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A Reliable Forecast of Lift System Wear

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INTRODUCTION

Lift System Condition Monitoring to support servicing activities has hitherto been restricted to calling up fault storages of the actual lift control systems and occasionally of the lift drive units, each manufacturer using its own concepts.
Sensors detecting the amount of wear in a lift system are currently used – if at all – in form of mobile systems only. They allow random tests to be made of the cab's acceleration behaviour, to determine how the noise is developing or to detect the rope tension and put respective measurements at the technician's disposal uncommented.
Such systems are used to conduct initial tests aiming at converting the interval-based maintenance activities common to lift systems into a condition-oriented or even proactive maintenance.

POINT OF DEPARTURE

Current maintenance strategies for lift systems. The lift system maintenance concept prevailing worldwide is a combination of reactive, preventive and in initial stages also condition-oriented servicing activities. Preventive maintenance of lift systems is carried out on the basis of intervals: within fixed intervals or after reaching a certain number of rides service technicians initiate measures to retard any further reduction of the wear potential e.g. by topping up gearbox oil, greasing the guide rails, etc. At the same time they usually check the degree of wear of certain lift components such as guide shoes or brake linings. The latter is already a first and simple attempt to carry out a condition-oriented service: based on the information available (e.g. of the wear), deadlines are determined on which components need to be replaced in order to prevent any unplanned system failure or even a safety-critical condition to develop.

Condition Monitoring in an industrial environment. Today and in nearly all industrial areas Condition Monitoring is one of the mainstays needed to efficiently operate and service technical plants. This concept is based on a regular and/or permanent recording of the condition of the machine by measuring and analysing meaningful physical parameters. The technological developments achieved in sensor technology, tribology and microprocessor technology allow an unparalleled quantity and quality of information to be used for the maintenance of production machinery. An industrial environment cannot be pictured without Condition Monitoring any more. It must more or less be regarded as a compelling requirement for a condition-oriented and/or proactive maintenance.
The benefit of Condition Monitoring. The more comprehensive the maintenance strategy and the requirements it has to meet, the more distinctive will be the significance of Condition Monitoring.
In trying to achieve maximum plant efficiency, Condition Monitoring can be of assistance in a number of ways:

- by improving the safety against failure on the basis of efficient forecasts relating to defects (and the resulting prevention),
- by minimising downtimes on the basis of an integrated planning of repair measures specified by the Condition Monitoring,

- by maximising the service life of components by preventing any conditions that shorten the life, and
- by a cost-reducing and nearly full use of the component's wear potential.

Condition Monitoring is composed of three steps:

1. determining the condition, i.e. measuring and documenting relevant machine parameters reflecting the current condition of the machine,
2. comparing the condition; reflecting the comparison of the actual condition with a specified reference value (with a growing plant complexity usually determined empirically) and
3. the diagnosis which has to use a comparison of the condition to pinpoint any possible fault as early as possible and to determine its cause.

CONDITION MONITORING IN LIFT SYSTEMS

Hardly any technical measuring systems are offered on the lift market for the first of the Condition Monitoring steps, the determination of the condition. It is only for the intermittent monitoring of vibration and noise data that ride quality measuring systems conform to ISO 18738 such as the EVA system[1] or the LiftPC system[2] can be used. These for example allow information on the condition of the system to be recorded at the time inspections are carried out and long-term developments to be established. But short-term or transient events cannot be detected and a link with other data such as the load condition, temperature, etc. is quite difficult.

A continuous monitoring of the physical lift system parameters in real time would allow long-term trends as well as erratic or transient changes in condition to be recorded. Any subsequent comparisons of the condition and diagnosis algorithms could then fall back on a comprehensive data stock and generate maintenance suggestions.

