Prioritizing Preventative and Repair Measures of Conveyor Belt Equipment Pieces Using Fuzzy TOPSIS Technique (Case Study: Pelletizing Plant of GolGohar Mining and Industrial Company)

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(Received: April 2017, Accepted: September 2017)

Keywords

Preventative and Repair Measures
Fuzzy TOPSIS
Pelletizing Plant
GolGohar Mining and Industrial Company
Conveyor Belt

Abstract

Increasing efficiency does not necessarily require the use of expensive technologies. Sometimes implementing properly management and engineering principles, employing skilled and efficient manpower, planning appropriately, and identifying effective priorities can increase efficiency and reduce costs. Conveyor belt equipment pieces are category components which carry heavy materials in factories and mines. Downtime of the pieces have many costs for the factory. Identification of parts of conveyor belts, taking preventative and repair measures and prioritizing measures in order to increase efficiency and reduce cost for downtime conveyor belt are important. In this study, using fuzzy TOPSIS technique to prioritize the preventative and repair measures of conveyor belt equipment pieces factory in the pelletizing plant of GolGohar mining and industrial company have been discussed. In this regard, the main and ten other parts of conveyor belt along with their practical roles are identified from viewpoint of engineers and technicians who deal with them. Besides, intended preventative and repair measures are identified according to previous records. Then maintenance repair parts and expert opinions are discussed to prioritize the preventative measures. Finally, recommendations are provided for increasing efficiency of conveyor belt and reducing cost and repair time.

1. INTRODUCTION

Today, in fierce competition with advanced and the current growth technology, one of the most important issues in the material handling industry is the choice of method and appropriate equipment. Depending on the type of material, equipment type may be different [1]. In GolGohar pelletizing plant of mining and industrial company, conveyor belt equipment is used to transport the materials. Industrial conveyor belts are portable devices that are used to transport material between two fixed points intermittently or continuously [2]. In general, mechanical tools for continuous transport of materials in certain directions are available in different types, capacities and speeds. Today conveyor belts are the most widely used and are considered very important elements in production systems and automation units, with their varying capabilities and efficiencies as an integral part of industry. The wide use of conveyor belt in mines, factories, and public places proves their usefulness in making the activity easy [3]. Due to its nature and importance in production line, gender and price, a conveyor belt is one of the most sensitive equipment pieces. Hence, it is important to know how to buy, inspect, quality control and warehouse it [4]. Conveyor belt equipment in pelletizing plant is key equipment in the material handling. To maintain this equipment, maintenance and repair system are required to identify all preventative and repair measures for each piece. Appropriate conveyor selection can reduce manpower requirements, electricity costs, production time, prices and delivery time, and thus increase profitability and productivity [5].

Material handling costs are significant in manufacturing, amounting to approximately 15% to 70% of the total manufacturing cost [6].

By reviewing and prioritizing preventative measures, experts and operators will be able to increase duriability of parts, reduce the rate of failure and improve efficiency of conveyor belts. This increases the efficiency of the conveyor belt besides saving money.

The aim of this study is to identify and prioritize preventative and repair measures for conveyor belt equipment using Fuzzy MCDM approach (FMCDM) in a pelletizing plant. First, a review on preventative and repair measures of parts of conveyor belt is provided. Then Fuzzy TOPSIS method is presented as used in this research and finally the results of prioritization will be presented and analyzed.

2. HISTORY

Fathallah et al argued that due to the type of machinery and conveyor belt, the cost of maintenance and repairs is a major part of the production costs (about 15 to 60 percent of the cost of production). Proper maintenance and repair management leads to great money savings. Researchers have already designed and implemented an intelligent system to achieve these goals. This smart system has been designed in such way the database of which includes expert information, the most important component testing, schematic maps, layouts mechanical parts and instructions for repair and replacement different parts of conveyors in giving advice on maintenance, repair and troubleshooting fixed conveyor belt. [7].

Karimi et al in their study analyzed the maintenance and operation situation of the conveyor belt in the concentration plant of industrial and minerals iron ore GolGohar Company. First they determined the value of MTBF and Net preventative time interval at 90% confidence level for each conveyor belt in the concentration plant separately, and then for the conveyor belts with high sensitivity and a higher priority (maintenance of vision). Then they reviewed repairs of different parts of the conveyor belt like belts, oil drums and drum and the like for all tapes individually, and compared their numbers quantitatively. Through this study, the main equipment parts of the conveyor belt in terms of maintenance (number of repairs) and sensitive to repair were determined, and at the end, operational strategies were examined in order to increase MTBF index [8].

Razavi et al believe that due to the undeniable importance of the conveyor belt in logistics and drilling material handling system from workplace to the outside of the tunnel through mechanized drilling method, the use of new technologies in the field of tunnels transport can be a significant increase in the efficiency of the conveyor belt system. In fact, one of the innovations is the use of automation in production systems. Generally, industrial automation means using control equipment to control industrial machinery and production processes. Razavi and his colleagues examined the process of designing automation system for intelligent control of conveyor belt systems in east-west Tehran Metro Line 7 and assessed its advantages and disadvantages. Due to the benefits of this approach, it was recognized necessary to use the conveyor belt system in all categories to transport materials that can be used in full length dimensions instead of launching the electrical control circuit [9].

