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ABOUT MONITORING THE FRONTAL SEALS' WORKING AT CENTRIFUGAL PUMPS

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Abstract: *This study presents the working of several identical centrifugal pumps; the vibrating measurements being performed in over a year. Periodically, vibrating measurements were performed, using an EasyViber spectrum analyzer / data collector (manufactured by VMI Sweden Company). The data were collected on route and then imported in a database. The measurement analysis was made by using SpectraPro software.*

Keywords: centrifugal pump, seal, monitor.

INTRODUCTION

The frontal seal's working at normal parameters in stationary behavior is a determinist function, dependent of time and instantaneous exploitation conditions. The security of an installation can be defined in several ways, in the technical literature:

- the capacity of a system to normally function, even in case of unpredicted accidents;
- the capacity of frontal seals to support the impact of unpredicted changes, due to the loss of parameters at the pump or at the action system etc.

Analyzing the security of frontal seals' functioning in permanent behavior has as main objective to define the security degree of the system from which it is part of, more specifically to establish those deficiencies of the system's elements that the frontal seal can support without exceeding certain restrictions.

The sealing capacity is the main characteristic of a frontal seal. It is measured by the loss flow of the seal. The frontal seals from centrifugal pumps are that equipment that cause the biggest troubles in dynamical machines' working. Approximately 60-70% of the maintenance cost for a centrifugal pump is due to the sealing deficiencies. The main problem is increasing the seal's functioning life and minimizing the loss.

To reach these goals, two conditions must be respected:

1) understanding the importance of sealing project;
2) developing theories of seal's functioning in various operating conditions.

It results that the main restriction is decreasing the loss of sealed environment.

$$Q_{calc} \leq Q_{lim} \quad (1)$$

This restriction can be resolved by:

- decreasing the clearance from the primary seal:

$$h \approx h_{min} \quad (2)$$

- using barrier fluids with lubricating characteristics:

$$p_{fb} > p_{me} \quad (3)$$

- the geometry of the sealing surface;
- small loss of power, mixed or fluid friction behavior;
- using predictive of proactive maintenance systems.

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DIAGNOSIS OF MECHANICAL PROCESSING SYSTEMS

An important aspect in dynamic machines' working is represented, beside the insurance of viability, availability and maintenance, by monitoring their working.
The monitoring purposes:

- tracking the working:
  - efficiency analysis;
  - performance analysis;
  - consume analysis.
- tracking the deficiencies:
  - avoiding extreme situations;
  - signaling extreme situations.
- diagnosis:
  - for preparing maintenance interventions;
  - for optimum designing.

DETECTING AND LOCATING DEFICIENCIES BY USING MONITORING METHOD

It can be done using the following methods:

- permanent monitoring method;
- periodical monitoring method;
- working parameters monitoring.

Based on the paper's subject, we will briefly analyze the working parameters monitoring method. The working parameters that can be monitored are: vibrations, temperature, and pressure and lubricants state.
Because the system we analyze is formed of centrifugal pump, coupling, bearings and electrical motor, we will shortly describe the diagnosis by using vibrations as parameter.

Diagnosis by using vibrations as parameter

The normal working of a system supposes that the vibrations are also maintained in normal specific limits. In time, in kinematic couples, wear appears and, in the same time, dimensions, pressures and clearances are modified. These modifications apply to the vibrations spectrum. Measuring the vibrations spectrum can offer information on the system's working state.
In the case presented in this paper, the system pump – coupling – electrical motor is included in a technological line. In the same time, this system exists in numerous samples, which allows the existence of a relatively great number of centrifugal pumps. This allows that the diagnosis of vibrations offers some advantages compared to the costs of the diagnosis equipment, because the accidental failure of a system in the technological line could automatically shut down the line. In this kind of situations, the advantage of having information on the working state of the pump and the forecasted moment of shut down is considerable.
This information is obtained by analyzing the variation of the vibrations spectrum.

IMPLEMENTING A SIMPLE PROACTIVE MAINTENANCE SYSTEM FOR MECHANICAL SEALS

Assumptions

The adequate working life of mechanical seals is proportional to the total vibrations level of the pump, but especially to the working state of the bearings near the seal. If these two values are small, one can assume that the mechanical seals will not suffer deficiencies.
The only difficult problem is to correctly establish, for each type of pump (per each type's working conditions) which are the vibration values to be considered acceptable. For pumps from a specific installation, to establish adequate limits, it is necessary a relatively great interval of time. Of course, the seal type, as well as its quality, are considerable factors, but this is virtually impossible to do. That's why it will be assumed that mechanical seals are qualitatively adequate and that they have been chosen per specific working conditions of each pump (circulated fluid, pressure, temperature, flow etc).

