Detection of wire disconnection using new rope tester

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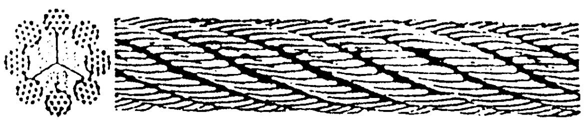
Abstract

In order to maintain the safety, it is important to examine the wire rope of an elevator. We have developed a rope tester that is a kind of sensor to detect damages of the wire rope for an elevator. The rope tester detects the damages by using leakage flux at the damaged point. The damages of the wire rope are detected and to quantitatively be recorded by the rope tester. In case of a former rope are excited the wire rope in direct current, remanence magnetic flux at a wire rope is not small and sometimes causes a misdiagnosis. In this paper, a new rope tester by AC excitation is described. The damage at the surface of the wire rope can be detected with this rope tester. The output voltages at damaged point of the rope are from 2.0 volts to 5.5 volts. It is experimentally confirmed that the output voltages are not influenced by scanning speed and the remanence magnetic flux.

Keywords: Elevator, wire rope, rope tester, leakage flux, AC excitation

1. Introduction

The inspection of the wire rope of the elevator is the important work for ensuring the safety of the passenger. We developed the flaw detector (hereafter rope tester) which applied the magnetic flux leakage method in order to detect the disconnection of wire rope [1]. By using this rope tester, we confirmed that it can measure and record the damage of the rope quantitatively. It means that the replacement prediction management of the rope becomes possible [2]. However, conventional DC excitation type rope tester makes the wire rope been magnetized. Therefore, there is a problem that the adverse effect of the residual magnetization of wire rope can not be disregarded. The wire rope has to be demagnetized before measuring. Therefore, there was the difficulty in the practice use in the application of the DC excitation. Then, we developed AC excitation type rope tester which detected the disconnection of the wire rope by the excitation of wire rope in the alternating current.



8×19 Warrington
8 strands, 19 wire per strand, 7/16 in, and smaller
8 strands, 19 wire per strand, 7/16 in, and smaller

Fig.1 Structure of wire rope for elevators.

2. Wire rope for the elevator and the strand noise

2.1 The structure of the wire rope for the elevator

The composition of the rope for the elevators (hereafter elevator rope) is shown in Fig.1. The structure of the elevator rope is strand structure which twisted the wire of the steel in 1mm diameter. The surface of the elevator rope is the roughness structure. With the use of the elevator, the elevator rope abrades, and the wire is disconnection. Therefore, the rope tester for the elevator rope must detect the disconnection of the small wire, and the supersensitive characteristic is required.

2.2 Strand noise

The strand noise is generated by the change of the distance of sensor part (probe head or detection coil) and rope surface of rope tester. Therefore, the period of the strand noise is the correspondent to the roughness of the surface of the wire rope. Frequency f_{sn} of the strand noise is given in the following equation;

$$f_{sn} = v/r \quad \text{[Hz]} \qquad (1)$$

Where, v: The mobile speed of the rope [m/s], r: Strand pitch of the rope (r = 10 mm) [m].

3. The operation principle of AC excitation type rope tester

3.1 Appearance and composition

The Appearance of the new rope tester is shown in Fig.2. The new rope tester consists of sensor part and system unit. The AC excitation frequency of the new rope tester is 50 kHz. The sensor part detects a magnetic flux which is emitted from part of damage, and it is converted into the induced voltage. Alternating current is generated in a system unit, and the noise which is included for the induced voltage from sensor part is eliminated. This AC excitation type rope tester can be applied to ϕ12mm wire rope for the elevator.

Fig.2 Appearance of the new rope tester.

3.2 Basic structure of the sensor part

The detection principle of the damage of this rope tester is based on the magnetic flux leakage method [3]. The sensor assembly of previous AC type is shown in Fig.3. The sensor part consists of excitation part and detecting part. The excitation part consists of exciting coil and excitation yoke.

The excitation yoke and the detection coil are made U-shaped in order to simplify the mounting/dismounting of the wire rope. The excitation yoke is made of laminated silicon steel plate, so AC frequency is 50/60 Hz (commercial power supply). The number of turns of exciting coil is 20. The number of turns of the detection coil is 100.

Basic structure of new sensor part is shown in Fig.4. New sensor part consists of just saddle structured exciting coils and pickup coil. The exciting frequency is 50 kHz, when the new sensor is used. The number of turns of exciting coil 1 and 2 are 100 respectively. The number of turns of the pickup coil is 150.