Condition Monitoring pilot project in lift systems. As early as 2004 Henning installed prototypes of a lift system condition monitoring system in eleven lift systems of the chemicals group BASF. Apart from acceleration and vibration sensors, also sensors monitoring the traction sheave speed, the current hoisting height, the overall cab load and the individual rope tensions were used. The measurements were analysed by an industrial personal computer located directly at the lift system and the results of this analysis were transferred by remote data transmission to a data centre. The main component of the Condition Monitoring system, a vibration and acceleration sensor, was directly fitted on top of the cab. In this position it could record the actual ride movements of the cab as well as the cab guides, door movements and - indirectly via the ropes - also the behaviour of the drive unit.

For each ride the recorded data of all sensors were converted to specific characteristic values and checked to see if they exceeded any limits. Then the characteristic values of each ride of one day were combined to one statistic mean value. These mean values resulting from several hundred rides per day were used for actual trend monitoring purposes. The following two examples e.g. show a trend over several days based again on thousands of rides.

[1] www.pmtvib.com
[2] www.henning-gmbh.de

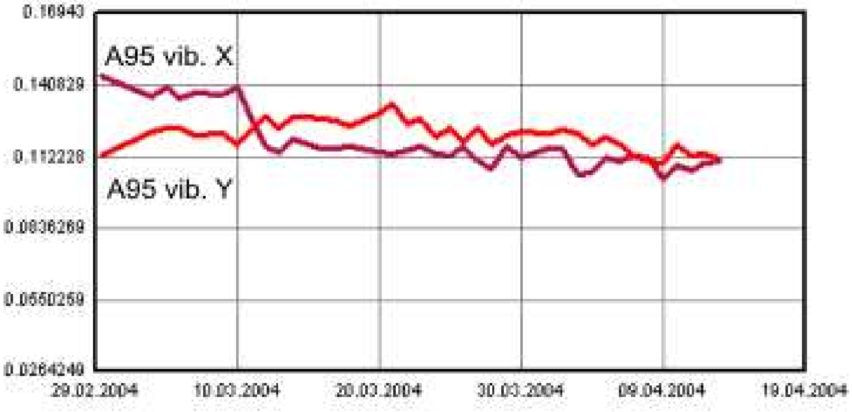

Figure 1: Vibration behaviour of the lift cab in the two horizontal directions in space. One clearly recognises the replacement of the cab guides on March 11.

At the start of the recording period shown in Fig. 1 the slide guides of the cab are already worn out. On March 11, 2004, the guides were replaced by new guide shoes. One clearly recognises that the vibrations in direction X (vertical to the actual distance between guide rails) are reduced immediately. On the other hand the vibration behaviour parallel to the actual distance between guide rails increases before again dropping to the original value after a period of some 25 days. The vibration course in direction Y can be explained by a non homogenous actual distance between guide rails over the entire hoisting height of the lift system: the new slide guides must be allowed to first "grind in" in this direction is space. The diagram shown now simply allows a limit to be determined for the vibration behaviour in direction X which the system is not allowed to exceed and – should it be exceeded – a guide shoe maintenance suggestion to be tripped.

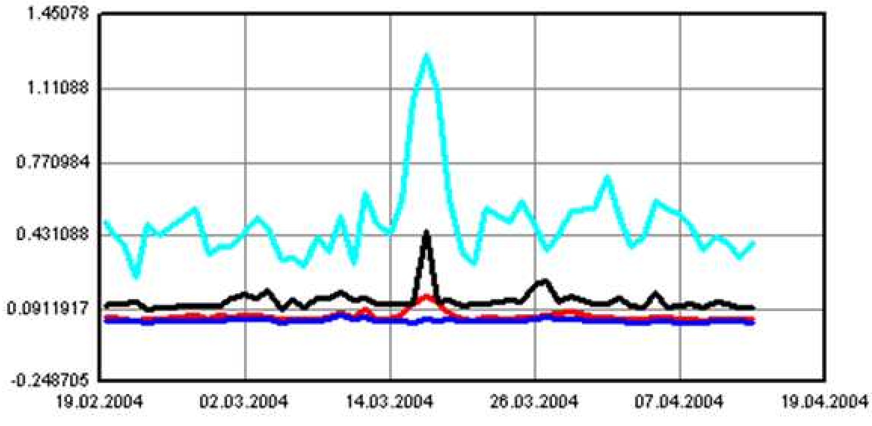

Figure 2: Characteristic vibration values of the movements of the cab door. One clearly recognises that the movement is impaired between March 15 and 17.

