Simulation of the Diagnosis Based on Model to a Nuclear Detritiation Installation

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Abstract: - The present paper is connected in the category of preoccupations linked by maintenance based on reliability (RCM) having as object the preventive maintenance management based on the state of the equipments and on time as the method of integration of the maintenance knowledge for life cycle of the product (the technical system) considered. The paper represents a modelling and simulation for operative maintenance of a nuclear plant existent to ICSI, Rm. Valcea, that achieves the detritiation of heavy water came from the CANDU reactor situated in Cernavodă (Romania).

Key-Words: - Simulation, Predictive Maintenance, Reliability Analysis, Diagnosis.

1 Introduction
Nuclear installations are installations of high complexity for which reliability or safety analyses are necessary or sometimes required both in the designing and in the operation stage. These analyses contribute at taking decisions concerning the best system structure, reaching the admitted quality level of the components, as well as at the best maintenance policy. Both the concerns described in the reference literature and our personal experience show how important is to [1].

A complete reliability analysis has to pass compulsorily certain more important stages that can be grouped into two categories, the first with a preponderant qualitative character, linked by knowledge, identification and organisation of the information and the second with a preponderant quantitative character, where the logical formalisms and the models are built and numerical data are obtained on the installation performance.

Both categories require detailed analyses at component level, including the research of causes and failure modes of elements as well as of their consequences, which compromise one or more indicators characteristic for safe operation of systems or even lead to possible extensions in the adjacent systems.

The essential problem for the maintenance function is the optimization of maintenance plans to make possible prediction with a bigger time before producing of a failure for critical equipments through preventive maintenance based on state [1].

2 Problem Formulation
The general conception of approach starts from Six Sigma methodology that consists of the steps "Define - Measure - Analyze - Improve - Control," for achievement of the proposed scope. So, it is imposed the responsibility to identify the process, the definition of defect, and the corresponding measurements.

From criticity analyse of the equipments from nuclear considered installation result critical equipments for which are established substantiated the predictive monitoring methods referring to vibrations, noise, wear combined with monitoring of physical process parameters.

The general algorithm for the solution of the modelling and simulation problem is presented in figure 1.

On basis of the studied behaviour of a equipment as basis of monitoring historic data ( e.g. vibrations) is arrived at the conclusion that it follows a law of probability for example:

\[ R(t) = e^{-\frac{t}{\lambda}} \]

where: \( t \) is time.
The cost of the components replacement is supposed as $C_p = 100 \text{ u.m.}$, and the cost of an accidental failure $C_d = 500 \text{ u.m.}$. In hypothesis that the replacement interval is reduced is obtained:

$$E(c) = C_p + [1 - R(t)] C_d$$  \hspace{1cm} (2)

and the average cost is:

$$C_{mu} = \frac{E(c)}{t}$$ \hspace{1cm} (3)

For finding of replacement optimum period of the respective component are systematized in table the duration($t$), $E(c)$ the si $C_{mu}$:

<table>
<thead>
<tr>
<th>$t$ (hour)</th>
<th>$E(c)$</th>
<th>$C_{mu}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>102.94</td>
<td>1.02</td>
</tr>
<tr>
<td>200</td>
<td>118.11</td>
<td>0.59</td>
</tr>
</tbody>
</table>

Table 1

From table shall result optimum period of replacement ($t_0$) is ($t$) for which $C_{mu}$ is minimum ($t_0$=300 hours). This time obtained as consequence of historic data concerning the failures of the considered component will be correlated with the establishment time of alarm threshold for the on-line monitoring of vibrations.

Initial for the reference of monitoring vibrations is considered the areas of the vibrations severity adequate to the standards how is for example SR ISO 23721974( Geneva – Elvetia, table 2), or VDI 2056( The Germany) or STAS 6910-87( Romania).

For the vibrations monitoring is followed the knowledge of the admissible limits of the vibration amplitude for each equipment, respective the following of the vibration evolution:

<table>
<thead>
<tr>
<th>SR ISO 2372 Domain</th>
<th>Domain limits $V_{rms}/s$</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.28</td>
<td>0.28</td>
<td>A</td>
</tr>
<tr>
<td>0.45</td>
<td>0.45</td>
<td>A</td>
</tr>
<tr>
<td>0.71</td>
<td>0.71</td>
<td>A</td>
</tr>
<tr>
<td>1.12</td>
<td>1.12</td>
<td>B</td>
</tr>
<tr>
<td>1.8</td>
<td>1.8</td>
<td>B</td>
</tr>
<tr>
<td>2.8</td>
<td>2.8</td>
<td>B</td>
</tr>
<tr>
<td>4.5</td>
<td>4.5</td>
<td>C</td>
</tr>
<tr>
<td>7.1</td>
<td>7.1</td>
<td>C</td>
</tr>
<tr>
<td>10.2</td>
<td>10.2</td>
<td>C</td>
</tr>
<tr>
<td>11.8</td>
<td>11.8</td>
<td>C</td>
</tr>
<tr>
<td>12.8</td>
<td>12.8</td>
<td>C</td>
</tr>
<tr>
<td>14.5</td>
<td>14.5</td>
<td>C</td>
</tr>
<tr>
<td>15.1</td>
<td>15.1</td>
<td>C</td>
</tr>
</tbody>
</table>

Table 2.

A,B corresponds the state of well function. In first part of the area C is fixed the level of alarm, over which the equipment isn't unusable, but it has the important failures can evolve sometimes unforeseeable until the inferior limit of the area D, over which the equipment can be compulsory stopped, because it can be destroyed anytime, can damage surrounding equipments or can put in danger human beings.

3 Problem Solution

The solution is the monitoring integration with LabVIEW software for predictive maintenance based on vibration analysis of the considered component part of maintainable nuclear installation.

The level of alarm established initial at one given time can be changed on measure of changing on-line of the
vibrations monitoring for the considered component, the decision being based on fuzzy logical method for historic data and on-line monitoring.

For the case which is exceeded the maximum limit pre-established for reliability of the monitoring system the simulation is foreseen with visual and auditory alarm system conform figure 3.

LabVIEW simulation has at basis the algorithm from Figure 3. Adequately of example in figures 2 are processed stages used fuzzy method in LabVIEW software.

With LabVIEW can be established on-line the reliability of the monitoring system.
LabVIEW permit integration with other techniques of simulations for realization of the maintenance predictive programme.

4 Conclusion
The monitoring integration with LabVIEW software of the historic date and of vibration level for critical equipment, monitoring in on-line for installation, solve decision with method fuzzy for operative maintenance activity that is fundamental in nuclear domain, and important for the nuclear installation operate, too.
The knowing and evaluation of the system components for monitoring vibration for amplitude level and reliability function for the historic data base, constitute an important variable among many other variables used for realization of an advanced Operative Maintenance Program for Nuclear Plant.
The conception of method permits the realization in dynamic regime of an on-line operative predictive program.

References: