

Description

Wire Rope Remote Surveillance System

Technical Field

[0001]

The present invention relates to a system for performing remote surveillance in terms of deterioration or abnormality of a wire rope used as a running cable.

Background Art

[0002]

Wire ropes are generally used not only as standing cables but also as running cables in various facilities and apparatuses. Since there is a high possibility that enormous damage will be caused by occurrence of a break accident, it is important to take measures such as replacement with a new wire rope for safety as soon as deterioration (inclusive of abnormality, which will apply to the following description) of a wire rope arises.

This tendency is particularly strong on a wire rope used in a cable way or a dam gate in an important facility not allowed to be stopped suddenly or a facility requiring safety kept first and foremost, such as a crane ship, a ladle crane in a steelworks, a ropeway, a gondola, etc.

[0003]

Although periodical inspection is required for ascertaining deterioration of such a wire rope, a visual

external inspection method of guesstimating deterioration of a wire rope by visual observation of the wire rope mainly for the rope diameter, breaking, corrosion, abrasion, losing shape, etc. was heretofore used because criteria for the inspection were not clear.

In this visual external inspection method, however, skill was required and accuracy varied widely according to differences among individuals. Moreover, since it took time to inspect a long rope and it was impossible to perform inspection unless movement of the rope was suspended, it was difficult to continuously inspect the whole length and it was impossible to perform on-demand inspection in the condition that operation could be hardly suspended. Thus, there was a problem in terms of safety measures.

[0004]

A magnetic leakage flux testing unit called rope tester is known as a testing unit which can inspect a rope without suspending movement of the rope. This unit uses the fact that a wire rope is axially magnetized by a magnet built in a detector while the wire rope passes through a detector coil. When there is breaking of a wire, magnetic flux is leaked into the air because of reduction in a section of the rope. A change of the leaked magnetic flux is detected by the detector coil and output as a signal.

Even when such a magnetic leakage flux testing unit was

used, data could be output only to an analog recorder, etc. so that it was difficult to specify an abnormal spot of the rope from an abnormal spot on the data. Moreover, judgment criteria were not placed. In addition, there was a problem that the abnormal spot was often missed.

Disclosure of the Invention

Problems that the Invention is to Solve

[0005]

The invention was accomplished in order to solve the foregoing problems. An object of the invention is to provide a wire rope remote surveillance system which can perform remote, accurate, objective and continuous surveillance concerned with deterioration of a wire rope used as a running cable in an important facility or a facility which has a tendency toward a serious accident when damaged.

Means for Solving the Problems

[0006]

In order to achieve the object, the invention is characterized by including: a unit which measures a status of a wire rope; a first surveillance apparatus which is connected to the measuring unit by a communication unit and which records, displays and accumulates measured data output from the measuring unit, makes a judgment based on the relation with the accumulated measured data as to whether or not there is an abnormality, and issues a warning when there is an

abnormality; and a second surveillance apparatus which is connected to the first surveillance apparatus through a communication unit and which exchanges data with the first surveillance apparatus, checks the data judged by the first surveillance apparatus again to make a final decision, and informs the first surveillance apparatus of the final decision.

Effect of the Invention

[0007]

According to the invention, it is possible to perform automatic and continuous surveillance in terms of a status of deterioration or abnormal of a wire rope while an apparatus or facility equipped with the wire rope is kept operative ceaselessly and even when any expert for judging deterioration/abnormality of the rope is absent in a site of use of the wire rope.

In addition, the first surveillance apparatus processes the measured data sent from the measuring unit, judges whether or not there is an abnormality based on the relation with the accumulated data, and issues a warning automatically when there is an abnormality. Further, upon reception of the notice of the abnormality occurrence warning, the second surveillance apparatus located at a remote place judges again whether or not there is an abnormality, and issues a command of rope replacement, etc. as the final decision to the first surveillance apparatus. Accordingly, it is possible to

improve surveillance accuracy and to consistently perform optimization and economic efficiency for the rope replacement time, so that it is possible to build a safe condition for use of the rope.

In addition, the system can be formed when a computer and a software program are used in combination with an existing measuring unit. Accordingly, the system can be carried out at a relatively low cost.