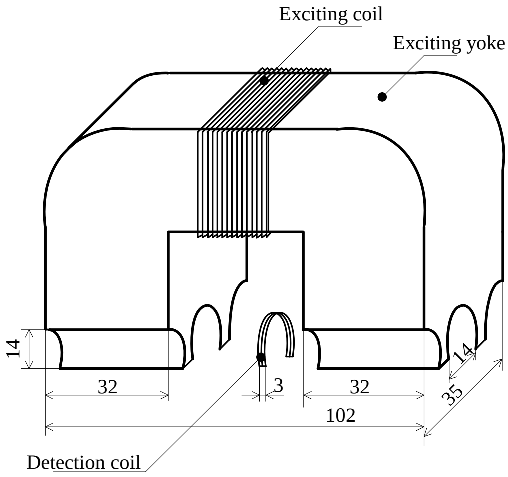


Fig.3 Previous sensor part (Unit: mm).

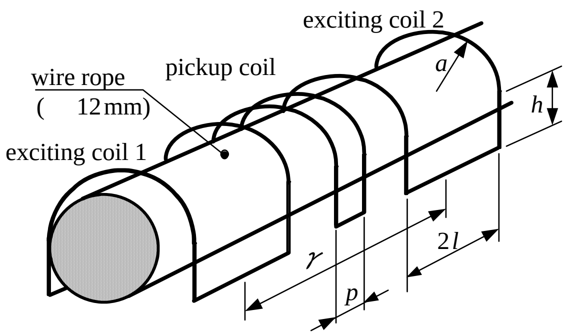


Fig.4 New sensor part.

A magnetic flux leaks out from the disconnection parts of excited wire rope, and the voltage is induced in the detection or pickup coil. Induced voltage V_e is given in the following equation;

$$V_e = -N f \varphi \qquad [V] \qquad (2)$$

Where, V_e: The induction voltage of the detection coil [V], N: Number of turns of the coil, f: The frequency of the exciting current [Hz], φ: The leakage flux from wire rope linked in the detection coil [Wb].

3.3 Block diagram of the system unit

Signal processing block diagram of the AC excitation type rope tester is shown in Fig.5. The induction voltage is amplified in the amplifier circuit, and the noise is eliminated by the band pass filter circuit. The existence of the disconnection is diagnosed by counter and meter.

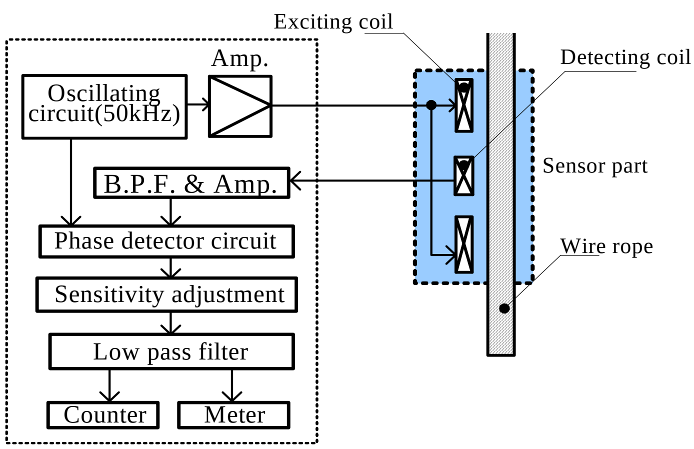
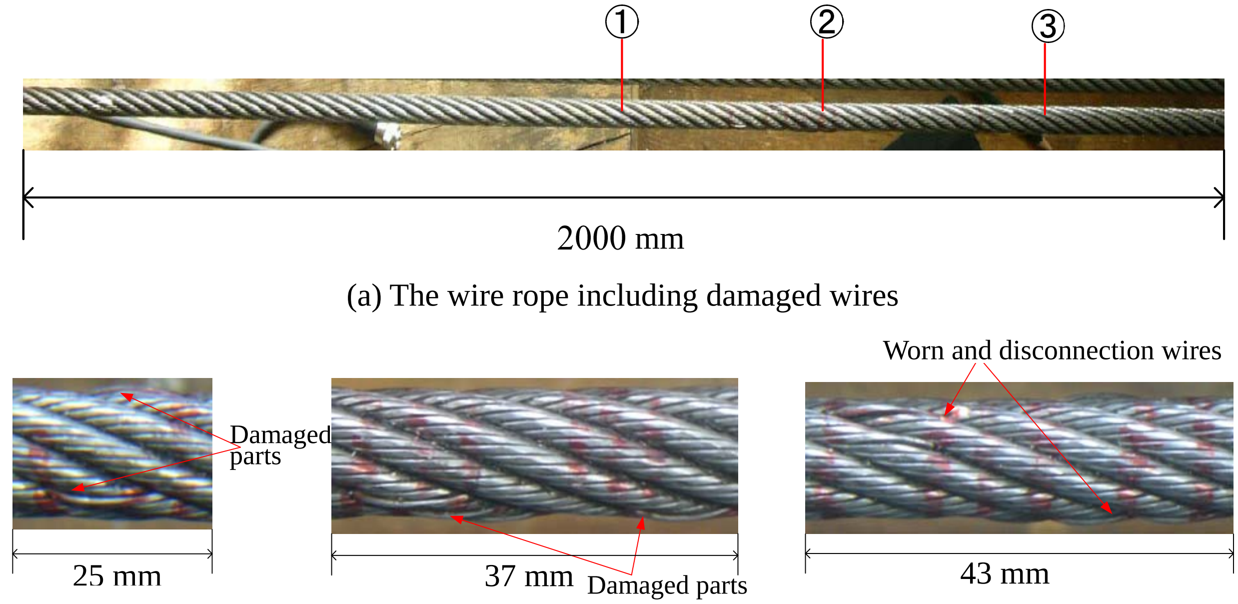


