Components Diagnostic System For Identifying Power Loss Problems

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COMPONENTS DIAGNOSTIC SYSTEM FOR IDENTIFYING POWER LOSS PROBLEMS

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ABSTRACT

Nowadays, when a malfuntioning of some component in the steam cycle in a Nuclear Plant is produced, the component provider is usually entrusted the care of detecting any kind of malfuntioning and its possible repair.

It is complicated to detect what kind of malfuntioning is which produces the efficiency loses during the normal operation of the thermal plant.

In some cases, the malfuntion diagnostic is carried out through different tests on the component with different load conditions with which the malfuntion is deduced.

It seems clear that the plant operator would be very interested in getting a system that gives him the first information about the type and seriousness of the component malfuntion when using available variables of operation in normal conditions. Besides that system could detect the impact that this malfuntion is supposing on the termic efficiency of the plant. About making decisions on the advantage or disadvantage of repairing it and when to repair it. This is what the diagnostic system would bring about the components malfuntioning. It is developed by UITESA with COFRENTES Nuclear Plant (Spain) help.

INTRODUCTION

Diacom is a System for the Diagnosis of the Condition of the Components which influence most in the thermal plant efficiency, thus making it possible to determine the causes of malfunctioning of the above mentioned components.

The evaluation of the impact of the various possible malfunctions upon the plant efficiency total provides the operators with essential information to be taken into account prior to future decisions related to maintenance and improvement in the design of the plant.

UITESA has developed a system of Diagnosis of the malfunctions of components and the Cofrentes Nuclear Thermal Plant has been chosen as the experimental plant.

The data processing system that UITESA has developed with the Cofrentes Nuclear Plant aims precisely at helping the operator diagnose the malfunctioning of a component, pointing at the nature and depth of the malfunction.

This product will be installed at the Cofrentes Nuclear Plant to determine the causes of power losses in the 0.25% to 5% range, with the plant perfomance during steady state operations and at 102% of its thermal power.

The software developed is applicable to other plants adapted, in each case, to the peculiarities of the plant.

SYSTEM DESCRIPTION

General Characteristics of the System

Figure 1 provides an outline of the working functions of Diacom. The diagnosis system feeds itself on data provided by two different sources: one is manual, the other automatic. The automatic data is obtained through on-line measurements stored at the process computers of the plant. The manual data entered by the user comes from manual readings related to the state of the components or variables of the process. These data are put together in work sheets of the plant in the form of reports.

From these data, and making use of the rules of diagnosis obtained from the decision logic diagram trees developed as described in the handbook of EPRI NP-4990P "Thermal Performance Manual for Nuclear Power Plant" (Ref. 1), see Figure 2, the system seeks out automatically possible malfunctioning of the turbine cycle.

The system diagnoses some 100 malfunctions, along with these probabilities directly related to results. The diagnosis system works on Windows 3.1, and sets itself punctually upon request by the user at any time during normal operation of the plant. Results are shown in a window detailing steps that have been taken to reach diagnosis. Incoming data, both manual and automatic, and the diagnosis, are stored on historical files to be kept.

Preparation of Diagnosis Rules

Diagnosis rules, usually have form:

"The cause for efficiency loss of yields is [malfunction X]