Brief Description of the Drawings

[0008]

[Fig. 1] (a) is an explanatory view showing a whole of a wire rope remote surveillance system according to the invention, and (b) is an explanatory view showing details of (a).

[Fig. 2] An explanatory view showing an example of the wire rope remote surveillance system according to the invention.

[Fig. 3] An explanatory view showing an example of a measuring device.

[Fig. 4] A flow chart of the surveillance system according to the invention.

[Fig. 5] (a) is a display screen view of measured data, and (b) is a display screen view at measuring time.

[Fig. 6] (a), (b) and (c) are graphs each showing change of a measured voltage corresponding to increase in the number of operating cycles.

[Fig. 7] (a) is a graph showing the relation between an

evaluation value and a residual strength rate, and (b) is a graph showing the relation between time and the evaluation value by two patterns.

[Fig. 8] A graph showing a voltage value of a signal.

[Fig. 9] A graph showing an area value of the signal in Fig. 8.

[Fig. 10] A graph showing the relation between the signal voltage and a residual strength.

[Fig. 11] A graph showing the relation between the signal area value and the residual strength.

[Fig. 12] A graph showing the relation between the signal voltage and the residual strength.

[Fig. 13] A graph showing the relation between the signal area value and the residual strength.

[Fig. 14] Graphs showing a whole waveform and an enlarged waveform at a certain number of operating cycles.

[Fig. 15] Graphs showing a whole waveform and an enlarged waveform when the number of operating cycles has further increased relative to Fig. 14.

[Fig. 16] Graphs showing a whole waveform and an enlarged waveform when the number of operating cycles has further increased relative to Fig. 15.

[Fig. 17] A graph showing the relation between the number of operating cycles in each of Figs. 14 to Fig. 16 and a signal voltage.

[Fig. 18] A graph showing the relation between the number of operating cycles in each of Figs. 14 to Fig. 16 and a signal area.

[Fig. 19] A graph showing the relation between a real number of operating cycles and the number of broken wires.

[Fig. 20] A graph showing transition of a signal area in accordance with the number of operating cycles by two patterns.

[Fig. 21] A graph showing the contents of Fig. 20 with increase of the signal taken as its vertical axis.

[Fig. 22] An explanatory view showing a second embodiment of the invention.

[Fig. 23] An example of measured data showing temporal change of a rope diameter.

Description of Reference Numerals

[0009]

- 1 crane (facility)
- 2 wire rope
- 3 measuring device
- 6 first surveillance apparatus
- 6a computer
- 7 second surveillance apparatus
- 7a computer

Best Mode for Carrying Out the Invention

[0010]

The first surveillance apparatus has a measurement

control portion which sets a measurement condition of the measuring unit and instructs the measuring unit to execute an operation such as start, stop or the like in the set condition, a recording and display portion which records measured data sent from the measuring unit and displays the measured data on a monitor, a collection portion which stores and accumulates data, a judgment function portion which analyzes the stored and collected data to thereby judge whether or not there is an abnormality, and a communication portion which communicates with the second surveillance apparatus when the judgment function portion decides that there is an abnormality exceeding a set value or level and which transmits the recorded data, etc. in accordance with a request or instruction from the second surveillance apparatus. The second surveillance apparatus has a data request judgment portion which checks an abnormality occurrence report sent from the first surveillance apparatus and judges whether or not detailed data such as image data and numerical data are to be requested, a judgment function portion which analyzes data sent from the first surveillance apparatus to thereby judge whether or not it is necessary to replace the rope, and a command sending portion which sends a result of the judgment to the first surveillance apparatus.

[0011]

Preferably, a measurement section is divided into segments in a lengthwise direction of the rope, increase of

a measured value with passage of time is analyzed in each cycle in one segment and a judgment is made as to whether or not there is an abnormality, based on whether or not a rate of the increase exceeds a predetermined criterion value.

According to this configuration, inspection does not depend on human's sense such as experience but judgment as to deterioration of a rope is performed objectively and quantitatively. Thus, a result of the judgment does not vary and the judgment time can be shortened. As accumulation of measured data increases, the measured data can be fed back to the past record. Thus, accuracy can be improved.

