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INCREASING RELIABILITY OF DEFECT CHARACTERIZATION ON SG TUBINGS USING A COMBINATION OF SIGNAL PROCESSING AND EXPERT SYSTEM

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INCREASING RELIABILITY OF DEFECT CHARACTERIZATION ON SG TUBINGS USING A COMBINATION OF SIGNAL PROCESSING AND EXPERT SYSTEM

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SUMMARY

The NDT laboratory (CEA-SACLAY) and UTC are developing an expert system for automatic analysis of EC signals provided by the multifrequency control of steam generators tubing. This article describes on one hand the aim and the results of the elimination of pilgrim noise, on the other hand the expert system which uses signal analysis and signal processing in unison.

INTRODUCTION

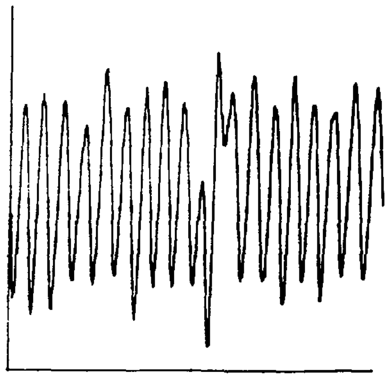
Since the verification of steam generator tubes, using the technique of multifrequency eddy currents, entails the processing of a great amount of data ; the automatic analysis of the signals is then necessary.

The objective of this communication is to present an expert system which can undertake this analysis. For this task noiseless signals are needed on all the channels. However, the fabrication of ST tubes, by pilgrim pass process, results in internal deformations which generate pilgrim noise on the original signals. In this same session [1], we have been presented a paper describing an algorithm which is very effective at resolving this problem.

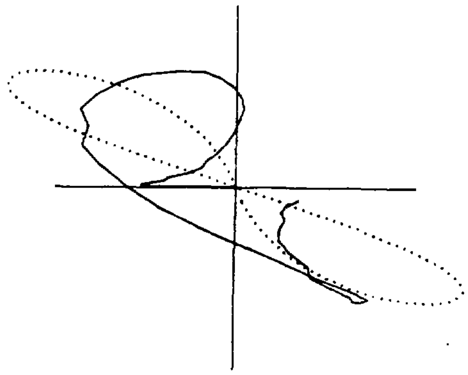
Firstly we will present the results obtained using adaptive interpolation [1] to eliminate noise on real signals. Secondly we will briefly present the generator of expert systems SUPER [2], which allowed the construction of a knowledge base which adapts to the interpretative reasoning. The essential elements of this knowledge base will be presented.

THE FILTERING OF PILGRIM NOISE

A result of adaptive interpolation of EC signal is illustrated in fig. 1. The pilgrim noise comes from a recording of Bugey PWR's tubing control. We chose an unstable noise (in amplitude) to present the efficiency of this algorithm.

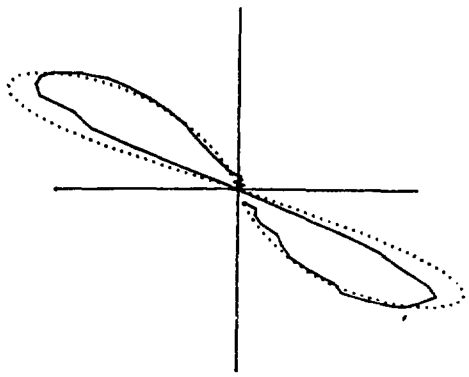


x-coordinate of graphe 1-b



1-a ..... defect signal

1-b —— defect signal plus noise



2-a ..... defect signal

2-b —— result of adaptive interpolation

Fig. 1 : example of adaptive interpolation

It is evident from the graphic display of the resulting signal, that the noise renders it inexploitable whereas after adaptive interpolation the signal can be analysed.

Finally to test the strength of this method we studied the different phases of the defect signals resulting from the adaptive interpolation with respect to the phases of the theoretical model representing the defect to be studied.

Table 1 shows the results of the statistical study of the interpolation on thirty recordings of pilgrim noise within which were added signals from the theoretical model with five different phases (- 5°, - 25°, - 45°, - 65°,- 85°).

TABLE 1
Statistical results of the measures of the phases of EC signals after adaptive interpolation

PHASE OF THE SIGNAL (DEGREES)	-5	-25	-45	-65	-85
MEAN OF THE OBSERVATION	-5.3	-24.95	-45.6	-66.3	-85.75
MEAN DEVIATION OF THE OBSERVATION	1.04	1.54	3.72	3.8	4.8

The mean deviation of the phase measurement is not greater than 4.8° which is quite sufficient for an evaluation of the depth of the defect.

Thus we will be able to use the interpolation in the expert system. This allows a use of all the acquisition channels to characterise the defects.

EXPERT SYSTEM FOR AUTOMATIC ANALYSIS OF EC SIGNALS

Method

The examination of SG tubes by the technique of multifrequency EC depends on the analysis in the complex plan of EC signals on different channels. Each of these channels is the result of the application of a different frequency or of a combination of different frequencies. The channels thus contain complementary information about the state of the tube.

The characterization of defects by analysis of these results depends partly on the application of control procedures and partly on the examination of the signals by a specialist. The aim of the expert system is to reproduce the reasoning of the specialist about isolated EC signals. The elaboration of the system is based on the cognitive analysis of the problem starting from the knowledge of the specialist.

It is never possible for a specialist to express his knowledge in a single unit. It happens that he forgets or simplifies details of his knowledge, which later necessitates the augmentation of the knowledge of the system. In this case it is easier to acquire knowledge incrementaly [3]. Thus we have chosen an expert system based on the production-rules (SUPER) developed at the University of Technology of Compiègne (U.T.C.) [2] [4].

