

METHOD AND DEVICE FOR CONTINUOUSLY INFORMING THE
OPERATOR OF A TUNNELLING MACHINE ON PHYSICAL FEATURES OF A
GROUND TO BE TUNNELLED

The invention concerns a method and a device to continuously inform the driver of a tunnelling machine equipped with a rotary cutting head fitted with a multiplicity of drilling mountings for rotary drilling cutters on the nature of the ground in front of the cutters.

The invention applies in particular to the detection of hard stones in loose ground as it is excavated by means of the tunnelling machine.

We are familiar in the case of vertical boreholes with measurement of the drilling parameters, as described for example in publication FR 2 642 791, by means of sensors installed between the drilling head and the column of drilling rods.

Publication WO 03/087537 describes a device that includes a wear detector, a revolution counter and a load detector placed on the cutting-wheel mounting.

We are aware of other publications (EP 1 098 066, US 5 330 292, EP 1 253 287, JP 11 270283, and JP 09 228 778) which place data acquisition sensors on the shaft of the cutter or on the shaft of the cutting head or on the cutting head.

These devices are liable to supply parasitic results due to the fact that they take account of the deformations of the shaft or of the mounting of the cutter, or of the cutting head or of the shaft of the cutting head.

Embodiments of the present invention seek to eliminate the influence of these parasitic factors.

In accordance with a first aspect of the present invention, there is provided a process for providing continuous information on ground conditions at the excavation face for the operator of tunnel boring machine equipped with a rotary cutting head

incorporating a multiplicity of individual mountings for rotary boring cutters, in which data acquisition sensors capable of generating signals concerning cutter operation are implemented, these signals being remotely transmitted and used to inform the tunnel boring machine operator, characterized in that one or more sensors selected from sensors suitable for generating signals representing cutter penetration force into the ground, cutter position, cutter rotational state and cutter temperature are directly placed on each cutter.

In accordance with a second aspect of the present invention, there is provided a boring cutter and its mounting for installing the rotary cutter on the rotary cutting head of a tunnel boring machine, characterized in that the cutter includes one or more sensors selected from sensors capable of generating signals representing cutter penetration force into the ground, cutter rotational state, cutter position and temperature, and in that the cutter and its mounting comprise means cooperating to transmit remotely the signals from the cutter sensors.

In accordance with a third aspect of the present invention, there is provided a tunnel boring machine fitted with a rotary cutting head, which carries the mountings for the rotary boring cutters, characterized in that the cutters and their mountings are as defined in the second aspect and in that the tunnel boring machine includes means of transmitting signals from the sensors to a central processing and display unit placed in the tunnel boring machine operating cab.

According to embodiments of the invention, one or more sensors chosen from among sensors designed to supply signals that are representative of the penetration force of the cutter into the ground, of the rotation status of the cutter, of the position of the cutter in the ground and of the temperature of the cutter, are placed directly on each cutter concerned.

The cutter is preferably equipped with all of the aforementioned sensors.

The mountings of the cutters concerned are fitted with transceivers for the signals supplied by the acquisition sensors.

These signals are transmitted remotely, and are used to inform the driver of the tunnelling machine.

It is preferable that each equipped cutter should be supplied with the necessary power to operate the sensors of the cutter by a battery incorporated into the cutter or by wireless transmission from the mounting of the cutter. It is also preferable that the mounting of each cutter should be equipped with a receiver designed to receive, by wireless transmission, the signals from the acquisition sensors on the cutter, and to transmit these to a communication network mounted on the drilling head, and that the said network be connected to a processing and display unit in the driver's cab of the tunnelling machine.

It is furthermore preferable that each cutter concerned should be equipped with stress gauges that are glued to the axle of the cutter and the signals from these gauges be used to obtain information on the loads imposed on the cutter.

It is also preferable that each cutter concerned be equipped with an inclinometer designed to send signals that are representative of the position of the cutter.

Again, it is preferable that each cutter concerned be equipped with a magneto-inductive rotation sensor.

Embodiments of the invention also relate to a drilling cutter and its mounting for mounting the rotary cutter on the rotary cutting head of a tunnelling machine, characterised in that the cutter includes one or more data acquisition sensors chosen from among sensors designed to supply signals that are representative of the penetration force of the cutter into the ground, the rotation status, the rotation speed and the temperature of the cutter, where the cutter and its mounting are fitted with means that work together to send signals that are representative of the position of the cutter.

The cutter is preferably equipped with all the aforementioned sensors.

The electrical power feed necessary to operate the sensors can be independent and incorporated into the cutter or
5 its mounting, or can come from an electrical source located remotely.