[0012]

There is used a judgment program which sets wire breaking as a target of measurement of the status of the wire rope, weights measured values respectively with a plurality of levels taken as voltage height due to the wire breaking in a measurement section, checks temporal change of the evaluated value, and makes a decision that the wire rope is abnormal when the evaluated value exceeds a permissive change rate.

According to this configuration, when a degree of deterioration at a time point after elapse of a predetermined period is equal but a change rate in the process to lead to the degree of deterioration is sudden, decision is made that the wire rope is abnormal. Accordingly, it is possible to cope with sudden abnormality, so that it is possible to keep safety

high.

[0013]

There is used a judgment program which sets wire breaking as a target of measurement of the status of the wire rope, sets, as a criterion, an integrated value (signal area value) from voltage values due to the wire breaking in a measurement section, detects change of the integrated value in accordance with the number of operating cycles, and decides that the wire rope is abnormal when the change is so large as to exceed a permissive change rate.

According to this configuration, it is possible to recognize the extent of occurrence of wire breaking easily in addition to the aforementioned effect, so that it is possible to improve accuracy of judgment.

Embodiment 1

[0014]

Embodiments of the invention will be described below with reference to the accompanying drawings.

Fig. 1 and Fig. 2 show an example where the invention is applied to remote surveillance of rope deterioration in a marine ship such as a crane ship. The reference number 1 designates a crane equipped in a ship A; 2, a wire rope used in the crane 1; and 3, a measuring device disposed in a proper place of a movement path of the wire rope 2. Although the measuring device 3 is located nearby a pole top portion in this

example, the invention is not limited thereto.

The reference number 4 designates a control panel disposed nearby the measuring device 3. The control panel 4 is equipped with a controller 4a and a wireless LAN unit 4b for data transfer. The reference numeral 5 designates a wireless LAN antenna; and 6, a first surveillance apparatus equipped in an observation room B on the ship.

The reference number 7 designates a second surveillance apparatus installed in a remote place such as a lookout station C in Japan; and 8, a transfer antenna installed on the ship. For example, the transfer antenna 8 is constituted by an INMARSAT antenna for performing communication via a communication satellite D.

[0015]

In this example, the measuring device 3 uses a magnetic leakage flux testing unit. As shown in Fig. 3, a body of the measuring device 3 includes a magnet 3a for magnetizing a wire rope, a detector coil 3b for detecting magnetic leakage flux when any wire is broken, and an acceleration sensor 3c for detecting a velocity of the wire rope moving in the magnetic field. An external detection portion includes a unit for correcting an electromotive force detected by the detector coil 3b based on the acceleration detected by the acceleration sensor 3c. This correction unit has a correction circuit 30 for correcting a signal detected by the detector coil 3b based

on the acceleration and outputting the corrected signal, and a correction quantity adjusting circuit 31 for sending a correction value to the correction circuit 30 based on an acceleration signal detected by the acceleration sensor 3c. The correction quantity adjusting circuit 31 calculates a degree for raising or reducing a detection signal level to keep the detection signal level constant regardless of the acceleration of the wire rope relative to the detector coil 3b, and inputs the calculated degree as a correction signal to the correction circuit 30. Incidentally, it is a matter of course that an amplifier, a filter, a wave detector, etc. are also provided though they are not shown in the drawings.

[0016]

A wire rope is made up of hard steel wires (carbon steel) which are ferromagnetic substances. Therefore, when the wire rope is intensely magnetized axially by the magnet of a magnetization detector, magnetic leakage flux varies according to the change of a local sectional area caused by wire breaking, etc. The change quantity of the magnetic leakage flux is detected by the detector coil 3b and converted into an electric signal so that abnormality of the wire rope can be found. A specific example of specification is rope diameter used: 40-60mm, measurement velocity: 15-90m/min, and magnetization method: DC magnetization using a permanent magnet.

Generally, the magnitude of the signal increases as the change of the sectional area increases. The magnitude of the signal is proportional to the measured velocity. When the wire rope moves fast in the magnetic field while the moving velocity of the rope is not kept constant, turbulence of the magnetic field due to wire breaking or lift noise increases so that small wire breaking or lift noise is detected. On the other hand, when the velocity of the wire rope is slow, there is a situation that even large wire breaking cannot be detected. Therefore, the acceleration sensor and the correction unit are used in combination as described above so that the detection signal level can be raised or reduced in accordance with change of the velocity of the wire rope. In this manner, wire breaking, etc. can be measured with constant detection accuracy.

