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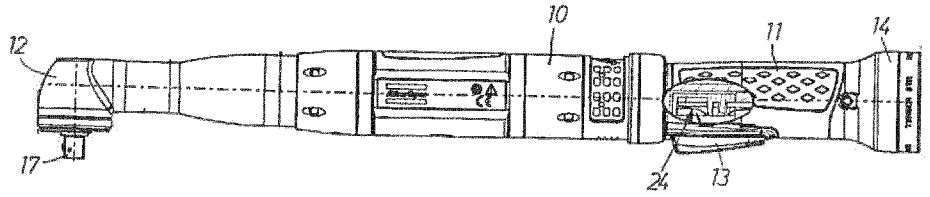
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(54) Title: METHOD FOR DIAGNOSING POWER TOOL CONDITION.

FIG 1



(57) Abstract: A method and a device for diagnosing the condition of a power tool and predicting forthcoming power tool malfunctions, wherein the method comprises the following features: pre-establishing reference characteristics by detecting vibratory movements in the power tool housing (10) of a correctly functioning power tool, detecting and recording vibratory movements in the power tool housing (10) during operation, and determining occurring discrepancies between vibratory movements detected in the tool housing (10) during operation and said reference characteristics to indicate the present power tool condition and enable prediction of forthcoming malfunction of the power tool.

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Method for diagnosing power tool condition.

The invention relates to a method and a device for detecting and diagnosing the condition of a power tool. In particular the invention concerns a method for avoiding future production problems by obtaining premature indications on forthcoming malfunctions of a power tool. Malfunctions that may occur are usually related to mechanical wear and failure of certain parts of the tool, for instance deformed teeth of reduction or angle type gearings, worn down bearings etc. These types of malfunctions may occur on different types of tools but would have the most decisive influence on the operation of power wrenches, especially when used at assembly lines where an unforeseen need for replacement of a malfunctioning tool would cause costly production disturbances.

In prior art there are described a number of different methods for this purpose all having been proved less reliable and/or too complicated to be practically useful. One such method comprises studying of the characteristics of the delivered output torque looking for abnormal fluctuations in view of time or angle of rotation. At power wrenches this is carried out by analyzing signals from a torque sensing device incorporated in the wrench, usually in combination with an angle encoder on the output shaft.

In case of electrically powered power tools there are previously described methods for discovering and predicting malfunctions by analyzing the characteristics of the supplied electric power per se or in view of the indicated output torque of the tool. Discrepancies found in such analyzes would indicate possible forthcoming malfunctions. A drawback of this known method is its limitation to electric tools only.

Still another method for predicting future malfunctions of a power tool is based on counting the actual number of working cycles performed by the tool and establishing whether the actual number of operation cycles would create a statistic risk of

failure or breakdown in view of a normal maximum operation cycles to be expected by the actual type of tool.

The methods described in prior art are less reliable, complicated or do not give a complete picture of what the reason may be for the indicated irregularities in the power tool function.

It is an object of the invention is to solve the problems inherent in prior art method by providing a power tool function analyzing method which is universally applicable on different types of power tools and which is able to give a complete picture of what causes occurring irregularity indications.

So, an object of the invention is to provide a reliable method and a device for predicting forthcoming malfunctions of a power tool which is universally applicable on power tools of different kinds and which does not require any redesign of the power tool parts.

It is a further object of the invention to provide a method and a power tool by which forthcoming malfunction problems may be predicted by studying and analyzing different types of occurring vibrations to which the power tool housing may be subjected during tool operations.

Further objects and advantages of the invention will appear from the following specification and claims.

A preferred embodiment of the invention is described below in detail with reference to the accompanying drawing.

In the drawing
Fig. 1 shows, partly in section, a side view of a power tool according to the invention.
Fig. 2 shows on a larger scale a handle section of the power tool in Fig. 1 illustrating a vibration detecting device.
Fig. 3 shows schematically three power tools communicating both with separate operation control units each connected to a common signal analyzing and fault detecting unit.

