16th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2012, Dubai, UAE, 10-12 September 2012

THE APPLICATION OF EXPERT SYSTEMS IN DIAGNOSTICS OF ROTATING MACHINES

Prof. dr Ranko Antunović
Mechanical Engineering of East Sarajevo
Vuka Karadžića 31, East Sarajevo
Bosnia and Herzegovina

ABSTRACT
The usage of expert system is necessary when in a limited part of field algorithms, solutions don't exist and there is not completely defined theoretical solutions, or in the case when the theory exict, but it is not possible practically include all theoretical cases process using the algorithm in real time. In both cases practical experience of expert is used to establish the solutions on the base of expert system.
In this paper the ably establishment of expert systems in the field vibrodiagnostic's mechanical transmissions. Presented the achievements to date and provide opportunities for further development of such systems
Keywords: vibration, diagnostics, expert systems

1. INTRODUCTION
Machine condition, damages and future damages are read, the machines in operation, through specific symptoms of damage, for example: mechanical vibration, noise, change of accommodation parts and machinery bearing temperature rise. It is possible to reverse the way that based on the symptoms of damage determines the condition of the machine. Of the many, according to the state of relevant symptoms, the damage shows up mechanical vibrations that contain, at the same time, information on the amount, phase angle and frequency. Mechanical vibrations are extracted and mapped because all significant damage to the machine, and because they can be measured with negligible equipment.
As an aid to man-expert, which processes data from sensors and performs failure detection, and develop automated systems to diagnose. The main difference between expert systems and other data processing systems is to use symbolic (rather than numerical representations) and heuristic search solutions (and not giving the final solution).

2. SECOND AUTOMATIC DERIVATION OF RELIABLE DIAGNOSIS
Most PdM (predictive statements) systems developed today are based on the observation (monitoring) changes in the frequency spectrum. When people PdM experts estimate the frequency spectrum, they are observing and evaluating the process of connecting the same basic symptoms observed in the spectrum of the mechanical elements of the machine. These identified characteristics or symptoms typically include the general level of vibration, changes with respect to the reference measurements, by a noise in the spectrum, the peaks in the spectrum, and harmonic minor, and family groups. To be closer to the human-expert and expert system automatically uses the same characteristics for the evaluation of the spectrum and to perform some basic conclusions. Obviously, the expert-system can not make observations in the same way as the human-expert, but instead calculates the frequency of symptoms using a limited database calculations symptoms and nominal value of RPM as a user input.
As already mentioned, symptoms of which are used in expert-system basis PDM, as a rule, the peaks in the spectrum corresponding to the characteristic vibration frequencies of the machine, for example.

amplitude of the operating speed (1X), the amplitude of the other harmonics of operating speed (2X), increase energy side groups around the blade passing frequency (BLPF). When setting parameters for a typical turbogenerator that monitoring should be included: X / Y axis vibration, axial position and temperature mazivnog oil for bearings.
Since the majority of symptoms associated with operating speed machines, when calculating these symptoms that parameter is used as part of the expression for the calculation. For example:
-groups for calculating the harmonic frequencies of a rotary machine, used RPM xn, where n = 1,2,3 ..
-to calculate TMF for the reducer, use RPM x (number of teeth).
Only in some special cases will be a nominal operating speed of the machine, which is the entrance to the expert-system, fully coincide with the mid frequency filters in the measuring range is represented by a line. In most cases, the error made in determining the value of RPM will be transferred in the system to other calculations of symptoms. For example, the fifth harmonic of operating speed is calculated with an error that was five times greater than the error originally entered. This would mean that it would be impossible to automatically identify the family of harmonic peaks. Furthermore, errors that are inherited in the machine can cause variations in the frequency of symptoms that can not be linked to the value of RPM simple mathematical relationships such as previously shown.
It is obvious that the derivation of reliable conclusions, the expert system must be equipped with the basic means of automatic,, observations, and automatically adjusting determinantnih peaks, such as RPM. In practice, the optimal computation of symptoms can be achieved by providing tools that address the four main problem areas. These are:
• fluctuations (changes) in the speed of the machine,
• Incorrect setting RPM
• The overall increase in total vibration or noise levels in the range and
• An increase of symptoms with very low absolute level of

