TECHNICAL DIAGNOSTICS OF VENTILATION INSTALLATIONS

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ABSTRACT: The operating reliability of the ventilators, the air compressors and the air distribution systems is of great importance for the industrial productions, connected with the liberation of noxious and explosion hazardous emissions. The present article examines vibration methods for technical diagnostics of ventilation installations. It also provides analyses in connection with the applicability of the respective acoustic and vibration indicators to specific meetings of the mechanical system with the purpose of providing an optimum diagnostic reliability.

ТЕХНИЧЕСКА ДИАГНОСТИКА НА ВЕНТИЛАЦИОННИ УРЕДБИ

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РЕЗЮМЕ: Експлоатационната надеждност на вентилаторите, въздуходувките и системите за разпределение на въздух е от съществено значение за промишлените производства, свързани с отделяне на вредни и взривоопасни емисии. В настоящата статия се разглеждат вибрационни методи за техническа диагностика на вентилационни уредби. В разработката се анализира, приложимостта на съответните акустични и вибрационни показатели към конкретни възли от механичната система, с цел осигуряване на оптимална достоверност на диагнозата.

Introduction

The operating reliability of the ventilators, the air compressors and the air distribution systems is of great importance for the industrial productions, connected with the liberation of noxious and explosion hazardous emissions. The control of these installations is regulated by the normative base for operating safety and sanitary labour standards in connection with the chemical composition of the air flow for the presence of noxious elements. The standard operation of the ventilation installations is mainly guaranteed by the good technical condition of the ventilation installations. A great number of methods, apparatuses and program resources for control and technical diagnostics of machine units were adopted during the past years. However, their practical application required the development of methods of control, including a system of indicators for control and apparatus resources that are in conformity with the technical characteristics of the specific object. The systems for control and ventilation installations are mainly based on the control of the vibrations.

Methodical approach for structuring a vibration control system

Structuring an appropriate vibration control and diagnostics system is implemented on the basis of the diagnostics of separate elements in accordance with the technical characteristics of the object and of its specific forming elements. In this specific case, the vibration control system of one ventilation installation shall consist of methods for diagnosing the work machine – a ventilator, of roller bearings, of the gearings and the connectors, as well as non-axes, lack of balance and others. The main purpose of the diagnostic methods is defining the work frequencies of the elements, the frequency ranges of control and illustrative vibration indicators for symptom expression in connection with damages. Moreover, the number and the location of the measurement points are to be determined, as well as the direction in which the vibrations are to be measured.

Normal practice is to take readings in three directions horizontal, vertical (these two for radial vibration), and axial.

Axial vibration is often caused by misalignment of the shaft.
Radial vibration, measured in the horizontal direction, is most representative of balance conditions. The reading in the vertical directions tends to give information about structural weakness.

To select the right frequency range for a vibration measurement, have to consider the rotational speeds of the various machine parts (fig.1 and fig.2).

These are primarily controlled by the rpm of the motor, and secondarily by the reduction rate of the gear box.

As input data we also need the number of gear teeth Z on the driving gear, the number of blades on the fan and, if we want to make a vibration analysis for the bearings, their ISO number and manufacturer.

For the purpose of clarity, a model of a ventilation installation of specific technical data has been used.

In the spectrum, can expect a number of lines for the first shaft (fig.1):

f1 is at 1X, the natural frequency of the driving shaft, 50 Hz. A misaligned coupling can cause lines (f2) at 2X and 3X (there can be more multiples of 1X).

The gear mesh frequency is 1X * Z1 (teeth on the driving gear), the modulation producing the side bands is 1X. The gear mesh pattern can have harmonics at multiples of 1X*Z1

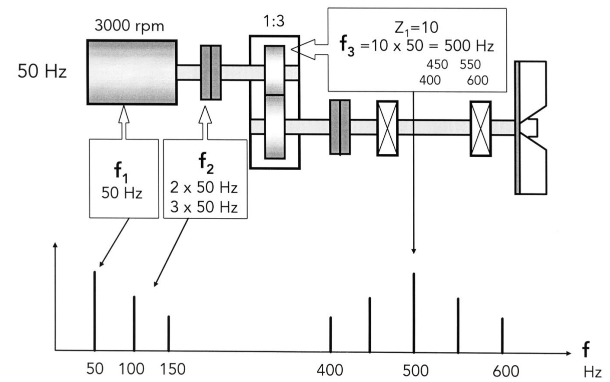

fig.1. Spectrum lines, first shaft

With a reduction of 1:3, the natural frequency f6 of the second shaft is 16.666 Hz (fig.2). This is the modulation frequency for the gear mesh symptom in case the gear wheel on this shaft has damaged teeth. Multiple of 16.666 Hz indicate misalignment and/or looseness on the second shaft.

For a fan with five blades, the blade pass frequency f7 is 5*16.666 Hz = 83.333 Hz.

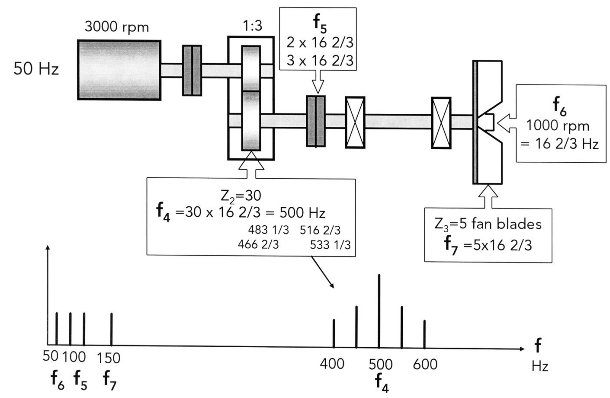

fig.2. Spectrum lines, second shaft

In connection with the diagnostics of the roller bearings the resonance methods of control are more effective. They provide anticipating diagnostics that allows failure prevention. The method of the wrapping and the acceleration-impulse method are mainly put into practice.

