THE IMPORTANCE OF USING NOISE DIAGNOSTIC METHODS TO ENHANCE THE SAFETY OF THE VVER REACTORS IN THE THIRD MILLENNIUM

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ABSTRACT

The history of noise diagnostics had a delayed start, since the necessary technology was not ready when contemporary nuclear power plants (NPP) were designed. Core barrel motion, in-core vibrations, and other types of vibration of the main components as well as important parameters, like reactivity coefficients can be monitored using fluctuations of the main measurable parameters of nuclear power plants. These are important to enhance the safety of NPPs. Contemporary measuring technique and developed expert systems are available today for an effective diagnostics of NPPs. A short list of such systems developed for WWER type reactors in Hungary are cited. We shall consider the safety aspects, as well as the problems of introducing noise diagnostics, and we conclude that it is high time to use such technology in both WWER and western type pressurised water reactors.

1. INTRODUCTION

Nowadays, diagnostics of nuclear power plants (NPPs) has a growing importance, because of the ageing of NPP. Noise diagnostics has a special advantage in comparison with most of the other methods. It derives its conclusion as to the malfunction or health of the given object by measuring the fluctuation of the main, measurable parameters of the given unit in a completely steady state operation, without any interference to the normal operation of NPP. The use of noise diagnostics was started with some delay in comparison with other diagnostic methods, because when the contemporary reactor types had been developed and established, this method was not yet ready to be used. There were and are at least three conditions for the introduction of this type of diagnostics, which is worth mentioning.

First, the fluctuation of the measurable quantity must be registered to a high quality. This means one has to be able to measure the fluctuation of the given parameter to the order of 10^{-4} (or less) times its mean value. Earlier, sensors had no ability to fulfil this request. Contemporary sensors can provide us with such dynamics. The fluctuation and the mean value of the given parameter must be accepted by the first unit of the amplifier with as small as possible background noise. This means that the first unit of the amplifier must have a dynamics better than 90 dB and a signal to noise ratio about the same or perhaps about 120 dB. It became possible only after the introduction of chip-technology to satisfy such requirements.

The second condition for introducing noise diagnostics in industry was to have a relatively fast data processing of stochastic signals. Before the age of computers this was absolutely impossible. Even at the beginning of the computer age we had only very limited possibilities since the memory and speed of the computers were very limited much and this reduced the accuracy of the data evaluation. Today it may sound incredible, but most of the publications from the late 70's or the early 80's were based on experiments where the number of averaging was between 4 to 16, which means the accuracy of the spectra was about 50% to 25%. Today, the computer cost, computer time and memory have no limiting effect anymore. In practice our limitation is due to the limits of the steady state operation time of the given NPP.

The third condition necessary for developing an effective noise diagnostics was to introduce effective tools for data handling and extracting the information from the measured fluctuation. First, one needs an effective data evaluation tool. It is hard to believe today, that although the Fourier transformation is as old as the French revolution, twenty five years ago, lacking the computer technique, most of the researchers had no experience of how to carry out Fourier transformation in practice. The author of this paper remembers that many aspects of windowing and overlapping were subjects of discussion even in the late 70's. Without the so called Fast Fourier Transformation (FFT) fast data evaluation would still not be possible today. FFT had been discovered in late 50's and became well known only in 70's, when everybody could try this method on computers. Today, besides the FFT technique, we have several other methods to transfer the stochastic signal into a statistic value or to model the process. The second component of the interpretation of noise measurements is some kind of classification method which can prepare the way for expert decision using the evaluated parameters or evaluated results. For this, one needs either a good theoretical basis of the processes going on and produced fluctuations in the given industrial object, or a very advanced pattern recognition technique, mathematical modelling and artificial intelligence (AI) technique. Today the arsenal of the noise diagnostics methods inevitably contains expert systems, AI methods, neural networks, auto-regressive modelling, wavelet technique, and physical modelling together with the good old FFT spectrum estimation methods and correlation techniques.

These three preconditions for noise diagnostics have became available only in the late 70's or in the 80's, therefore most of the old fashioned NPPs, even those in United States have no corresponding diagnostics systems. This was even more true for Soviet built NPPs, which originally lacked effective computer systems. The traditional testing of equipment became a routine in all NPPs. WWER is an old fashioned NPP with technology dating back to the 50's. It has undergone several modernisations, but still most of the methods prescribed by the main constructor bureau remained valid for the diagnosis of different components.

In the early 80's noise diagnostics became possible and we have developed methods and systems for that purpose. In the following we give some examples of the most important events and methods used in the practice of noise diagnostics of WWER reactors.

2. DETECTION OF CORE MOVEMENT

Soviet built WWER reactors suffer very frequently from core barrel motion. The importance of detecting core barrel motion is unquestionable. If the core barrel[1] is going to have a large pendular movement it may touch the reactor vessel, which is dangerous. The most prominent case reported until now was the core barrel motion registered in NORD NPP (Greiswald) in 1988. This occurrence has been openly analysed in detail (see publications [1],[2]) From the detailed description of the event it was clear, that the failure of a hold down spring was the cause of the problem. That lead to a near pendular motion of the core barrel. The core barrel was swinging and touching the guide lug(s). One of the guide lugs was half worn during the fuel campaign. One of the roles of these guide lugs is to prevent the core barrel from knocking directly against the wall of the reactor vessel. Noise diagnostics methods based on frequency analysis of neutron flux fluctuation measured by state excore neutron detectors were able to detect the motion, then to analyse its measurement and to follow the effect during the whole fuel campaign. The detailed analysis of these measurements made it possible to prove that there was still some remaining part of the guide lug acting as a bumper to prevent free motion, therefore the situation was still tolerable from the point of view of safety of the reactor vessel. This is an outstanding example of the usefulness and effectiveness of the noise diagnostics methodology.

2.1. DESCRIPTION OF THE CORE HOLDER STRUCTURE OF WWERS

Thermal shield and core barrel motion can be detected using the excore ionisation chambers around the reactor vessel. This idea was first published by Kryter et al [3]. Among others a decomposition method was presented in the early 80's by Dragt and Turkcan [4]. It became widely used in WWER reactors.

However the construction of WWER reactors differs very much from their western counterparts in the core holder structure. In most of the western made PWRs there is a so called core support structure, which plays an important role. There is no such structure in WWER-440 reactors. What is generally called "core basket" in WWER reactors, is really just a basket holding together the fuel assemblies. This basket sits in a so called "reactor shaft", which in fact plays the same role as a core barrel in western made reactors. It is cylindrical and having a flange it is hanged from the upper edge of the reactor vessel. It also has an attached bottom part below the core. While the shaft itself has a cylindrical shape, the bottom part of the shaft is shaped like a basket. This basket contains the damping elements for the control assemblies under a long, six-edged, fuel assembly-shaped tube, which allows the bottom elevation of the control assemblies containing real fuel pins to be lowered in this tube, inserting the upper boron-steel part into the core. The bottom part of the shaft is so similar to a basket, that it really has holes in its half spherical bottom, allowing the coolant to enter under the core. The bottom part of the shaft has a weight of 3.1 Mp itself, the shaft weighs 4.6 Mp, and the so called basket, which is a core-holder has a weight of 2.13 Mp without the fuel assemblies. All this is pressed down by the guide tube

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WWER or VVER are different abbreviations for the same type of Russian pressurized water reactor. In contrary to the more distributed abbr. VVER, we prefer abbr. WWER since its original full name was: Water moderated Water cooled Energy producing Reactor

[1] It is important to clarify that in this respect the terminology might differ due to different translation. We understand under core barrel the holder, which is hanging from the upper flange of the reactor vessel, holding the core.

section, which sits firmly on the core-holder-basket and serves as transition for all control rod driving mechanism and measuring lines (219 temperature sensors and 36*7 incore neutron detectors). There are two hold-down mechanisms, one on the upper edge of the shaft via a non-linear spring and the second is the hold down springs of the guide tube section. The most unusual elements are the guide lugs at the middle level of the shaft-bottom of the shaft construction. These are eight welded bumpers on the inner surface of the reactor vessel. Their primary aim is to guide the core shaft, when it is lowered into the reactor vessel. For this purpose there are vertical holes at this elevation of the reactor shaft on the outer surface. When there is a core motion, the shaft will bump on these bumpers, which prevents the damage to the reactor vessel. This is not simply a nightmare, it really happened in Nord NPP (Greiswald, Germany).

It is easy to understand, that such a construction can easily get into motion. It has a total weights of more than 10.0 Mp. In many WWER reactors it is even possible to close one of the primary cooling loops using the so called main valves. It is allowed even to operate the reactor further. This means there is an operational state, when an absolutely uneven jet of coolant would hit the core shaft, where the incoming coolant water turns down to the downcamer, i.e. below the bottom part of the core shaft. This is a driving force for a pendular motion.

2.2. THE METHOD OF DETECTING THE CORE MOTION

The method of detecting the core barrel motion is well known from literature [1-5]. There are ionisation chambers of the safety system. They are built in the (concrete) biological shielding around the reactor vessel (see Fig.1.). When the inner part of the reactor vessel, i.e. the core barrel or the core shaft has a pendular motion relative to the reactor vessel, then the water gap between the shaft and the reactor vessel is moderated by this motion. The reduced absorption due to the change of the water gap produces corresponding fluctuations in the detector current of excore ionisation chambers on both sides. The methodology which is used to detect and measure the pendular core barrel motion is based on spectral analysis of the measurable neutron flux fluctuation. Usually the excore neutron detectors are used (see Fig.1.), which are part of the safety channels as well. But in addition some other sensors (like in-core neutron detectors or accelerometers positioned on the reactor vessel) are also involved [2],[4].

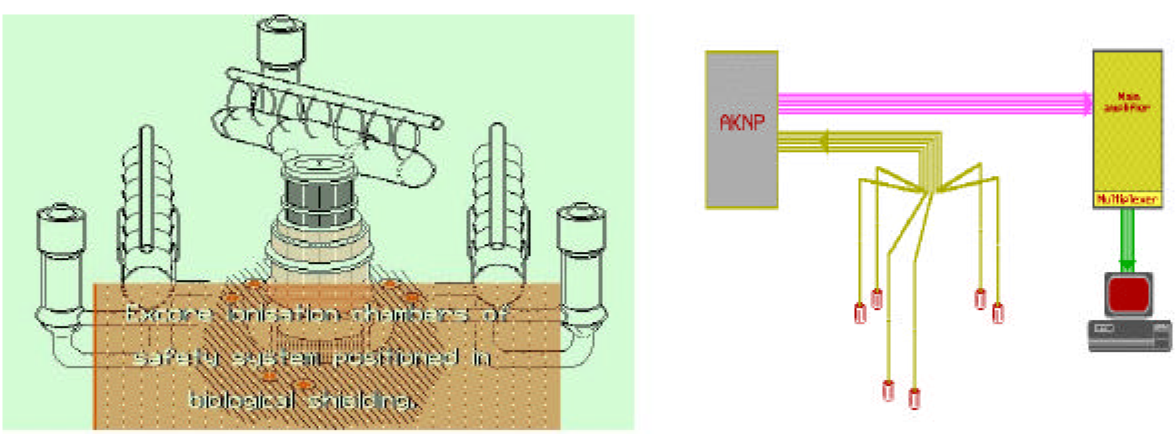

Figure 1. Physical positioning and electronics using the six state excore ionisation detectors of the AKNP safety system, which are positioned around the reactor vessel, for core barrel monitoring in WWER type reactors

In Hungary two Units of Paks Nuclear Power Station have been equipped with a reactor noise diagnostics system containing a half automated core barrel monitoring software package [5], [6]. It measures autospectrum (APSD) as well as coherence and phase between excore ionisation chambers. APSD does not exhibit a characteristic peak in frequency range, where antiphase between ionisation chambers is registered (see Fig.2.). This can be explained by the model of WWER construction, which does not prefer a pendular motion, but an irregular motion of the shaft.

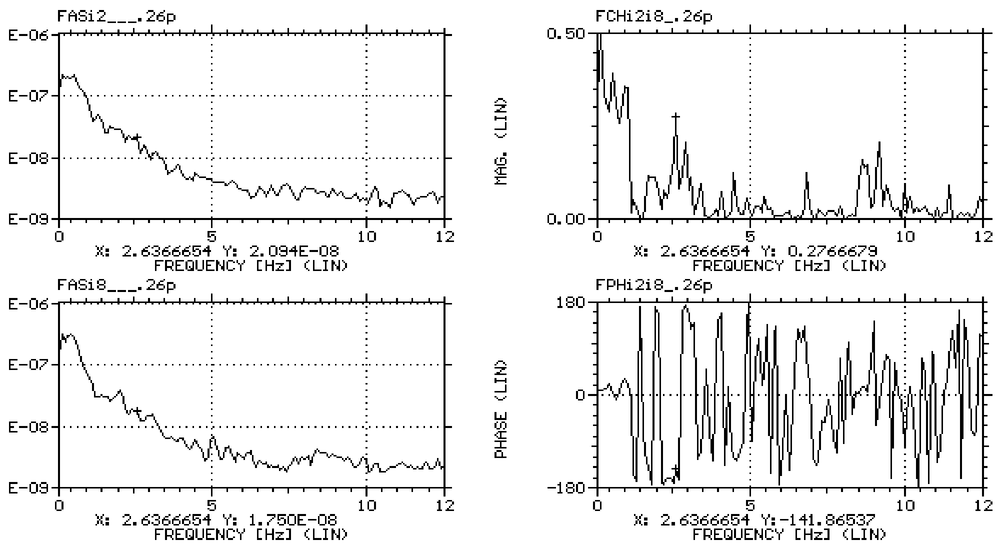

Figure 2. APSD, Phases and Coherence between ex-core detectors. Pedular motion would exhibit a peak, which is not found in the frequency range from 2 to 6 Hz, where antiphase was detected.

It is well known, that core barrel motions have occurred in several WWER[2] reactors. One of them was reported earlier from Rheinsberg at the IAEA Meeting [7]. But we have heard about core barrel motion from Khemnitsky, from Kola, and from other sites as well. We have reported about core barrel motion from a WWER-1000 type reactor as well [8], which was caused by closing one of the primary coolant loops, which is also possible in WWERs during normal operation (see the result on Fig.3).