Fig. 4 shows a torque/speed-to-angle diagram of a typical two-step screw joint tightening process.
Fig. 5 shows a torque/acceleration-to-angle diagram illustrating vibratory movements indicated in the tool housing of normally operating power wrench during a two-step tightening process.
Fig. 6 shows a diagram similar to Fig. 5 but illustrating increased vibration amplitudes indicating some mechanical wear or damage.

The power tool illustrated in Fig. 1 is an electric angle type power wrench which comprises a housing 10 with a handle 11 at its rear end and an angle drive head 12 at its forward end. On the handle 11 there is supported a power control trigger 13 and a connection socket 14 for a combined power and signal communicating cable 15. In the angle drive head 12 there is supported an angle gearing and a square ended output shaft 17 for connection to a nut socket. Within the housing 10 there is supported a non-illustrated motor and a reduction gearing which are connected to the output shaft 14 via the angle gearing. The motor, and the reduction and angle gearings are of a conventional types and, therefore, a detailed description thereof are left out of this specification.

In the handle 11, which is connected to and forms a rigid unit together with the housing 10, there is mounted a combined gyro and accelerometer unit 24 which is arranged to detect vibratory movements of the housing 10 in three different planes. This gyro and accelerometer unit 24 comprises a programmable chip and a number of electric components affixed to a printed circuit board 25 mounted on a bracket 26 in the handle 11. A flat type of wiring 27 is connected to the circuit board 25 and communicates signals from the unit 24 to a signal receiving and analyzing unit which could be located inside the power tool housing itself or in a separate unit 22.

The gyro and accelerometer unit 24, which in itself is of a commercially available type, may detect vibratory movements in

three different planes forming right angles relative to each other. Since different types of faults related to gearings or bearings of the power tool will cause tool housing vibrations in different directions it will be possible to detect different kinds of forthcoming malfunctions of the tool.

The reference data stored for analyzing purposes should correspond to vibratory movements in different directions reflecting different types of faults that may occur in the power wrench and detected by the gyro and accelerometer unit 24.

So, signals responding to detected vibrations induced in the housing 10 during operation of the power wrench are received by a signal receiving and analyzing unit and compared to reference data relating to vibratory housing movements of a normally functioning power wench. So, by comparing these reference data with vibratory movements detected in the power wrench housing during operation it is possible to discover occurring discrepancies between the reference data and the signals emitted during operation and thereby obtain an indication on possible forthcoming malfunctions of the tool.

A signal receiving and analyzing unit may be located at different places, for instance in an operation control unit 22 a-c separated from the power tool wherein emitted vibration related signals are communicated via the combined power and signal cable to the operation control unit. The analyzing process may be performed in the operation control unit or communicated further to a common central unit 30. In Fig. 3 there are illustrated three identical power wrenches a, b and c each connected to a separate operation control unit 22 a-c via cables 15 a-c, wherein the units 22 a-c are connected to a common central signal analyzing and fault detecting unit 30. Identification as well as reference data valid for each one of the power wrenches are stored in this central unit 30 and alert signals will be emitted as vibration related signals received

from either one of the power wrenches differ from the stored reference data.

A typical two-step screw joint tightening process is illustrated by a torque/speed to rotation angle diagram in Fig. 4, wherein the torque output in relation to rotation angle R from the power wrench is illustrated by curve T and the rotation speed by curve V. The two-step tightening process comprises an initial high speed running down phase A wherein the resistance from the screw joint is low and a low speed pre-tensioning phase B during an increased torque and screw joint pre-tensioning level.

In Fig. 5 there is illustrated a torque/acceleration to angle diagram illustrating vibratory movements indicated in the tool housing of normally operating power wrench during a two-step tightening process as illustrated in Fig. 4. Also in this diagram the torque output from the power wrench is illustrated by curve T, whereas the detected acceleration Y is illustrated by curve Y1. The curve Y1 is responsive to the signal emitted by the gyro and accelerometer unit 24 during operation of a normally functioning power wrench, i.e. a power wrench where no noticeable mechanical wear or damage has been detected. It is to be noted, though, that the ripple frequency of the emitted signal is constant during the high speed running down phase A but is lower during the slower pre-tensioning phase B. The frequency corresponds to the rotation speed of the power wrench.