3. THIRD CLASSIFICATION OF AUTOMATIC DIAGNOSIS

For a dynamic PdM applications is not enough even calculate optimal symptom. Machines, like humans, have their own history and distinctiveness that often defy even the most comprehensive set of rules, symptoms and diagnosis. The system diagnoses one thing, but everyday korisnci system know that this is something completely different. In such situations, the tools for fine modulation can be helpful, but not solve the basic problem of how to incorporate the knowledge and experience of users in the core system, and thus allow the expert system automatically qualifies derived diagnosis and diagnoses made compensation by faulty or incomplete.
Furthermore, there is also a fundamental problem of the parameter processing of other non-vibration. Vibration machines may vary depending on the operating state of the machine, for example. changes in active and reactive power and the oil temperature in the bearings. The evidence strongly suggests that the solution to this problem is to use a dynamic knowledge base containing the rules of the symptoms and diagnoses that only user-defined.
Unfortunately, it is not easy to implement such an approach. As mentioned above, rule based systems are supplied with a fixed knowledge base containing a finite number of symptoms, diagnosis, and rules. They are, fixed, in order of difficulty and time required for verification, validation and verification of the reasons hundreds of positions. One way to avoid this problem is to create a huge and comprehensive database of rules to cover all current and future contingencies. However, this idea is linked to a specific problem of the accumulation of knowledge. Because the supply system is still primarily a knowledge intensive human activity, the availability of human experts (which is essentially the initial reason was to design an expert-system) is a major stumbling block for the development of large expert systems based on rules for PdM and other dynamic applications. Statistical pattern recognition provides another way of implementation in this area has led to significant progress. However, the complexity in the modernization of the system is still a major drawback of this method. Another method uses a model form of identification (pattern recognition), but no advanced skills in computer simulation and statistical methods in the method of artificial neural networks (ANN) . ANN technology is the latest attempt to create the most similar human performance expert, and they offer the best way to implement fast and efficient dynamic knowledge base.

3.1. Implementation of the ANN for a PdM

The principles and advantages of ANN technology are well known and commercially available ANN-pillars are now used in a wide range of applications. Visually, the pattern of orientation nature of ANN expert system extends the range of AI and the complements, otherwise cold and mechanical process an additional human dimension. Where the rules-based systems require explicit knowledge of the rules, expert systems require only the basics ANN implicit knowledge in the form of specific facts or characteristics (patterns of data on the sample), to quickly interpret, classify, and generalized the input data streams. One of the most popular types of commercial ANN-backbone, and one of the easiest to implement the ANN return transfer. For the diagnosis of faults in machines, as in many other dynamic applications, it is very difficult to obtain for several examples of cases that would cover all eventualities in decision making. Furthermore, when a new practice patterns become really available, this entire process must be restarted. Another advantage of this approach is that the designer has control over the work of hidden layers, the expert system is able to provide an explanation of their diagnosis. The structure of ANN base function allows users to quickly and easily join the network of their own experience through new educational patterns or facts.

For pre-existing diagnosis, the user can create and update a network completely new pricelist, or to supplement the facts that are copied from a standard rule base which is equipped with the system. Defined fact may relate to a particular component in the machine,, real life, the scope and number of turbines: bearings, gears and becomes an intrinsic characteristic of the component. The facts that define the user can be used for influencing any of the diagnoses in the system. If none of the current diagnosis is not appropriate, the user can inputirati brand new diagnosis. For example, if the user experience on a specific pattern of symptoms measured value indicates an error that the system has not yet been discovered, the user may be entitled to add a new fault-based rules defined by user. The system can immediately take advantage of this fact for the diagnosis of a fault.

4. ADVISOR

Bruel & Kjaer CMS software, ADVISOR (advisor), the nervous system is a diagnostic machine. It was created for use in electrical and petrochemical industries / 5 /. It allows diagnosis of a wide range of defects on all types of rotating machines that are in standard use.