Sharifi et al noted that they were looking for advanced and automatic machines in their research to increase production speed and efficiency, optimize use of time with less manpower to bring more profit. They mentined the converyor belt as the most common example of such automatic machines. Their study point to the effective role of conveyor belt in the development of the material transport industry and therefore the significant impact on increasing the efficiency material transport by designing conveyor belt systems according to their specific function. Finally, the researchers found that conveyor belt transport system is the most practical, the most common and often the most accessible system. Therefore, in the design of conveyor belt systems various parameters should be considered such as environmental conditions such as wind and sun, material size, moisture, dryness, adhesion, etc. [10].

Aliabadi et al considered material handling as one of the important issues in large industries. Therefore, transport of materials by conveyor belt seems popular. Their study focused on the problems in the conveyor belt in Iranian Ghadir Iron and steel site. They concluded that the conveyor belt should be designed to suit the environmental conditions, type and size of materials to carry as well as other working conditions. Also in the construction and design of new conveyor belt, past administrative and repair problems should be detected and rectified [11].

Simon et al suggested that the reliability and maintenance in the industry and mining plants are taken into consideration more than ever. Since mine systems are more complex and the equipment is more expensive, more attention is needed to pay for repair and maintanance. So unexpected failure can bring about considerable cost especially when the hard machines and spare parts are not easily accesssible. Simon and his associates analyzed the reliability and maintenance of main conveyor belt systems located in coal mine in Norway. Data were collected from daily maintenance reports in 2010. They found that the analysis of reliability and maintenance should be an integral part of mining engineering and management for effective utilization of the mine equipment [12].

Molnar et al provided a regression model to predict the relationship between conveyor belt and its rolls. According to their research, performed experimental measurements, obtained models correspond with the actual operation and represented the direct relation of involved forces, such as length conveyor belt [13].

Previous studies emphasized the important role of conveyor system in industry. Some researchers recommend the use of innovative technologies and advanced machinery to increase the efficiency and effectiveness of conveyor belt. However, many organizations should stand the cost in implementing technologies and the purchase of machinery. In case you can identify preventative and repairs measures in conveyor belt and determine the priority of each of them, the efficiency of the conveyors will increase and the cost will be reduced. Although some researchers have investigated the importance of reliability and maintenance, no study has yet determined via survey the priorities of preventative and repair measures of conveyor belt pieces. Using fuzzy TOPSIS technique, the present study aims to to determine the priority of preventative and repair measures in the pelletizing plant.

3. METHODOLOGY

The present study is applied research through which preventative and repair measures for the conveyor belt equipment are taken into scrutiny. A self-made questionnaire with a Likert scale to reduce the number of unwanted stops is used to collect data. The questionnaire was distributed among all the people who had the technical knowledge necessary for the maintenance of the conveyor. Accordingly, 20 engineers and technicians in the field of electrical engineering and mechanics were identified through snowball sampling. Each person was asked to describe his expertise briefly, and then introduce other people who are familiar in the field of similar or non-similar issues with regard to the functions of the conveyor. The extraction of questionnaires was done in two steps. In the first stage, the technical instructions of the conveyor were assisted. The original framework was extracted on this basis. Then, with the help of a group of specialists in the maintenance and repair of the machine, the parts that were subjected to the instructions were adjusted and completed and attempts were made to identify the disadvantages and preventive measures that were effective over time.

In this regard, in order to analyze data and to rank measures for each piece and to reduce the number of unwanted stops in equipment Fuzzy Topsis method was used. Due to the nature of piece in that could not be easily attributed to certain specifications and quantities, the triangular fuzzy numbers were used to express uncertainty and ambiguity in the data. Linguistic variables and the triangular fuzzy numbers for the values are shown in Table 1.

Table 1. Triangular fuzzy numbers to assess preventative and repair measures parts[14]

Fuzzy equivalent	Verbal amount
Unimportant	(0, 0, 0.2)
Somewhat important	(0, 0.2, 0.4)
Important	(0.2, 0.4, 0.6)
Very important	(0.4, 0.6, 0.8)
Extremely important	(0.6, 0.8, 1)

Yoon and Hwang introduced TOPSIS method in 1981 [15]. This method is widely used to solve rankings. But it is also criticized because of its inability to observe the inherent ambiguity in the perceptions of decision-makers. Chen is one of the researchers who managed TOPSIS techniques to transfer the fuzzy space properly[14]. The introduced method as used by Chen is as follows:

Step 1: Fuzzy Decision Making Matrix

The fuzzy decision making matrix, initially for criteria, options and results of the evaluation mathematical symbols are marked as follows:

$$\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})\tilde{D} = \begin{bmatrix} \tilde{x}_{11} & \cdots & \tilde{x}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{x}_{m1} & \cdots & \tilde{x}_{mn} \end{bmatrix}$$

$\widetilde{D}$: Decision Making Matrix

$\tilde{X}_{ij}$: Performance option i, (i = 1, 2, ... m) A_ in relation to the criterion j, (j = 1, 2, ..., n) C_j with variable

X = {x_ij, i = 1,2, ... m, j = 1,2, ..., n} is shown.

