OPERATOR SUPPORT SYSTEM FOR PRESSURIZED WATER REACTOR

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Abstract

Operator Support System for Pressurised Water Reactor (OSSPWR) has being developed under the sponsorship of IAEA from August 1994. The project is being carried out by the Department of Engineering Physics, Tsinghua University, Beijing, China. The Design concepts of the operator support functions have been established. The prototype systems of OSSPWR has been developed as well. The primary goal of the project is to create an advanced operator support system by applying new technologies such as artificial intelligence (AI) techniques, advanced communication technologies, etc. Recently, the advanced man-machine interface for nuclear power plant operators has been developed. It is connected to the modern computer systems and utilises new high performance graphic displays.

1. INTRODUCTION

Operator Support System for Pressurised Water Reactor (OSSPWR) is developed under the sponsorship of IAEA from August 1994. The project is being carried out by the Department of Engineering Physics, Tsinghua University, Beijing, China. The Design concepts of the operator support functions and the method based on them have been established. The prototype systems of OSSPWR have been developed as well. The basic aim of the project is to create an advanced operator support system by applying new technologies such as artificial intelligence (AI) techniques, advanced communicative technologies and so on. Recently the advanced man-machine interfaces for nuclear power plant operations connecting with modern computer systems and new technologies such as high performance graphic display, etc., have been actively developed. The AI techniques seek to offer a new possibility to enhance the performance of man-machine systems though more powerful diagnosis, procedure synthesis, and user friendly man-machine interface.

The goals of the OSSPWR are as follows:

1. Support the efficient and reliable plant operation.
2. Support the detection of anomalies in plants and the identification of their causes and provide appropriate operational countermeasures.
3. Support the realisation of user friendly and intelligent man-machine interfaces, matching the operator's cognitive processes.
4. Support the training of operator.

Now OSSPWR will be coupled with the simulator in Beijing, China.

2. SYSTEM DESCRIPTION

The main role of OSSPWR is to support operators' decision making under various situations of plant operation. In a result, operators are able to gain an efficient control over a nuclear power plant by using knowledge of its detailed structure of functions and expertise obtained from their long term operation experience. Such knowledge is installed into the knowledge base of OSSPWR and used for inference of operators' decision. The functional constitution of OSSPWR is shown in Fig.1.

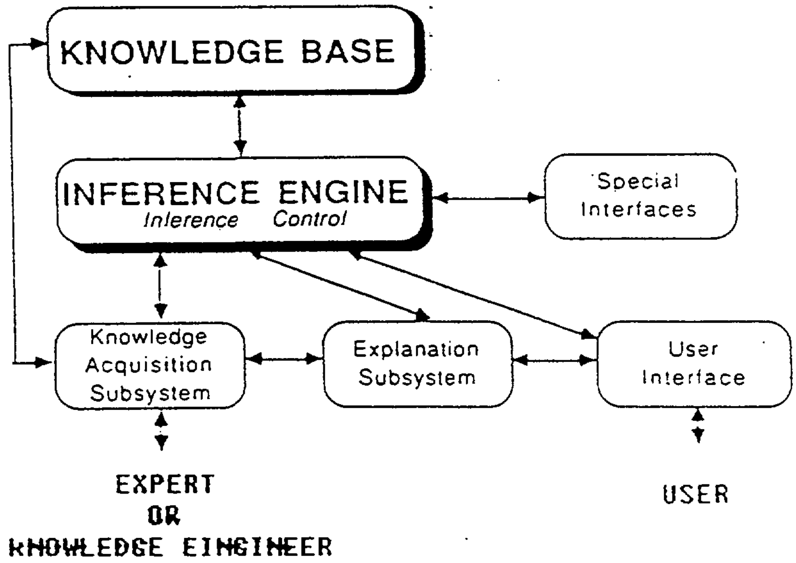

Fig.1. Structure of Operator Support system for PWR

OSSPWR is applied to the simulator of Beijing Simulation Training Centre of China. Based on the Abnormal Operating Procedures (AOP) and the Emergency Operating Procedures (EOP), both the Abnormal Operating Subsystem (AOS) and the Emergency Operating Subsystem (EOS) are developed.

2.1. AOS description

With object-oriented strategies adopted in the inference engine of AOS, the subsystem pursues to search rules and then create inference trees. The diagnostic flow chart in AOS is shown in Fig.2.