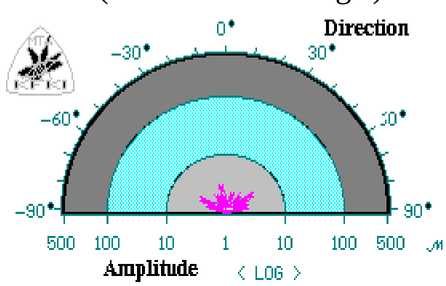

Figure 3a. Core barrel motion less than 10 micron (no motion) was observed

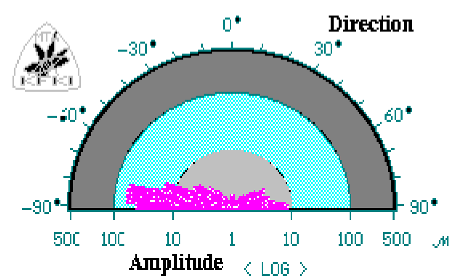

Figure 3b. Core barrel motion larger than 10 microns (less than 100 microns) was detected into 80 degree direction when one primary loop was closed.

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[2] We always use terminology WWER instead of VVER, since it serves for abbreviation of Water cooled Water moderated Energy Reactors

This methodology is advantageous not only for soviet built WWER reactors but for other types as well. As a result of their different construction they are less liable to dangerous motion. They do not usually knock directly against the walls. But they usually have core support and sometimes they also have measuring tubes inserted from the bottom of the reactor vessel. Therefore, in spite of the fact that the amplitude of their motion is usually less than those of the WWER reactors (since the core support serves as a damping), these smaller amplitudes are enough to damage those guide tubes for the measuring installations. We have heard about such occurrences in German reactors as well as in French pressurised water reactors. Breakage in those tubes can lead to leakage, and what is more dangerous, those measuring channels can be lost. Therefore we believe that core barrel motion monitoring is one of the methods that should be introduced to automatic noise diagnostic systems.

3. IN-CORE VIBRATION MONITORING

WWER-440 type reactors have absorber assemblies, which have two elevations: the upper part has the absorber tubes sited on the lower part, which is a normal fuel assembly. Their driving apparatus might be jammed. Such a case was reported in 1995 from Paks NPP. The excessive vibration of such control assemblies can cause the failure of their moving apparatus as well as damages to neighbouring fuel assemblies. Reports of excessive vibration of such control elements have been published earlier [9].

There are no accelerometers available in the core of WWER reactors. The first such test has been published just recently in one of German reactors, but still their burn out rate is too high, they can withstand radiation only for a couple of months. Today the only reliable information on in-core vibration can be achieved using in-core self powered neutron detectors (SPND), which are state composite of WWER reactors. In WWER-440 reactors there are 36 strings containing 7 SPNDs above each other in the core. In WWER-1000 type reactors there are 56 strings in a core. As it has been proved by numerous successful observations each string can see its own fuel assembly excellently. Good visibility was reported from the neighbouring fuel assemblies, while poor visibility was reported for transport effect from further assemblies, but still acceptable for horizontal correlation. The latter means that in the case of an excessive vibration of one of the control assemblies, acceptable coherence and phase was achieved [9] between far standing SPNDs, whose distance from each other was 4 to 6 fuel assemblies (each assembly has a diameter of 144 mm).

The main sign of a control assembly vibration was the appearance of opposite phase with certain coherence between horizontally placed in-core neutron detectors. The task is obvious: we need software with automatic control of phase. Experience shows, that all combination between in-core detectors should be checked first. Once antiphase has been detected a manual package is needed to analyse the nature of that effect. If equipped with such manual package, an expert can comment on the nature of that antiphase. The expert should take into account all previous lessons learnt during normal operation. Antiphase can appear due to erroneous connection of cables, due to transport effects, due to bad statistics, due to transients, etc. In principle it is possible to build in a knowledge based support system for experts. This system would contain knowledge and lessons learnt from previous experiences. Still an expert is needed to analyse the appearance and manpower is necessary to avoid false alarms.

