

CONVEYOR REAL TIME PERFORMANCE MONITORING

FIELD OF INVENTION

- 5 The invention relates to the field of conveyor system. More particularly, the invention relates to a method for monitoring performance of a conveyor system.

BACKGROUND OF THE INVENTION

- 10 Screw conveyor systems are widely used for transporting bulk loads for example wood chips because they are highly efficient and low-cost systems with good throughput control. However, the performance of these systems is affected mainly due to these abnormal conditions such as V-belt slip, motor overcurrent, and screw conveyor throughput efficiency. The V-belt is a rubber belt arranged between an electric motor
- 15 and a gearbox. It is designed to absorb the shock from initial start-up torsional forces of the motor towards the gearbox. Since the rubber material deteriorate over the time the V-belt may slip while transporting the bulk load and the operation comes to a halt. The motor overcurrent/motor trip condition maybe caused due to the high-density or low-density type of the woodchip, which impacts the loading forces and affects the
- 20 motor current levels. In addition, the screw conveyors that operate under a woodchip silo are influenced by the level of the woodchip in the silo, which exerts different degree of gravity forces on the woodchip screws. The screw conveyor throughput efficiency condition maybe caused due to screws when exposed to abrasive and non-compressible the woodchip surfaces cause wear on the surfaces, and screw plight distortion or
- 25 bending in the longer term. When the screw plight is distorted, the throughput of the screw is reduced, leading to inefficiency in woodchip deliveries. Serious cases of distortion due to metal fatigue leads to screw body cracks, breakage, causing emergency production shutdowns. Therefore, there is need for early prediction of the abnormal conditions for planning the production shutdown in advance, and avoiding losses

caused due to the screw conveyor terminal failures.

Over the years, various methods for monitoring of the conveyor systems were developed. For instance, United States of America Granted Patent No. US11194318B2
5 discloses a system for monitoring a plurality of components of a conveyor in an industrial environment may include a data acquisition circuit to interpret a plurality of detection values, each detection values corresponding to at least one of a plurality of input sensors operationally coupled to the conveyor. A data processing circuit may utilize at least one of the detection values to perform a noise processing operation on at
10 least a portion of the detection values. A signal evaluation circuit may determine a conveyor performance parameter in response to the noise processed portion of the detection values and a response circuit may then perform at least one operation in response to the conveyor performance parameter. This system fails to predict the abnormal conditions such as the V-belt slip, motor overcurrent and the screw conveyor
15 throughput efficiency caused by the load carried on the conveyor system.

Accordingly, it would be desirable to provide a method for monitoring the performance of the conveyor system based on the abovementioned abnormal conditions. This invention provides a solution to the problem.

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SUMMARY OF INVENTION

The present invention provides a method for monitoring performance of a screw conveyor system comprising the steps of: acquiring, a plurality of stored historical data
25 from a database; transforming, via a data pre-processing module, the acquired historical data into machine learning model readable format; specifying a data range from the transformed historical data related to running profiles of the screw conveyor system captured by at least one sensor, via the data pre-processing module, wherein the data range includes the motor current, rotation per minute, digester load cell, load density

and load silo level; developing and training, via a machine learning training module, a set of training models for predicting abnormal conditions of the screw conveyor system based on the specified data range; inputting, via an input module, real-time data captured by the sensors into a trained model, wherein the real-time data includes load
 5 density, load silo level, and forward/backward direction of the load; computing, via the trained model, the abnormal conditions based on the real-time input data; and, displaying, via a display module, the performance result of the screw conveyor system based on the computed result. Characterised in that, the machine learning training module develops the set of training models to determine a V-belt slip condition, a motor
 10 overcurrent condition, and a conveyor throughput efficiency condition.

Preferably, the set of training models are variants developed from generic non-linear dynamic algorithm or nonlinear generalization of autoregressive exogenous algorithm.

15 Further, the machine learning training module develops the set of training models to determine speed switch faults condition, a digester chute block condition, and a conveyor plug up condition.

Preferably, the step of developing and training the training model by the machine
 20 learning training module includes: conducting tests on the trained model using running profiles of the screw conveyor system for validating the trained model.

Further, the method comprises the step of selecting by the machine learning training module, only appropriate validated models based on the real-time input data.

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Preferably, the step of developing the set of training models via the machine learning training module includes: reading the specified data range; converting the read data into a uniform scale; extracting features from converted data using one or more feature extraction technique; comparing the extracted features with one or more trained data

sets; and, classifying the historical data into different abnormal condition categories using one or more machine learning algorithms.

Further, the method comprises the step of determining by the selected trained model if
5 the number of abnormal conditions exceed one or more predetermined thresholds, and providing one or more indicators to indicate if the abnormal conditions exceed the predetermined thresholds.