Step 2: Determining the criteria weight matrix

At this stage, determining important factor decision criteria, is defined as follows:

$$\widetilde{W}_j = (w_{j1}, w_{j2}, w_{j3}) \quad (1)$$

$\widetilde{W}_j$: Criteria important factor j, j= 1, 2, … , n

So the triangular fuzzy numbers are used, each component $\widetilde{W}_j$ (weight each criteria) will be defined as $\widetilde{W}_j = (\widetilde{w}_{j1}, \widetilde{w}_{j2}, \widetilde{w}_{j3})$.

In this study, experts' opinions are considered identical and the weight of each criterion is one and is shown as follows:

$$\widetilde{w}_j = (1,1,1)\forall_j \epsilon\, n \quad (2)$$

Step 3: Scalarizing Decision Making Matrix

For the scalarizing fuzzy decision making matrix, the procedure is similar to the classical ideal option, and the linear scale is used for normalizing.

When the decision matrix elements $\tilde{x}_{ij}$ are fuzzy, scalarizing fuzzy decision matrix elements will also be fuzzy. For fuzzy triangular numbers, scalarizing fuzzy decision matrix elements for positive and negative criteria, respectively, is calculated from the following relationship:

Positive Criteria

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j{}^*}, \frac{b_{ij}}{c_j{}^*}, \frac{c_{ij}}{c_j{}^*}\right) \quad (3)$$

So in this formula, $C_j{}^*$ for each person is: $C_j{}^* = \max_i c_{ij}$

Negative Criteria

$$\tilde{r}_{ij} = \left(\frac{\bar{a}_j}{c_{ij}}, \frac{\bar{a}_j}{b_{ij}}, \frac{\bar{a}_j}{a_{ij}}\right) \quad (4)$$

In this formula, the value of $\bar{a}_i$ is for each person is calculated through the following formula:

$\bar{a}_i = \min_i a_{ij}$

Scalarizing fuzzy decision making matrix (R) is obtained as follows:

$$\tilde{R} = \left[\tilde{r}_{ij}\right]_{m\times n}\ i = 1,2, \dots m; j = 1,2, \dots, n \quad (5)$$

Where "m" is the number of options and "n" represents a number of criteria.

Step 4: To determine the weighted fuzzy decision matrix

However due to the weight of different criteria, weighted fuzzy decision matrix is obtained by multiplying fuzzy importance factor of each criterion by the scalarizing fuzzy decision making matrix as follows. $\widetilde{w}_j$ Importance factor in this relationship represents C_j criteria and $\tilde{r}_{ij}$ are weighted fuzzy matrix elements.

$$\tilde{V}_{ij} = \tilde{r}_{ij} \times \widetilde{w}_j \quad (6)$$

The weighted fuzzy decision matrix $(\tilde{V})$ is as follows:

$$\tilde{V} = \left[\tilde{v}_{ij}\right]_{m\times n}, i = 1,2, \dots, m \text{ ، } j = 1,2, \dots, n \quad (6)$$

Step 5: Determining ideal fuzzy positive solution and ideal fuzzy negative solution

The purpose of this stage is to achieve the best options according to desired criteria. So the logic of principles, ideal positive solution and ideal negative solution should be defined because the ideal solution is the response to maximizing profit criterion and to minimize its cost metrics. Briefly, the positive ideal solution is the best available doses while the negative ideal solution is a combination of the worst available values, and the optimal option is an option that has the shortest distance from the positive ideal solution and the greatest distance from the negative ideal solution.

The fuzzy positive ideal solution and the negative ideal solution are represented below:

$$A^+ = \{\tilde{v}_1{}^+, \tilde{v}_2{}^+, \dots., \tilde{v}_n{}^+\} \quad (8)$$

$$A^- = \{\tilde{v}_1{}^-, \tilde{v}_2{}^-, \dots., \tilde{v}_n{}^-\} \quad (9)$$

Among all options in matrix j the worst value is $\tilde{v}_j{}^-$ and the best value is $\tilde{v}_j{}^+$ that is weighted fuzzy decision matrix. These values are obtained from the following relations:

$$\tilde{v}_j{}^+ = max\{\tilde{v}_{ij}\} \quad i = 1,2, \dots, m; j = 1,2, \dots, n \quad (10)$$

$$\tilde{v}_j{}^- = min\{\tilde{v}_{ij}\} \quad i = 1,2, \dots, m; j = 1,2, \dots, n \quad (11)$$

Options in $A^+$and A^- indicate that the options are quite good and quite bad respectively.

Chen's fuzzy positive and negative ideals are used in this study.

$\tilde{v}_j{}^+ = (1,1,1)$

$\tilde{v}_j{}^- = (0,0,0)$

So the normalized weighted matrix to determine the positive and negative ideal options, the best and worst values for each criterion through the comparison of weighted fuzzy normal values were determined on the basis of Equation 8 and 11.