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SYSTEM ARCHITECTURE

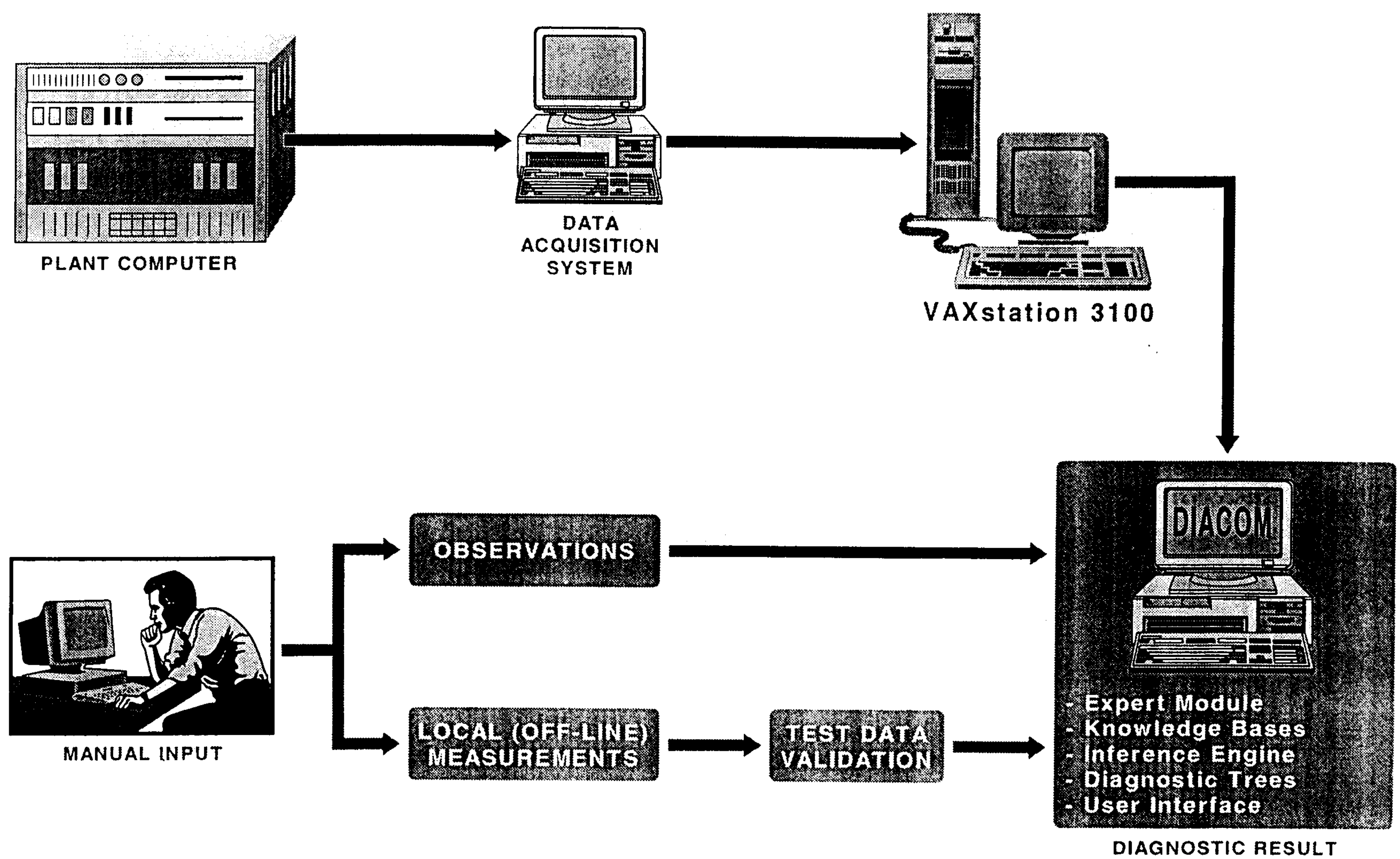

FIGURE 1

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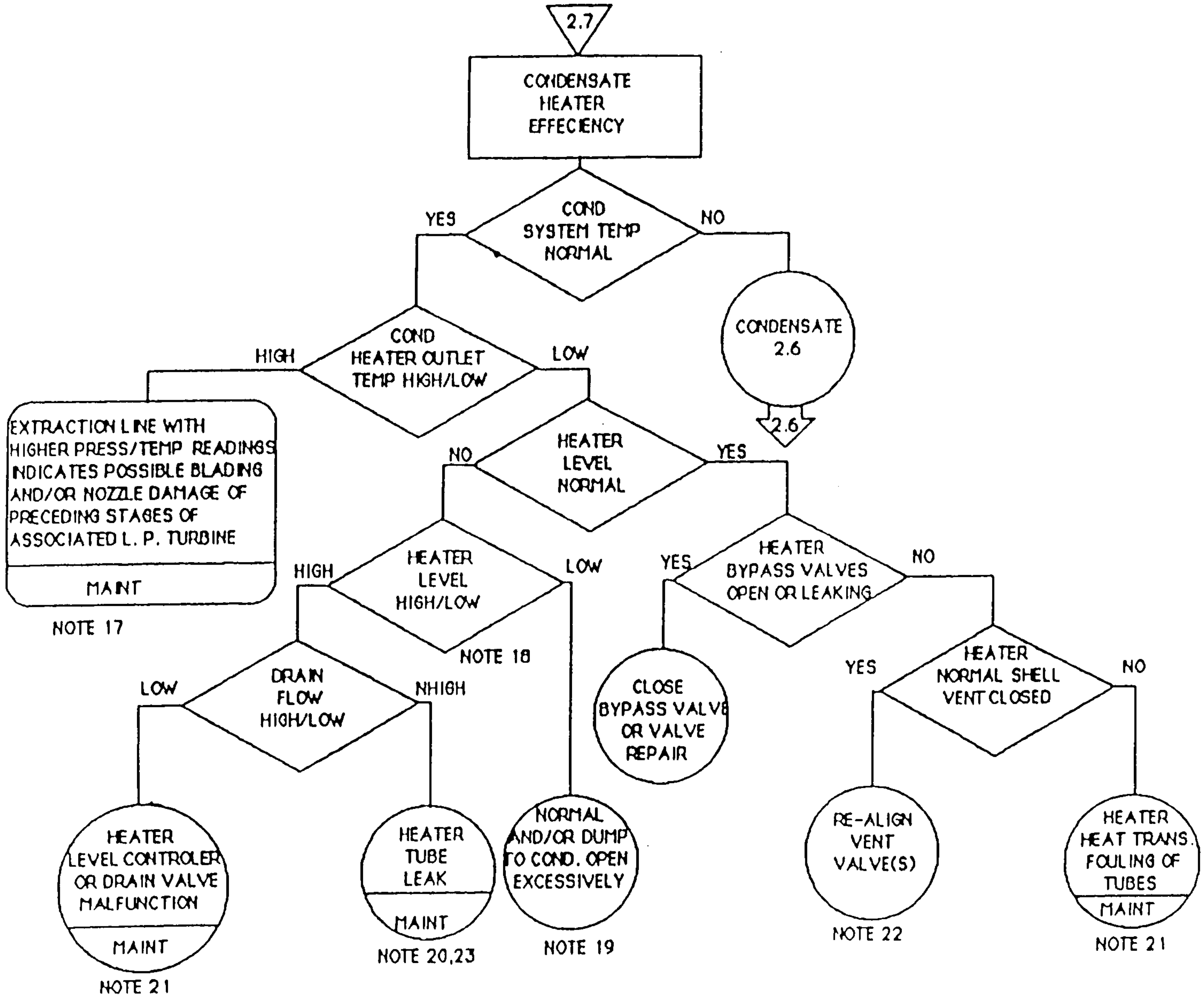


FIGURE 2

If: [Quality 1] is [Label 1]

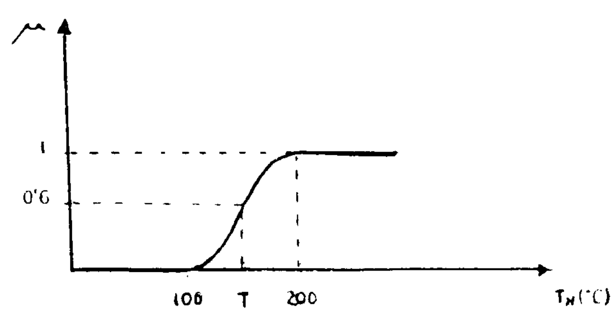
[Quality 2] is [Label 2]

[Quality 3] is [Label 3]

In these rules, appearance of [malfunction X] can be infered when specific symptoms show up. Each symptom consists in that a specific [Quality n] of the process, such as the estimation of a variable on the condition of a component, take a value that can be qualified as [label n]; normal, high, low, open and closed, amongst others. Description of this expression can be set in a group of fuzzy rules of diagnosis.

Since normal or reference values change, depending on the function of the condition of the process for specific values, it is neccessary that fuzzy evaluations of the rules be redefined everytime the conditions of the process vary. This redefinition of the label (also called linguistic labels) is done considering the variables of the process, together with the curves that determine the normal values in relationship to the above mentioned variables, as well as the nominal errors throughout the process measurements that may affect the definition of the linguistic labels.