Fig.5 Block diagram of the signal processing.

4. The basic property of AC excitation type rope tester

4.1 Measurement method

The wire rope is moved by driving the elevator, and the damage of the wire rope is measured using the AC excitation type rope tester. The damaged wire rope and its enlarged views are shown in Fig.6. The parts with the damage over the standard were shown in the enlarged views, (b), (c) and (d). The measured wire rope is actually used for the elevator. As shown in Fig.6, disconnection of a wire rope is confirmed by viewing. In test measurement, a new wire rope without the damaged part was also prepared in order to know the SN ratio of the disconnection signal.



(a) The wire rope including damaged wires

(b) Enlarged part① (c) Enlarged part② (d) Enlarged part③

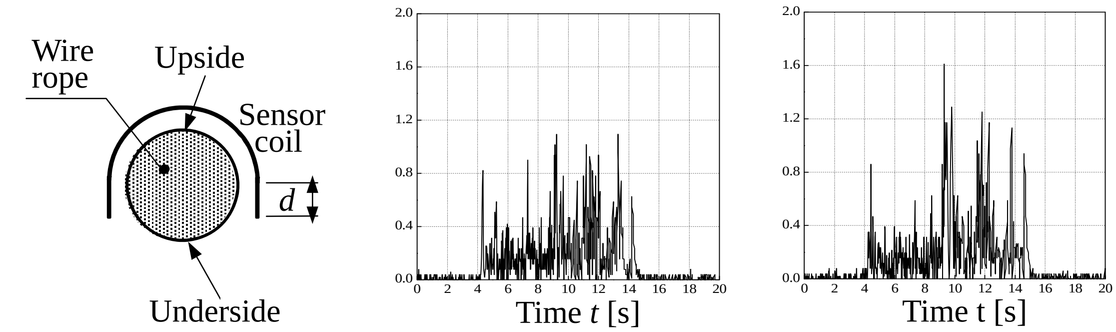
Fig.6 The damaged wire rope and its enlarged parts (Diameter of rope: ϕ12mm).

4.2 The effect of the position of disconnection wire

Excitation yoke and detection or pickup coil are U-shaped. Therefore, the output voltage changes by the position of disconnecting wire. The effect of the positional relation of disconnection wire and sensor part on output voltage was confirmed by the observation. The result by the observation of the effect of sensor part and wire disconnecting of the positional relation on output voltage is shown in Fig.7. The output voltage became a maximum, when the wire had been disconnection in just under of the detection or pickup coil (upside). The output voltage became a minimum, when the wire had been disconnection in the side where there were no detection coil and excitation yoke (underside). The effect of the position of the wire disconnecting is large, and the difference of minimum value and maximum value was 0.5 V.

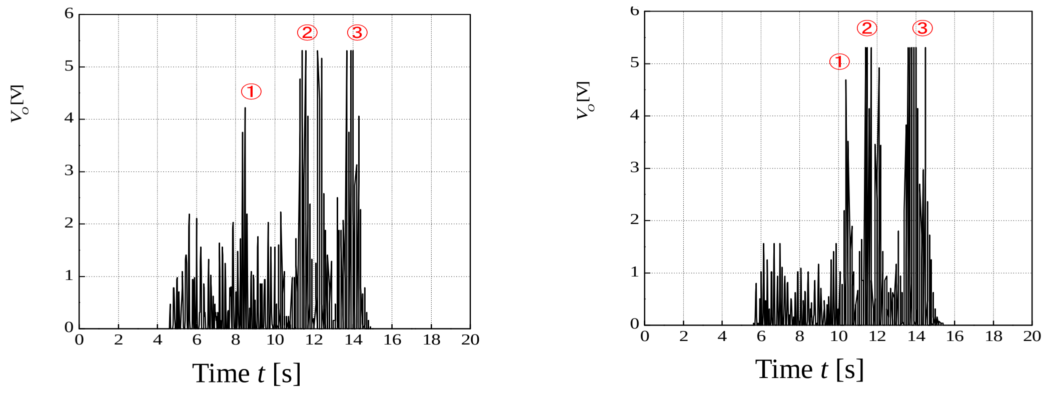
4.3 The detection of the wire disconnecting

The output voltage waveform is shown in Fig.8. The pulse wave was confirmed corresponding to the position where disconnection was confirmed by viewing. 3 times were measured in order to confirm the reproducibility of the measurement. The similar pulse wave was also able to confirm anyway.

