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Expert system for the control of emergencies of a process plant

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Abstract

The chemical industry due to its great potential of danger, as much for the human health and for the environmental one, requires exceptional safety measures. Not in vain there appear new more strict norms concerning the systems of control and study of the consequences of a possible accident. The investigation group has been developing an expert system for the integral management of the procedures of emergency of a refinery, the greatest and most complex of the chemical industries.

The tool has two missions that are fundamental for the safety of any chemical plant, on one side advises to the operator for the actions to take in case of an emergency and on the other hand the expert system makes a complete program of formation for new workers. In this formation it simulates emergency situations that the user must solve successfully.

In order to achieve this double objective, almost a year has been dedicated to the compilation of all the information necessary to nourish the knowledge base. The inference motor governed by logics rules will use all this information for, under several premises, to decide which the best action to take is.

In addition the system is able to complete the formation of new technicians simulating emergency situations, soliciting data of equipment, safety norms, and function of the units...

Due to the structure with which the expert system has been constructed, is easy to export it to another type of process plants. It as easy as finding an expert who, with the aid of a knowledge engineer, would introduce in the data base the particularitities of that type of industry.

Keywords: Expert System, Emergency procedures, Safety, Refinery

1. Introduction

When this project began, the collaborating refinery trusted the answer to any alarm on its experts' knowledge. The operators based on their experience, decided the actions to take in order to avoid that risk situations became serious emergency situations. This scenario raised an amount of inherent problems to human condition like loss of capacity to reason in case of a panic attack, negligence by the excess of confidence and suppression of apparently unnecessary actions among others.

In view of this situation the company decided to invest in a research program to construct an Expert System that provides a second opinion in case of real emergencies, as well as a program for complete training of new operators.
The Expert System must accomplish the following objectives:

- It must contain all the necessary information for making the correct decisions and, when there is a lack of a necessary parameter, it should formulate a question asking for it.
- It must include all the plant units for considering the repercussions of each action taken and for avoiding, therefore, the denominated 'domino effect'.
- It must be very clear and easily understood by users.
- It must provide a complete training module on which users can complement their formation about the Plant and about specific subjects on safety.
- It must have an updating subsystem so that the responsible person can introduce all changes occurred in the Plant.

2. The Expert System

The first step for the construction of the Expert System is the knowledge database design, where the information that the inference engine will use for taking decisions is stored.

2.1 The Logical Tree

The information of the knowledge database must be structured following logical rules in order to associate concepts in the same way that the human brain of the expert would. For this purpose, logical trees used for making decisions have been developed. A logical tree defines chain actions related by cause-effect associations. The relation between two actions can be direct or be associated by other conditions, appearing in this way, necessary conditions, sufficient conditions and both necessary and sufficient conditions.

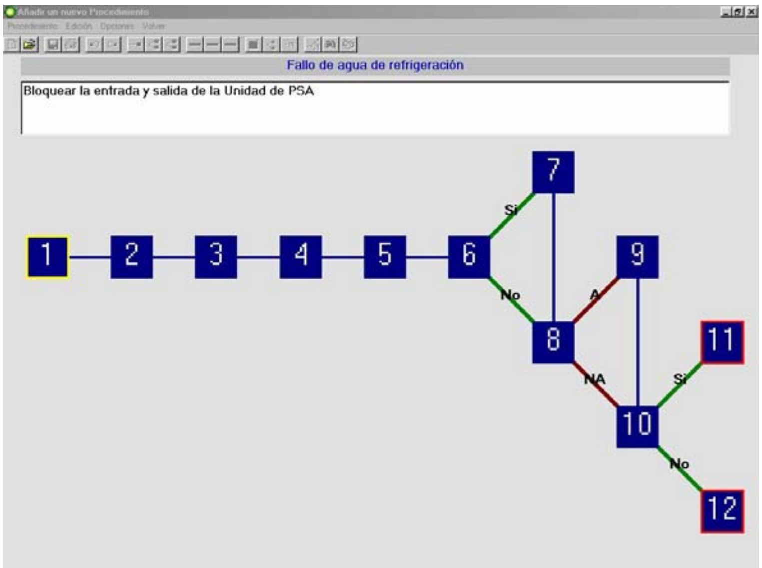

Figure 1. Logical Tree

As it can be observed in Figure 1, the logical tree presented has three kinds of relations between the actions: the consecutive relation (blue colour) , the dilemma relation (green colour) and the waiting relation (red colour).

- Consecutive relation: This relation is necessary and sufficient, the following action is essential among the list of actions to take, but because of logistic reasons the order on which actions have to be taken is not of forced accomplishment, again, the decision is leaved to the operator.
- Dilemma relation: This relation is necessary and sufficient, the following action is essential among a list of actions to take, but because of logistic reasons the order on which the actions are taken is not of forced accomplishment, the decision is left to the operator.
- Waiting relation: This relation creates the possibility to execute different actions depending on the particular reasons of the emergency during the actions sequence. The difference with the previous bifurcation is that in this kind of relations two different branches of the tree can be taken to be merged later on.

Besides the information concerning the actions to take in case of an emergency the database contains the specifications of the equipment in the plant and their operation conditions.

Once the database contains all the information, the inference engine is able to predict the possible consequences of an alarm or incident and suggest in this way, the recommended actions to take in order to avoid further problems that would lead to more serious problems.

This information is useful for the staff as a reminder and as a second opinion in case of doubt but never makes an action in the plant. The operator has the task of acting and feed the expert system with the required information as well as introducing the actions already taken.

