ADVANCED LOOSE PARTS DETECTION SYSTEM FOR NUCLEAR POWER PLANTS

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EXTENDED ABSTRACT

We introduce a loose part detection system which is easy to attach to existing vibration measuring assemblies in any nuclear power plants. It is rather simply to reinstall the system for another Unit of similar type. It excludes automatically non-loose part effects like the motion of control rods. It also can give hints on the size of the object.

One of the major concerns in the operation of any pressurised water reactor is the possible presence of loose parts. They can contact the walls causing mechanical and material damages which is extremely dangerous for steam generators and for the fuel pins. Loose parts drifted with the stream of water can be broken into small pieces therefore they can also reach the reactor core and block the coolant channels, as it happened in Paks NPP. The most common consequence of loose parts is the ageing of the material. Steam generator tubes can also be broken or blocked.

Recently installed loose part monitoring systems are similar in design (since the most important design criteria are fixed in IEC-988). The inspected signals (typically 4-6 sensors per loop) arrive to a central data acquisition unit and are processed by an electronic logical unit to select suspicious signals. Such a selection can use a simple windowing method in the simple systems or a short-time RMS or floating RMS method in the more sophisticated systems. The suspicious signals are first archived by a transient recorder then the sampled signal may be processed by an expert system. The task of such an expert system is to analyse the selected event in details.

One of the problems of the contemporary loose part detection systems is their high false and missed alarm rate. Our system improves the signal to noise ratio by using a built-in pre-whitening method. It is based on univariate autoregressive modelling of the system and is capable not only to decrease the unwanted background noise level but also to eliminate (quasi)periodical noise components which are always present at nuclear power plant environments and disturb to set a low alarm level for loose parts. As a second step in improving the performance in order to establish a low missed alarm rate we use the sequential probability ratio testing method real time synchronised with the sampling. This allowed us to reduce the missed alarm rate below 1%. On the other hand it is also very disturbing to have false alarms in a nuclear power plant, which use to be a common problem of earlier systems. The applied software allows to reduce the false alarm rate below 1% in the detection process.

The best proof for these statements comes from the experiences with the HELPS system, which is the predecessor of our loose part monitoring system. That system was originally designed for and installed on the Unit 3 of Paks NPP and on request of the power station we could remove and reinstall it to Unit2 within a couple of hours including the impact measurements aimed to collect unit-specific reference data. During the impact
measurements a couple of minutes were enough to completely change the detector configuration.