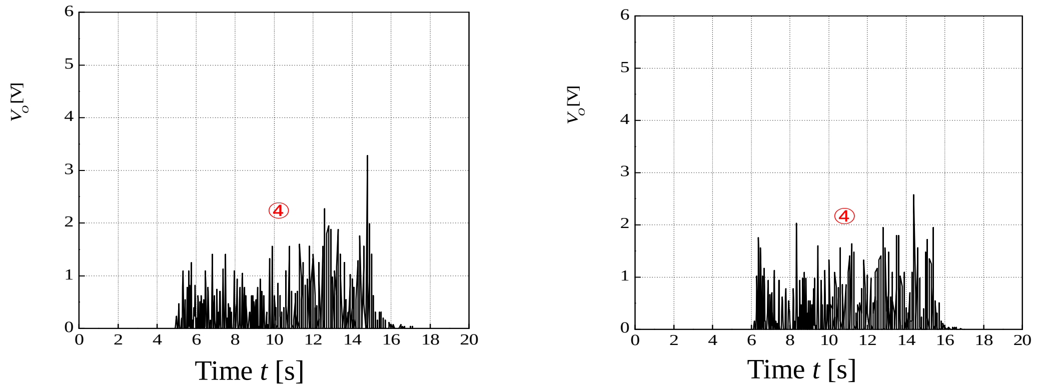


(a) Wire rope and sensor coil (b) Output with underside (b) Output with upside

Fig.7 The output voltage by the position of the sensor coil for the wire rope.



(a) Upside of the damaged wire rope (b) Underside of the damaged wire rope



(c) Upside of a new wire rope (d) Underside of a new wire rope

Fig.8 Output of the new rope tester (scanning speed: 7.5 m/min)

4.4 The measurement of the effect of the residual magnetism

The effect of the residual magnetism of wire rope on output voltage was confirmed by the observation. It was magnetized at 2 places of wire rope. They were magnetized by the permanent magnet. The wire rope of a new article without the wire disconnecting is also used.

The effect by the residual magnetism is shown in Fig.9 and 10. In the conventional DC excitation type rope tester, the influence of the residual magnetism has appeared. However, there was no influence in the AC excitation type rope tester.

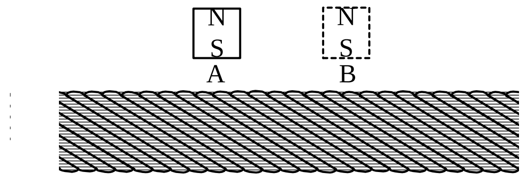


Fig.9 Magnetization method.

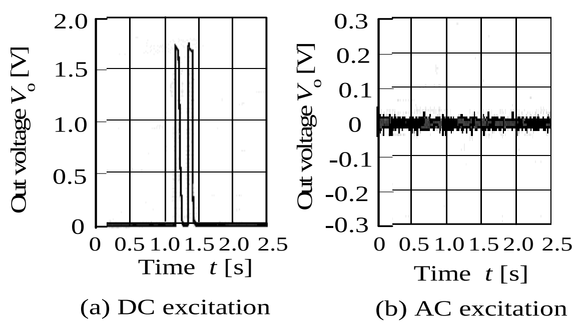


Fig.10 Influence of residual magnetic flux (v=0.25 m/s).

5. Conclusion

The conclusion is described as follows.

(1) Structure of the elevator rope and mechanism of the generation of the strand noise is shown. The frequency of the strand noise is expressed using the equation.

(2) The sensor parts of previous and new AC excitation type rope tester are shown. The damage signal is surely able to be detected by using these sensors.

(3) Basic structure and detection principle of AC excitation type rope tester is shown. And the basic property is measured. The detecting voltages were 2.5 V or more. And, it is confirmed that AC excitation rope tester was not affected by the residual magnetism of the rope.

It is confirmed that it can detect the disconnection of the wire rope of the elevator by using the AC excitation type rope tester. And, it is able to confirm that output voltage was not affected by residual magnetism using an AC excitation type rope tester.

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