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(54) Title: TORQUE WRENCH EQUIPPED WITH OBSTACLE DETECTION DEVICE AND CORRECT GRIP

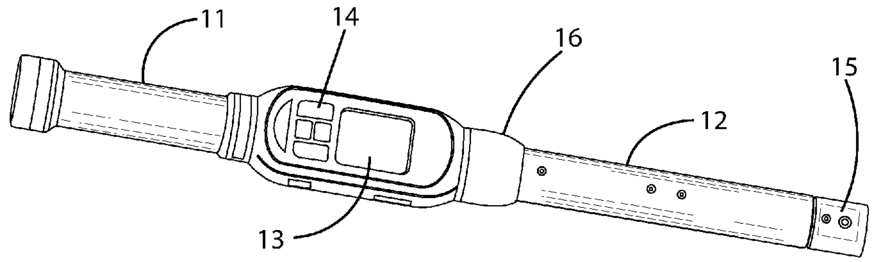

Fig. 1

(57) Abstract: Method of checking the tightness of a torque wrench, said wrench comprising a body, containing control circuits and an electronic processing unit, having at one end a handle (11) to be gripped by an operator who performs the tightening, and at the other end an arm (12), such an arm at its free end comprises a seat (15) in which a plurality of inserts, suitable for engaging the tool with a corresponding type and/or size of a mechanical member on which the tool is intended to act, are alternatively engaged to perform a tightening operation, on such an arm there being sensor means suitable for detecting the tightening conditions exerted on said mechanical member, said electronic processing unit which communicates with said sensor means and receives the data detected during the tightening. This method comprises a step of training an artificial intelligence model and a step of detecting the tightening conditions on the basis of such a trained model.

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Torque wrench equipped with obstacle detection device and correct grip.

The present invention relates to a torque wrench wherein it is possible to control the tightening torque exerted on the bolt to be tightened, and wherein there is a device suitable for detecting the presence of any obstacles that may be encountered when turning the wrench to perform a tightening operation. In addition, this wrench is also equipped with a device suitable for verifying the correct grip of the wrench by an operator during the aforesaid tightening operation.

Tightening tools, such as torque wrenches, are known in the state of the art which comprise a body, containing control circuits and an electronic processing unit having, at one end, a handle to be gripped by an operator, and an arm at the other end. Such an arm comprises at its free end a seat in which a plurality of inserts, suitable for engaging the tool with a corresponding type and/or size of a mechanical member on which the tool is intended to act, can be alternatively engaged to perform a tightening operation. Sensor means are provided on said arm suitable for detecting tightening conditions exerted on said mechanical member. From these sensor means, the signals are transferred to the central processing unit, which processes and simultaneously displays them, so that the tightening performed can be verified.

Patent EP2326464 describes a tool of this type in the form of a torque wrench, which comprises a body, containing the control circuits and processing unit of the wrench, at one end a handle (advantageously containing rechargeable batteries for powering the wrench) and on the other end an arm. Advantageously, a display for visualizing information and operating data is provided on the body and a wrenchboard allows data and commands to be entered. A tool head which must be coupled with the type of mechanical member (for example, the head of a screw, with male or female coupling) on which the wrench is intended to operate is inserted interchangeably in a special seat at the end of the arm.

The sensors which measure the torque to be exerted on the member to be tightened are placed on the arm and comprise at least one strain gauge, which is a sensor whose electrical resistance varies with the deformation it undergoes; so it converts the force, pressure, voltage, weight, etc., into a variation in electrical resistance that can be measured.

The value of the torque exerted is normally available on the wrench display or is indicated near it by means of special light and/or acoustic signals.

Patent Application EP4003656 describes a tool of this type comprising a body having an axial extension along a longitudinal axis, a front end equipped with a coupling intended to engage the wrench on a joint to be tightened by manual rotation about an axis of rotation that is transverse to the longitudinal axis, a handle along the body for manoeuvring the wrench. The wrench is equipped with a sensor to detect a torque applied to the coupling having two strain gauges spaced apart from each other along the longitudinal axis. An electronic control circuit receives signals from the sensors and, depending on the deflection values detected by the two sensor elements, possibly issues an error signal. In particular, if the deflection value detected by the sensor element closest to the front end is lower than the deflection value detected by the sensor element furthest from the front end, it emits this error signal. This is because, during normal tightening, the torque value detected by the sensor closest to the tool head of the wrench should normally be higher than that detected by the sensor closest to the handle. If this is not the case, an anomaly is signalled.

