

## New Strategy of Turbo-Compressor Maintenance

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**Abstract:** Nowadays, the turbo compressors discussed by the turbines HP and LP pose many problems in the chain of production. Generally, the turbo compressors are affected by a series of external factors (Temperature, clogging, pressure) acting directly on the performances. Thus, in this present research, we tried to identify by the means of a correlation and a regression, the behavior of oil by vibratory analysis and the causes of these disturbances to present methods of turbo compressor sweeping.

**Key words:** Turbo compressor, performances, vibrations, oil, analysis, temperature

### INTRODUCTION

The vibratory monitoring of the machines is one of the techniques which is spread more and more in industry. With the current technological development, the vibratory effects observed can be connected to the material causes, which generate them for the user (Gills, 1995).

The vibratory analysis itself is not significant for a decision-making, a complementary oil analysis can improve the judgment and bring a justification to the causes of failures (David, 2004; Gwidon and Andrew, 2002).

These new possibilities offer mechanisms bringing into play theoretical and practical lightings for a phenomenon as old as the invention of mechanics.

The causes are not limited to the simple unbalance of the revolving machines; they are also for origin of the terminological components used, as well as the physical principle on which their operation rests such as problems of process.

**Basic configuration:** The turbo shaft engines are apparatuses in which a fluid energy exchange with one or more wheels (rotors) which are provided with paddles (wings).

These paddles are profiled obstacles, plunged in the flow and spare between channels by which the fluid runs out. They can be directional to guide the flow of the fluid and to exchange mechanical efforts (Heinz, 2003; Jacques, 2004). This results from the difference in pressure between the two faces of a Fig. 1.

The failure rate for some components of the turbo compressors after the current damages is:

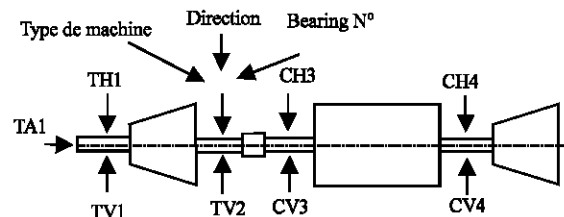


Fig. 1: Turbo compressor installation

Element	Failure rate (%)
Rotor	30%
Bearing	16%
Instrumentation	11%

### MATERIALS AND METHODS

A very representative sample was taken at the same time in order to affirm the connection between the behavior of oil and the vibratory level, over a 6 months period.

Going beyond of a limit (threshold), enters in a detection strategy of defect from which the goal is to supervise and protect the machine.

The alarm threshold is  $V_{iteff} = 3 \text{ m s}^{-1}$ , going beyond of this value supposes an anomaly which requires a confirmation.

In more one can know the speed with which move the curves of tendency and the point of tendencies inflection. However we can associate an alarm of the threshold type to an alarm of the percentage type of evolution or increase compared to the preceding value (measurement).

Figure 2 represents the curves of tendency for the first bearing with dimensions harnesses. A brutal increase