Step 6: Calculating the measured distance from the positive ideal solution and negative ideal solution

The best and worst possible options were specified in the previous step. However, at this step, the distance of each option from the ideal positive solution and ideal negative solution is calculated through the following relations:

$$d^{+}_{i} = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}^{+}_{j}\right) \ , i = 1,2,\dots,m \qquad (12)$$

$$d^{-}_{i} = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}\ , \tilde{v}^{-}_{j}\right) \ , i = 1,2,\dots,m \qquad (13)$$

Step 7: Calculating the proximity distance

At this stage, proximity of each option with respect to the ideal solution is calculated through the following relation:

$$CC_i = \frac{d_i^{\,-}}{d_i^{\,+} + d_i^{\,-}} \qquad i = 1,2,\dots,m \qquad (14)$$

For final grading options in this stage, distance from the ideal positive is calculated as a sum of the option distance from the best value of criteria, and distance from the ideal negative is calculated as a sum of the option distance from the worst value of criteria. Accordingly, proximity index for each option can be obtained through Relation 14.

4. CASE STUDY

Iron ore as a raw material is not a good value per se, but the processing, production of pellets, sponge iron production and finally steel production, as well as employment will add a much higher value for producers. Growing steel production in the country depends on the growing need of pelletizing units. In this direction, GolGohar Company decided to build a pelletizing plant besides ore concentration plant (concentrate). This factory is capable of producing high-quality pellets for use in direct reduction plants and suitable quality pellet is for use in high furnaces.

GolGohar pelletizing plant with a capacity of 5 million tons per year was made in the mining and industrial GolGohar Company. GolGohar concentrates are carried through the elevator bar with over 470 meters in length into the primary storage tanks of concentrate pelletizing unit, each with capacity of 2000 tons (A reservoir containing hematite ore lots).

Generally GolGohar pelletizing plant of mining and industrial consists of six main areas: mill area, pulp-storage area, area of raw pellets, pellet cooking area, riddled area, storage and harvest area. Conveyor belt equipment in pelletizing plant contains ten original pieces, including the following.

Table 2. Main parts of conveyor belt equipment

No.	Component
1	bearings and drum Conveyor belt
2	Conveyor belt motor and system
3	Conveyor belt unit drive
4	Conveyor belt speed switch
5	Conveyor belt drift switch
6	Conveyor belt emergency switch
7	Conveyor belt - roller and ribbons
8	Cleaner and scraper
9	Conveyor belt loading hoper and unloading hoper
10	Conveyor belt system motor and gear box

4.1. Repairs and preventative measures indicators

In this study, for searching the necessary repair work and preventative measures in reducing the number of unwanted stops of conveyor belt equipment all parts of the conveyor belt equipment were identified and evaluated through interviews with industry experts and to finalize the measures was used Delphi approach. The pieces are grouped in the form of 10 pieces according to the following tables. The measures for each piece is shown with the abbreviations that facilitate the task. It should be noted that the function and role of each part is extracted from engineers and operators' opinions.

Bearing: It is a mechanical piece that is used to connect the rotating axis to the backrest without interfering with the rotation. It is usually made up of two cylinders, one is placed inside the other and steel small shots are used between them to reduce the friction between them during rotation of the conveyor belt (Table 3).

Drum: A cylindrical metal object through the sides of which a solid steel shaft connects the two ends of the conveyor belt. It has passed through the bearing steel structure at opposite ends of conveyor belts to move the bar at changes, and practically it plays the role of conveyor belt support at the two ends (Table 3).

Motor: It is an electro-mechanical piece that assume electrical energy and produce rotatory motion and used it as a driver and rotatory mechanical parts (here conveyor belt and rotatory attachments) (Table 4).

Table 3. Measures of conveyor belt bearings and drums piece

No.	Repairs and Preventatives Piece Measures	Pieces
A1	Replacing bearing in case of breakdown	Piece 1: conveyor belt bearings and drums
A2	Disassembling pillow block at penetration of dust into the bearing housing	
A3	Replacing grease if penetration of dust into the bearing housing	
A4	Checking tension of belt and if necessary adjustment by tension adjustment screws	
A5	Replacing seals of pillow block at break and detachment and/or penetration of dust into the bearing housing	
A6	Replacing lubricant at bearing lubricant damage	
A7	Opening pillow block and tigenhting chuck nut when chuck nut loosen at back of bearing	
A8	Replacing bearing at damage or failure of internal and external cons	
A9	Replacing bearing at jamming of bearing on the shaft	
A10	Replacing bushe or replacing bearing if damage to bushe sleeve	
A11	Cleaning bearings and pillow block	
A12	Measuring bearing clearance and comparing it with SKF table	
A13	Replacing bearing if more clearance	
A14	Tightening pillow block foot bolts	
A15	Adjusting cunter weight guides and replacing steel cable if deformed or damaged	
A16	Adjusting cunter weight height relative to the ground	
A17	Cleaning pillow blocks from dirt	
A18	Controlling unusual noise situation of pulleies	
A19	Controlling temperature status of pillow blocks	
A20	Controlling abrasion status of drum segments and polly metallic	
A21	Evaluating cunter weight performance and steel cable status	
A22	Cleaning grease fitting place and its around by cloth	
A23	Charge bearings grease according to the operation hours	
A24	Ensuring the health of labyrinth in back of pillow blocks and dusters	
A25	Grease seals bearing gearbox	
A26	Cleaning input grease fitting with cloth	

Drive Unit: Collection of motor and its brake and gearbox installed after production motive force for rotating conveyor belt (Table 5).

