Abstract: Method and system for controlling a wire tension system for a diamond wire saw in a diamond wire machine, comprising monitoring the cylinder extension (CE) as a measure of the wire extension and comparing the wire extension with the maximum allowable wire extension (WEM) before starting feeding, monitoring that the set pretension (PT) in addition to the feeding force (FF) is smaller than a maximum feeding threshold (FTI), and monitoring that the cylinder extension (CE) is smaller or equal to a cylinder extension threshold (CET).
A wire tension system for a diamond wire saw

The present invention is related to a wire tension system for a diamond wire saw in a diamond wire machine and a method for controlling such a wire tension system, according to the preamble of the claims.

A diamond wire machine comprises a frame or body in which a diamond wire is tensioned between two or more wheels secured to the frame where at least one of the wheels is a drive wheel. Machines having only two wheels usually are used for simple cutting operations sub-sea and within the quarrying industry. For larger or more accurate cutting operations three or four wheels usually are used of which one or two are drive wheels.

To control the wire during cutting the wire has to be pre-tensioned. This usually is achieved with one of the wire wheels in a three wheeled machine or two of the wheels in a four wheels machine being driven. The force used will typically be from 100 to 600 kg, depending on the length of the wire.

Cutting with diamond wires has some limitations connected with to the method as such and especially connected with the diamond wire. A diamond wire comprises of a core wire of steel on to which are threaded cylindrical diamond beads with spacers in between. The spacers normally are springs enclosed in plastics or rubber.

Diamond wires are manufactured as open coil or closed-loop. One of the problems is connected with joining the wire. In an open coil wire it usually is used a sleeve of steel or metal which is clamped against the core wire. In a closed-loop wire, the ends of the wire are weaved together in the production.

Both methods will have disadvantageous. An open coil joint establishes a stiff portion on the wire which are disposed for fractures during use. Connectors with joints are also used to avoid this problem. These, however, weakens substantially the wire.

The biggest problem with closed-loop wires is that the joint expands or slips in the joint. This is especially a problem with relatively short wires were the woven portion also is short. This has connection with the spacers which must be compressed to achieve free ends for the weaving and short wires allowed for only short weaving.

The wire is exposed for huge mechanical loads during operation. Among matters which decide the lifespan of a wire, are the number of wire wheels and the diameter of the same, the pre-tension of the wire around the wire wheels, the feeding force used during cutting and which material is to be cut.

The most common problem with the wires is telescoping. This occurs when the core wire is stretched too much, i.e. plastic deformation occurs in the metal during operation, or the weaving in a closed-loop wire is slipping. The core wire therefore will be
too long in relation to the number of diamond beads and the spacers and the beads will slip to and fro on the wire during cutting. A result of this is also that the beads are displaced on the wire and cutting is discontinued. For open coil wires fractures in the joint also is common.

A good control of the wire during operation is the best way to handle these problems. Especially is what is defined as a wire extension, i.e. a gradually extension of the core wire during a period of time, critical for the lifespan of the wire. This is a parameter which up till now has been difficult to control and monitor. One of the reasons for this extension of the wire is the pre-tension of the wire. This ensures that the wire is cutting straight with as little wire lag as possible in the cutting object. This pre-tension contributes largely to the wire extension in addition to the mechanical load the wire is exposed from the wire wheels and the cutting object.

Different technical solutions may be utilized to achieve this pre-tension. Most common is to use a hydraulic cylinder or an electric actuator in the case the tension system should have a linear movement, or a hydraulic or electric motor for solutions incorporating particulate arms. Both of these methods are simple and applicable but do not consider it the wire extension and the wire lag.

The wire extension according to the present invention provides a solution for tensioning the wire without the disadvantageous mentioned above. The system used is defined with the features stated in the patent claims.

The drawing is discloses in figure 1 and overall view of a diamond wire cutting unit, figure 2 discloses portion of the unit including the tensioning system, figure 3 discloses schematically the different parts of the tensioning system according to the present invention, and figure 4 discloses a block diagram of the tensioning process.

A wire tensioning system has to serve several duties, such as providing the wire with a defined pretension, for example 300 kg, take up wire extension during operation thereby to avoid this extension to end up as unnecessary wire lag, provide a spring function when the wire is exposed to strokes from the cutting object, to maintain the pretension also at different feeding forces, and to stabilize the wire for as large a contact surface as possible in the cutting surface.