Facilities

It is sufficient to have a vibro-meter capable to measure the total value of vibrations and a performant state coefficient of the bearings.

Proactive measures

- The adequate lubrication of bearings, to avoid their degradation.
- After repairs, aligning the machines each time they are repositioned.
- The adequate choice of used mechanical seals, per their working conditions.
- Measuring the vibrations after each repair (for the electrical motor, as well as for the pump). The machines that don't fit in the adequate limits will be sent again for repairing the flaws. We must not accept machines that present higher vibration values after the repair, this indicates an inadequate repairing process.

Procedures

- Periodically, each machine will be measured. The total vibration value will be collected, as well as the bearings' state coefficient. ALL the machine's bearings will be measured, not just the pump's. The measuring will be done on three directions, for each bearing.
- The evolution trend will be tracked. Every significant increase will be reported, to repair the cause. The machine will not be left working, if the danger limits are exceeded.
- Periodically, the alarm and danger limits will be re-examined (for the total vibration value and the bearing's state coefficient), per previous experiences.
- If necessary, a complete diagnosis will be performed, using complex instruments.

Collecting data on route

Most of computerized monitoring systems demand the establishment of routes or tracks of data collection, even from the database configuring step. These routes specifically define the entire measuring sequence, for each machine trains or factory. Except for certain limits

imposed by certain vibration monitoring systems, the routes should represent a logic track for an installation.
Most of computerized monitoring systems of vibrations allow the adjustment of field data acquisition, offering the operator the possibility to intervene inside the track to the specific machine he wants to measure, or to the measuring point of interest, no matter its location. Also, there is the possibility to rearrange the machines on the route, together with its definition in the computer application (figure 1).

Loading / discharging the route's database

A measuring route is a collection of machines which will be measured in a single visit to the field. Before the real measurement operation, it must exist a database of machines. Also, a route must be created. Rules of creating a measuring route:

- It must contain a reasonable number of machines, so that collecting the data could be done in maximum 3-4 hours.
- It is recommended that it would contain machines in a small area, which will not assume a big movement effort.
- When creating a route, it is recommended that the list of machines will respect their position in the field.

In the example below we present a route of four machines. In the database, they are placed in a *logical* order. Inside the route, the machines must be placed in a *physical* order [2, 3].

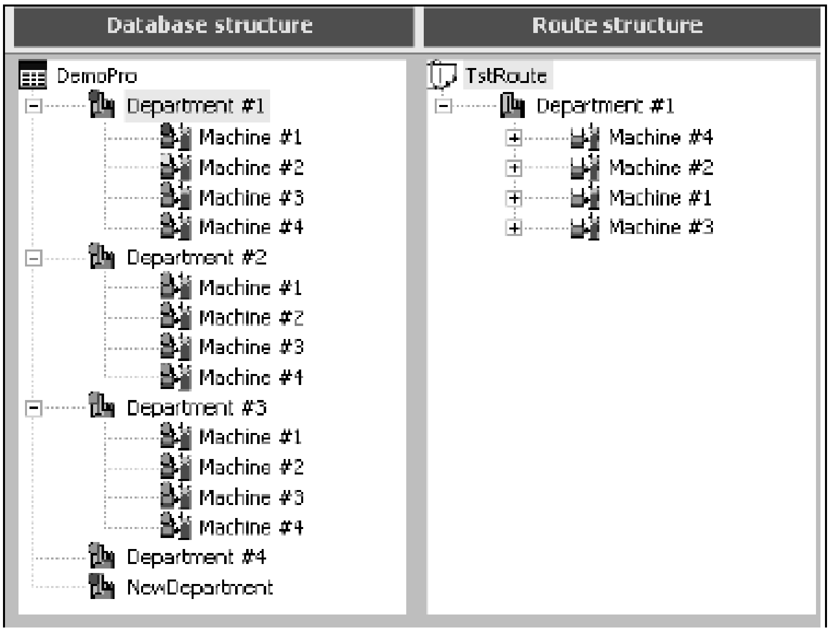

Figure 1. Defining the route [3]

It is important that the name of one machine will respect the labels from the field. In this way, we can avoid future confusions or difficulties in finding the place of a machine.
One basic rule is that the measuring points will always be numbered beginning from the leading machine towards the follower.
Also, it is advisable that in the database should exist a machine blueprint mentioning the measuring point's location. The machine presented in figure 2 has 8 measuring points, starting from the electrical motor [2, 3].