Speed Switch: an electronic device with a rigid cylindrical frame made of metal or hard plastic to detect rotating of conveyor belts (Table 6).

Table 4. Measures of motor system conveyor belt piece

No.	Repairs and Preventatives Piece Measures	piece
B1	Cleaning motor by compressed air	Piece 2: motor system conveyor belt
B2	Checking terminal box screws and their tightening and if oxidized, have cleaned them	
B3	Measuring insulation resistance cables and checking motor cable lugs and their insulation	
B4	Close motor terminal box or sealing off by silicone adhesive	
B5	Appearance and clean motor	
B6	Health of fan cover and fan	
B7	Measuring motor vibration by vibrometer and motor temperature by thermometer	
B8	Checking temperature and noise of motor bearings	

Table 5. Measures of conveyor belt drive unit piece

No.	Repairs and Preventatives Piece Measures	Piece
C1	Search motor and gearbox in terms of temperature and noise	Piece 3: conveyor belt drive unit
C2	Search gearbox and hydraulic coupling in terms of oil leakage	
C3	Report if excessive leakage and noise	
C4	Cleaning drive unit and tightening gearbox and motor screws	
C5	Cleaning surroundings conveyor belt	
C6	Checking gear of gear coupling in terms of sharpen and crushing	
C7	shrink disk screws Tightening	

Table 6. Measures of conveyor belt speed switch piece

No.	Repairs and Preventatives Piece Measures	Piece
D1	Cleaning probe in terms of appearance by cloth and dry spray	Piece 4: conveyor belt speed switch
D2	Checking connections and their cables	
D3	Tightening support speed switch	
D4	Checking and cleaning target	
D5	Checking distance between switch and target (800 mm)	
D6	Checking function switch	

Drift switch: Electromechanical piece of metal with a body-centered cubic form connected to the body through metallic lever that could move on hinges. It can detect drift conveyor belt from its permitted range of motion that may result in damage (Table 7).

Emergency switch: electromechanical piece that is connected from both sides to two steel cords through the conveyor belt. It provides quick stop conveyor belt in emergencies by pulling a cord attached to one hand (Table 8).

Table 7. Measures of conveyor belt drift switch piece

No.	Repairs and Preventatives Piece Measures	Piece
E1	Cleaning conveyor belt switch drift by compressed air or brush	Piece 5: conveyor belt drift switch
E2	Open the switch door and clean the inside by compressed air	
E3	power outage by multimeter Ensure from	
E4	Tighten activator limits disk	
E5	Checking mechanical pieces in switch	
E6	Checking cable status and switch connections visually	
E7	Not loose switch stimulating arm	
E8	Checking switch performance and their signals at control room	
E9	Seal and close switch door	
E10	Controlling switch installation status generally and visually	

Table 8. Measures of conveyor belt emergency switch piece

No.	Repairs and Preventatives Piece Measures	Piece
F1	Cleaning conveyor belt emergency switch	Piece 6: conveyor belt emergency switch
F2	Checking limits in switch by multimeter	
F3	Checking the Limits Activator Disk and make sure that it's firm	
F4	Fix or replace mechanical pieces in conveyor belt emergency switch	
F5	Fix connections emergency switch	
F6	Checking emergency switch in terms of signals in control room	
F7	Checking the reset lever operation status of the emergency switch	
F8	Checking switch status visually	
F9	Vertical actuating lever rope	
F10	Be suitable steel cable tension	
F11	Checking cables and connections	

Belt: It is a strap made of rubber and special yarns with different widths and lengths (depending on user requirements) with a metal wire mainly at its center along its length to strengthen it. Belt is used in various industries to transfer raw materials or final products in the manufacturing process from one place to another at a distance of several meters to several hundred meters (Table 9).

Roller: It is a metal or plastic cylinder that functions as a rotatable fulcrum for conveyor belt and all round the belt at intervals of half to one meter. It also helps belt to maintain its shape in order to prevent the discharge of substances along the way The rotatable rollers under the belt, with a minimum of friction provide the possibility of transferring (Table 9).

Ribbon: It is a skirt board or arm stuck that is always installed on either side of belt under loading hoper. It helps prevent falling of material as the loading hoper is discharged from both sides of the belt and mainly covers whole falling of materials area in order to minimize the possibility of falling materials. Ribbon is made of rubber and is softer than the belt to prevent abrasion (Table 9).

