor levels. These factor levels affect the belt conveyor assembly performance. By using these factor levels and Saaty scale four different weight sets are obtained (Table 3).

Table 3: *Four Different Weight Sets.*

Factor	Weight Set-1	Weight Set-2	Weight Set-3	Weight Set-4
BC-1	5	1	5	3
BC-2	2	1	3	1
BC-3	3	3	4	5
BC-4	7	5	2	1

Criteria are independent variables which are used as input values for TOPSIS model to determine TOPSIS score. Four different random weights set used to determine TOPSIS score are shown in Table 4. It is possible to represent all these combination using a regression meta-model using 2^k full factorial design. In this article, a 2^4 full factorial design approach is used in two levels (i.e., high/low) such that they are in the permissible range. This approach requires 16 combinations, where only minimum and the maximum level of each factor are considered to collect the data through TOPSIS result.

TOPSIS

TOPSIS Method has been employed in the present work for the calculation of TOPSIS score [15]. TOPSIS Score provide the ranking of the alternatives. TOPSIS method orders all the alternatives from best to the worst [16]. Higher value of beneficial alternatives and lower values of non-beneficial alternatives are considered to determine TOPSIS Score.

Table 4: *Result of 2^4 Full Factorial Designs.*

Design of Experiment Points	Replication				Total
	A (X_1)	B (X_2)	C (X_3)	D (X_4)	
1	12	5	10	11	1.14
2	20	5	10	11	1.84
3	12	120	10	11	0
4	20	120	10	11	0.68
5	12	5	200	11	2.99
6	20	5	200	11	3.02
7	12	120	200	11	1.98
8	20	120	200	11	1.68
9	12	5	10	18	1.42
10	20	5	10	18	2.02
11	12	120	10	18	0.32
12	20	120	10	18	0.84
13	12	5	200	18	3.31
14	20	5	200	18	4
15	12	120	200	18	2.35
16	20	120	200	18	2.86

Table 4 shows the result of 2^4 full factorial design using different random weight sets for each 16 combinations. Now, each 16 combination was run four times in TOPSIS model and for each run, there where independent random attribute weights so that independence of each combination was assured. In the application of TOPSIS, once the weight of criteria is calculated using Saaty's scale they are integrated into the decision matrix [17].

The decision matrix contains the assigned factor weights against the factor level. The full factorial experiment design on two levels, four variables and replication total shown in Table 4. Table 5 shows effect and coefficients of all 16 combinations.

Table 5: *Effect and Coefficient for All 16 Combinations of All Four Criteria.*

Term	Effect	Coef	Se Coef	T	P
Constant		1.90	0.03	71.55	0 .009
L	0.42	0.21	0.03	7.98	0 .079
M	-1.13	-0.57	0.03	-21.30	0 .030
N	1.73	0.87	0.03	32.69	0 .019
O	0.46	0.23	0.03	8.76	0.072
L*M	-0.07	-0.04	0.03	-1.33	0.411
L*N	-0.19	-0.09	0.03	-3.55	0 .175
L*O	0.17	0.09	0.02	3.62	0.172
M*N	0.02	0.01	0.03	0.38	0.770
M*O	0.04	0.02	0.03	0.75	0.590
N*O	0.25	0.12	0.03	4.65	0.013
L*M*N	0.06	0.03	0.03	-1.15	0.455
L*M*O	0.01	0.01	0.02	-0.26	0.840
L*N*O	0.19	0.10	0.02	4.07	0.015
M*N*O	0.02	0.01	0.03	0.39	0.762
L*M*N*O	0.05	0.03	0.02	1.19	0.445

