WIRE ROPE
TECHNOLOGY AACHEN

Magnetism in rope wires

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Content

Quite often we find things that we are not looking for at the time. This paper describes such an occasion - magnetic effects on rope wires first noticed by the author in 1978 during routine use of a scanning electron microscope. Since then, and many wire samples later, the data suggests that wires subject to tension-tension fatigue become strongly magnetised, and to a lesser degree those subject to bending fatigue also exhibit the same tendency.

1. Introduction

When analysing used steel wire ropes, from time to time you come across magnetic steel wires. These wires were not magnetic when the rope was made, so they must have become so in service. But how?

The obvious explanation is that the steel wire rope has been NDT tested using a magnetic tester. During such a test, the rope will be magnetised to saturation, and often the rope wires remain slightly magnetised afterwards. This is one of the reasons, by the way, why magnetic markers on ropes cannot be used in mining ropes: The magnetic marker would be overwritten during the mandatory NDT inspection.

Another possible explanation for magnetism in rope wires could be that the wires have become magnetic because of their mode of operation.

Being non magnetic for a steel body only means that in its structure the magnetic dipoles are arranged randomly. These can be orientated, however, by subjecting them to a magnetic field.

All wire ropes are permanently subjected to a magnetic field: the magnetic field of the earth. But why do some become magnetic and others not?

The author has collected magnetic samples over years and now dares to present a first hypothesis.

2. The first indicators

When a wire sample is analysed in a scanning electron microscope (Fig. 1) it is put in a vacuum chamber (Fig. 2). After evacuating the chamber, a high voltage is applied between a heated cathode and the specimen which acts as an anode. Electrons are then emitted from the cathode and accelerated towards the specimen. A scintillator then detects the secondary electrons emitted from the specimen, and an image of the specimen surface can be created.

If the rope wire, however, is magnetic, its magnetic field affects the electron beam, and the image collapses. This is why detecting magnetism in rope wires is so easy when using a scanning electron microscope: When the microscope does not work properly, one of the possible causes is magnetism of the specimen. A demagnetiser is part of the standard equipment.

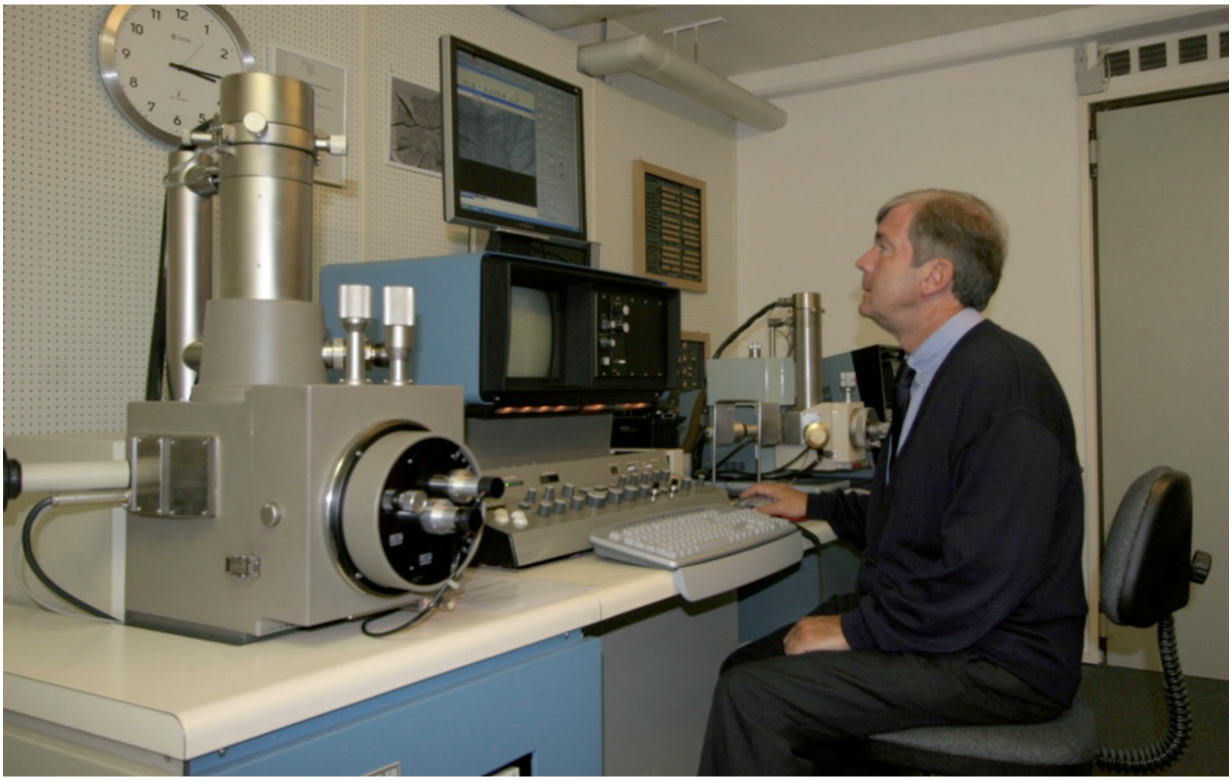

Fig. 1: A Scanning Electron Microscope (SEM)