Table 9. Measures of conveyor belt, rollers, cleaner belt and ribbons piece

No.	Repairs and Preventatives Piece Measures	Piece
G1	Controlling level and belt edge strips situation in terms of detachment, cutting, two scaling and drift	Piece 7: conveyor belt, rollers, cleaner belt and ribbons
G2	Mark rollers that are having unusual noise and jumming	
G3	Idler gear situation which has noise, limp and jumming	
G4	Checking cleaner belt performance and efficiency	
G5	Controlling situation of self-centering and guide rollers in terms of performance and efficiency	
G6	Controlling ribbons around the bar in terms of abrasion and deformation	
G7	Unloading and loading hoper situation in terms of abrasion	

Cleaner and Scrubber: Parts that are used for cleaning of the belt. They are of two types: V cleaner that cleans the underside of the belt and blade scrubber (installed on loading hoper) that cleans the belt surface (Table 10).

Table 10: Measures of cleaners and scrubbers piece

No.	Repairs and Preventatives Piece Measures	Piece
H1	Loosen the holding screws of cleaner belt and adjustment contact blade of cleaner belt to strip	Piece 8: cleaners and scrubbers
H2	Cleaning materials from cleaners	
H3	Replace cleaner belt in strip	
H4	Replace blade of cleaner belt	
H5	Replace corner on the ribbon and then make the necessary adjustments, tightening the preservative connections	
H6	Tightening tray screws front of tail drum and checking distance between tail drum to tray	
H7	Checking distance cleaner rubber with belt	
H8	Replace rubber if abrasion	

Loading Hoper: The loss material place on the conveyor belt, mostly at the beginning of the conveyor belt and higher than its surface. It is a large funnel-shaped metal inner surface coated with a special kind of compressed plastic named Teflon (In order to prevent abrasion metal body over time due to exposure to the material loss) (Table 11).

Unloading Hoper: It is the material discharge area at the end of the conveyor belt and lower than its surface. It is a large funnel-shaped metal inner surface coated with a special kind of compressed plastic named Teflon (In order to prevent abrasion metal body over time due to exposure to the material loss) (Table 11).

Table 11: Measures of conveyor belt loading and unloading hoper piece

No.	Repairs and Preventatives Piece Measures	Piece
I1	Cleaning whole conveyor belt loading and unloading hoper	Piece 9: loading and unloading hoper
I2	Replace or disassembled defective weir plate and Teflon	
I3	Repair or welding body shot	
I4	Discharge conveyor belt loading and unloading hoper when filled	

Motor and Gearbox System: Motor and its brake and gearbox installed to produce a driving force for rotating conveyor belt.

Table 12: Measures of conveyor belt motor and gearbox system

No.	Repairs and Preventatives Piece Measures	Piece
J1	Open drain plug screw and collect old oil in a container	Piece 10: conveyor belt motor and gearbox system
J2	Put the brake cover in place and tightening its screws	
J3	Cleaning the engine by compressed air	
J4	Close motor box door and sealing it with silicone adhesive	
J5	Tightening earth wire	
J6	Measurement of insulation resistance of cables and the motor cables and their insulation	
J7	Appearance and clean motor	
J8	Checking oil seal and gearbox	
J9	Checking flexible connector pipe and connecting earth wire	
J10	Checking switch for brake	

5. IMPLEMENTATION AND RESULTS

TOPSIS which is a process used for preventative and repair measures for the conveyor belt equipment in order to reduce the number of unwanted stops includes the following steps:

In this step linguistic variables were collected from a questionnaire forming triangular fuzzy numbers. The decision matrix is m × n matrix where m is the number of measures and n represents the number of experts. Fuzzy matrix of the first piece is shown in Table 13.

Table 13: Results of the first piece fuzzy decision making matrix

Repairs and Preventatives Measures \ Expert	C1	C2	C3	…	C17	C18	C19
A1	(0.6, 1, 0.8)	(2.0, 0.6, 4.0)	(0.6, 1, 0.8)	…	(0.6, 1, 0.8)	(4.0, 0.8, 6.0)	(0.6, 1, 0.8)
A2	(2.0, 0.6, 4.0)	(2.0, 0.6, 4.0)	(0, 0.4, 2.0)	…	(4.0, 0.8, 6.0)	(4.0, 0.8, 6.0)	(0.6, 1, 0.8)
A3	(2.0, 0.6, 4.0)	(2.0, 0.6, 4.0)	(0, 0.2, 0)	…	(4.0, 0.8, 6.0)	(4.0, 0.8, 6.0)	(2.0, 0.6, 4.0)
⋮	⋮	⋮	⋮	⋱	⋮	⋮	⋮
A24	(0, 0.4, 2.0)	(2.0, 0.6, 4.0)	(2.0, 0.6, 4.0)	…	(4.0, 0.8, 6.0)	(0.6, 1, 0.8)	(2.0, 0.6, 4.0)
A25	(2.0, 0.6, 4.0)	(0, 0.4, 2.0)	(2.0, 0.6, 4.0)	…	(2.0, 0.6, 4.0)	(0.6, 1, 0.8)	(0, 0.4, 2.0)
A26	(2.0, 0.6, 4.0)	(2.0, 0.6, 4.0)	(2.0, 0.6, 4.0)	…	(2.0, 0.6, 4.0)	(0.6, 1, 0.8)	(2.0, 0.6, 4.0)

According to the results of Fuzzy TOPSIS method to prioritize the preventative and repair measures, parts of conveyor belt equipment have been discussed in GolGohar pelletizing plant of mining and industrial company (Table 14).