[0017]

The controller 4a of the control panel 4 is a unit for applying an A/D conversion process to the detection signal output from the measuring device 3 and recording the converted detection signal. The digitized measured data are transferred to the surveillance apparatus 6 through an LAN unit by a wireless LAN.

The first surveillance apparatus 6 includes a computer 6a and a wireless LAN antenna 6b. The computer 6a includes a measurement control portion which sets a measurement condition of the measuring unit 3 and instructs the control

panel 4 to start/stop the measuring device 3 in that condition, a recording and display portion which records measured data sent from the measuring device 3 and displays the recorded measured data on a monitor, a collection portion which stores and accumulates the measured data, a judgment function portion which analyzes the stored and collected measured data and judges whether or not there is an abnormality, and a communication portion which communicates with the second surveillance apparatus 7 when decision is made that there is an abnormality exceeding a predetermined value or level, and which transmits the recorded measured data, etc. in accordance with a request or instruction from the second surveillance apparatus 7.

[0018]

The second surveillance apparatus 7 is located at a remote place where an expert stays for judging deterioration or abnormality of a rope. The second surveillance apparatus 7 has a computer 7a and an Internet connection device 7b, similarly to the first surveillance apparatus 6.

The computer 7a has a data request judgment portion which checks an abnormality occurrence report sent from the judgment function portion of the first surveillance apparatus 6 via the Internet connection device 7b and judges whether or not detailed data such as image data, numerical data, etc. are to be requested, a judgment function portion which analyzes data

sent from the first surveillance apparatus 6 and judges whether or not rope replacement is required, and a command sending portion which transmits a result of the judgment to the first surveillance apparatus 6. The command sending portion contains a function for instructing the first surveillance apparatus 6 to change the measurement condition such as an interval and change the judgment condition of the program, etc. Upon reception of a command from this command sending portion, the first surveillance apparatus 6 performs measurement, judgment, etc. in the designated measurement condition and judgment condition.

[0019]

Incidentally, the judgment function portion for analyzing the measured data stored and collected in the first surveillance apparatus 6 and judging whether or not there is an abnormality, the judgment function portion for analyzing detailed data of the abnormality in the second surveillance apparatus 7 and judging whether or not rope replacement is required, the data request judgment portion, etc. are constructed as software.

[0020]

Measurement is basically performed in such a manner that a measurement section is divided into segments in a lengthwise direction of the rope, and magnetic leakage flux voltage is detected continuously in this example while the rope is moved

at a required velocity. Preferably, this measured data are data subjected to a velocity correction process by the acceleration sensor and the correction unit as described above.

The measured data are wirelessly transferred from the control panel 4 to the computer 6a of the first surveillance apparatus 6 and stored. The aforementioned measurement is performed at intervals of a predetermined time. Measured data in one and the same segment are displayed and recorded each cycle, and temporal change of the measured data is analyzed by the judgment function portion. When decision is made that the value or increasing rate exceeds a predetermined criterion, occurrence of an abnormality is transmitted to the computer 7a of the second surveillance apparatus 7.

[0021]

Fig. 4 shows a surveillance chart according to the system of the invention. While the detector 3 and the controller 4a are connected to each other by a dedicated cable as operation preparation, the detector 3 is installed in a predetermined place and then setting of the controller 4 is performed. This is to turn ON a channel (1ch) for measurement and select a measurement velocity changeover switch. Confirmation is made as to whether the direction of the wireless LAN antenna is normal, and the observation room-side antenna is directed toward the detector-side antenna 5. Connection of an INMARSAT phone is checked.

[0022]

As for the computer 6a of the first surveillance apparatus 6, an LAN cable, a phone line cable and a power supply cable are connected to the computer and the computer is powered on. Activation of the program is confirmed, and an IP address of the LAN, a connection PORT and a mail-sending address are entered in communication setting. In addition, mail communication setting (message check time, transmission/reception interval and end time) is performed. A rope velocity (real velocity), a value of a judgment level (e.g. 2V) and a judgment start position (e.g. 2m) are set and a data storage folder name is entered in measurement setting.