Up to the point where is measure a time record, rectify and envelope the signal and measure the amplitudes, the SPM method and enveloping are almost identical (fig.3). The difference is the special SPM transducer, which picks up shocks without the user having to search for a suitable measuring range.

The shock pulse method returns two values for shock magnitude, taken from the time record. At present, it does not carry the measurement over into the frequency domain to look for matches with bearing frequencies.

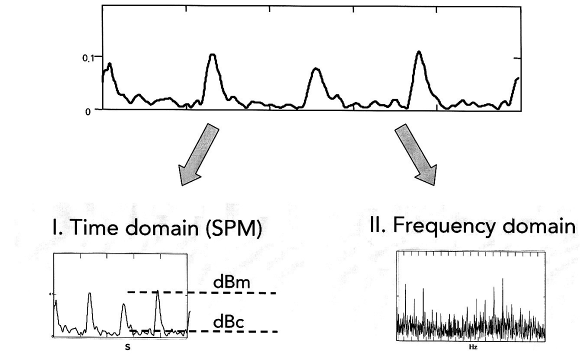

Fig.3. SPM versus enveloping

The resonance phenomena also need to be recorded within the process of determining the possible frequencies. For example, for a ventilator with 5 blades, connected directly to an engine with a work frequency of 25 Hz, presence of resonance is given in Fig.4.

Machine resonance can lead to a misinterpretation of the vibration spectrum. In the second diagram (fig.4), the fan has a resonance that coincides with the vane pass frequency of 125 Hz. The result is exaggerated amplitude of this frequency line. If the resonance were at another frequency, the line amplitude would be much lower.

If frequency lines appear in the spectrum without an obvious cause, like in the third diagram, machine resonance is often the explanation. Test by “ringing” the machine when it is off: measure vibration while hitting it, e. g. with a copper hammer. Have to get peaks at the resonance frequency.

Thus, in connection with the example in Fig.3, the structure scheme for control and diagnostics shall include the following indicators and measurements, implemented in the respective direction (Fig.5), as follows:

- Bearing SPM point 1 - 4
- Unbalance VIB H point 1, 3
- Vane pass VIB H point 1
- Misalignment VIB A point 2, 3
- Looseness VIB V point 1, 3

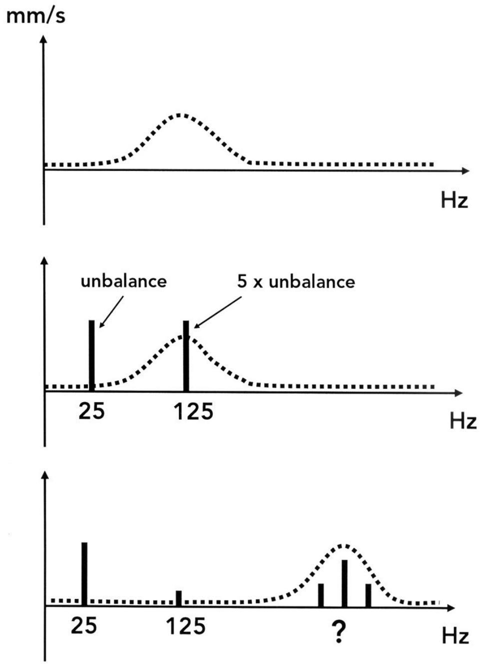

fig.4. Amplitude of spectrum line

Bearing condition (SPM) is measured on all bearings, in four points. Vibration is measured in three points. The unbalance and the vane pass symptoms are used next to the fan. On the other fan bearing housing, use the symptoms for misalignment and looseness. On the motor, use the symptoms for unbalance, misalignment and looseness.

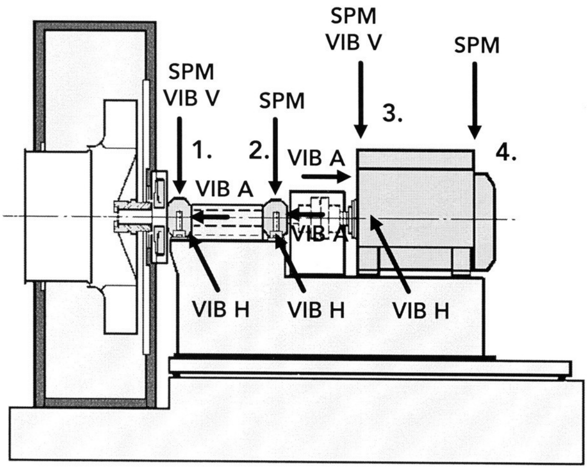

Fig.5. Measuring a fan

Except for the measurement indicators, it is also necessary that the frequency ranges for measuring each measurement point and the dividing capacity of the screen during the spectrum visualization are indicated as well, namely:

Number of lines	400	point 1 - 4
Range	3-200 Hz	point 1 - 4
Number of lines	800	point 1
Range	3-1000 Hz	point 1

Conclusions

The vibration control is one of the most effective methods of maintaining the ventilation installations in good technical condition. Applying this control is connected with the preliminary assessment of the suitability of the various vibration and diagnostic approaches to the specific object. The correct structuring of the methods of control, which includes a system of indicators, measurement recourses and software in conformity with the technical and operating characteristics of a specific ventilation installation, is of great importance with respect to the diagnostic reliability and to the further repair measures, as well as to the operating reliability of the whole installation.

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