Patent Application EP4003655 describes the same type of wrench as Application EP4003656, wherein data processing from the two strain gauges is used to check whether the wrench has been correctly gripped. Specifically, the wrench processing unit calculates, based on deflection values measured by the two strain gauges, the point P along the longitudinal axis related to the application of the manual rotational force of the wrench and compares the position of the point P with predefined positions. If this point does not correspond with at least one of these positions, an error signal is issued.

The Applicant noted that the method of detecting the obstacle proposed by this Application EP4003655 only reveals the anomaly if the obstacle is located between the position of the sensors and the handle. In fact, under such conditions there is an inversion of the values measured by the strain gauges, whereas if the impact against the obstacle occurs in a portion of the wrench between the sensors and the tool head, this inversion of the detection values does not occur. In addition, by contrast, an increase in the tightening torque value is detected. Thus, in such a condition, an anomaly is not detected, the wrench validates the measurement, and this measurement is not correct, indicating a higher-value tightening torque than the one actually exerted.

Among other things, the impact with an obstacle placed close to the tool head is a frequent occurrence, for example when the bolt to be tightened is recessed in a housing and parts of that housing can impact against the wrench, or when the bolt to be tightened is surrounded by other bolts, such as in a flange.

One aspect of the present invention relates to a torque wrench having the characteristics of the enclosed claim 1.

Further objects and advantages of the present invention will become clear from the following description and from the attached drawings, provided purely by way of non-limiting example, in which:

- Figure 1 is a perspective view of the tightening tool according to the present invention;
- Figure 2 is a front view of the tool of Figure 1;
- Figure 3 is a top view of the wrench of Figure 1 with the

position of the strain gauges highlighted and the direction of rotation of a tightening indicated;

- Figure 4 is a view of the wrench of Figure 3, wherein two obstacles in a position of possible collision with the wrench are highlighted;
- Figure 5 is a flow algorithm of an embodiment of the present invention of the detection method of the tightening conditions;
- Figure 6 is a flow algorithm of a further embodiment of the present invention of the detection method of the tightening conditions.

With reference to the aforementioned figures, the tightening torque wrench according to the present invention comprises a body containing electronic control circuits and a central processing unit having at one end of that body, along a longitudinal axis X of the tool, a handle 11 (preferably containing rechargeable batteries for powering the tool) and on the other end an arm 12, still on the same axis. Advantageously, a display 13 for visualizing information and operating data is advantageously provided and a wrenchboard 14 allows to enter data and commands.

Obviously, it is understood that if the processing or storage of data requires a unit which cannot be easily or completely contained in the body, the body can be connected, by means of a cable or a wireless connection, to external processing units. A wired connection can also be envisaged to provide external power supply.

At the end of the arm 12, a plurality of inserts can be alternatively engaged in a suitable seat 15. For example, each insert will be suitable for engaging the wrench with a corresponding type and/or size of mechanical member or element (screw, nut, etc.) on which the tool is intended to operate.

Although for simplicity's sake inserts having all a similar dimension are shown, elongated inserts or inserts with arms of particular shape can also be provided, as known in the art.

Each insert may comprise therein a transponder in a suitable position (typically in the shank engaging the seat) to couple with a suitable antenna close to the seat when it is mounted on the tool.

The coupling modes between transponder and antenna for the activation of the transponder (usually known as "tag") and the communication are widely known and will therefore not be herein described in detail.

The wrench comprises sensor means 2 of the tightening conditions and an electronic processing unit that communicates with these sensor means and receives the data detected during the tightening.

For example, such sensor means comprise torque sensors exerted on the mechanical member, comprising a first 21 and a second strain gauge 22, arranged spaced apart from each other at predefined positions of the arm along the longitudinal axis of the arm 12.

Such sensor means further comprise angle sensors, e.g. whose detection values originate from gyroscopes, both in the longitudinal axis X of the wrench and in the rotation axis Y.

In general, there can be sensor means of any kinematic or dynamic magnitude of the tightening conditions.