As can be observed bearing replacement action in case of failure or break internal or external cons bearing have the highest rank and cleaning input grease with cloth has the lowest rank in order to minimize the number of stops for conveyor belt equipment (Table 15).

Checking temperature and noise of motor bearings have highest rank and measurement insulation resistance cables and checking motor cable lugs and their insulation have the lowest rank (Table 16).

Checking gear of gear coupling in terms of sharpen and crushing have the highest rank and cleaning surroundings of the conveyor belt have the lowest rank (Table 17).

Tightening support speed switch have the highest rank and cleaning probe in terms of appearance by cloth and dry spray have the lowest rank (Table 18).

Checking switch performance and their signals at control room have the highest rank and cleaning conveyor belt switch drift by compressed air or brush have the lowest rank (Table 19).

Table 14: The results of ranking the first piece using fuzzy TOPSIS

Piece	Piece Measures	Distance to positive Ideal	Distance to Negative Ideal	CC_i Amount	Rank
Piece 1: conveyor belt bearings and drums	A1	1.633	3.235	0.665	2
	A2	2.312	2.519	0.521	8
	A3	2.417	2.485	0.507	9
	A4	2.036	2.889	0.587	4
	A5	1.84	2.964	0.617	3
	A6	2.224	2.747	0.553	5
	A7	2.036	2.889	0.587	4
	A8	1.492	3.351	0.692	1
	A9	1.492	3.351	0.692	1
	A10	1.608	3.223	0.667	2
	A11	2.439	2.397	0.496	10
	A12	2.206	2.582	0.539	7
	A13	2.197	2.651	0.547	6
	A14	2.269	2.559	0.53	7
	A15	2.414	2.455	0.504	9
	A16	2.463	2.338	0.487	11
	A17	2.698	2.101	0.438	14
	A18	2.551	2.169	0.46	13
	A19	2.277	2.487	0.522	8
	A20	1.99	2.81	0.585	4
	A21	2.53	2.266	0.472	12
	A22	2.942	2.078	0.414	15
	A23	2.355	2.636	0.528	8
	A24	2.312	2.519	0.521	8
	A25	2.566	2.364	0.479	12
	A26	2.991	1.883	0.386	16

Table 15: The results of ranking the second piece using fuzzy TOPSIS

Piece	Piece Measures	Distance to positive Ideal	Distance to Negative Ideal	CC_i Amount	Rank
Piece 2: motor system conveyor belt	B1	2.725	2.104	0.436	3
	B2	2.828	2.082	0.424	4
	B3	2.993	1.922	0.391	6
	B4	2.847	1.977	0.41	5
	B5	2.859	2.154	0.43	4
	B6	2.769	2.16	0.438	3
	B7	2.286	2.574	0.53	2
	B8	2.094	2.79	0.571	1

Table 16: The results of ranking the third piece using fuzzy TOPSIS

Piece	Piece Measures	Distance to positive Ideal	Distance to Negative Ideal	CC_i Amount	Rank
Piece 3: conveyor belt drive unit	C1	1.977	2.847	0.59	3
	C2	1.829	2.889	0.612	2
	C3	2.33	2.535	0.521	4
	C4	2.383	2.452	0.507	6
	C5	2.723	2.069	0.432	7
	C6	1.717	3.09	0.643	1
	C7	2.304	2.59	0.529	5

Table 17: The results of ranking the fourth piece using fuzzy TOPSIS

Piece	Piece Measures	Distance to positive Ideal	Distance to Negative Ideal	CC_i Amount	Rank
Piece 4: conveyor belt speed switch	D1	2.425	2.723	0.529	5
	D2	2.094	2.79	0.571	2
	D3	1.977	2.984	0.602	6
	D4	2.236	2.708	0.548	4
	D5	1.98	3.009	0.603	1
	D6	2.191	2.887	0.569	3

Table 18: The results of ranking the fifth piece using fuzzy TOPSIS

Piece	Piece Measures	Distance to positive Ideal	Distance to Negative Ideal	CC_i Amount	Rank
Piece 5: conveyor belt drift switch	E1	2.735	2.239	0.45	7
	E2	2.651	2.197	0.453	7
	E3	2.449	2.517	0.507	5
	E4	2.104	2.868	0.577	2
	E5	2.132	2.819	0.569	3
	E6	2.605	2.321	0.471	6
	E7	2.364	2.406	0.504	5
	E8	1.851	2.903	0.611	1
	E9	2.277	2.643	0.537	4
	E10	2.251	2.543	0.53	4

Table 19: The results of ranking the sixth piece using fuzzy TOPSIS

Piece	Piece Measures	Distance to positive Ideal	Distance to Negative Ideal	CC_i Amount	Rank
Piece 6: conveyor belt emergency switch	F1	2.38	2.582	0.52	8
	F2	2.33	2.535	0.521	7
	F3	2.233	2.681	0.546	6
	F4	1.956	2.971	0.603	2
	F5	1.997	2.861	0.589	4
	F6	2.176	2.898	0.571	5
	F7	2.03	2.975	0.594	3
	F8	2.372	2.495	0.513	9
	F9	2.73	2.349	0.463	10
	F10	1.829	3.024	0.623	1
	F11	1.956	2.971	0.603	2

Checking switch status visually have the highest rank and cleaning conveyor belt emergency switch have the lowest rank (Table 20).