The wire tension system according to the present invention comprises a hydraulic cylinder 1 or an electric actuator, an encoder 2, a weight cell 3, as well as necessary hydraulic and electric hoses and cables. Depending on the parameters used, one or more wire tension systems may be used in connection with the same wire saw.

The hydraulic cylinder 1 is used to provide pretension of the wire and additionally will act as a spring to absorb strokes in the wire during cutting. The cylinder 1 is controlled from a control system such as a PLC or computer.

The encoder 2 is used to provide an accurate position of the cylinder/actuator which especially is of great importance when several wire tension systems are used
simultaneously, and also to measure the extension in the wire during cutting. The encoder 2 also is controlled by the control system.

The weight cell 3 is used to monitor the pretension force, the feeding force and as well to register quick changes in the load during operation. The weight cell 3 as well is monitored by the central control system.

There are several ways to control the cutting sequences. The most common is stepping based on time and speed, constant feeding speed or monitored feeding with a combination of these. The best method is considered to be a constant feeding force which is continuously monitored. A set value is stored and the system as such tries to stay as close to this value as possible during operation. This maximizes the cutting speed at any time. Another advantage with this method is that the wear of the diamonds are considered. The feeding speed will never increase beyond what the wire can cope with.

To measure and monitor the wire extension several parameters must be considered. The most important is to establish a reference measure when a new wire is installed. This is made by providing a stored pretension value to the tension cylinders, for example 250 kg and thereafter measuring a distance between the wire wheels by means of the encoder 2 and thereafter store this value.

The measured length of the tension cylinder at the time of the first operation with the new wire is the wire length reference. The maximum allowed wire length is the wire length reference plus recommended wire extension in %.

For monitoring the extension during cutting a reference measure must be established after the wire has been fully loaded. This means after the pretension is set, the wire motors have started, the feeding is started and the wire has achieved maximum load in the cut for the first time. In such a situation the length of the tension cylinder is measured at maximum pretension plus maximum feeding force, which will be defined as the wire length reference B. The maximum load wire length then will be the wire length reference B plus recommended wire extension in %.

Figure 4 discloses a block diagram comprising the control of the wire tension system according to the present invention. Any saw action starts with setting the pretension PT. In case the cylinder extension CE is larger than the maximal wire elongation WEM the wire has to be changed. In case not the sawing action may start by starting the feeding operation. In case the pretension PT and the feeding force FF is smaller than the maximum feeding treshold FT1 feeding starts again. In case not the feeding is stopped. In case the cylinder extension CE is not smaller than the cylinder extension treshold CET, the wire is changed. In case the cylinder extension CE is smaller or equeal til the cylinder extension treshold CET the minimum feeding treshold has to be ensured and feeding starts over again.
1. Method for controlling a wire tension system for a diamond wire saw in a diamond wire machine, characterized by monitoring the cylinder extension (CE) as a measure of the wire extension and comparing the wire extension with the maximum allowable wire extension (WEM) before starting feeding, monitoring that the set pretension (PT) in addition to the feeding force (FF) is smaller than a maximum feeding threshold (FTI)_5 and monitoring that the cylinder extension (CE) is smaller or equal to a cylinder extension threshold (CET).

2. Wire tension system for a diamond wire saw in a diamond wire machine, characterized in that a weight cell (3) and a hydraulic cylinder (1) are providing pretension between two consecutive wire wheels (4) of the wire machine, and that an encoder (2) is adapted to provide position signals to a computer for control of the wire tension system, which system also is receiving weight cell signals from the weight cell (3).
Fig. 3

Fig. 4
INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO2005/000293

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
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)

IPC: B23D, B28D, E21C

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

SE.DK,FI,NO classes as above

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

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Date of the actual completion of the international search: 17 March 2006

Date of mailing of the international search report: 23-03-2006

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International patent classification (IPG)
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B23D 61/18 (2006.01)
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### INTERNATIONAL SEARCH REPORT

**Information on patent family members**

**International application No.**

PCT/NO2005/000293

**31/12/2005**

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