[0023]

Successively, time trigger setting is performed in the measurement setting. When measurement is performed once a day (measurement starts at a predetermined time point), a check is put in "measurement time point" and a measurement start time is entered. When measurement is performed at intervals, a check is put in "interval" and a measurement interval is entered. Finally, a measurement time (e.g. 30 min at maximum) is entered and a set button is clicked. In this manner, measurement starts automatically at each set time point.

[0024]

In the case of another setting mode than time trigger, manual trigger or simple measurement is selected. In the case

of manual trigger, measurement is started at the same time as clicking of a measurement start button. In the case of simple measurement, a format is made as measurement preparation, and measurement begins at a measurement start and terminates at a measurement end. Alternatively, encoder trigger may be used. This is a mode in which a rotary encoder attached to the measuring device 3 is used as shown in Fig. 2, and when a rope moves, measurement starts based on output from the encoder. Based on the encoder output, a movement distance of the rope can be recorded so that a measurement place of the rope can be specified.

[0025]

After the aforementioned preparation operation, a start command is transmitted from the computer 6a to the controller 4a of the detector 3 by the wireless LAN to start measurement. The controller 4a fetches data about the set time, analog-to-digital converts a measured electric signal, records the signal as a digital signal on a memory of the body and on a memory of the computer 6a by the wireless LAN, and displays the measured data on a monitor. A velocity of a rope as a target of the measurement and a voltage of a judgment level are entered in advance in a text box of the computer 6a. The judgment level is a voltage used when judgment is performed. Fig. 5(a) shows a monitor screen before the measurement starts. In Fig. 5(a), the upper part is a whole graph of measured data,

and the lower part is an enlarged graph in which a position selected from the whole graph is displayed while enlarged. Fig. 5(b) shows an example of measured data in which high voltage (magnetic leakage flux) portions appear in 5 places. The measured data are obtained in such a manner that a signal detected by the detector coil is corrected based on an acceleration sensed by the acceleration sensor.

[0026]

Such data are stored and accumulated in the collection portion of the computer 6a whenever measurement is performed. The judgment function portion of the computer 6a analyzes whether or not the data exceed a preset criterion (setting) and judges whether or not there is an abnormality. Figs. 6(a), (b) and (c) show an example of temporal change in waveform of measured data. For example, Fig. 6(a) shows a voltage waveform after 340,000 operating cycles. Fig. 6(b) shows a voltage waveform after 520,000 operating cycles. It can be found from Fig. 6(b) that wire breaking occurred. Fig. 6(c) shows a voltage waveform after 560,000 operating cycles. It can be found from Fig. 6(c) that the number of broken wires increased.

[0027]

Here, evaluation based on voltage height is taken as an example of the way that the judgment function portion judges (evaluates) data. This is performed in such a manner that a maximum magnetic leakage flux voltage with elapsed years is

set in advance so that occurrence of abnormality can be decided when a value exceeding this voltage appears. For example, the maximum magnetic leakage flux voltage with elapsed years is set at 4V so that occurrence of abnormality can be decided when data after one year exhibit a maximum voltage of 1.8V and data after two years exhibit a maximum voltage of 4.9V.

For example, when data after two years have a large number of values in a predetermined section though the data exhibit a maximum voltage of 3.5V which does not reach the set level, there is however a possibility that decision may be made improperly that the rope is normal based on the aforementioned criterion though the decision should be made that the rope is abnormal in terms of safety measures.

[0028]

Therefore, the invention proposes a proper evaluation method. A first mode of the preferred evaluation method is as follows. A certain level of voltage height in a predetermined measurement section and the number of pieces of data (time or length) exceeding the level of voltage height are checked. For example, assume that the weight is set at 1 in the case of over 1V, and the number of pieces of data is set at 50 points for 0.5 sec. in a length of 10mm. The number of pieces of data may be replaced with the number of voltages.