The diagram shown in Fig. 6 is similar to that of Fig. 5 but the amplitude of the signal ripple of the acceleration curve Y2 is bigger in comparison with the curve Y1 of Fig. 5 which is a reference curve representative of a normally functioning power wrench. This change in amplitude or character of the signal ripple indicates that some mechanical wear or other changes to the power transmission of the power wrench has occurred and that a forthcoming malfunction of the power wrench is to be expected. This indication makes it possible to predict forthcoming tool problems and to plan for a premature replacement of the power

wrench thereby avoiding a later production disturbance due to tool failure.

It is to be understood, however, that the invention is not limited to the above described example but may be freely varied within the scope of the claims. For instance, the invention may very well be applied on battery powered tools where communication with remote operation control and supervising units are performed via wireless transmission.

Claims.

1. A method for diagnosing the condition of a power tool comprises the following features,

- pre-establishing reference characteristics of vibratory movements in the power tool housing of a correctly functioning power tool,
- detecting and recording vibratory movements in the power tool housing during operation, and
- determining occurring discrepancies between vibratory movements detected in the tool housing during operation and said reference characteristics to indicate the present power tool condition and enable prediction of forthcoming malfunction of the power tool.

2. Method according to claim 1, wherein said pre-established reference characteristics are related to different possible malfunction sources of the tool, and comparing occurring vibratory movements indicated in the tool housing during tool operation with said pre-established reference characteristics to establish what specific malfunction to be expected.

3. Method according to claim 1 or 2, wherein vibratory movements of the power tool housing are detected in at least two different planes.

4. Method according to claim 3, wherein said at least two different planes comprise three planes located at right angles relative each other.

5. Power tool intended for performing the method according to claims 1 -4, comprising a housing (10), a motor, an output shaft (17) and a gearing connecting the motor the output shaft (17), said housing (10) carrying a vibration detecting

device (24) arranged to emit signals in relation to vibratory movements of the housing (10) in at least two different planes.

6. Power tool according to claim 5, wherein said vibration detecting device (24) is connected to a signal receiving and analyzing unit (22 a-c, 30) having stored reference data on vibratory movements of the housing (10) at a correctly functioning power tool, wherein said signal receiving and analyzing unit (22 a-c, 30) comprises means for establishing occurring discrepancies between said stored reference data and vibratory related signals received during tool operation.

7. Power tool according to claim 5 or 6, wherein said vibration detecting device (24) comprises a combined gyro and accelerometer unit.