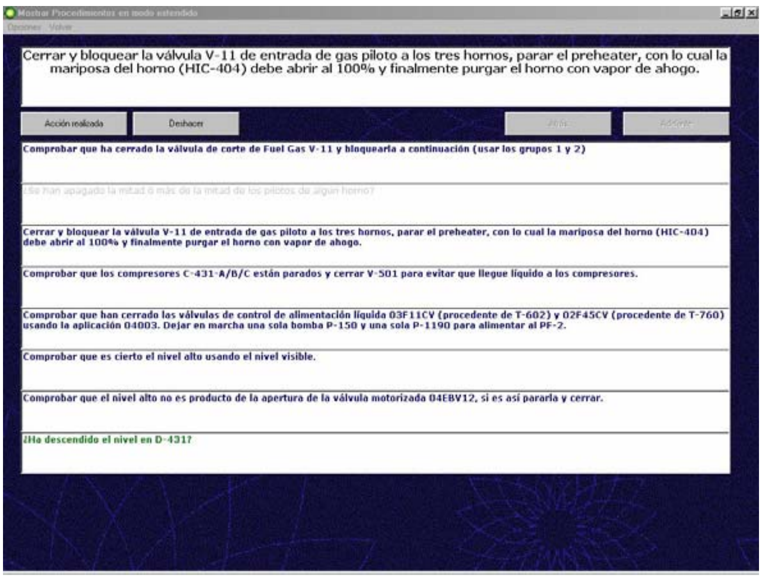

Figure 2.Action List

As it can be seen in figure 2 the structure given to the action form has been studied in a way that results simple to use and allows to see 10 actions at once, giving in this manner a general vision of the emergency procedure to follow.

2.2 Training System

With the information present in the database a learning subsystem has been prepared in a way that generates simulated emergency situations. Once the warning pops up the operator must decide what actions have to be taken. The questionnaire is organized in a test form in a way that four possible answers are presented and only one of them is correct. In these test series, questions about the equipment and concepts related to safety can be asked.

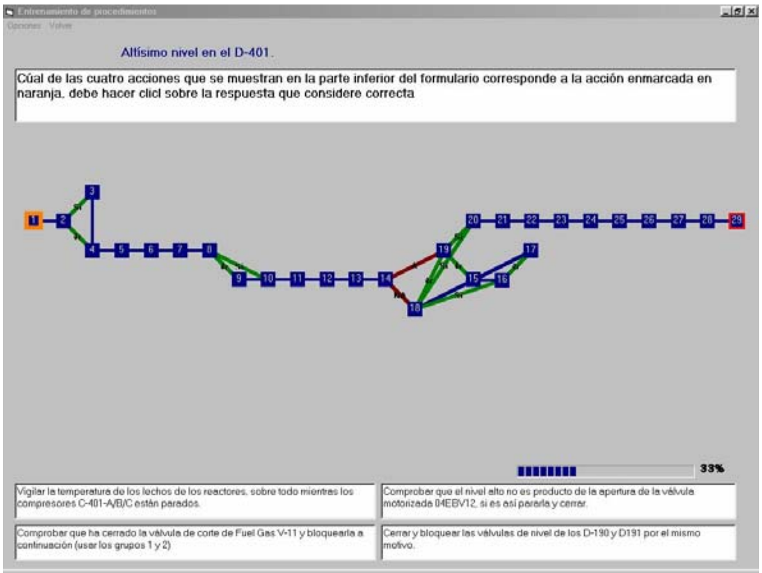

Figure 3.Training test

Finally, the application was provided with multiple options that make its use more dynamic and easy, like the possibility of consulting the map of the section where an item of equipment or a particular accessory appears. In this way it results more simple to understand its utility and predict the consequences of its malfunction.

In the figure 4 appears an example of a unit diagram.

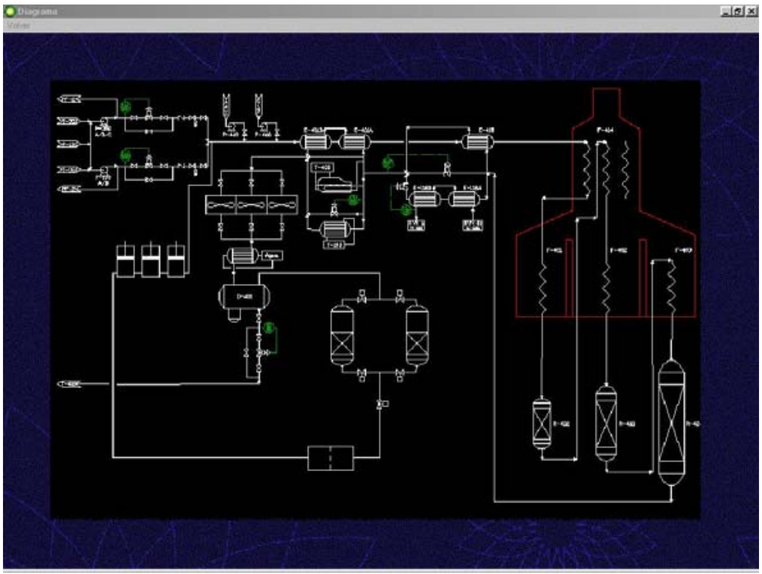

Figure 4.Unit diagram

3. Conclusions

An application has been developed with the purpose of accomplishing two main functions, it gives an objective second opinion to the operator concerning the actions to be taken in case of an emergency, and also, is a suitable tool to teach, train and update the personnel.

In order to build the application it has been necessary to acquire a deep knowledge of the refinery units and the definition of the emergency procedures, structured in logical trees and saved in a database.

The designed inference engine acts on this database. It manages all the information, suggesting the necessary actions that have to be taken in case of an emergency. Furthermore, it generates the questionnaires that will be used in order to train the staff.

Besides this features a device that maintains the application has been integrated; it allows the user to update the system (add items or modify the database), without using the source code, making the application non dependent on the original programmers.

References

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