The fuzzy logic allows us to relate a "soft" definition to a linguistic label. For example, a simple rule "The efficiency loss is C1 if temperature Tn is high". In this rule the label "high" represents a fuzzy group. The degree of dependence of a Tn value to a fuzzy set of temperatures is represented as:



The meaning of this graphic is that if Tn is worth less than 100 °C it is "high" with grade 0, i.e., it is not high if it is worth more than 200 °C, it is high with grade 1, i.e., it is certainly high, whereas if it is within the range of 100 and 200, Tn could be qualified as high, with a degree of certainty, in between 0 and 1. Consequently:

1°. The degree of certainty "Tn is high", and with it the possibility (the subjective interpretation of the possibility has been adopted here) of diagnosing C1, varies as slightly as Tn does.

2°. Each malfunction can be assigned, with some certainty, to the possibilities of occurence, coming from each diagnosis rule.

Technical Description of the System

Figure 3 contains the architecture of the system.

Fundamentally, it is a conventional expert system architecture, made up of the main following parts:

-Data Base: The system has modules to register, read and store the data the system receives (manual and automatic) as well as the diagnosis it gives place to, thus allowing to retrieve and study past situations, such as the "off-line" studies of trends or to obtain statistics.

-Knowledge Base: The rules of diagnosis are codified as texts (ASCII format) following expression patterns (syntax) comprehensible to the expert module. This is called the Knowledge Base. The system, at the first stages, reads the file and