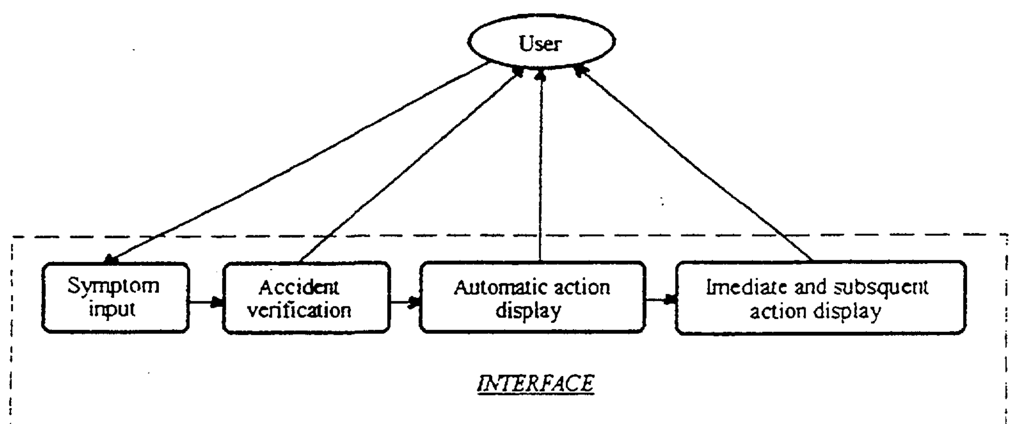

Fig.2. Diagnostic flow chart in Abnormal Operating Subsystem (AOS)

As an example, Fig.3. presents the inference progress of an abnormal condition - turbine trip without reactor trip.

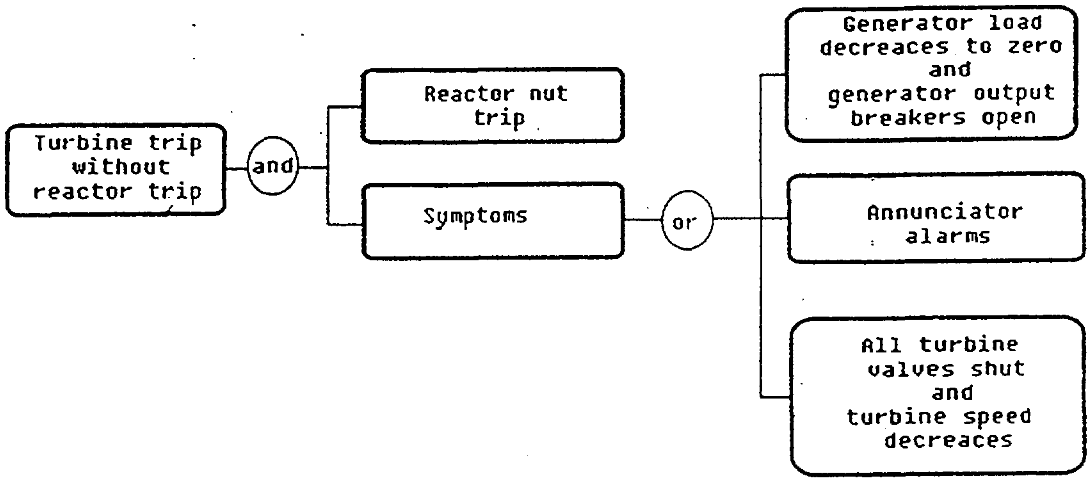

Fig.3. Inference tree of turbine trip without reactor trip

At present the system AOS can diagnose 32 abnormal operating conditions and display automatic actions and subsequent actions that the operator should adopt. The abnormal conditions which can be diagnosed and treated in AOS are presented in Table I.

Table I. Abnormal operating conditions in OSSPWR Accident Type

No.	Abnormal operating conditions
1	Failure of a control bank to move
2	Continuous insertion of a control bank
3	Continuous withdrawal of a control bank
4	Dropped control rod
5	Misaligned control rod
6	Malfunction rod position indicators
7	Indications of misaligned rod
8	Emergency boration
9	Turbine trip without a reactor trip
10	Inadequate feedwater flow
11	Loss of circulating pump
12	Control room inaccessibility
13	area monitor system
14	Progress monitor system
15	High turbine vibration of eccentricity
16	Accidental release of waste gas
17	Partial loss of condenser vacuum
18	Fuel handling accident
19	Loss of component cooling water
20	Secondary load rejection
21	Loss of instrument air
22	Loss of component cooling water to reactor coolant pumps
23	Loss of seal injection to reactor coolant pumps
24	Failure of reactor coolant seal pump
25	High reactor coolant pump vibration

26 Abnormal RCS pressure of high pressure
27 Abnormal RCS pressure of low pressure
28 Loss of residual heat removal system
29 Earthquakes
30 Loss of containment integrity
31 Loss of instruments bus
32 Steam generator tube rupture

2.2. EOS description

Emergency Operating Procedures (EOP) of PWR are divided into two parts, Optimal Recovery Procedures and Function Restoration Procedures. Base on EOP, the Emergency Operating Subsystem (EOS) is developed and consists of the Optimal Recovery System (ORS) and the Function Restoration System (FRS).