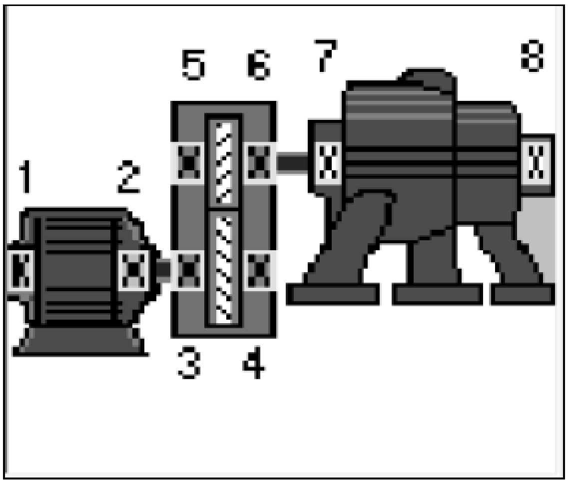

Figure 2. Numbering the measuring points

Loading the route in the data collector

This operation must be done each time before the actual measurements. Numerous data collectors allow deleting the measurements or re-measuring the records from the route. Even in these conditions, it is necessary to discharge the route from the computer before the measurement, because the route also contains the set of previous available measurements. During data collection, this information is vital for a correct data validation after the measurements. If a route (that already exists in the collector) will be re-measured, the last measurements will be, in fact, some old ones, with no relevance.
Depending on the data collector type, the route is loaded in the collector by connecting it to the computer. The loading process is automatic, so that the operator's interventions are limited to connecting the collector to the computer, as well as choosing the route to be loaded.
Most of data collectors allow loading several measuring routes in the same working session [2, 3].

Discharging the data from the route

The discharge operation of routes containing the measurements from the field is simple and similar to loading the routes. The only condition for assuring the success of data discharge is that the machines structure (points and definite directions) will not be changed.
If not, if certain points or measuring directions have been deleted between the moment of route loading and its discharge, there is the possibility that certain measurements could not be discharged. The specific data discharge procedure depends on the data collector type and the machine's database managing program [2, 3].

Data validation after the measurements

After performing a set of measurements for a route direction, it is very important to verify its results. The data collector must be able to clearly indicate, at the end of a measurement set, at least the following data:

- previous value (from the database);
- current measured value;
- optionally, modern collectors indicate also:

- the gradient, as a percent of the change between the last measurement and the current one;

- the alarm limits or an alarm indicator (OK, Attention or Danger).

Using the data mentioned above, the operator will easily be able to validate the performed measurement or, in case of certain doubts, will repeat it. In this way, we can avoid doing abusive measurements in the route. If it's the case, the operator can temporary abandon the measuring and verify the following aspects:

- if the machine to be measured it the correct one;
- if the point and measuring direction are those indicated in the route;
- if the measuring head fixation is correct.

Also, a total value measurement outside the route can be performed, to confirm the route measurement [2, 3].

CONCLUSIONS

The vibration sources in a frontal seal put on a pump can't be standardized because of not knowing their quantified contribution to the sealing. The frontal seal must not be considered as a piece put on the ax of a pump, but as a component part of a pumping system. The data presented in [3] bring into discussion various ways, vibration frequencies and amplitudes of the frontal seal and their influence on the frontal sealing.

Based on the information presented, we can elaborate a simple and efficient method for preventing the damage of mechanical sealing, especially for installations where a predictive maintenance system is not implemented.

By implementing a maintenance system, we must not only take into consideration the monitoring part – surveilling – diagnosis, but also implementing other activities such as: training the technological staff, organizing the deposits and stocks by diminishing them, establishing a relationship with the (external) restorer based on viability, working safety, performance, decreasing the accidental falls and not the number of repaired machines, labor costs etc.

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