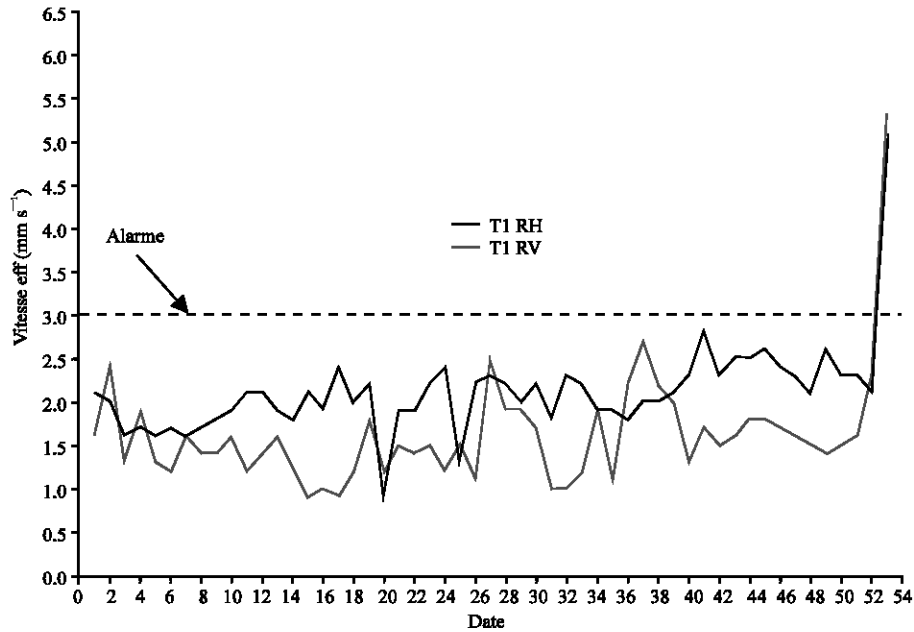


Fig. 2:- Curves of tendency bearing 1

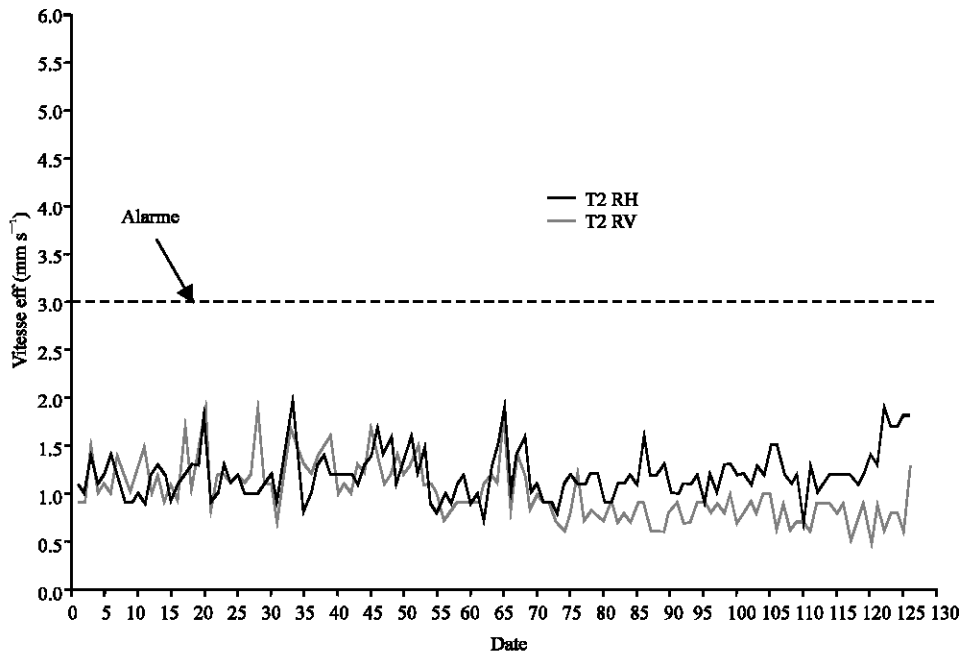


Fig. 3: Curves of tendency bearing 2

in the value effective speed in the directions radial horizontal and radial vertical and which are, respectively of:  $5.1 \text{ m s}^{-1}$  and  $5.3 \text{ m s}^{-1}$ . More than that there is a point beyond the alarm threshold which is of  $3 \text{ m s}^{-1}$  effective speed what translates an anomaly on the turbine.

The curves of tendency in this case have a double interest; the first is the point beyond of threshold what

informed the owner and the second is the confirmation of an anomaly since really it had an increase in the horizontal vibration radial of 3.4 and vertical radial vibration of 3.5.

Figuer 3 represents the curves of tendency for the bearing (T2) n° 2 of the turbine with coupling. On this figure no going beyond of threshold is announced,