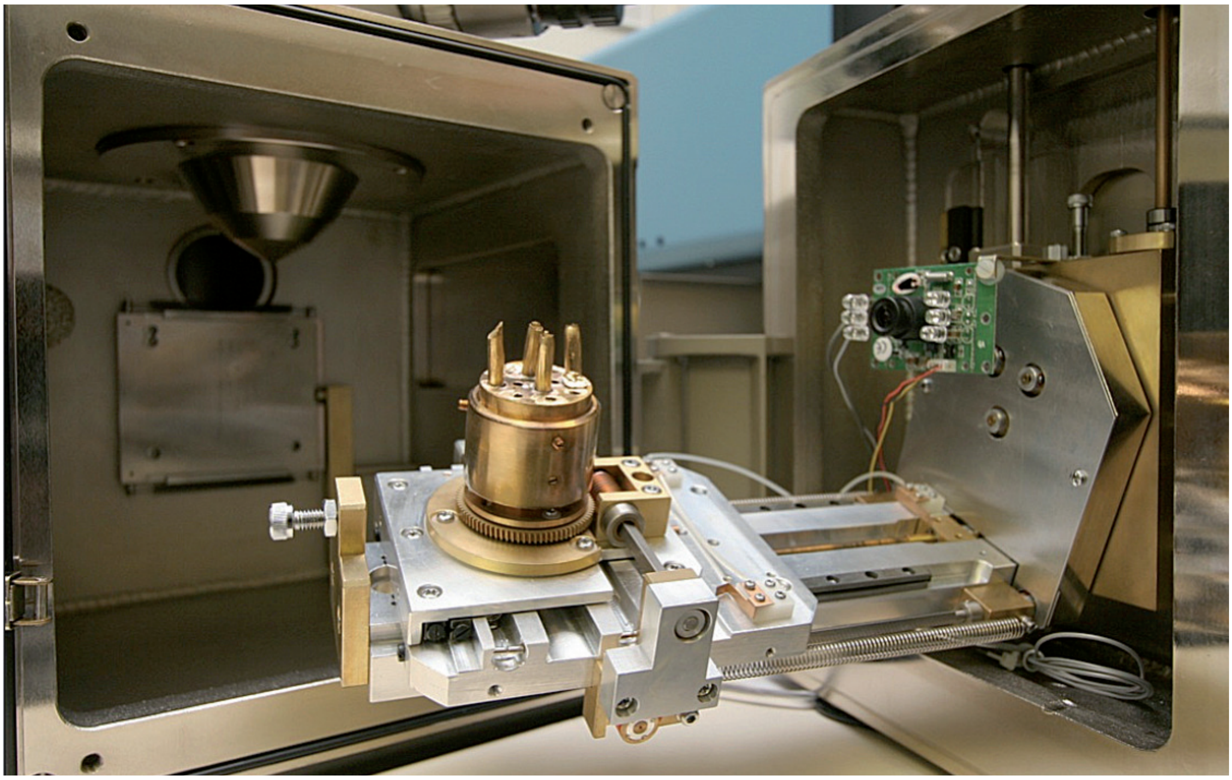

Fig. 2: Detail of the vacuum chamber of a scanning electron microscope. This chamber can be seen closed at the left hand side of Fig. 1.

The author has been analysing rope wires in scanning electron microscopes since 1978 [1]. In many cases where a wire had to be demagnetised in order to stabilise the image created by the microscope, the wire break surface later revealed the typical structure of a wire that has fatigued in bending fatigue or tension-tension mode (Fig. 3).