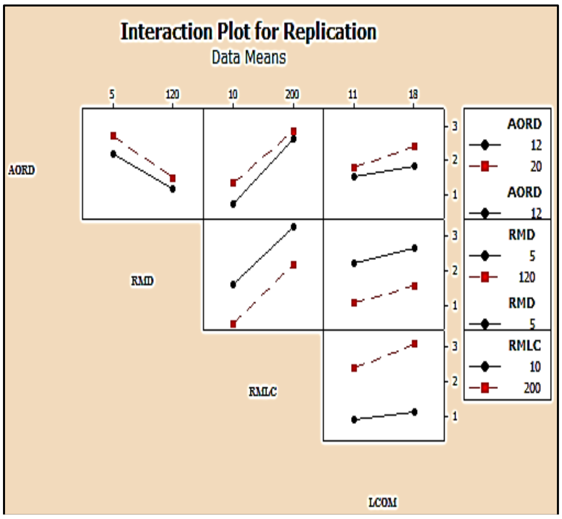

Fig. 4: *Interaction Plot for Replication.*

The interaction of the variables is displayed on "Interaction Plot" which is shown in Figure 4.

With the help of Analysis of Variance (ANOVA) procedure the experimentation result are analyzed. The integration effects are given in Table 6. The sequential sums of square and the adjusted sums of square are calculated by using MINITAB-16.

REGRESSION EQUATION

The regression equation is a generalization of TOPSIS model [18].

Y=1.9096+0.2112L–5666M+ 0.8696N+ 0.2317O +0.1228N*O+0.0956L*N*O.

Table 6: *Analysis of Variance.*

Source	DOF	Seq SS	Adj SS	Adj MS	F	P
Main Effects	4	21.17	18.86	4.71	416.10	0.03
2-Way Interactions	6	0.58	0.56	0.09	8.29	0.26
3-Way Interactions	4	0.20	0.21	0.05	4.65	0.33
4-Way Interactions	1	0.02	0.05	0.02	1.42	0.45
Residual Error	1	0.01	0.01	0.01		
Total	16	21.98				

RESULT

The final ranking of each belt conveyor assembly in the form of a chart. It can be seen that Belt Conveyor Assembly-1 is the best belt conveyor assembly among the four alternatives (Table 7).

Table 7: *Final Ranking.*

Belt Conveyor (BC)	TOPSIS-Meta Model Score	Ranking Result
BC-1	6064.0274	1
BC-2	2265.8903	3
BC-3	3121.2857	2
BC-4	152.557	4

Score of Attributes in graph form is shown in Figure 5.

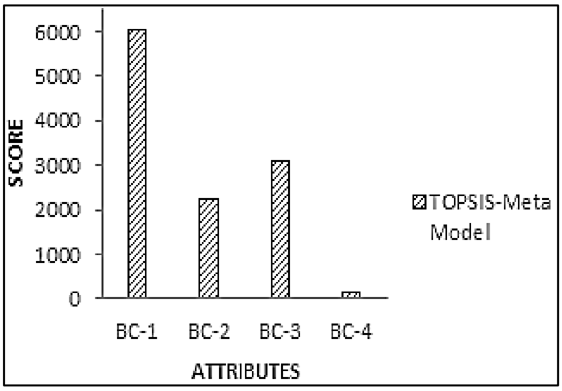

Fig. 5: *Score of Attributes.*

CONCLUSION

An integrated AHP-TOPSIS-DOE approach is presented for the selection of Belt Conveyor Assembly on the basis of their performance. Once the attribute weights are determine by AHP using Saaty's scale the Meta modeling approach can be effortlessly implemented. Then the TOPSIS-DOE methods are used to recognize the alternatives evaluated for empirical data suited to a polynomial in a multiple linear regression analysis. The present integrated approach is found to be robust as it can be consider quantitative and qualitative attributes, while offering a more subjective selection. The present integrated approach overcomes the short coming of the individual methodology for Belt conveyor assembly selection offers a cheaper and faster selection.

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List of Abbreviations

Y	Topsis Score
L	Angle of Response
M	Raw Material Dimension
N	Raw Material Load Capacity
O	Load Capacity of Motor
$BC_{1,2,3,4}$	Belt Conveyor Assembly

COMPETING INTERESTS

The authors declare that they have no competing interests.

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