1.8.10. VIBRATION MEASUREMENT UNCERTAINTY AND DIAGNOSTICS RELIABILITY IN ROTATING SYSTEMS

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Large complex industrial rotating systems usually use some kind of monitoring system to observe their state by measuring the predefined parameters to use them for object, separate equipment, or the machinery state evaluation. These measurement results later are used to diagnose possible defects or faults other by integrated automatic diagnostic system or by operator. The reliability of the measurement results depends on many factors – these may be the features of observed object, the structure of measurement system, and also the operating environment in which the observed system works also influences the object equipment or machinery and the control system itself. The measurements of the monitoring system always can be characterized with a specific uncertainty. As the measurement results are used in diagnostic procedures then the measurement uncertainty enlarges the probability of diagnostics false decision. The reliability of monitoring and diagnostic system, in this case is understood as probability to make false decision which should be minimized. This could be done analyzing the factors, influencing the reliability, including uncertainty.

In this paper three problems are discussed:

– evaluation of the factors influencing the estimate of vibration measurement uncertainty in monitoring and diagnostic systems;

– identification of the criteria which evaluates reliability of the diagnostics;

– investigation of the reliability criteria which determines influence of measurement uncertainty to the diagnostic result.

The components of measurement uncertainty of permanent and periodic vibration monitoring and the significance of this uncertainty are also discussed.

In order to evaluate the influence of uncertainty to decision making the measurement results were classified into two sets X_1 and X_2: the results X which do not exceed the predefined limit value x_0 (that is, $X_1 < x_0$) and the results which exceed the predefined limit value (that is, $X_2 > x_0$) (only one limit value x_0 is predefined).

There are several cases, when measurement uncertainty U will have effect. The most questionable cases are:

$$\begin{cases} x < x_0, \text{ but } x + U > x_0; \\ x > x_0, \text{ but } x - U < x_0. \end{cases}$$

This problem allowed formulating the tasks of investigation for measurement uncertainty factors and their influence to diagnostic procedures.

The main difference between permanent and periodic monitoring systems is that here the main roles are played by different measurement error types. In permanent monitoring system the measurements are performed constantly and the statistical uncertainty component is very small, as the number of measurements is large, and the transducers are calibrated periodically, for example, once per year. Influence factors, determined during calibration, still affect the measurement procedure if it is performed in environmental conditions other than of calibration. So the systematic measurement error here plays the main role rather than the random measurement error. In case of periodic monitoring system, the transducer calibration is usually performed before every measurements set. But in contrary, as the measurements are rarer, their variance is bigger and the value of data set is very small – the random error dominates the measurement uncertainty value.

When using numerical transformation to extend measurement set, the numerical method error emerges. In this case some measurement uncertainty components are added.

Using the simple decision making rule, the influence of measurement uncertainty to diagnosis reliability was analyzed. Measurement uncertainty usually reflects in diagnostic parameters, which are applied to the decision making rules. The analysis was performed on the base of particular measurement, the analysis was made.

As the probability of taking a false decision compound of false alarm and fault miss probabilities, with incorporating the "cost" of those errors we can get a risk average value.

The results showed that then there is a clear dependence on the ratio of the mean and uncertainty m / U – the bigger is uncertainty, the bigger fail probability we can expect. We suggest using this ratio as a parameter to calculate a decision making probability change.

Applying this to different vibration monitoring systems, we should notice that in permanent vibration monitoring systems the variance of the normal distribution will be small enough due to large data sets, so in critical cases, the uncertainty influence will show the effect immediately. In the case of periodic monitoring system, the data sets are small and variance is much bigger. Due to that, the uncertainty might have a big influence to decision making with portable systems having initial data. The data set might be expanded using the particular methodology, while transformation function will enlarge data set, in this way reducing the statistical uncertainty component. Using this method additional uncertainty contribution should be added, which calculates the impact of the increase of the set to measurement reliability. In the other hand, this contribution has a less impact than the difference between the primal statistical uncertainties and uncertainties calculated after the transformation.

As example of the real monitoring and diagnostic system was used vibration monitoring system, installed in Kaunas Hydroelectric Power Station.