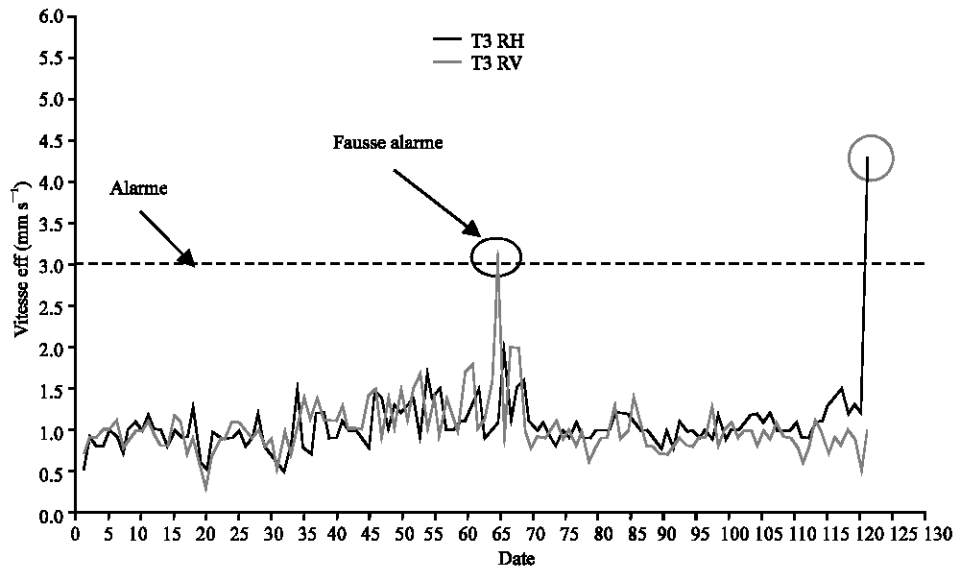


Fig. 4: Curves of tendency bearing 3

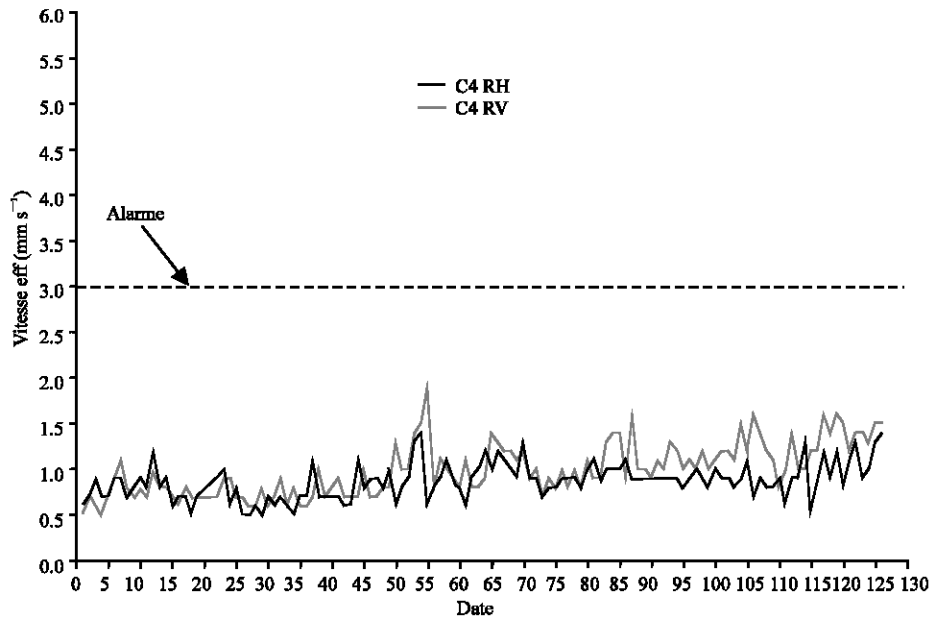


Fig. 5: Curves of tendency bearing 4

therefore no anomaly. Remain to correlate the two figures of the 2 bearings to confirm or cancel the existence of a defect.

Figure 4 represents the curves of tendency for the stage (C3) n°3 of the compressor with coupling. On this figure one notices two points beyond of threshold the first has a value of 3.1 in the horizontal radial direction and the second has a value of 4.3 in the vertical radial direction.

Concerning the first point beyond; the value of 3.1 master key with 2.2 for the following collection;

acceptable value. And there gives a progress report on the interest to associate a standard alarm percentage of evolution compared to the preceding value an alarm of the threshold type; since evolution for the value of 3.1 and 34.78% still acceptable value.

Passing now to the value of 4.3 which represents an increase marked for the measure to the direction radial vertical compared to horizontal radial measurement.

This measurement represents 258.33%, evolution very alarming and very worrying. However, the weak evolution of the horizontal indicator makes it possible to

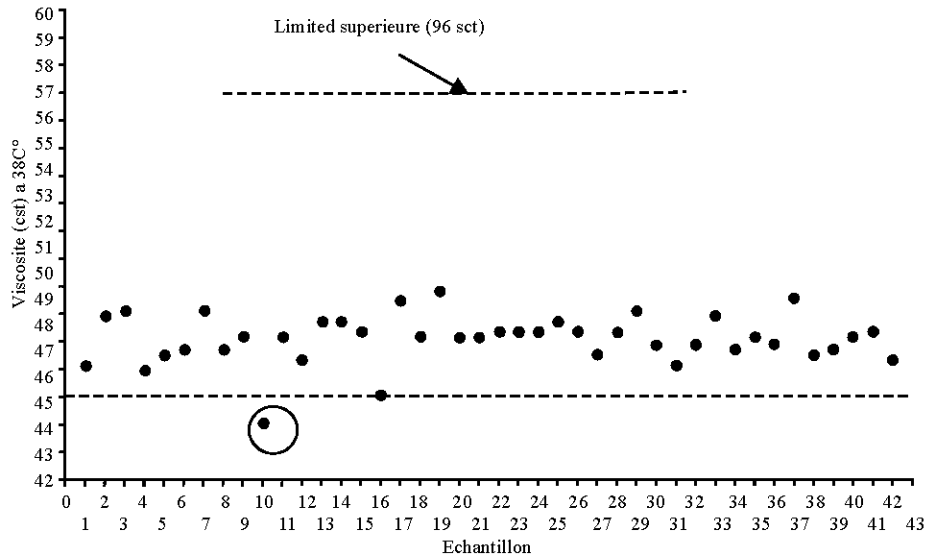


Fig. 6: Analyze viscosity (sct)

exclude imbalance as causes anomaly; in more than the vibration is radial and than the compressor used is of axial type, alarm is followed by a noise to the level of the compressor what confirms a phenomenon of pumping.