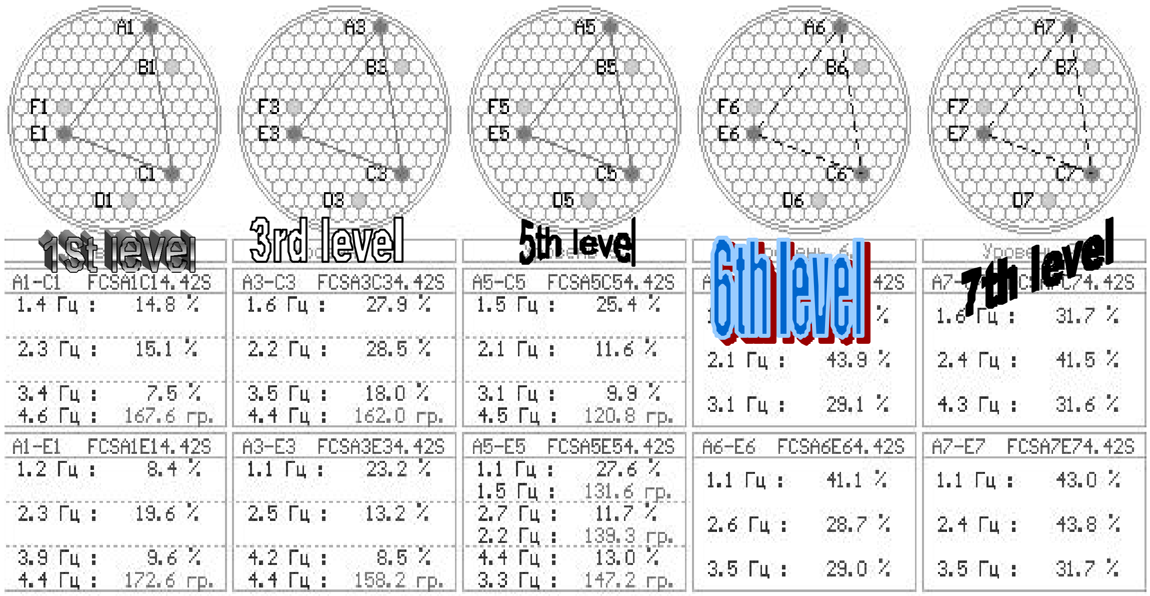

Figure 4. An example of the expert support display. Solid lines show in phase, dash lines show antiphase behaviour at different elevations between SPND signals at different frequencies (see table, in Russian)

Several in-core vibrations were reported in WWER type reactors. Their detection and analysis was solved successfully with the existing system. We conclude, that it is recommended to have such a system for safety purposes. Since many aspects of data analysis cannot be automated, such systems cannot be made into a part of the safety system, but they can be an important part of the operator support systems or information machines.

4. REACTIVITY COEFFICIENT MONITORING

Reactivity coefficients are regarded as important parameters for the operation and safety of nuclear reactors. Safety margins for the reactivity temperature coefficients are not monitored today on-line at all, only the sign of that parameter is checked during the start-up process. We wish to underline the importance of detecting the changes of that parameter during the whole of the operation. We think that its large negative value is also dangerous for reactor operation in the case of an emergency halt. Earlier this had not been considered as a safety concern, but it has become clear by now that when the emergency system injects cool water into the reactor core, it can respond with a positive reactivity jump, due to the large negative reactivity coefficient.

Existing techniques for measuring reactivity coefficients require a sufficient change of the reactor coolant temperature. An advantage of the noise method is, that it can infer the value of the reactivity coefficient from the ratio of different spectrum estimates from measured fluctuation of the parameters in steady state, full power operation. Nobody would like to introduce a thermal jump each day to check if that parameter is still within the allowed margins. Noise monitoring methods are favourable in the sense that they do not disturb the normal operation at all.

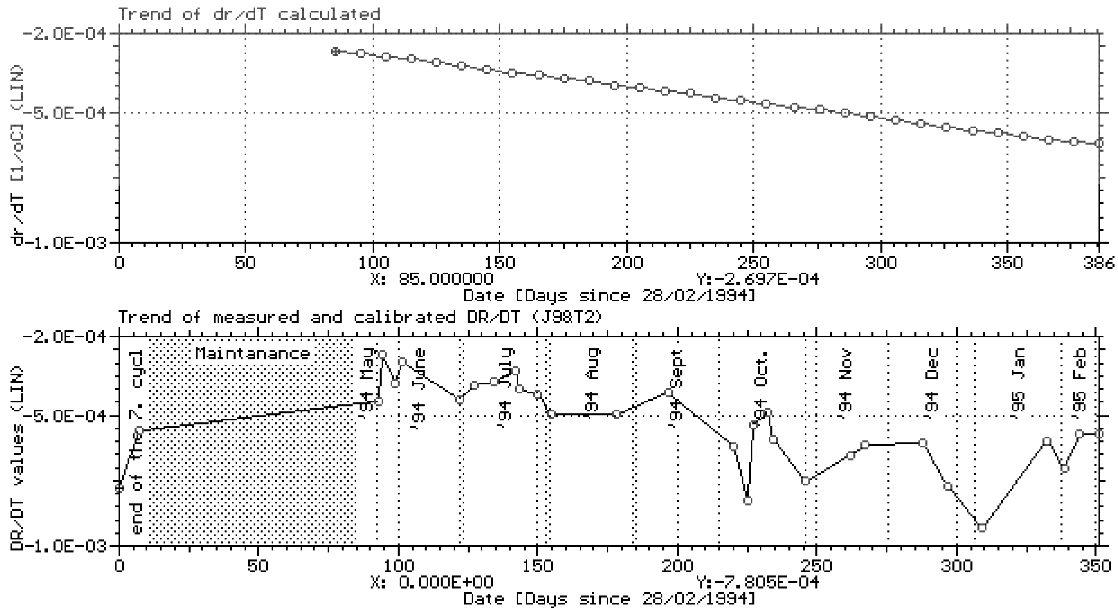

Figure 5. Estimated and actually measured (using noise method) values of temperature reactivity coefficient during a fuel campaign

There are two methods which have been reported to follow successfully the changes of reactivity coefficients during normal operation in a whole fuel campaign [10], [11]. They are only partly independent, but they complement each other quite well. It has been demonstrated that the general change of the reactivity coefficient could be followed quite well during a fuel campaign in spite of the fact that there were disturbing effects as well. Consequently we can state that such a computer based reactivity coefficient follower can be built in as an operator support measuring device in each Unit. Once we have equipment which is capable of following the changes of that parameter we can request limits for the given parameter.

5. SAFETY ASPECTS OF LOOSE PARTS FOUND IN PRIMARY CIRCUITS AND IN THE CORE

Loose parts (forgotten objects) found in WWER reactors have been said to be not too dangerous from a direct safety point of view for WWERs. Recently (in 1997) a rather large object (about 8 kg) had been forgotten in the steam generator of Unit 2 of Paks NPP. This steel plate was broken into the smallest pieces during a year of operation, while impacting on the wall of the collector of the steam generator. The surface of the collector was damaged just a little. Tube inlets were noticed to be only slightly worn. Some small pieces from that steel object were stuck in the tubes of the steam generator, some of them had to be plumbed, but there was still enough reserve. It was a great deal of work during the maintenance period at the end of the fuel campaign. The cost of this maintenance work was rather huge and it also caused a delay in restarting the Unit. In the first place these are minor consequences from the point of view of safety of the nuclear installation, because at the same time small broken pieces were swept away towards the reactor vessel. Small fragments of forgotten object were found in the reactor core and on the top of the reactor core. Since it was difficult to wash them due to high radiation about 41 fuel assemblies were removed from the core. No real damage to the fuel pins was observed. However, during the operation one of the regulating rods was stuck in a middle position. It has not been proven that these two effects were in direct correlation, but one suspects that this was one of the possible causes of the failure of the movement of the control rod. And this has a direct impact on the safety of the nuclear installation.

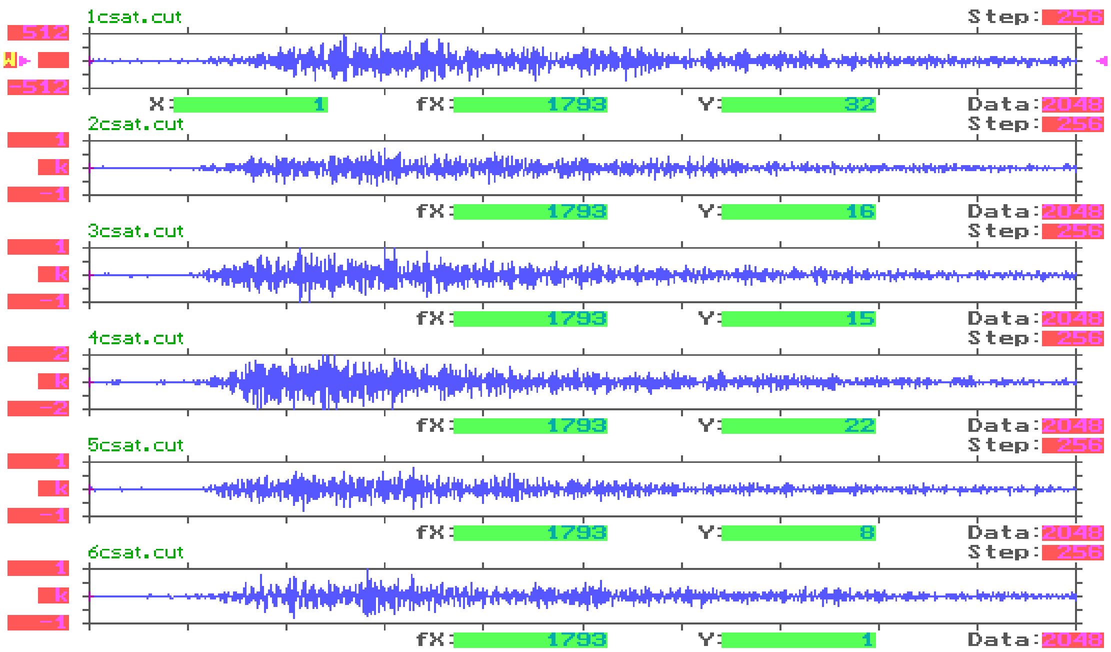

Figure 6. Screen of the HELPS loose part monitoring system during analyse of an event

Consequently even if we can conclude that WWER reactors were designed to withstand rather large loose parts from a material point of view, loose parts monitoring during the start up (and during normal operation as well) is still advisable to avoid such cases, which might have a direct impact on safety. Since we are talking about a continuous monitoring process we believe that such an analysing picture as shown in Fig.6. is good for experts when the event has to be found [12]. For continuos monitoring we use a fully automated, digital expert system which makes recommendations directly to the expert (see Fig.7. which was borrowed from HELPS -Hungarian Expert Loose Parts system [13,14]). Experts can still use manual methods and the display of figure 6 to analyse details. A revolutionary new method in this field, the so called sequential probability ratio test (SPRT) has been used, for identification and classification of the event. Thus, the largest problem of the existing loose part monitoring system has been solved. The problem was that the existing system had high missed alarm and false alarm rates. It has been proven [14], that SPRT needs the shortest amount of data to give decision on the event with given accuracy. Using SPRT, it became possible to get the false alarm rate even below 1%.