Control level and belt edge strips situation in terms of detachment, cutting, two scaling and drift have the highest rank and control ribbons around the bar in terms of abrasion and deformation have the lowest rank (Table 21).

Loosening the holding screws of cleaner belt and adjustment contact blade of cleaner belt to strip have the highest rank and tightening tray screws front of tail drum and checking distance between tail drum to tray have the lowest rank (Table 22).

Discharging conveyor belt loading and unloading hoper when filled have the highest rank and repair or welding body shot have the lowest rank (Table 23).

Table 20: The results of ranking the seventh piece using fuzzy TOPSIS

Piece	Piece Measures	Distance to positive Ideal	Distance to Negative Ideal	CC_i Amount	Rank
Piece 7: conveyor belt, rollers, cleaner belt and ribbons	G1	1.763	2.984	0.629	1
	G2	2.286	2.574	0.53	4
	G3	2.224	2.597	0.539	3
	G4	2.597	2.224	0.461	5
	G5	2.056	2.762	0.573	2
	G6	2.877	2.053	0.416	7
	G7	2.673	2.132	0.444	6

Table 21: The results of ranking the eighth piece using fuzzy TOPSIS

Piece	Piece Measures	Distance to positive Ideal	Distance to Negative Ideal	CC_i Amount	Rank
Piece 8: cleaners and scrubbers	H1	2.321	2.447	0.513	1
	H2	2.613	2.242	0.462	4
	H3	2.681	2.233	0.454	5
	H4	2.511	2.389	0.488	3
	H5	2.474	2.46	0.499	2
	H6	2.666	2.215	0.454	5
	H7	2.597	2.224	0.461	4
	H8	2.812	2.026	0.419	6

Table 22: The results of ranking the ninth piece using fuzzy TOPSIS

Piece	Piece Measures	Distance to positive Ideal	Distance to Negative Ideal	CC_i Amount	Rank
Piece 9: loading and unloading	I1	2.503	2.295	0.478	3
	I2	2.26	2.471	0.522	2
	I3	2.605	2.142	0.451	4
	I4	1.807	3.011	0.625	1

Table 23: The results of ranking the tenth piece using fuzzy TOPSIS

Piece	Piece Measures	Distance to Negative Ideal	Distance to Positive Ideal	CC_i Amount	Rank
Piece 10: conveyor belt motor and gearbox system	J1	2.129	2.793	0.433	3
	J2	1.943	2.871	0.404	5
	J3	1.88	2.966	0.388	7
	J4	1.925	2.882	0.4	6
	J5	1.728	3.16	0.354	9
	J6	2.013	2.85	0.414	4
	J7	1.736	3.079	0.361	8
	J8	2.688	2.151	0.556	1
	J9	1.901	2.98	0.389	6
	J10	2.43	2.471	0.496	2

Checking oil seal and gearbox have the highest rank and appearance and cleaning motor have the lowest rank.

6. CONCLUSION AND RECOMMENDATIONS

Increasing the volume information in repairs and maintenance units and the need to review and analyze information in order to make appropriate decisions at critical time highlights the need for automation in the maintenance and repair of equipment. The present information in the maintenance and repair system should be managed as the effectiveness of network operations are not acceptable in the factories. The purpose of the present study was to identify and prioritizie preventative and repair equipment measures of repair and maintenance information system, simplifying and clarifying the present information on the network which can be available to the organization in emergency situations. It can also lead to reducing the number of stops in the equipment, providing employees with knowledge.

Overall prioritize measures help increase lifespan and prevent corrosion, reduce the hours of work stoppages, operating costs and the consumption of spare parts.

According to the results, each preventative and repair measure has priorities in reducing the number of unwanted stops in the conveyor belt equipment. In the first piece, bearing replacement action in case of failure or break internal or external cons have the highest rank and cleaning input grease with cloth has the lowest rank. In the second piece, checking temperature and noise of motor bearings have the highest rank and measurement insulation resistance cables and check motor cable lugs and their insulation have the lowest rank. In the third piece, checking gear of gear coupling in terms of sharpen and crushing have the highest rank and cleaning surroundings conveyor belt have the lowest rank. In the fourth piece, tightening support speed switch have the highest rank and cleaning probe in terms of appearance by cloth and dry spray have the lowest rank. In the fifth piece, checking switch performance and their signals at control room have the highest rank and cleaning conveyor belt switch drift by compressed air or brush have the lowest rank. The remaining pieces are respectively the highest and lowest measures in accordance with tables to reduce the number of unwanted stops for the conveyor belt equipment. The researchers also recommend that in the future the breakpoints of the conveyor be studied through the FMEA approach to remove the points of failure.

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