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FUNCTIONAL DIAGRAM

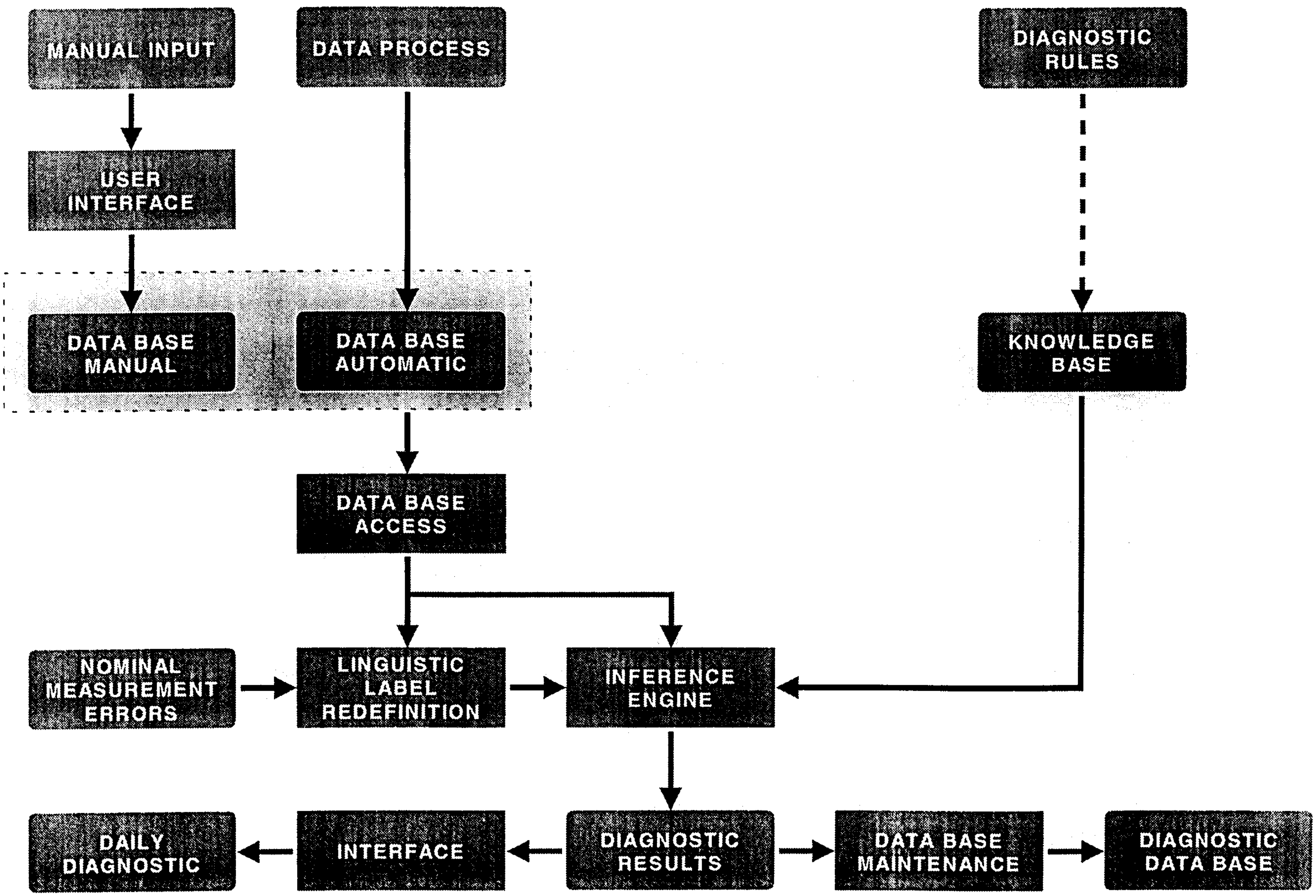

FIGURE 3

changes it from the text form rules into data structures that the inference motor can utilize. This is the Knowledge Base Compilation process.

-**Inference Engine**: This module introduces reasoning through the knowledge bases, pairing adequately the state of the process with that of the condition of the rules and then reaches the corresponding conclusions. The design of the Inference Engine may answer to various approaches. Notwithstanding, in the system that has been developed, the convenience of obtaining a gradual and light response in the system. as well as to accompany the diagnoses to a degree of certainty or probability, has made necessary the use or fuzzy logic in the inference mechanisms.

-**Interface with the user**: The interface of the system with the user is proper to that of a Window utility, so it can be operated easily with the system. Through this interface the user can start the diagnosis system, can change the plant operating reference data as well as any operation parameter, may enter the data corresponding to the manual reading and, finally, the results obtained by the Inference Engine are shown. The detected malfunctions go hand in hand with the likelihood that they might occur.

The user is also provided with the possibility to receive an explanation about how each diagnosis has been obtained. Figure 4 is a screen example of the diagnosis process and its outcome.

On the other hand, the results are filed in a diagnostic Data Base, where they can be used to see trends, or just as a simple historic register. See Figure 5.

Diagnostic

Inlet circulation water is low (0'56).

Electric generation 900 MW (low, 1.0).
Thermal power 2953 MW (normal, 1.0).
1st stage pressure 62'5 Kg/cm^2 (normal, 1.0).
MSR1 pressure 15'2 Kg/cm^2 (normal, 1.0).
MSR2 pressure 15'2 Kg/cm^2 (normal, 1.0).
MSR1 outlet pressure 13'85 Kg/cm^2 (normal, 0.56).
MSR2 outlet pressure 13'90 Kg/cm^2 (normal, 1.00).
MSR1 outlet temperature 268'2 °C (normal, 1.00).
MSR2 outlet temperature 268'2 °C (normal, 1.00).
Condenser-A back pressure 10'0 mmHg (baja, 1.0).
Condenser-B back pressure 86'0 mmHg (baja, 0.0).