The emergency operating conditions in ORS consist of Loss of Coolant Accident (LOVA), Main Steam Line Beak (MSLB), Steam Generator Tube Rupture (SGTR) and Station Blackout (BO). The structure of Optimal Recovery System is shown in Fig.4.

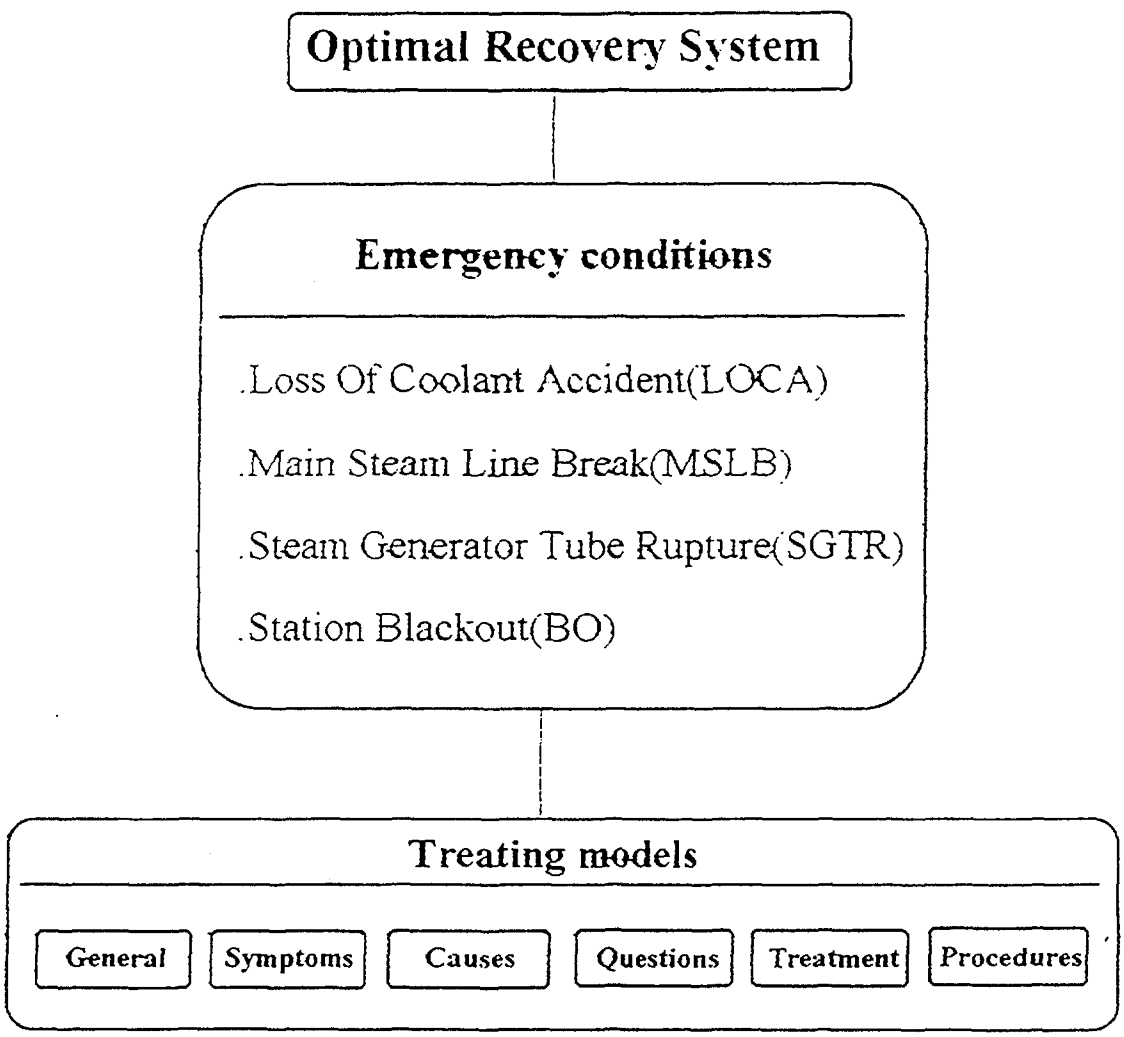

Fig.4. Structure of Optimal Recovery System (ORS)

Based on the safety function concept, FRS contains six automated tasks, each for every critical safety function (subcriticality, core cooling, heat sink, integrity, containment and inventory).

3. CONCLUSION

Currently, OSSPWR can successfully operate on PC-486 and will be tested on the simulator in Beijing Simulation Training "Centre of China. In the near future, the system will be improved in quality and function.

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