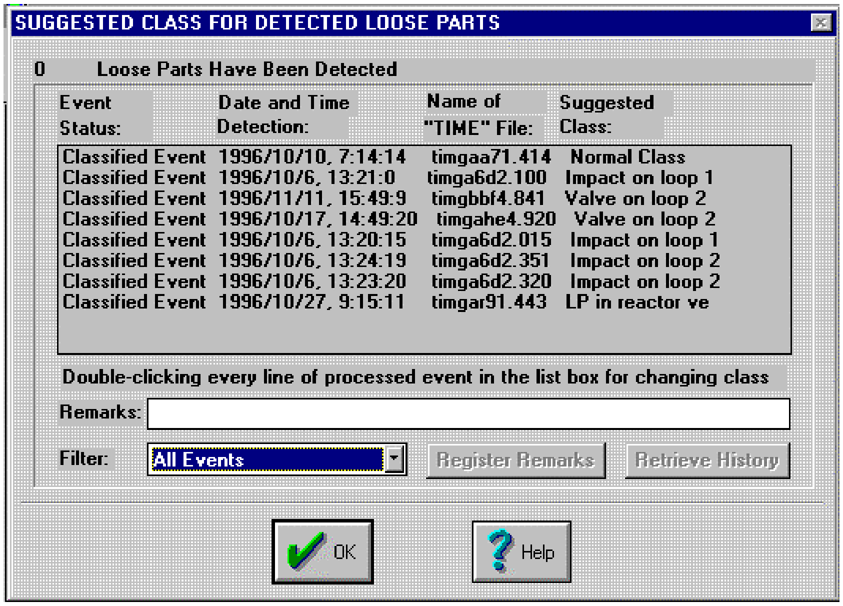

Figure 7. Example of the expert system display of HELPS loose parts monitoring system

PERMANENT SYSTEMS DEVELOPED FOR NOISE DIAGNOSTICS OF WWER PLANTS

Here we restrict ourselves to those permanent noise diagnostics systems which were developed by Hungarian firms for WWER type NPPs.

PDR This used to be the abbreviation for Paks Reactor Diagnostics measuring chains when the first Unit was started in 1981. They contain amplifiers for noise measurement using incore self powered neutron detectors, top-of-core thermocouples, some special pressure fluctuation transducers and a specially designed set of amplifiers for excore neutron detectors, which enabled us to attach noise systems to safety related channels and to make noise measurements on pulse mode signals. The first solution has proven its ability, channels still work after 15 years. Their modifications were used in later systems. Today electronics allows us to attach noise systems directly to plant amplifiers (see ZOMBI), but the solution for excore detectors in WWER reactors is still different as they need to use the safety channels.

ARGUS is a vibration monitoring system using accelerometers to monitor vibration behaviour of the components of the primary and secondary loops of WWER type reactors [15]. In its first version there were simple measuring channels and a CAMAC based system, later PC based sampling, data evaluating and a processing system were also included and contained a really expert shell based expert system for turbine diagnostics.

ALMOS is an Acoustic Leakage MOnitoring System, based on high frequency acoustic transducers. Its data evaluation system is based primarily on rms level [16]. Later an analysis package was added to the system and this relied on rise time and frequency content and the arrival time of the signals.

DIS (Diagnostic Information System) can be broadly defined as an interactive computer-based information system, which is used to facilitate the implementation of a plant-wide failure monitoring and diagnostic system in large-scale systems [17]. It was created to apply more and more sophisticated mathematics to reactor noise analysis and interpretation. DIS includes BDIR94 data acquisition system as well as RTiME NEtData, which is a diagnostic resource equipped with a full variety of contemporary tools for diagnostics. One of the most important features of RTiME is the non-parametric modelling of the measured signals using auto-regression, moving average and other more sophisticated models with built in probability analysis. It can automatically discard the unreliable measurement allowing the user to deal only with reliable measurements. It works as a supervisory system for reactor noise and vibration measurement at Unit 1 and 2 at Paks NPP.

CARD is a Computer Aided Reactor Diagnostics system, which is capable of collecting and processing fluctuating parts of signals from the reactor [18]. Its inputs accept signals from in-core self powered neutron detectors, excore ionisation chambers, thermocouples, pressure fluctuation transducers and some of the accelerometers mounted on the reactor vessel and in primary loops. The system automatically estimates FFT spectra and MAR models, and trends of parameters. All those are compared with previous values. A physical model based expert system helps the user to find occurrences like: core barrel motion, incore vibration, stability of the feedback system, hot spots in the reactor. Signal validation and parameter estimation (for example, reactivity coefficient estimation, thermocouple time constant estimation) complete the system.

HELPS is a Hungarian Expert Loose Part System [13,14]. It is completely model based. Firstly, a non-parametric modelling (using a combination of auto-regressive modelling with sequential probability ratio test) helps to find if there is any abnormal occurrence in the system (in primary loops of NPP). All deviation from normal statistical behaviour can be found even in the case when the rms value does not change at all. Then the occurrences found are analysed using an adaptive learning algorithm, which uses part rms, while there is also an expert making comparisons of all moments and signatures from the operator room. Finally this kind of analysis leads to more reliable loose part detection with less false alarm rate.

