

The alternating stresses exerted on the lines when the energy chain is displaced can also lead, under certain circumstances, to a certain slackening of the holding of the lines, in particular also at the strain relief of the respective line. These alternating stresses can
5 also lead to the respective line undesirably changing its nominal position within the energy chain. The nominal position of the line is usually determined so that when the chain is displaced, line sections do not undesirably come into contact with other components such as e.g. the chain link inner sides, including with other lines. If the line
10 changes position at least in a partial region in deviation from the nominal position, the line section can undesirably come into contact with another component of the chain, for example, one that defines the chain interior space, or with another line. However, such contact, in particular rubbing, bumping or hitting, can also lead to considerable
15 wear of the line.

The wear of the line, in particular due to the chain displacement, however, requires maintenance of the lines at intervals to avoid failure of the same. A line failure would result in machine down time
20 and line replacement and could also lead to damage to the machine supplied with the line, loss of fluids routed in a line through leakage into the environment, breakage of a line, damage to other lines or the chain, etc. On the other hand, such maintenance itself always also means undesirable machine downtime, which should be minimized when
25 possible.

US 2015/0122047 A1 discloses a cable track monitoring system and method. In one embodiment, a monitoring system for a cable track is operatively mounted between an anchoring unit and a mobile unit in
30 designating a deployable cabling path therebetween as the mobile unit travels relative to the anchoring unit. The system comprises a monitoring cable to be run within the cable track along the cabling path; and a sensor fixedly mountable relative to one of the anchoring unit and the mobile unit and operatively coupleable to the monitoring
35 cable in sensing a tension variation therein as the mobile unit travels

relative to the anchoring unit. The sensor is operable to monitor the tension variation during operation of the cable track.

DE 20305479 U1 discloses a strain relief element for an energy guide chain to lead conductors between two connection points, and which comprises many connected links with an inner space to receive a cable, has a fixing means to connect to the cable and is constructed to divide the inner space within the guide chain. An energy guide chain comprising a strain relief element as above is disclosed.

It is therefore the object underlying the invention to provide a monitoring system for the operation of an energy chain with at least one line guided in it, through which the maintenance intervals for checking the state of the lines can be optimized and/or beginning damage to a line can be identified early without shutting down the energy chain.

This object is achieved by a monitoring system according to claim 1 and by the provision of a strain relief device for such a monitoring system according to claim 16~~18~~. Advantageous embodiments are apparent from the dependent claims.

According to the invention, at least one measuring device is provided for measuring forces ~~which are exerted on the line to be fixed or on the fixed line during operation of the energy chain and/or~~ which are transmitted during operation of the chain from the at least one line in the direction towards and/or into the carrier part. It has thus been found in the course of the invention that the forces transmitted during operation of the energy chain by the at least one line in the direction towards and/or into the carrier part (in general also: called "line forces") can be a measure of the wear of the line, in particular with otherwise same operating parameters of the chain; or wear can be concluded or at least suggested from line forces changing over a period of time with otherwise same operating parameters of the chain. Said period of time can represent a significant fraction of an otherwise

usual maintenance interval, in which a significant wear of a line can thus already occur.

A monitoring device for an energy chain is already known from WO
5 2004/090375 A1. The wear of chain links and the articulated joints between them can be monitored by means of this. However, the wear of the chain or articulated joints of chain sections with one another does not correlate in any way with the wear of lines guided in the chain since other materials and other mechanical stresses are given. This
10 applies in particular when cables of different construction types are guided in the chain. The line wear for a given chain displacement depends on the one hand on the type of line, but possibly also on the arrangement of the line within the chain, for example, whether the line is arranged near or distant from the line connecting the chain link
15 joint elements. Also, the sensitivity of the lines for mechanical load peaks, for example, with rapid acceleration of the chain, can depend on the specific line structure. The monitoring device of WO 2004/090375 A1 thus does not solve the object underlying the invention.

20 For example, if a line (in general also: "lines") changes its position within the energy chain (in general also: "chain") in deviation from the nominal position for intended operation, this can cause a section of the line to strike another component such as a region of the chain link or a device thereof or against another line or to rub against the
25 same. This can occur repeatedly, for example, at each displacement cycle, and thus lead to wear. A change in position of a line section from the nominal position can take place, for example, when the holder fixing the line slackens slightly or the line undesirably deforms with respect to its longitudinal extension, for example, i.e. laterally
30 slips with a partial region in the chain link. This line section is spaced from the end region of the line in the longitudinal direction of the line, for example, arranged in the middle region of the line. In the course of the invention, it was found that the forces generated by this striking, rubbing or the like at the end region of this line are
35 metrologically detectable and are

Claims

1. A monitoring system for the operation of an energy chain,
which guides at least one line ~~such as cables, hoses or~~
5 ~~the like~~, between two connection points being movable
relative to one another, comprising:

an energy chain having two end regions, which are each
connectable or connected to one of the connection points,
10 and which, in the case of relative movement of the
connection points, comprises chain sections, which are
positionally variable relative to one another or
position-changing relative to one another, as guide
regions of the at least one line;

15 at least one strain relief device having a line holder
which ~~can~~ is configured to be coupled or is coupling to
the line;

20 a carrier part at at least one of the connection points,
wherein the carrier part fixes the strain relief device
in stationary manner, by means of which the at least one
line is at an end side fixable or fixed in a strain-
relieving manner; and

25 at least one measuring device for monitoring the
operation of the energy chain,

characterized in that

the at least one measuring device is arranged and
30 configured to measure forces ~~which are exerted on the~~
~~line to be fixed or on the fixed line during operation of~~

~~the energy chain and/or~~ which are transmitted by the at least one line in the direction towards the carrier part.