The level of voltage height is divided into several levels and weights are given to the levels respectively. For

example, assuming the level over 1V: weight 1: 50 points (the number of pieces of data), the level over 2V: weight 2: 30 points (the number of pieces of data), the level over 3V: weight 3: 15 points (the number of pieces of data), the level over 4V: weight 4: 5 points (the number of pieces of data), then $1 \times 50 + (2 - 1) \times 30 + (3 - 2) \times 15 + (4 - 3) \times 5 = 100$ can be obtained. Accordingly, when the weight for a high voltage value is set to be heavy, that is, when, for example, the weight for a voltage value over 3V is set at 5 and the weight for a voltage value over 4V is set at 8, the influence of the voltage height can be reflected. When the change rate is not smaller than a predetermined value from view of the temporal change (slope of change) of the evaluation value in the aforementioned condition, decision is made that the rope is abnormal and needs to be replaced.

[0029]

For example, assume that the aforementioned evaluation value was 10 after one year, 20 after two years, and 30 after three years (pattern A) in one case, and the aforementioned evaluation value was 5 after one year, 8 after two years, and 30 after three years (pattern B) in another case.

In these cases, the maximum change rate is 10 per year in the pattern A and 22 per year in the pattern B. Therefore, when a change rate not smaller than 20 per year is preset as a replacement level, unexpected or sudden deterioration can

be supported because decision is made that the rope is still usable based on the pattern A but decision is made that the rope needs to be replaced based on the pattern B.

Fig. 7(a) shows the relation between an evaluation value and a rope strength rate. A residual strength rate 90% is equivalent to an evaluation value 20. Fig. 7(b) shows the relation between time and an evaluation value. Since the angle in the pattern B is larger than a critical slope angle, decision is made that the wire rope needs to be replaced.

[0030]

Next, a second mode of the evaluation method in the judgment function portion according to the invention is as follows. An integrated value (signal area value) from voltage values expressing wire breaking in a predetermined measurement section is set as a criterion. Change of the integrated value is detected in accordance with the number of operating cycles. When the size of the change exceeds a permissible change rate, decision is made that the wire rope is abnormal.

[0031]

In detail, Fig. 8 shows a waveform of a signal voltage value due to wire breaking. The voltage is 4.4V. Fig. 9 shows the relation between the wire breaking in the case of Fig. 8 and a signal area value. In this example, the area is 120. The signal area value is an integrated value of lengths (positions) in a waveform expressed by voltage values shown

in Fig. 8. When data are taken finely at a uniform velocity, the signal area value can be obtained by discrete integration of $\sum(\text{voltage value} \times \text{number of pieces of data})$. This is automatically obtained by a calculation function in the judgment function portion. In comparison with Fig. 8, Fig. 9 shows a waveform which is close to the shape of a normal distribution so that the waveform is flattened in other positions than an abnormal signal. Accordingly, the status of occurrence of wire breaking can be recognized correctly.

Incidentally, when the velocity of the rope in the data is not uniform, the number of pieces of data per unit length decreases as the velocity increases. Therefore, the weight for the data may be corrected or added in accordance with the velocity. When, for example, there is a velocity difference of 2 times, data of two-fold velocity may be multiplied by 2 so that the weight for one data is increased.

[0032]

Fig. 10 shows the relation between voltage in the case where the number of pieces of data is 6 and rope residual strength. Fig. 11 shows the relation between area (voltage $\times$ number of pieces of data) and rope residual strength. R^2 means a correlation coefficient.

When the relation between residual strength and voltage is applied as a criterion to the aforementioned example, it can be found that the correlation coefficient is low and error

in estimation of the residual strength is large, as shown in Fig. 12. For example, as for the signal in Fig. 12, the voltage is about 4.4V and the residual strength is estimated to be in a range of 50% to 95%. Since 50% is used in safety evaluation, the residual strength is estimated to be lower than general permissible strength 80%, resulting in that the rope needs to be replaced.

[0033]

On the other hand, when the relation between area (voltage x number of pieces of data) and rope residual strength is used as a criterion, the area is estimated to decrease like a quadratic curve from a range over 100 and the correlation coefficient becomes very high, as shown in Fig. 13.

In the case of a value 120 in Fig. 13, the residual strength is estimated to be about 90%, so that decision is made that the rope is still usable. Lowering of strength by 10% however occurs, so that decision is made that the rope needs replacement preparation and periodic inspection.