According to the present invention, the wrench electronic processing unit acquires the detection values made by these sensor means and implements a method of checking the tightness comprising a step of training an artificial intelligence model and a step of detecting the tightening conditions on the basis of this trained model.

This training step involves performing a plurality of tightenings, wherein:

- at least one wherein the impact against a first obstacle P1 occurs in a first zone Z1 between the tool head and the sensor means, preferably the first strain gauge 21,
- at least one wherein the impact against a second obstacle P2 occurs in a second zone Z2 between the sensor means, preferably the second strain gauge 22, and the handle 11 of the

wrench,

- at least one in which there is no impact against obstacles and the tightening is carried out correctly.

The number of tightenings with impact and without impact must be a sufficient number such as to stabilise the model parameters.

Once the artificial intelligence model has been trained, each time an actual tightening is carried out, data is acquired from these sensor means and it is determined whether there has been an impact against an obstacle and if so, the anomaly is reported and the tightening is not validated.

The learning step of the model is for determining weights that determine the importance of the acquired data. Those with a higher value contribute more significantly to determining the output of the model.

A possible operating sequence of the method according to the present invention is shown in the flow algorithm in Figure 5.

At the start of the tightening operations, the acquisition is actuated, preferably from all sensors comprised in the sensor means (i.e. torque, angle, strain gauges, and gyroscopes).

This acquired data is stored and provided as input to the inferential model, which, by means of the weights calculated in the model training step, determines whether an impact against an obstacle has been detected. In addition, it is detected if the magnitude of the anomaly is such as to invalidate the measurement of the tightening condition.

The proposed method does not depend on the impact zone and covers all possible impact cases (ZONE Z1 and ZONE Z2). Once an impact against an obstacle has been identified, the algorithm alerts the operator.

The algorithm is able to distinguish whether the obstacle is hit in a dangerous zone, resulting in an overestimation of the applied torque (ZONE Z1), or not.

This method may be applied not only to check whether the impact against an obstacle has occurred, but in general it can be applied to check the tightening conditions.

For example, it is possible to check whether the operator was gripping the wrench correctly during tightening.

In fact, an operator, due to distraction or lack of training, could carry out the tightening improperly and a wrong grip of the wrench could result in an wrong measurement of the torque applied to the joint.

Also in this case, the training step of the method involves performing at least one tightening with an incorrect grip and at least one with a correct grip.

The number of tightenings with correct and incorrect grip must be an appropriate number such to stabilise the model parameters.

A possible operating sequence of the method for checking the correct grip according to the present invention is shown in the flow algorithm in Figure 5.

Also in this case, a neural model analyses the signal from the wrench on-board sensors and assesses whether or not a wrong handling event has occurred.

Once the wrong handling event has been identified, the algorithm alerts the operator. The algorithm is able to distinguish whether the wrong handling results in an overestimation of the applied torque or not.

CLAIMS

1. Method of checking the tightness of a torque wrench, said wrench comprising

- • a body, containing control circuits and an electronic processing unit, having at one end a handle (11) for gripping an operator who performs the tightening, and at the other end an arm (12),
- • said arm at its free end comprises a seat (15) in which a plurality of inserts suitable for engaging the wrench with a corresponding type and / or size of a mechanical member on which the wrench is intended to act can be alternatively engaged perform a tightening operation,
- • on this arm there are sensor means suitable for detecting the tightening conditions exerted on this mechanical member,
- • said electronic processing unit which communicates with said sensor means and receives the data detected during tightening,

characterized in that this method comprises a training phase of an artificial intelligence model and a phase for detecting the tightening conditions on the basis of this trained model.

2. Method according to claim 1, wherein the detection of the tightening conditions comprises the detection of a possible impact against an obstacle during the tightening.

3. Method according to claim 2, in which said training step provides for carrying out a plurality of tightenings, of which

- • at least one in which the impact against a first obstacle (P1) occurs in a first area (Z1) between the tool head and the sensor means,
- • at least one in which there is an impact against a second obstacle (P2) in a second area (Z2) between the sensor means and the handle (11) of the wrench,
- • at least one in which there is no impact against obstacles and

the tightening is carried out correctly.

4. Method according to claim 1, wherein detecting the tightening conditions comprises detecting the correct grip of the wrench by an operator during tightening.