Preferably, displaying, via the display module the indicators on a user interface based
10 on the determined number of the abnormal conditions.

One skilled in the art will readily appreciate that the invention is well adapted to carry out the objects and obtain the ends and advantages mentioned, as well as those inherent therein. The embodiments described herein are not intended as limitations on the scope
15 of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

For the purpose of facilitating an understanding of the invention, there is illustrated in
20 the accompanying drawing the preferred embodiments from an inspection of which when considered in connection with the following description, the invention, its construction and operation and many of its advantages would be readily understood and appreciated.

25 Fig. 1 is a block diagram illustrating a process flow for monitoring the performance of a conveyor system.

Fig. 2 is a block diagram illustrating a process flow for developing a set of training models.

Fig. 3 is a schematic diagram illustrating a general architecture of a system for monitoring the performance of the conveyor system.

5 DETAILED DESCRIPTION OF THE INVENTION

The invention will now be described in greater detail, by way of example, with reference to the drawings.

10 Fig. 1 illustrates an overview of a method for monitoring the performance of a conveyor system transporting a load towards a destination. The load can include but not limited to wood chips. Preferably, the conveyor system is a screw conveyor system. Preferably, the method employs a machine learning based training models for determining any abnormal conditions of the conveyor system.

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In a preferred embodiment of the invention, the method begins by Step 110 acquire a plurality of stored historical data from a database (310). Preferably, the database (310) is a relational database management system (RDBMS) for storing and processing input data and/or historical data in real time. The database (310) can be in the form of a cloud
20 server operated by one or more heavy duty computers and any known devices or group of devices to provide sufficient capacity for storing the input data and/or historical data. Then Step 120, transform the acquired historical data into a machine learning model readable format via a data pre-processing module (320); Then Steps 130 to 180, specify a data range from the transformed historical data related to running profiles of the
25 conveyor system captured by at least one sensor via the data pre-processing module (320). Preferably, the data range includes but is not limited to the motor current, rotation per minute, digester load cell, load density, load silo level and any combinations thereof.

Next Step 190, develop and train a set of training models for predicting abnormal

- conditions of the conveyor system based on the specified data range via a machine learning training module (330). Preferably, the machine learning training module (330) develops the set of training models (335) to determine V-belt slip condition, motor overcurrent condition, conveyor throughput efficiency condition, speed switch faults
- 5 condition, digester chute block condition, and conveyor plug up condition. Next Step 200, conduct tests on trained models using the running profiles of the conveyor system for validating the trained models, via the machine learning training module (330). The above process Steps 110 to 200 is preferably carried out in offline-mode.
- 10 Preferably, the set of training models (335) are variants developed from generic non-linear dynamic algorithm or nonlinear generalization of autoregressive exogenous algorithm.
- In Steps 210 to 250, select only appropriate validated models based on a real-time input data (220 to 250) via the machine learning training module (330). By way of example,
- 15 the real-time input data (220 to 250) is captured by a plurality of sensors arranged along the conveyor system. The captured data is then received via an input module (340), and provide the real-time input data into the selected trained model via the input module (340). Preferably, the real-time data includes but is not limited to load density (220), load silo level (230), forward/backward direction of the load (240), and load dispensing
- 20 to digester in transit (250). In Step 260, compute the abnormal conditions based on the real-time input data, via the selected trained model. Preferably, the selected trained model performs analysis for predicting the abnormal condition based on the real-time input data. Preferably, determine if the number of abnormal conditions exceed one or more predetermined thresholds, and provide one or more indicators to indicate if the
- 25 abnormal conditions exceed the predetermined thresholds. In Step 270, display the indicators on a user interface based on the determined number of the abnormal conditions via a display module (340). The above process Steps 210 to 270 are preferably carried out in real-time mode.

Fig. 2 illustrates a method for developing the training model (335) via the machine learning training module (330). In a preferred embodiment of the invention, the method begins by Step 191 read the specified data range. Then Step 192, convert the read data into a uniform scale. Then Step 193, extract features from the converted data using one or more feature extracting techniques. Next Step 194, compare the extracted features with one or more trained data sets. In Step 195, classify the data into different abnormal condition categories using one or more machine learning algorithms