The sensors of the cutter are preferably fixed on a base, such as a disk for example, which is attached laterally on the cutter or in the hub of the cutter, and this base, and the
10 mounting, include means that work together to receive and transmit the signals of these sensors.

The figures of the attached drawing are diagrams respectively illustrating a front view of an installation of cutters on the drilling head of the tunnelling machine (figure
15 1), a section view in a plane perpendicular to that of figure 1, of the head with electrical transmission from the sensors to a processing and display unit (figure 2), and an axial section view of a cutter (figure 3).

In figure 1, each cutter has been illustrated
20 schematically by a circle (M) and its individual mounting by a rectangle (R). The cutter is mounted loose on an axis formed by the mounting, and the mountings are distributed on arms (B) attached to the head (T) of the tunnelling machine.

These arrangements are well known to the professional
25 engineer. According to the invention, each cutter is equipped with a multiplicity of sensors, and in particular:

- a position sensor
- a pressure sensor
- a rotation status sensor
- 30 - a speed sensor
- a temperature sensor

The professional engineer chooses these sensors from the known sensors designed to perform these functions.

For the position sensor, the preferred choice is an
35 inclinometer.

For the pressure sensor, the preferred choice is a set of stress gauges.

The position, speed and temperature sensors are advantageously mounted on a base which is attached firmly to the cutter, such as a disk attached to one side of the cutter for example. This base can be equipped with acquisition and
5 processing modules, an interface for communication with the mounting of the cutter, and an electrical power unit.

The mountings R of the equipped cutters are connected by a transmission system, wireless or otherwise, to a processing and display unit C located in the driver's cab of the
10 tunnelling machine. Figure 2 schematically illustrates a transmission line F which carries the individual signal transmissions from the sensors on the cutters and/or from the mountings of the cutters carried by a given arm B, by means of rotating joints.

15 The figure 3 is a schematic axial section view of a cutter M equipped with inclinometers 1, a rotation sensor 2, temperature probes 3 and stress gauges 4.

The cutter M and its mounting R include their respective communication means 5, 6 which work, together to allow the
20 remote transmission of the signals from the sensors.

The invention is not limited to this implementation example.

CLAIMS

1. Process for providing continuous information on ground conditions at the excavation face for the operator of a tunnel boring machine equipped with a rotary cutting head incorporating a multiplicity of individual mountings for rotary boring cutters, in which data acquisition sensors capable of generating signals concerning cutter operation are implemented, these signals being remotely transmitted and used to inform the tunnel boring machine operator, characterized in that one or more sensors selected from sensors suitable for generating signals representing cutter penetration force into the ground, cutter position, cutter rotational state and cutter temperature are directly placed on each cutter.

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2. Process according to Claim 1, in which each cutter concerned is supplied with electrical power required for operating the cutter sensors from a battery integrated into the cutter or by wireless transmission from the cutter mounting.

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3. Process according to Claim 1 or 2, in which the mounting of each cutter concerned is fitted with a receiver capable of receiving by wireless transmission signals from the cutter sensors and transmitting them to a communication network carried by the cutting head and the said network includes a processing and display unit in the tunnel boring machine operating cab.

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4. Process according to any one of Claims 1 to 3, in which each cutter concerned is fitted with stress gauges glued to the cutter shaft and in which the signals from these gauges are used to obtain information on the loads sustained by the cutter.

5. Process according to any one of Claims 1 to 4, in which each cutter concerned is fitted with an inclinometer.

6. Process according to any one of Claims 1 to 5, in which each cutter concerned is fitted with a magneto-inductive rotation sensor.

7. Boring cutter and its mounting for installing the rotary cutter on the rotary cutting head of a tunnel boring machine, characterized in that the cutter includes one or more sensors selected from sensors capable of generating signals representing cutter penetration force into the ground, cutter rotational state, cutter position and temperature, and in that the cutter and its mounting comprise means cooperating to transmit remotely the signals from the cutter sensors.

8. Boring cutter and its mounting according to Claim 7, the cutter of which is fitted with a set of the aforesaid sensors.

9. Boring cutter and its mounting according to Claim 7 or 8, the cutter sensors of which are mounted on a base incorporated in the cutter and which is fitted with acquisition and processing modules, a communication interface with the cutter mounting and an electrical supply unit.

10. Tunnel boring machine fitted with a rotary cutting head, which carries the mountings for the

rotary boring cutters, characterized in that the cutters and their mountings are as defined in any one of Claims 7 to 9 and in that the tunnel boring machine includes means of transmitting signals from the sensors to a central processing and display unit placed in the tunnel boring machine operating cab.