With stopping and after consultation of the machine it had a rupture of wing what confirms our diagnosis (consequence of pumping).

Figure 5 represents the tendency curves for the bearing (C4) n° 4. On this figure no point beyond of threshold is announced, therefore no anomaly exists.

Figure 6 shows that there is a lower going beyond of the viscosity limit what represents the fluxing of oil and what obliges us to intervene immediately while carrying out the oil change used by another new oil.

After this operation by controlling new oil until the appearance of another point beyond the limit (lower or higher) and as that can about it obtain an interval of change; or to optimize the period of change by using oil until degradation by decreasing the periodicity of analysis, therefore by increasing the sampling rate.

### RESULTS AND DISCUSSION

There are 2 processes to study the stochastic connection: Regression and the correlation. These processes differ primarily by the technique from test sample selection.

Thus, when one wants to study the vibration according to the viscosity of lubricating oil, one will carry out tests with viscosities; viscosity is the independent variable; it is the regression.

Thus, the regression is characterized by a sampling directed, which approaches the traditional techniques of

experimentation where one ensures the variations of a certain number of factors, to measure and study the unknown variations of the other factors.

The correlation, contrary to the regression, does not distinguish from dependant variables nor independent and all the variables are random. In obtaining the results, the experimenter is not a master of any the variables. The taking away is carried out randomly during the time of study; to all the taken measures, the experimenter measures the studied parameters. The connection viscosity vibration, it randomly draws a sample in the population and measures viscosity and the vibration.

**Coefficient of correlation:** One defines the coefficient of correlation by the expression:

$$\rho = \frac{C}{\sigma_x \sigma_y}$$

With C covariance  $\sigma_x, \sigma_y$  standard deviations.

Whatever the law of probability of the couple of random variables viscosity and vibration,  $\hat{\rho}$  lies between -1 and + 1 and:

- ✓  $\rho = 0$  if X and Y are independent between them;
- ✓  $|\rho| = 1$  if X and Y are bound by a functional relation (mathematical model).

For measurements in vibration we were interested that by the case of the direction where there is a significant evolution of an abnormal behavior.

For the bearing n° 01 turbine there is an evolution of the scalar indicator speed EFF in the two directions radial horizontal and radial vertical. Thus one will study the correlations

- ✓ Viscosity - T1 RH: ( $\rho_1$ );
- ✓ Viscosity - T1 RV: ( $\rho_2$ ).

**After analysis one finds:**

- The coefficient of correlation  $|\rho| = 0,357631$ .
- The coefficient of correlation  $|\rho| = 0,303363$ .

These results shows that there is a dependence between the variables but not very important, therefore it is the evolution of the effective indicator speed in the radial direction horizontal and vertical by the viscosity of lubricating oil one is caused must find a strong dependence, in short a coefficient of correlation in the vicinity or equal to 1.

For the bearing n° 03 compressor there is an evolution of the scalar indicator speed EFF in the vertical radial direction. Thus one will study the correlation:

- ✓ Viscosity-C3 RV: ( $\rho_3$ ).

After analysis one finds:

The coefficient of correlation  $|\rho| = 0,011602$ .

This result shows that the small coefficient of correlation what enabled us to judge that both variable are of a tiny dependence and from there can about it conclude that the cause of the evolution is not the viscosity of oil i.e.; reduction in the hydrodynamic bearing pressure (contact metal-metal) or the impossibility of the relative movement (increase in viscosity).

**CONCLUSION**

The use of the curves of tendency in particular in curves 3 and 6, one can conclude that only one indicator in only one direction does not allow the identification of

a defect like the case of the scalar indicator effective speed for the horizontal radial direction of Fig. 4. Thus it is essential to associate a measurement of this indicator in the orthogonal direction.

In more it is necessary to always seek with better managing the results of the monitoring and not to cause false alarm (Fig. 4). The solution is to associate limits of the threshold type and the limits of the evolution percentage type compared to the preceding value.

The evolution or not of the scalar indicator measured (speed EFF) in a direction of both can eliminate or add one or more defect to the list of the defects likely to appear on the machine as well as a statistical study (vibration-viscosity).

The analysis of oils is an important tool to evaluate the state of the machine as well as the state of the lubricant.

In addition to the evaluation of the lubricant state and in parallel; find the machine state.

The independence of viscosity and the vibration give us with effectiveness to judge that the evolution of the vibrations is caused by other causes than viscosity. What also enabled us to eliminate the defects caused by bad lubrication from the list of the defects suitable for affect the machine.

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