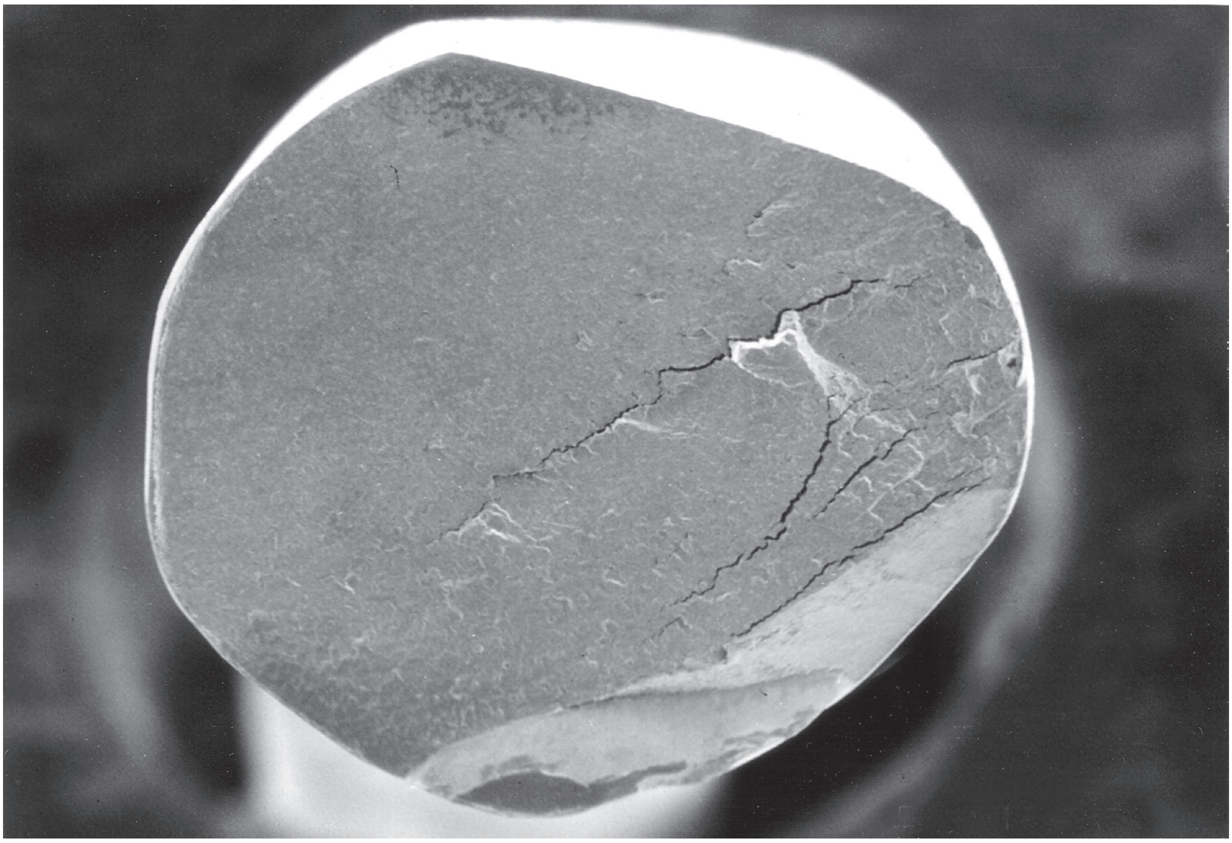

Fig. 3: Typical fracture surface of a wire which has failed owing to tension-tension fatigue

3. Laboratory tests

The author has therefore subjected several steel wire ropes to both bending fatigue and tension-tension fatigue tests. It could be stated that tension-tension fatigue created a high degree of magnetism, and bending fatigue a lesser degree. This could simply be measured by using iron powder (iron filings) which was either attracted by the wire (Fig. 4).

Further tests will reveal whether the frequency or the e.g. the amplitude of the tension-tension test or the D/d ratio in a bending fatigue test has an influence on the degree of magnetism.

Fig. 4: The wire fracture end of of wire which has failed due to tension- tension fatigue after dipping it into iron powder. The wire is highly magnetic.

4. A practical example

The author was called to an amusement park in Sweden in 2005. One of two steel wire ropes used to launch the train of a roller coaster had failed during a launching operation. The rope had broken close to the socket. The user of the installation attributed the failure to a single overload which had occurred during the launch.

An investigation in the vicinity of the break, however, showed a great number of fatigue fractures. Of course, a single overload does not create fatigue breaks. An examination of the second rope, which had not failed, showed the same fatigue wire breaks in the same rope area. And all fatigued wires in both ropes were extremely magnetic!

It was directly clear that these observations would strengthen the hypothesis mentioned above, because these rope sections had never travelled over sheaves. The fatigue which had created the wire breaks (and the magnetism) could therefore only be tension-tension fatigue.

The author analysed the wires in the scanning electron microscope, and the typical structure for tension-tension fatigue was found.

Fig. 5 shows a wire from the roller coaster in the original, non demagnetised condition. Because of the disturbance from the magnetic field of the wire the image quality is not too good.

