The Induction Motor as a Mechanical Fault Sensor in Elevator Systems

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1. Abstract

An efficient maintenance carried out on a building elevator system can contribute to guarantee a safer people transportation. An elevator failure must be avoided as much as possible, as it may have negative consequences on different levels, as fear, trust lack, people's elevator phobia or even people's life.

This paper presents a method that uses the induction motor as a sensor, to diagnose mechanical faults in the worm gear reducer of an elevator system. This study complements another work already done, by the same authors, concerning elevator guides remote monitoring.

Key words: induction motor, mechanical fault, remote monitoring, worm gears.

2. Introduction

"Lifts provide an essential means of comfortable and safe access to modern buildings. (...) The safety of lifts installations may be considered practically absolute, so much so that it may be said, backed up by incontrovertible data, that today the lift is the safest means of transport that people can use" [1].

In order to achieve this goal, maintenance routines include cleaning, lubricating, bulb replacements, inspecting and adjusting of components to ensure the correct functioning and safety of the elevator installation. Besides, by law, lifts must have a valid Certificate of Lift Maintenance and Testing.

Maintenance companies have a large group of lift machines to look after and may not be able to follow precision maintenance practices as they should. To evaluate equipment condition, predictive maintenance can take advantage of non-intrusive testing method, such as the motor current signature analysis.

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3. Induction Motor Current Analysis

Motor Current Signature Analysis (MCSA) is a diagnosis methodology based on the recognition that an induction motor, driving a mechanical system, also acts as an efficient and permanently connected transducer, detecting short torque variations generated within the mechanical system. MCSA has been used for condition monitoring of different mechanical components such as bearings [2], motor fan [3], rotor unbalance [4] and gearboxes [5], giving information about the fault localization. A mechanical load fault associated with the increase of the torque demand, caused by a mechanical failure in the worm gear reducer of an elevator, can be seen, by the induction motor, as a load torque variation. There is a cause-effect between a load torque fluctuation and a stator current signature. Using the elevator induction motor as a torque sensor of its own driven load can be a valuable method to quickly diagnose the entire mechanical system.

4. Analysis of the Worm gear Reducer Fed by the Induction Motor of an Elevator

The worm gearing is used in elevator systems because a large torque is needed at the driven shaft at a greatly reduced speed.

Fig. 1: Worm gears.

The worm, with its continuous helix, forms one continuous tooth, engaging the worm wheel (Fig. 1).

Worm gears are inefficient because gears experience sliding, rather than rolling contacts, presenting surface wear (Fig. 2) and unique lubricating demands.

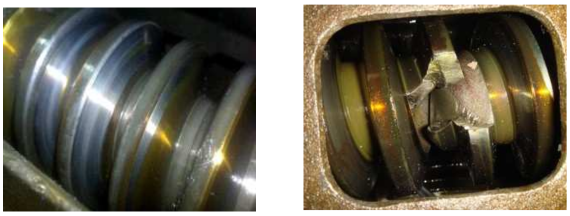

Fig. 2: Detail of a worm showing surface wear (left); detail of a broken worm (right).

With a worm gear, sliding motion is the only way power is transferred. As the worm slides across the teeth of the wheel, it slowly rubs off the lubricant film, until there is no lubricant film left, and as a result, the worm rubs at the metal of the wheel in a boundary lubrication regime. When the worm surface leaves the wheel surface, it picks up more lubricant, and starts the process over again on the next revolution [6].

For satisfactory performance, the total gear tooth load, also called the dynamic load Fd, must be less than the strength of the bending fatigue, Fb, and surface fatigue Fs strengths. When this condition is not fulfilled a machine breakdown may occur: the teeth may crack or even the worm may break (Fig. 2).

In order to study and prevent failures within the worm gear reducer, several tests and measurements were made using the Motor Current Signature Analysis (MCSA).

5. Experimental Setup

The tests were carried out using a 4.4/1.1 kW induction motor, 1400/310 rpm and a 1/45 reducer. The driving elevator set, composed by an induction motor, worm gear reducer, clamping brake and grooved sheave, was used in order to find how far the Motor Current Signature Analysis could be helpful in worm gear mechanical fault diagnosis. The induction motor current was measured and it was found that a repetitive signal appeared in the absorbed current (Fig. 3).

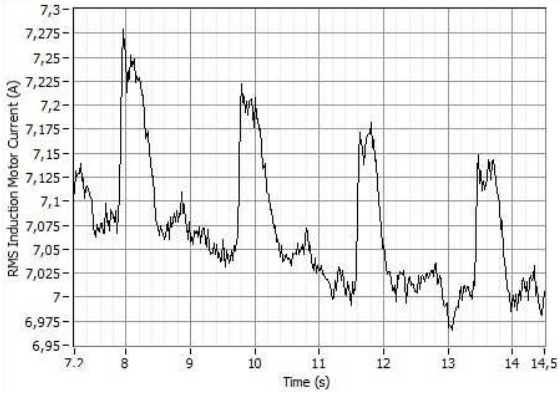

Fig.3: The induction motor current was measured at 1400 rpm.

The reducer was disassembled and some damaged teeth were found in the worm wheel (Fig. 4). This kind of damage could be caused by incorrect handling during assembly operations.

Fig. 4: Detail of a worm wheel showing tooth damage.

The periodic induction motor current signals, due to mechanical faults in the wheel worm reducer, can be easily distinguished from the ones due to the guides support misalignment, presented in a previous paper [7]: the time intervals are different and also the ones due to the guide problems have normally different amplitudes, as the support misadjustments are not closely related to each other.

6. Conclusion

This paper presents an experimental study in order to understand the current signature of an induction motor that drives a worm gear used in elevator systems. The results showed that this method may contribute to remote monitoring of this kind of faults. Thus, besides its main role of supplying mechanical energy to the load, the induction motor can play a second role as an efficient and permanently connected transducer, helping to detect faults within its mechanical load system.

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