5. Method according to claim 4, in which said training step provides for carrying out at least one tightening with an incorrect handle and at least one with a correct handle.

6. Method according to claim 2, in which the phase of detecting the tightening conditions provides for the signaling of an anomaly if a collision with an obstacle is detected.

7. Method according to claim 4, in which the step of detecting the tightening conditions provides for the signaling of an anomaly if an incorrect grip of the wrench is verified.

8. Method according to claim 1, wherein the sensor means comprise a first (21) and a second strain gauge (22) arranged spaced apart from each other in predefined positions of the arm along the longitudinal axis of the arm (12), angle sensors, such as gyroscopes, both on the longitudinal axis (X) of the wrench and on the rotation axis (Y) of the tool head.

9. Torque wrench comprising

- • a body, containing control circuits and an electronic processing unit, having at one end a handle (11) for gripping an operator who performs the tightening, and at the other end an arm (12),
- • said arm at its free end comprises a seat (15) in which a plurality of inserts suitable for engaging the wrench with a corresponding type and / or size of a mechanical member on which the wrench is intended to act can be alternatively engaged perform a tightening operation,
- • on this arm there are sensor means suitable for detecting the tightening conditions exerted on this mechanical member,

characterized in that said sensor means communicate with said electronic processing unit which is configured to carry out the method according to any one of claims 1 to 8.