2. The monitoring system according to claim 1, characterized
5 in that the measuring device is arranged in a measurement-effective manner between the line and the carrier part with respect to the direction of a flow of force from the at least one line to be fixed or line fixed on the strain relief device into the carrier part,
10 including on the line itself.
3. The monitoring system according to claim 1 or 2, characterized in that the measuring device couples with the strain relief device in a measurement-effective
15 manner.
4. The monitoring system according to claim 3, characterized in that the measuring device couples to at least one line holder of the strain relief device in a measurement-
20 effective manner.
5. The monitoring system according to claim 3 or 4, characterized in that the strain relief device comprises at least one support region, by means of which the at
25 least one line holder is fastened to the strain relief device, and in that the measuring device couples to the support region in a measurement-effective manner.
6. The monitoring system according to one of claims 3 to 5,
30 characterized in that the strain relief device comprises a base element, with which the strain relief device is fixed to the carrier part, and in that the measuring

device couples to the base element in a measurement-effective manner.

7. The monitoring system according to one of claims 1 to 6,
5 characterized in that the strain relief device comprises a base element, with which the strain relief device is fixed to the carrier part, and that the measuring device is coupled with the holding region of the carrier part for the base element in a measurement-effective manner.
- 10 8. The monitoring system according to one of claims 1 to 7, characterized in that the measuring device is formed such that it is coupled to different regions of one and the same component or component group in the force
15 transmission direction from the line in the direction towards the carrier part to receive measured values, for measuring relative differences in forces which act on both said regions.
- 20 9. The monitoring system according to claim 8, characterized in that the measuring device comprises at least two sensors, which couple to different regions of one and the same component, ~~preferably couple with a support region of a strain relief or with a base element of the strain relief or with a holding region of the carrier element for the strain relief to receive measured values.~~
- 25 10. The monitoring system according to claim 9, characterized in that the at least two sensors couple with a support region of a strain relief or with a base element of the strain relief or with a holding region of the carrier element for the strain relief to receive measured values.
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101. The monitoring system according to one of claims 1 to
910, characterized in that the measuring device is formed
such that it is coupled with different components in the
5 force transmission direction from the line in the
direction towards the carrier part to receive measured
values, for measuring relative differences in forces
between the two different components.

10 112. The monitoring system according to one of claims 1 to
101, characterized in that a respective strain relief
device is provided at both connection points,
which respectively relieve the at least one line to be
fixed in terms of tensile forces relative to the energy
15 chain, and that two measuring devices are provided, which
are arranged and configured to measure forces which are
exerted on the line to be fixed or on the fixed line
during operation of the energy chain and/or which are
transmitted by the at least one line in the direction
20 towards the carrier part.

123. The monitoring system according to one of claims 1 to
112, characterized in that the system comprises an
evaluation unit, by means of which the measured values of
25 the at least one or both measuring devices ~~can be~~ are able
to be acquired, and that the evaluation unit is
configured to compare the measured values of the
measuring device respectively with a predetermined
threshold value, and in the event of deviations from the
30 threshold value beyond a predetermined tolerance range,
sends a signal to a signal device for triggering the
signal device.

134. The monitoring system according to one of claims 1 to
123, characterized in that the system comprises an
evaluation unit which acquires and/or evaluates signals
of the at least one sensor of the measuring device,
wherein the evaluation unit ~~in particular further~~
acquires and/or evaluates the signals of the reference
sensor, ~~wherein the evaluation unit preferably triggers a~~
~~stopping of the relative movement between the connection~~
~~points in the event of a fault.~~

15. The monitoring system according to claim 14,
characterized in that the evaluation unit triggers a
stopping of the relative movement between the connection
points in the event of a fault.

146. The monitoring system according to one of claims 1 to
135, characterized in that the system comprises an
evaluation unit, by means of which the measured values of
the measuring device ~~can~~ are able to be evaluated, and
that the energy chain is displaced with a predetermined
displacement cycle as a reference cycle and that the
measured values of a displacement cycle of the chain
different from the reference cycle are compared with the
measured values of the reference cycle.

157. The monitoring system according to one of claims 1 to
146, characterized in that the measuring device comprises
at least one force sensor for measuring the forces acting
on the line and/or being transmitted therefrom in the
direction towards the carrier part.

168. A strain relief device for one or more lines guided in an energy chain, ~~in particular~~ for a monitoring device according to one of claims 1 to 157, comprising a line holder for fixing the at least one line in a strain-relieving manner and having at least one sensor which is coupled or ~~can be~~ is able to be coupled to a partial region or a component of the strain relief device and which is part of a measuring device for measuring forces which are exerted on the line to be fixed or on the fixed line during operation of the energy chain and/or are transmitted during operation of the energy chain by the at least one line in the direction towards the carrier part.

179. The strain relief device according to claim 168, characterized in that the measuring device comprises at least one, ~~preferably or~~ a plurality of sensors, ~~in particular strain gauges,~~ which are attached between the line holder and the base region of the strain relief device.