KNOWLEDGE ACQUISITION

The general structure of the system is represented on fig. 2.

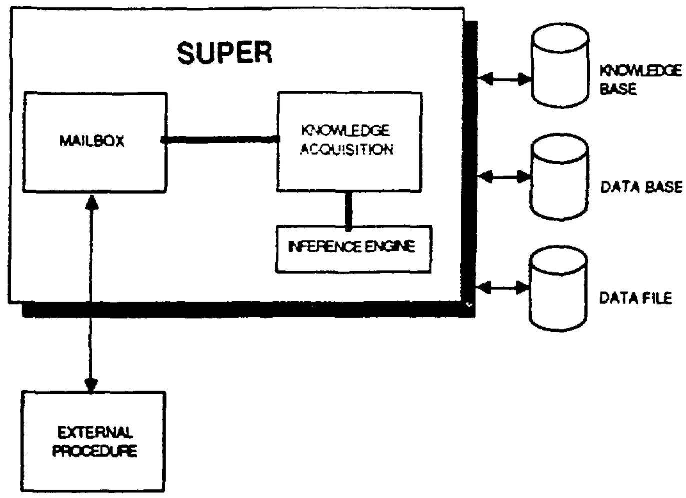


Fig. 2

The knowledge representation in SUPER is based on production-rules organised in two networks : an expert network and adjoining network.

The expert network corresponds to what we call in general the knowledge base. The adjoining network comprises rules for changes of state which allow the guidance of heuristic research. The action + conditions of a rule are propositions which can be evaluated and which can also contain valuable items (comparison of phases...).

Finally, a module of the system allows the linkage of the action of triggering of certain rules to the triggering of procedures of external computations. During the execution of a procedure the reasoning is suspended. At the end of the execution, after the updating of the data base, the reasoning continues, which calls on the properties of reasoning in non monotonous logic of the inference engine [4].

The mechanism of transmission can be devided into three steps :

- the execution of the procedure by the triggering of a rule,
- the sending of the values and names of valuable items to be treated by the procedure,
- the evaluation of all the propositions from the knowledge base which use these items.

STRUCTURE OF THE KNOWLEDGE

The expert network is made up of rules which reflect the comportment of the specialist during an analysis. The knowledge base has been elaborated starting from production-rules which represent fragments of knowledge concerning the EC theory and the specifications of control of SG tubes. The expert system almost reproduces the reasoning of the specialist. Starting from isolated EC signals of a defect, the observer can, after having expressed the state of the tube (with or without pilgrim noise) be proposed a characterization which consists of defining :

- the type of the defect (fig. 3),
- the depth of the defect,
- the reliability of the characterization.

The system types the defect by evaluating on one hand the symmetry of the signal (phase wise) and on the other hand the coherence of the interpretation of the defect following the examination of all the acquisition channels. Defects can then be characterised ie. asymmetric single and multiple defects, as well as symmetric single and multiple defects.

CONCLUSION

The expert system has permitted an improvement in the interpretation of defects in SG tubes by the multifrequency eddy current testing . Actually the evaluation of the coherence between the acquisition channels has allowed the interpretation of defects with multiple characteristics, and also to use an expert system and algorithmic in unison. This primarily allows the complete analysis of defective tubes with pilgrim noise. Finally this approach renders accessible the usage of the pattern recognition technique to clarify the characterization of defects.

The continuation of this study consists of a prototype for the caracterization of defects in support plate zone + rolling zone.

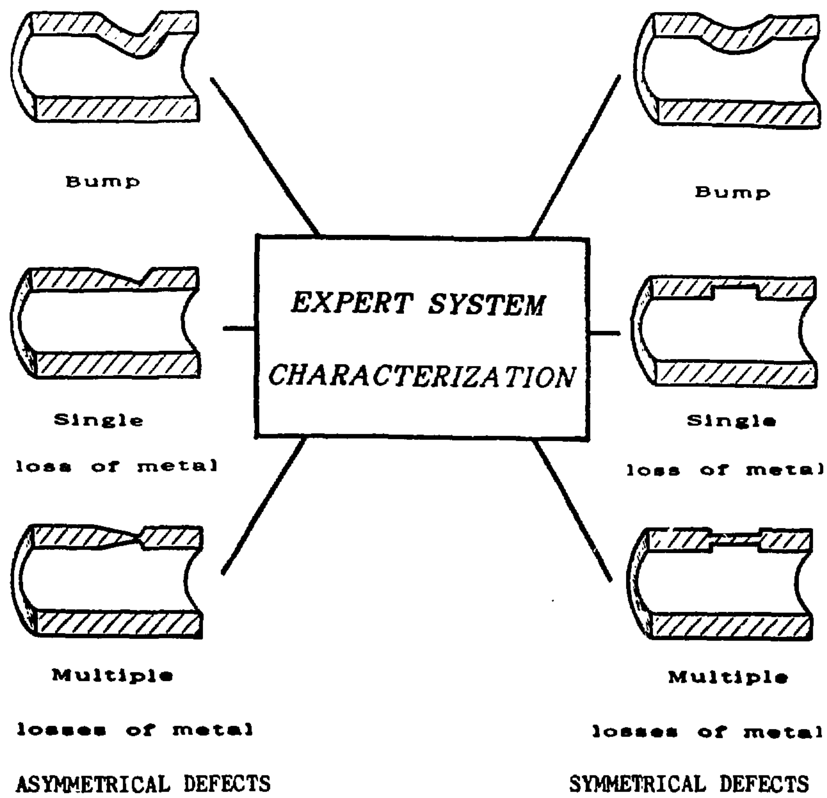


Fig. 3 : type of defects characterised by using the expert system

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