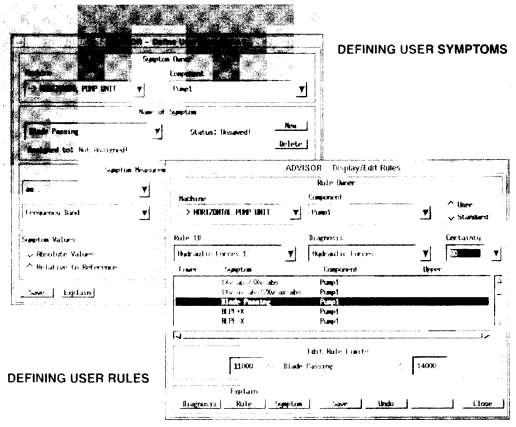

Figure1. Entering a user's knowledge in an expert-system ADVISOR

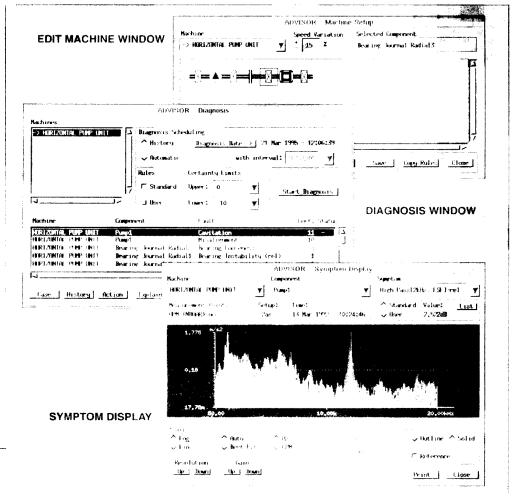

Figure 2. Graphical display symptoms of defects in the expert-system ADVISOR

To enable the ADVISOR developed in parallel with the user, normative, it provides an introduction to the user's knowledge base increases and continually improve the standard knowledge base that comes with the software.
For a complete review of diagnosis, ADVISOR provides graphic representations of the measuring range of frequencies with an error, and explanation and listing of all rules used in the diagnosis, historical tendencies for selected diagnoses, statistical prediction, the reports created by the user and so on.

5. CONCLUSION

It can be concluded that the majority of commercially available expert systems in vibrodiagnostic has certain disadvantages in order to fully replace the human expert. However, it can be argued that this resource is certainly a promising option for improving and automating the process of diagnosis of mechanical transmissions. What are some current disadvantages of such systems:
• The majority of expert systems that are now available to us are systems of artificial intelligence (AI) systems known as expert systems based on rules. Experts do not usually think in the form of rules, because the logical and analytical techniques of AI-systems generally do not mimic the actual process of thinking-man experts which would inevitably lead to more reliable and cognitive diagnoses.
• Expert systems are rule based fixed and finite number rules and therefore are essentially useless for the ability of continuous learning what is required for dynamic applications. As a person who uses the system acquired enough experience to make better estimates and more reliable diagnosis, the system is less and less used. To create a dynamic knowledge base is used more advanced methods such as statistical pattern recognition, but these methods require considerable skills in a computer simulation and statistical methods to modernize the system.
• How computerized PdM (predictive claims) systems become more sophisticated, so it increases the complexity of the symptoms that are used in the automatic process of detection and diagnosis. For the majority of expert systems remains a problem how to reconcile the differences between theoretical calculations and the actual symptoms of the existence and location of these symptoms in a spectrum.
• Most expert systems are usually designed as separate systems of individual users. As such, they are limited to the privileged few and limited the use-value to the organization as a whole. So how is it possible to make an expert system more effective, more economical and more reliable for analysis and diagnosis of automatic vibration. To answer this question, we must return to basics and take into consideration the fundamental activities that are covered by manual analysis of vibration-SQUAD process.

6. REFERENCES

[1] Michael Flanagan, Expert System Data Acquisition, PROFILE Newsletter, Vol.4, No.2, Bruel & Kjear CMS A/S, 1996
[2] Michael Flanagan, Effective Automatic Expert System for Dynamic Predictive Maintenance Applications, the American Society of Mechanical Engineers, Paper No. 97-GT-64
[3] J. Efstathiou, Queen Mary College, INTRODUCTION TO EXPERT SYSTEMS, Belgian Institute for Automatic Control, Antwerp, Belgium
[4] L. Boullart, Rijksuniversiteit Gent, INTRODUCTION TO ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS, Belgian Institute for Automatic Control, Antwerp, Belgium
[5] Technical Documentation, COMPASS Monitoring System Version 6, Bruel & Kjaer, Schenck
[6] Seminar C40e, Machine Diagnossis