[0034]

Accordingly, it can be said that the relation between area (voltage x number of pieces of data) and residual strength, not the relation between voltage and residual strength, is preferably set as a judgment criterion for abnormality judgment.

Figs. 14 to 16 show temporal change of a waveform in

accordance with the number of operating cycles in a certain facility. The upper part of each of Figs. 14 to 16 is a whole waveform while the lower part thereof is an enlarged waveform. An area is obtained by using the lower part. Fig. 14 shows 20,000 operating cycles, Fig. 15 shows 30,000 operating cycles, and Fig. 16 shows 40,000 operating cycles. V expresses voltage and S expresses signal area.

Fig. 17 shows the relation between voltage and the number of operating cycles in Figs. 14 to 16. Fig. 18 shows the relation between signal area value and the number of operating cycles in Figs. 14 to 16. These relations are obtained automatically by a program in the judgment function portion. As shown in Fig. 17, the signal voltage is about 5V and does not change so much. On the other hand, the signal area value in Fig. 18 shows a tendency toward increase in accordance with the number of operating cycles. Fig. 19 shows a result of practical examination into the status of wire breaking. It can be found that the status of wire breaking agrees well with the signal area value. Thus, in the invention, the relation between signal area value and the number of operating cycles is used as a judgment element, so that replacement judgment is made based on an increasing rate of the waveform.

[0035]

Fig. 20 shows transition of signal area (signal integrated value) in accordance with the number of operating

cycles. In the pattern A, some deterioration occurs from the beginning but increase of the deterioration is small. On the other hand, in the pattern B, deterioration occurs late but increase of the deterioration is large. The slope of such a change is compared with a preset critical slope. When the slope is large (increase is intensive) like the pattern B, the rope is evaluated to be dangerous, so that decision is made that the rope needs to be replaced. For example, in 60,000 cycles, the signal area is 200 for the pattern A and 180 for the pattern B. When evaluation is made only based on the absolute value, the pattern A is worse. However, since the pattern B has a large slope of increase, decision can be made that the pattern B is more dangerous than the pattern A. When the critical slope is set at 150 per 10,000 operating cycles in advance, the pattern A exhibits 50 per 10,000 operating cycles at the time point of elapse of 60,000 cycles while the pattern B exhibits 170 per 10,000 operating cycles which exceeds the replacement criterion.

Incidentally, the critical slope can be conceived as a critical increasing amount. Fig. 21 is a graph in which the increasing amount (slope) of the signal area is taken as the vertical axis. When the slope obtained thus exceeds a threshold value, decision is made that the rope is dangerous. In this manner, the limit of use of the rope can be found accurately and exactly.

[0036]

A mail of the thus decided result is transmitted as a warning to the second surveillance apparatus 7 from the computer 6a of the first surveillance apparatus 6. As for the computer 6a of the second apparatus 7 which has received the mail, a mail for requesting data necessary for judgment as to whether or not rope replacement is required is transmitted from the computer 7a. The requested data are image data, digital data, programs, etc. The computer 6a of the first surveillance apparatus 6 transmits the requested data to the computer 7a of the second surveillance apparatus 7.

[0037]

In the computer 7a of the second surveillance apparatus 7, the judgment function portion analyzes the transmitted data, further makes a final judgment by also examining temporal change of the data and comparison of the data with past data, and transmits the final judgment to the computer 6a of the first surveillance apparatus 6. In response to this, measures such as preparation of a new rope and dispatch of an expert to the site are taken. Thus, rope replacement can be performed without disturbance of operation of the facility on the site, so that it is possible to continue operation with high safety.

Embodiment 2

[0038]

In the invention, "measurement of rope" is not limited

to the case of detection of wire breaking. Examples of measurement contents (: measuring means) other than wire breaking include detection of corrosion: total magnetic flux method; decrease of rope diameter: outer diameter measuring device; detection of losing shape: pitch measuring device; detection of position: rotary encoder; measurement of tension: load cell; measurement of companding: displacement meter; measurement of velocity: accelerometer and rotary encoder; measurement of vibration: accelerometer; etc.