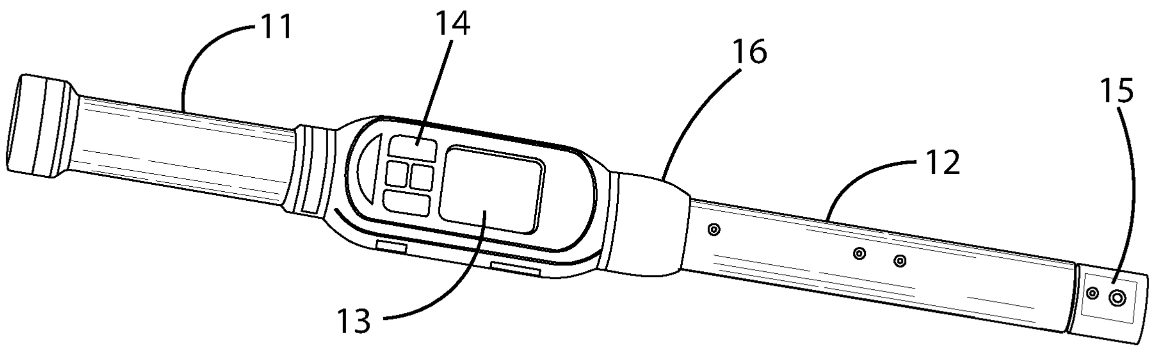


Fig. 1

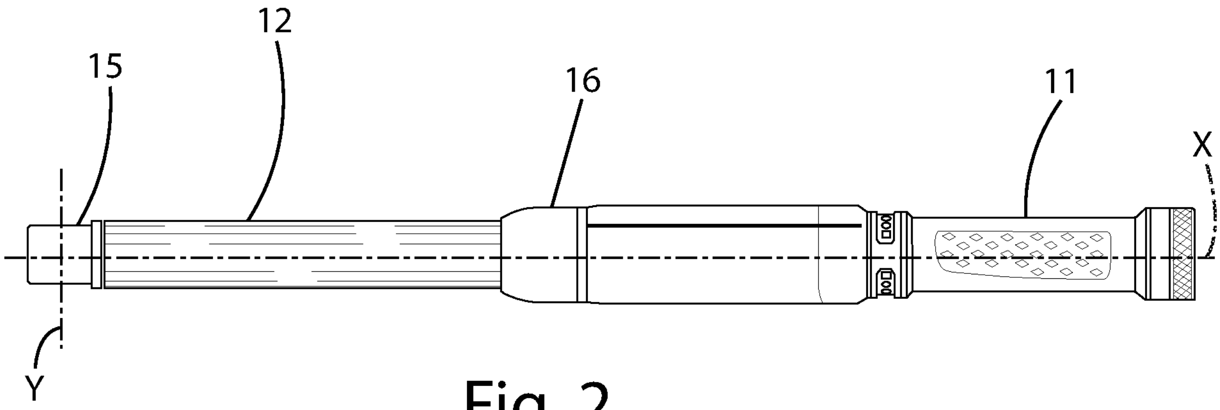


Fig. 2