ZOMBI is a system under installation which enables the CARD system to reach all in-vessel signals in WWER reactor [19]. There are many in-vessel signals: 216 thermocouples and 288to336 incore neutron signals in WWER types of reactor. The whole core diagnostics can be solved by periodically monitoring these, using the advanced diagnostics methods.

JEDI is a system under development, which is partly based on the CARD system. It also includes new methods (like Kalman filtering techniques) and covers methodology for leak detection and sensor validation as well [19]. It should be recognised that with a growing amount of information the man machine interface part of such half automated diagnostics systems becomes very important.

In those systems which have actuators automatically driven by the system the importance of the man machine interface maybe less important. None of the diagnostics system really has actuators. Diagnostics is meant to recognise the malfunction and to give some information on that. It may even give hints, but usually decisions are taken by experts. Diagnosis always means an early warning and early failure detection. The parameters of the given system are still within the allowed limits (both from a regulatory point of view and from a physical point of view). If they are out of range then the system must be halted. When we speak about diagnostics the system is still running, but some tendencies in it are going in a direction which can lead away from the allowed range. That also means there is still time to take decisions. There is no need to attach any automatic actuators to the system.

Diagnostic systems are not safety systems but systems to improve the reliability of NPPs hence they assist with the safety. They are information systems which are safety related. How to arrange the information? How to present it? How to lead the attention to the important occurrences? How to ensure that the important part would not be hidden by numerous miscellaneous effects? This is very important for such a system.

A good man-machine interface can help very much with that. This is the final goal of the development of the system of JEDI.

HOW TO ORGANISE THE DIAGNOSTICS IN NPPs

There are different points of view as to what kind of diagnostics we need in NPPs. Some specialists claim that we only need diagnostics which have been prescribed by manufacturers of the main components of NPPs. They disregard the developments in data collection systems and computer aided expert diagnostics systems. Some other people would like to order a ready made, rather sophisticated, fully automated, intelligent, expert system, which would give them a guarantee, and if any malfunction takes place then it gives a warning or an alarm, and if the system shows that everything is OK then it is 100% OK. They do not like such terms as missed alarms or false alarms. They are used to safety systems, and they believe that they should get a system which acts automatically.

We believe that both attitudes toward diagnostics are erroneous. What we need today is the following. We can and we have to purchase diagnostics systems based partly on fluctuations of different measurable parameters or on vibrations. Recordings and primary data evaluation should be done automatically. The most time consuming data analysis work as well as that expert analysis which can be automated should be automated. As a product of such a system we get warnings that something is going wrong with some indication as to what can be the cause, and where to start further analysis, or we can get a message that everything was unchanged in the measured parameters.

Here starts the role of the experts who should analyse the warnings coming from the automated system with manual methods and by comparison with the plant data. Such activity cannot be automated in the future as well since there is always a chance that one gets something new, a new effect or new problem, which had not existed before, consequently there is no way to learn it from any intelligent learning system. We believe that we cannot miss the careful analysis made by expert today and in the future as well.

The human factor is of overwhelming importance in diagnostics. Humans are the best way avoiding false alarms. Also they are able to present the results in a form which is acceptable to others: for maintenance work, for management, for safety people etc. This is a second task, and it is as important as the first one. One of the biggest tasks today is to make comprehensive reports which are easy to understand for other specialists. If the expert tries to explain his or her conclusion using terminus of noise diagnostics, like spectra, coherence, auto-regressive modelling, etc., then the others cannot follow that and they will not accept the conclusion, and they will not take actions. If an expert gives only the final conclusion without explanation then nobody will believe that, plus it does not corresponds to the requirements of the quality assurance either. The latter gives the correct solution to this problem. According to the quality assurance program it is essential that the types of the report, their routes to the interested persons, their content and how to use it will be prescribed in detail. For example, experts should have a detailed plan, in case of a loose part, where and to whom the report should be made. What should be the content of that report? It is clear that each case differs from another case. There must be a part, which is flexible. But this must be the smallest part of those reports (less than 20% of the total report). It cannot be the task of the expert to define to whom to send the report. Also the action to be taken by the addressee should be a part of the plant regulations. And it is a task for the plant management to organise now this part of noise diagnostics.

CONCLUSIONS

The technical part of noise diagnostics can be regarded as well analysed, and mathematically solved. Many well organised noise measuring systems are working in different NPPs. They usually have more or less expert systems as well. We presented some areas, which have an overwhelming importance for WWER diagnostics and which can be regarded as well understood, and also which have proved that methods used in noise diagnostics can contribute a lot to the safety of nuclear installation. We conclude, that most of the technical part has been solved or is in process being solved. The human factor and the reporting of the results of noise diagnostics are one of the most vulnerable parts of this methodology today. The most important task for plant management and also for diagnostics today is to work out regulation, reporting system, limits and an action plan for any given plant which is in accordance with the quality assurance program.

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