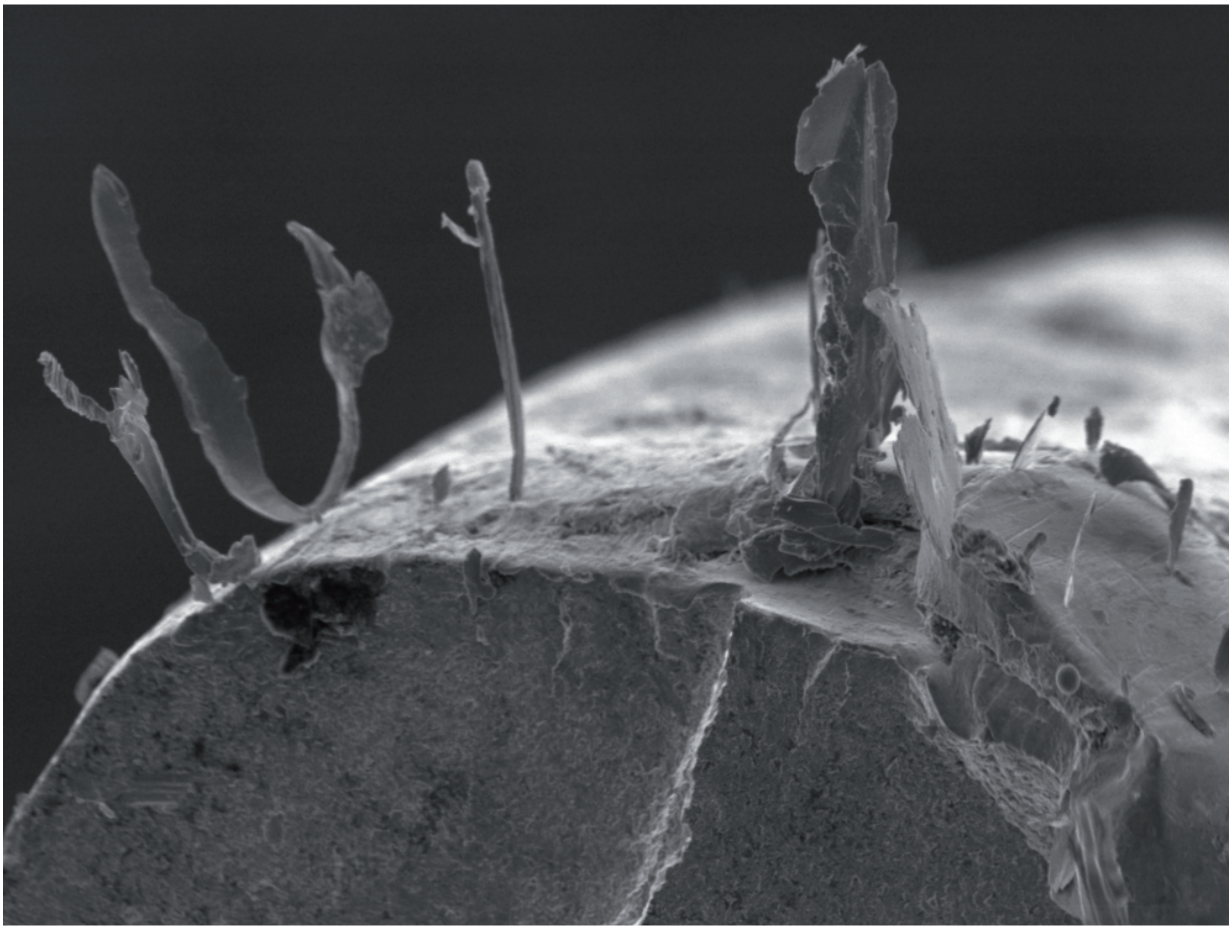

Fig. 5: Typical fracture surface of a wire which has failed owing to tension-tension fatigue

Further analysis of the rope forces in the launch system of the roller coaster revealed that the two ropes did not work as a pair. Therefore the pusher system would tilt and get stuck several times during the launch. Instead of being loaded and unloaded once during a typical launch, the ropes would continuously be overloaded and unloaded many times during one single launch.

5. Postscript

The author has also found another reference of wire magnetism, and, funnily enough, this magnetism was detected on an almost identical roller coaster in the Netherlands [2]. In this case, the magnetism in the rope wire had been explained by a lightning strike, although no impact traces of a lightning are reported in the paper. The author is convinced that in this case of the Dutch roller coaster the failure mechanism was the same as described above, and that the reason for the wire magnetism was also tension-tension fatigue.

References

[1] Verreet, R. & Ridge, I.M.L. : *Wire rope forensics.* The 10th International North Sea Offshore Crane Conference, Stavanger, 10th-12th May 2005 48pp. Available for download from www.ropetechnology.com

[2] Wiek, L.: *Wire rope fracture by exceptional damage.* Proceedings of the OIPEEC Technical Meeting “Experiences with ropes” Lenzburg, Switzerland 1st – 3rd September 2003, ed. I.M.L. Ridge ODN 0748 pp109-115. ISBN: 070491185X, and OIPEEC Bulletin No. 88, 23-29, ISBN: 1018 8819.

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