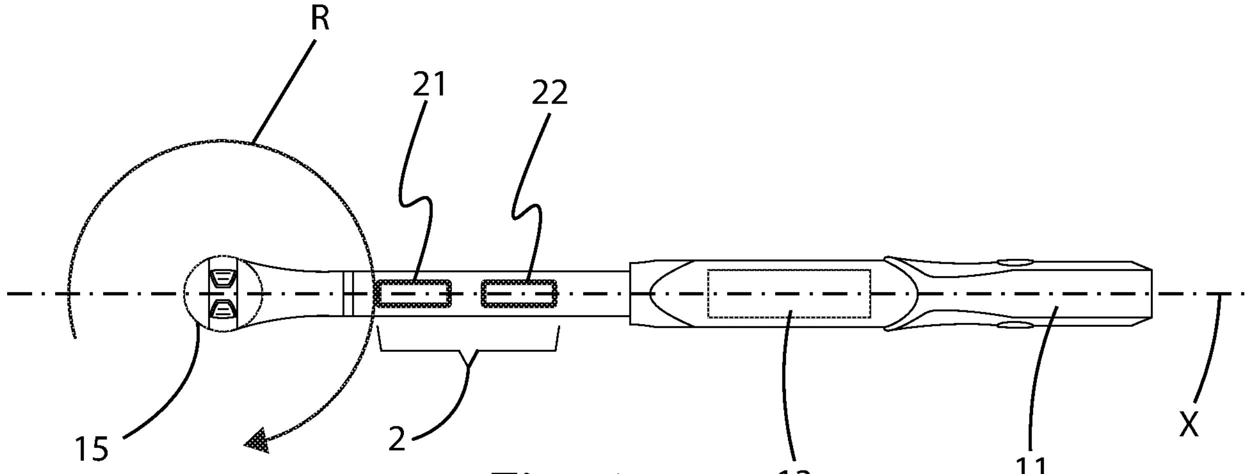


Fig. 3

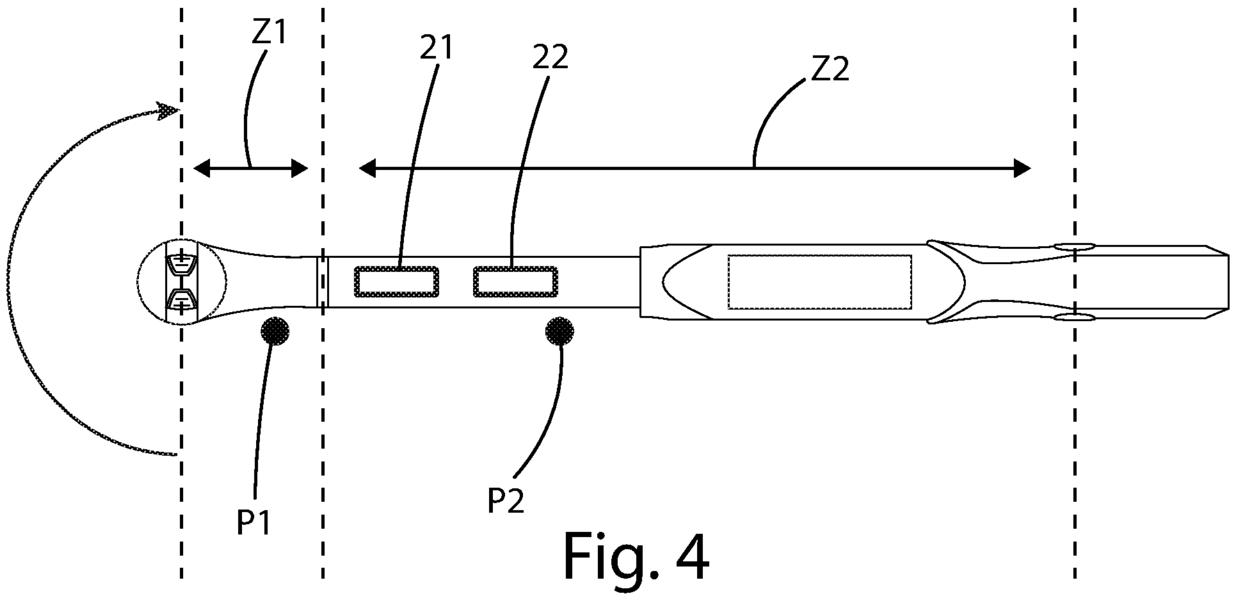
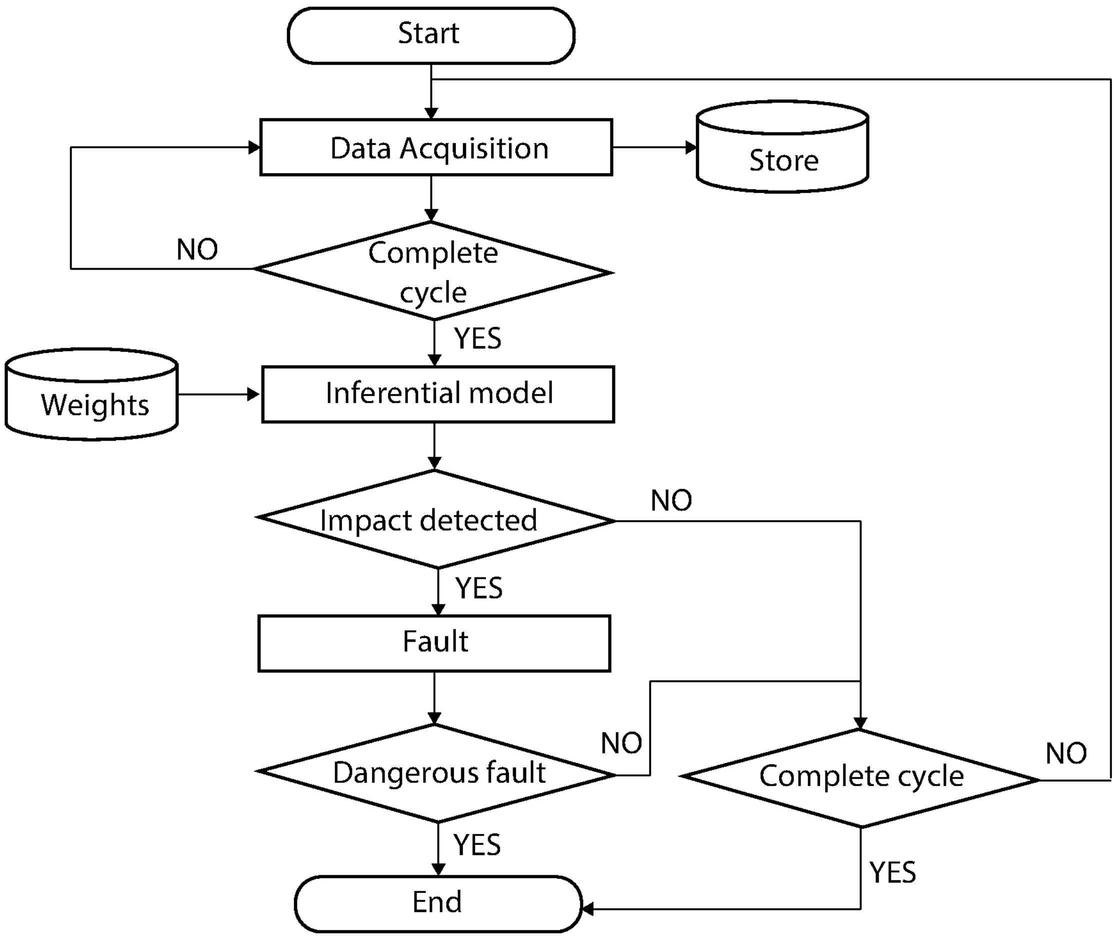