The second example (Fig. 2) shows four characteristic vibration values for the door movements. The period between March 15 and 17 is out of the ordinary, the event being of a sporadic nature this time: the guides of the cab door were contaminated by winter grit probably originating from the tyres of a fork lift truck. In this particular case the automatic door monitoring system tripped an alarm and the fault was eliminated within a relatively short time so that door rollers and guides could not suffer consequential damages.

Apart from the vibration data a measurement of the individual rope tensions and of the loading condition has proven to be extremely relevant. As a matter of course the loading condition affects the vibration levels so that these can only be evaluated in combination with the actual load. The individual rope tensions in the rope set should also be taken into account. A replacement of the motor torque by the motor speed generates a trend in the lift industry to use increasingly thinner ropes and higher suspension ratios. Rope research shows that the rope bending capacity is continuously reducing with the diameter [1]. A smaller traction sheave diameter to rope diameter ratio (D/d) additionally reduces the bending capacity; this also applies to multiple rope deviations. This immensely boosts the influence of only one badly adjusted rope of one rope set: the wear of the rope can for example reduce the life of the entire rope set by 60 % if one rope merely deviates by 15 % from the mean value of the single rope loads (see calculation of the rope life by K. Feyrer [2]).

Based on the pilot project conclusions and the exhaustive examination of measuring methods suitable for lift systems, Messrs. Henning have devised in the past few years a Condition Monitoring system for lifts the development of which will be completed at the end of 2012 with a field test in Germany. This system uses an intelligent vibration sensor permanently monitoring the wear of important lift system components. The sensor is mounted on top of the cab and autonomously detects (without being connected to the lift control system) the current ride condition so that door movements, ride starts, constant rides, etc. can be examined separately. In each of these ride conditions significant characteristic values are generated which in their entirety allow long-term trends as well as erratic or transient changes in condition to be detected and fully documented. Even gearboxes and motors can be indirectly recorded since vibrations are transmitted to the sensor via the suspension gear. The sensor is able to make a distinction between numerous wear aspects of critical components such as doors, drive units and guides. At the same time sensors detect the load on each suspension rope and therefore also the load in the cab.

The system has adequate interfaces allowing it to be connected to higher-ranking building management systems. Under favourable conditions, significant changes in the transmitted characteristic values will then generate a warning well before the failure limit of a component is reached so that the required servicing activity can be planned in advance and is no longer subject to fixed maintenance intervals.

SUMMARY

Condition Monitoring already widely used in other branches of industry is still largely ignored in the lift industry. Even though only a small number of lift systems need servicing strategies ending up in a condition-oriented and proactive maintenance, a cost-intensive preventive servicing strategy is the only alternative for lift systems which are part of a production process, which are used in public sectors to secure the mobility of people with physical impairments or which are indispensable for representation purposes. The partially massive cost reductions affecting lift components in the past few years can only be compensated by adequate countermeasures in form of a monitoring of safety-relevant and function-critical components. Automatic Condition Monitoring systems provide an efficient solution and warrant an optimum resource efficiency combined with a high plant availability.

REFERENCES

[1] Dr. W. Scheunemann, “Randbedingungen für den Einsatz von Tragseilen unter 8 mm im Aufzug”. *Schwelmer Symposium*, (2007).

[2] K. Feyrer, *Drahtseile: Bemessung, Betrieb, Sicherheit.* Springer Verlag, Berlin Heidelberg New York, 2. Auflage (2000).