Fig. 3 illustrates a system (300) for monitoring performance of the conveyor system. In another preferred embodiment, the system (300) comprises a database (310), a data pre-processing module (320), a machine learning training module (330), an input module (340) and a display module (350). Preferably, a server acquires a plurality of stored historical data from a database (310). Then a data pre-processing module (320) transforms the acquired historical data into a machine learning model readable format and specifies a data range from the transformed historical data related to running profiles of the conveyor system captured by at least one sensor. Preferably, the data range includes the motor current, rotation per minute, digester load cell, load density, load silo level and any combinations thereof. Then a machine learning training module (330) develops and trains a set of training models for predicting abnormal conditions of the conveyor system based on the specified data range. Preferably, the machine learning training module (330) develops the set of training models to determine V-belt slip condition, a motor overcurrent condition, a conveyor throughput efficiency condition, a speed switch faults condition, a digester chute block condition, and a conveyor plug up condition. Preferably, the machine learning training module (330) develops the set of training models includes the steps to read the specified data range. Then, convert the read data into a uniform scale. Then, extract features from converted data using one or more feature extraction technique. Next, compare the extracted features with one or more trained data sets and classify the data into different abnormal condition categories using one or more machine learning algorithms. Further, the

machine learning training module (330) conducts test on trained models using the running profiles of the conveyor system for validating the trained models. Furthermore, via the machine learning training module (330) selects only appropriate validated models based on a real-time input data. Then, an input module (340) receives real-time
5 input data captured from the plurality of sensors arranged along the conveyor system and provides the received real-time input data into the selected trained model. Preferably, the real-time data includes load density, load silo level, forward/backward direction of the load, load dispensing to digester in transit and any other combinations thereof. The selected trained model computes the abnormal conditions based on the
10 real-time input data, via. Preferably, the selected trained model performs analysis for predicting the abnormal condition based on the real-time input data. Preferably, determine if the number of abnormal conditions exceed one or more predetermined thresholds, and provide one or more indicators to indicate if the abnormal conditions exceed the predetermined thresholds. A display module (350), displays the indicators
15 on a user interface based on the determined number of the abnormal conditions. Preferably, the display module (350) can be a browser application or an alert application which is dedicated to a user device for displaying real time and/or forecasted conditions of the conveyor systems and providing alerts when the real time and/or forecasted conditions of the conveyor systems are in critical condition.

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The present disclosure includes as contained in the appended claims, as well as that of the foregoing description. Although this invention has been described in its preferred form with a degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in
25 the details of construction and the combination and arrangements of parts may be resorted to without departing from the scope of the invention.

CLAIMS

1. A method for monitoring performance of a screw conveyor system comprising the steps of:
 - 5 acquiring, a plurality of stored historical data from a database (310);
 - transforming, via a data pre-processing module (320), the acquired historical data into machine learning model readable format;
 - specifying a data range from the transformed historical data related to running profiles of the screw conveyor system captured by at least one sensor, via the data pre-
 10 processing module (320), wherein the data range includes the motor current, rotation per minute, digester load cell, load density and load silo level;
 - developing and training, via a machine learning training module (330), a set training models (335) for predicting abnormal conditions of the screw conveyor system based on the specified data range;
 - 15 inputting, via an input module (340), real-time data captured by the sensors into a trained model, wherein the real-time data includes load density, load silo level, and forward/backward direction of the load;
 - computing, via the trained model, the abnormal conditions based on the real-time input data; and,
 - 20 displaying, via a display module (350), the performance result of the screw conveyor system based on the computed result,

Characterised in that, the machine learning training module (330) develops the set of training models (335) to determine a V-belt slip condition, a motor overcurrent condition, and a conveyor throughput efficiency condition.
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2. The method according to claim 1, wherein the set of training models (335) are variants developed from generic non-linear dynamic algorithm or nonlinear generalization of autoregressive exogenous algorithm.

3. The method according to claim 1, further the machine learning training module (330) develops the set of training models (335) to determine speed switch faults condition, a digester chute block condition, and a conveyor plug up condition.
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4. The method according to claim 1, wherein the step of developing and training the training model (335) by the machine learning training module (330) includes: conducting tests on the trained model using running profiles of the screw conveyor system for validating the trained model.
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5. The method according to claim 4, further comprising the step of selecting by the machine learning training module (330), only appropriate validated models based on the real-time input data.
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6. The method according to any of the previous claims, wherein the step of developing the set of training models via the machine learning training module (330) includes:
- reading the specified data range;
 - converting the read data into a uniform scale;
 - extracting features from converted data using one or more feature extraction
- 20 technique;
- comparing the extracted features with one or more trained data sets; and,
 - classifying the historical data into different abnormal condition categories using one or more machine learning algorithms.
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7. The method according to any of the previous claims, further comprising the step of determining by the selected trained model if the number of abnormal conditions exceed one or more predetermined thresholds, and providing one or more indicators to indicate if the abnormal conditions exceed the predetermined thresholds.

8. The method according to any of the previous claims, displaying, via the display module (350) the indicators on a user interface based on the determined number of the abnormal conditions.