Z1
21
22
Z2
P1
P2

Fig. 4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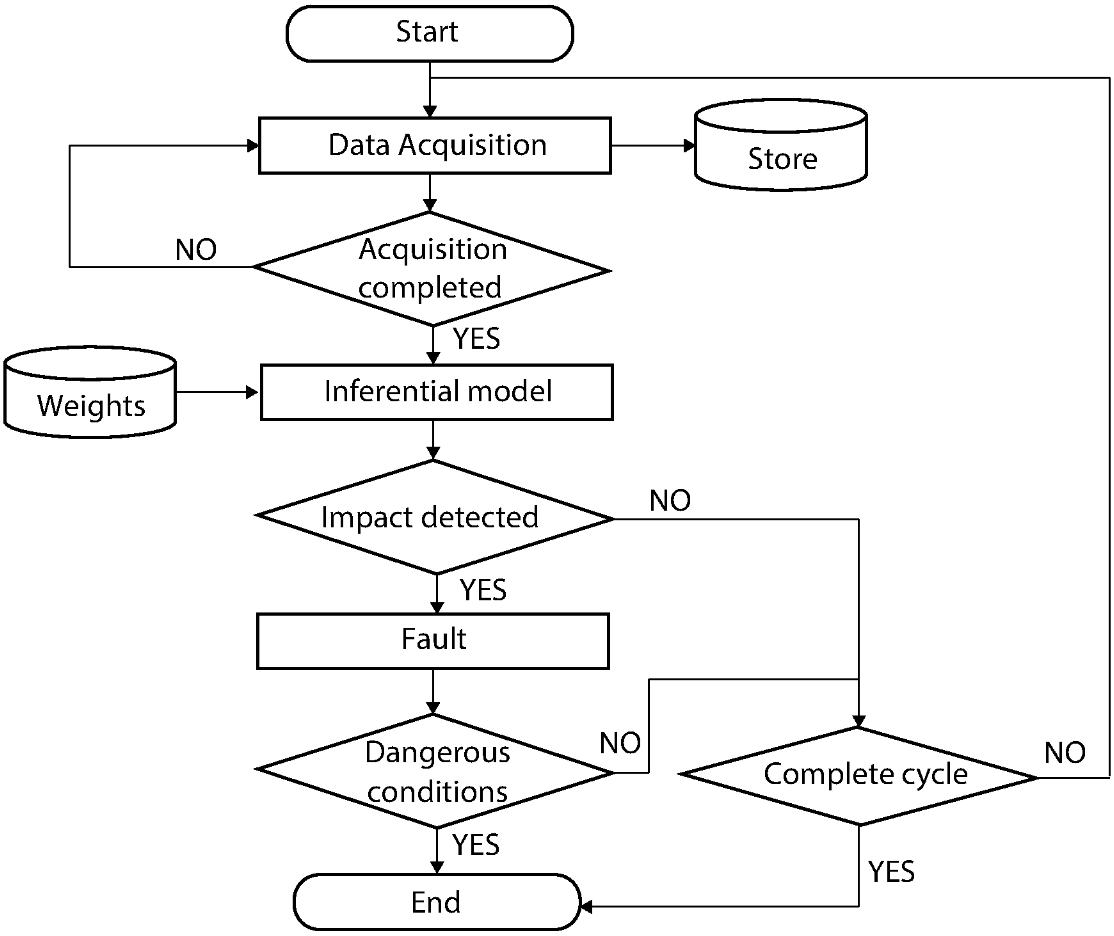
Data Acquisition
Store
Complete cycle
NO
YES
Weights
Inferential model
Impact detected
NO
YES
Fault
Dangerous fault
NO
YES
Complete cycle
NO
YES
End

Fig. 5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Store
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Acquisition completed
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Weights
Inferential model
Impact detected
NO
YES
Fault
NO
Dangerous conditions
Complete cycle
NO
YES
YES
End

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2023/060417

A. CLASSIFICATION OF SUBJECT MATTER
INV. B25B23/142 B25B23/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B25B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2021/019392 A1 (SCS CONCEPT S R L [IT]) 4 February 2021 (2021-02-04) figures 1, 4 page 3, paragraph 8 - page 4, paragraph 1 page 6, paragraph 5 page 8 -----	1-9
Y	EP 2 326 464 A1 (ATLAS COPCO BLM SRL [IT]) 1 June 2011 (2011-06-01) cited in the application	1,9
A	paragraph [0011] - paragraph [0031]; figures 1,2 paragraph [0023] -----	2-8
Y	US 2009/308178 A1 (KUSHIDA TOSHIHIKO [JP] ET AL) 17 December 2009 (2009-12-17) paragraph [0030] - paragraph [0031]; figure 1 -----	1,9

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
13 December 2023	26/01/2024

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2023/060417

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