[0039]

Fig. 22 shows a second embodiment of the surveillance system according to the invention. As the measuring means, all magnetic flux data are extracted in addition to detection of magnetic leakage flux by the aforementioned rope tester 3. Further, an outer diameter measuring device 9 is disposed in a rope path to measure rope diameter successively and measure position, tension, etc. at a sheave. These detected signals converted into electric signals are analog-to-digital converted and recorded. These digitized data are sent to the computer 6a of the first surveillance apparatus 6 via a data collection board by the wireless LAN, so that the judgment function portion analyzes the data and makes a synthetic judgment while taking the status of wire breaking into account. Figs. 23(a), (b) and (c) show temporal changes (brand new, 30,000 cycles and 50,000 cycles) of the rope diameter measured

by the outer diameter measuring device 9. It can be found From Figs. 23(a), (b) and (c) that periodic reduction in diameter is in process.

[0040]

In this case, there is installed a program which sets evaluation points respectively for wire breaking, diameter decrease, corrosion, etc., and issues a warning when deterioration exceeds a predetermined evaluation point. If configuration is made thus, the necessity and time of replacement can be supervised more accurately from a remote place.

Incidentally, the rope deterioration/abnormality judgment in the invention is not for exclusion of a parameter as to whether or not a voltage exceeds a set maximum voltage, but includes synthetic judgment based on combination of this parameter and either of the aforementioned two modes.

Claims

1. A wire rope remote surveillance system characterized by comprising: a unit which measures a status of a wire rope; a first surveillance apparatus which is connected to the measuring unit by a communication unit and which records, displays and accumulates measured data output from the measuring unit, makes a judgment based on the relation with the accumulated measured data as to whether or not there is an abnormality, and issues a warning when there is an abnormality; and a second surveillance apparatus which is connected to the first surveillance apparatus through a communication unit and which exchanges data with the first surveillance apparatus, checks the data judged by the first surveillance apparatus again to make a final decision, and informs the first surveillance apparatus of the final decision.

2. A wire rope remote surveillance system according to Claim 1, wherein: the first surveillance apparatus has a measurement control portion which sets a measurement condition of the measuring unit and instructs the measuring unit to execute an operation such as start, stop or the like in the set condition, a recording and display portion which records measured data sent from the measuring unit and displays the measured data on a monitor, a collection portion which stores and accumulates data, a judgment function portion which analyzes the stored and collected data to thereby judge whether or not there is

an abnormality, and a communication portion which communicates with the second surveillance apparatus when the judgment function portion decides that there is an abnormality exceeding a set value or level and which transmits the recorded data, etc. in accordance with a request or instruction from the second surveillance apparatus; and the second surveillance apparatus has a data request judgment portion which checks an abnormality occurrence report sent from the first surveillance apparatus and judges whether or not detailed data such as image data and numerical data are to be requested, a judgment function portion which analyzes data sent from the first surveillance apparatus to thereby judge whether or not it is necessary to replace the rope, and a command sending portion which sends a result of the judgment to the first surveillance apparatus.

3. A wire rope remote surveillance system according to Claim 1, characterized in that the system uses a judgment program which divides a measurement section into segments in a lengthwise direction of the rope, analyzes increase of a measured value with passage of time in each cycle in one segment and judges whether or not there is an abnormality, based on whether or not a rate of the increase exceeds a predetermined criterion value.

4. A wire rope remote surveillance system according to any one of Claims 1 to 3, wherein the system uses a judgment program which sets wire breaking as a target of measurement of the

status of the wire rope, weights measured values respectively with a plurality of levels taken as voltage height due to the wire breaking in a measurement section, checks temporal change of the evaluated value, and makes a decision that the wire rope is abnormal when the evaluated value exceeds a permissive change rate.

5. A wire rope remote surveillance system according to any one of Claims 1 to 3, wherein the system uses a judgment program which sets wire breaking as a target of measurement of the status of the wire rope, sets, as a criterion, an integrated value (signal area value) from voltage values due to the wire breaking in a measurement section, detects change of the integrated value in accordance with the number of operating cycles, and decides that the wire rope is abnormal when the change is so large as to exceed a permissive change rate.

6. A wire rope remote surveillance system according to Claim 1, wherein measurement of the wire rope includes, in addition to detection of wire breaking, at least one of detection of corrosion, detection of decrease of rope diameter and detection of losing shape.