FIGURE 4

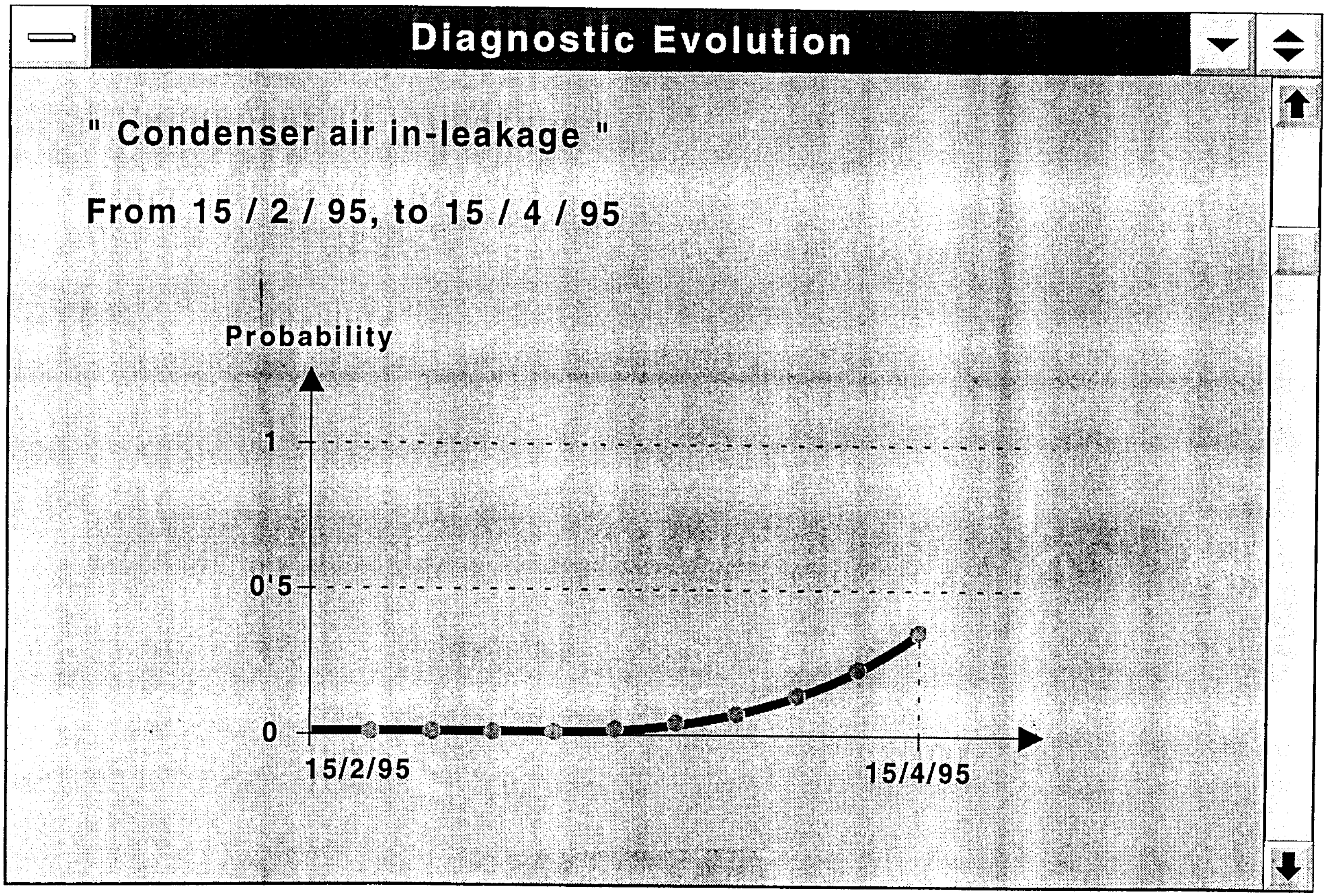
Diagnostic Evolution
" Condenser air in-leakage "
From 15 / 2 / 95, to 15 / 4 / 95
Probability
1
0'5
0
15/2/95
15/4/95

FIGURE 5

Integration with PEPSE code

The first step in developing the DIACOM was to define the perfomance diagnostic tree for thermal power plant.

Cofrentes Nuclear Power Plant perfomance diagnostic tree was developed by a team of plant engineers. Sometimes, the Fossil Thermal Plants need aid to develop these trees. For this it is necessary to generate analysis using a heat balance code such as PEPSE (Ref.2).

On the other hand, DIACOM provides automatic assistance to the personnel plant in identifying problems that make the result the of lost megawatts but it cannot be used to quantify the magnitude of the losses. This magnitude can be quantified using PEPSE code.

CONCLUSIONS

Quantify the impact of the possible malfuncions in the total thermal plant efficiency, provides an essential information to take future decisions on the part of the plant operation as for maintenance and improvement in the plant design.

UITESA has developed a Component Diagnostic System called DIACOM, to assist to plant operators and perfomance engineers in identifying the source of lost megawatts. It is being applied at the Cofrentes Nuclear Thermal Plant.

Fuzzy process control is probably the main application of intelligent system to the industry. An adequate formulation of the goal enables this system to be applied in other processes, as it could be chemical processes.

REFERENCES

1. D.J. Finnicum and R.C. Webber, "Thermal Perfomance Diagnostic Manual for Nuclear Power Plant", EPRI NP-4990P, Volume 1-3, April 1987.

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3. XXI Spanish Nuclear Society Meeting, "Sistema para el Diagnóstico de Malfunciones de Componentes", Nuria López, Javier García, Manuel Rodriguez. October 1995.