FIG 1

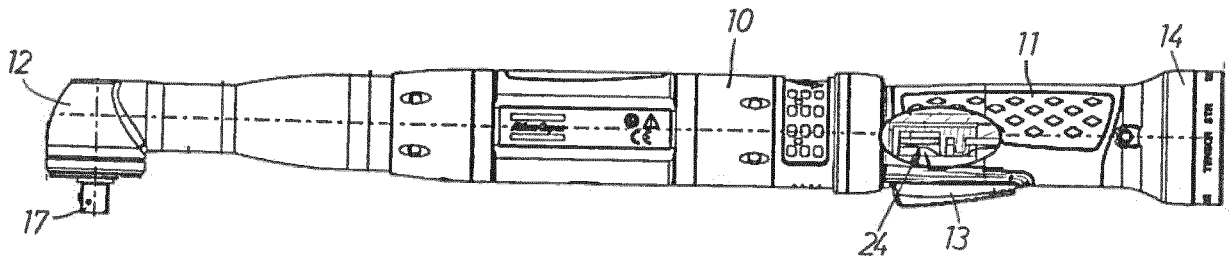


FIG 2

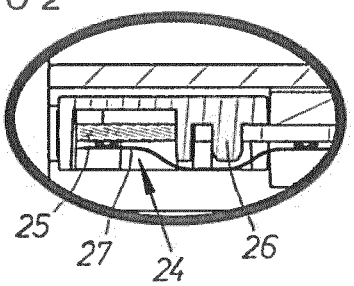


FIG 4

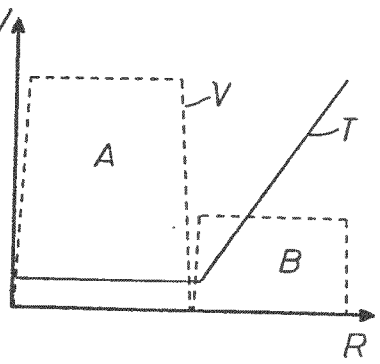


FIG 5

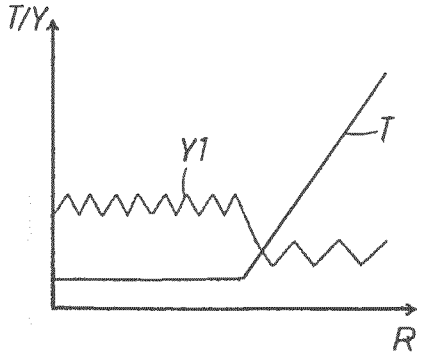


FIG 6

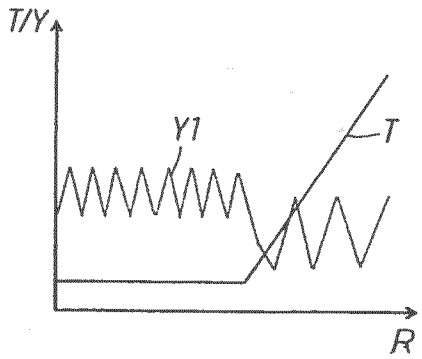
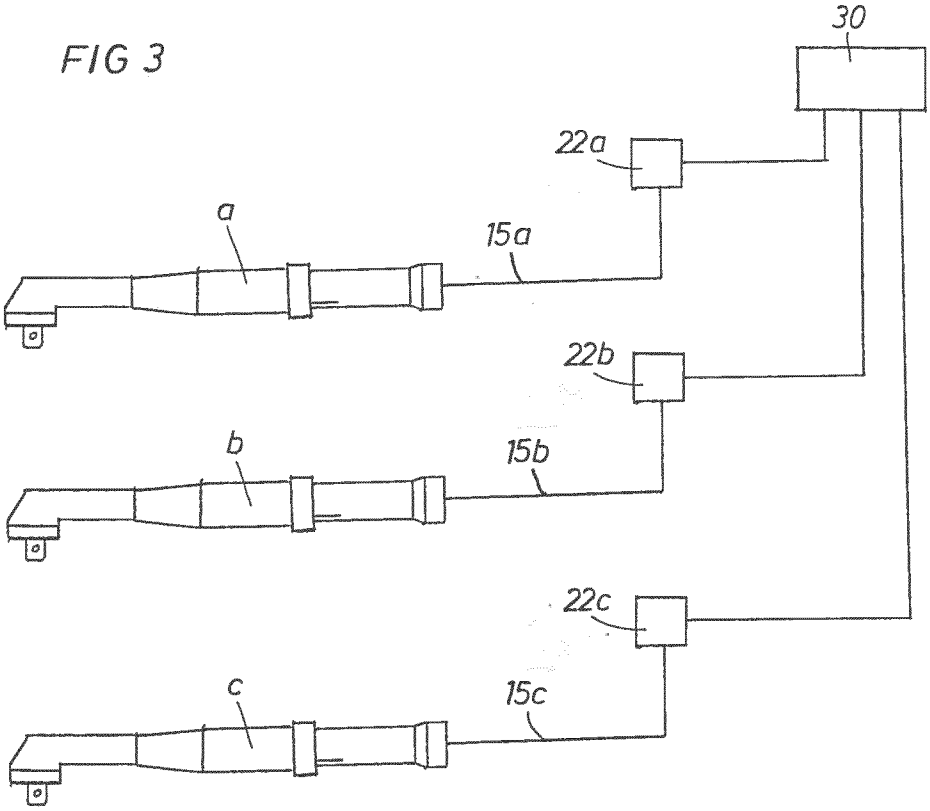


FIG 3



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/063007

A. CLASSIFICATION OF SUBJECT MATTER
INV. B25B21/00
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 B25F

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

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
8 September 2017	19/09/2017

Name and mailing address of the ISA/	Authorized officer
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Information on patent family members

International application No
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