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Design of a Programmable System for Failure Modes and Effect Analysis of Steam-Power Plant Based on the Fault Tree Analysis

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Abstract:-

In this paper, the system of the power plant has been investigated as a special type of industrial systems, which has a significant role in improving societies since the electrical energy has entered all kinds of industries, and it is considered as the artery of modern life.

The aim of this research is to construct a programming system, which could be used to identify the most important failure modes that are occur in a steam type of power plants. Also the effects and reasons of each failure mode could be analyzed through the usage of this programming system reaching to the basic events (main reasons) that causing each failure mode. The construction of this system for FMEA is depending on the logical relationships of the fault tree analysis for the systems that contained in the power station.

The designing of such system could be used as an assistance tool for the specialist user (the power engineer) in identifying of all reasons and effects for any type of failures. So this is help to fastening the repairing operation of the identified failure mode to improve the efficiency of operating system as represented by the maintainability, which is a function of system reliability.

The selection of the steam type of power generation systems for the application of this study, because this type is the most common type of Iraqi power plants. While such the designed system could be programmed to be use in another types of industrial systems.

Keywords: Fault Tree, Reliability, Maintainability, Industrial Systems, Failure Mode and Effect Analysis, Diagnostic Expert System, Steam Power Plant

1. Introduction

With the increasing of complexity degree for the industrial systems, there is an importunate need to the application of developed techniques in operating and maintaining of such systems. The failure modes and effect analysis (FMEA) is one of modern technique that is especially applied with complex systems to facilitate the identification process of the systems failure modes and to analyzing of their reasons and effects.

The research deals with the power plant as a significance type of industrial systems. Where the reliability improvement of such systems has respective importance since the objective function of the power plant is to produce energy with reliable factors and available quality as planned as possible during the required period of time. Then the maintainability improvement has the main role for reliability enhancement, which is defined as "the probability that a failed component or system will restore or repaired to a specified condition within a period of time when maintenance is performed in cordance with prescribed procedures." [1]

Although thermal generating facilities are aging, flexible operation in response to changes in the demand for electrical power is required. To extend the life and manage the operation and control activities of power generation unit, the information and network technologies have become their important role to ensure the safety functioning and control of the unit operation. Also, the focusing on the application of advanced preventive maintenance technology and scheduled inspections of the unit facilities such as the boiler, steam turbines, gas turbines, and other machinery used in thermal power generation, which were controlled by computerizing diagnostic systems. All of these facilities lead to strengthen preventive maintenance and increase the efficiency of the power unit production.

2. The Method of Fault Tree Analysis

"Fault tree analysis (FTA) is reliability/safety design analysis technique, which starts from consideration of system failure effects, referred to as Top Events. The analysis proceeds by determining how these can be caused by individual or combined lower level failures or events". [1]

By the FTA technique many events that interact to produce other events can be resulted using simple logical relationships such as (AND, OR,etc.), and these relationships permit a methodical building of a structure that represents complicated systems.

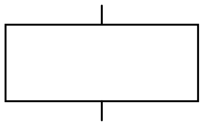
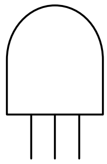
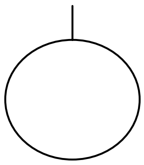
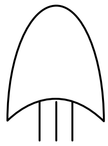
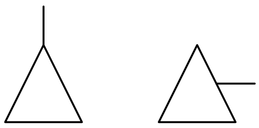
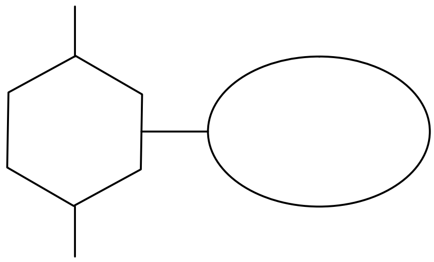
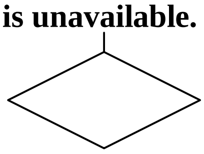
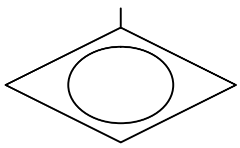
When the tree structure has been established, subsequent analysis is deductive and takes two forms: [2]

- *Qualitative analysis* to reduce the tree to a logically equivalent form in terms of specific combinations of basic events (primary faults) sufficient to cause the undesired top event to occur. Each combination will be a "minimal cut set" of failure modes for the tree. (A minimal cut set is a set of events, which cannot be reduced in number, whose occurrence causes the top event).
- *Quantitative analysis,* which consists of transforming its established logical structure into an equivalent probability form and numerically calculating the probability of occurrence of the basic events.

Standards symbols are used in constructing a FTA to describe events and logical connections, these symbols are shown in table-A.

AND/OR gates are simply graphical symbols, which represent Boolean operation on the various events. The OR gate is equivalent to the Boolean symbol "+" and represent the union of the events attached to the gate. The AND gate is equivalent to the symbol "**.**" representing the intersection of events

Table-A:
Standard Fault Tree Logic and Event Symbolism: [(2), (3)]

Event Representations	Logic Operations
The rectangle identifies an event that results from the combination of fault events through the input logic gate. 	**AND gate describes the logical operation whereby the coexistence of all input events is required to produce the output event.** 
The circle describes a basic fault event that requires no further development. 	**OR gate defines the situation whereby the output event will exist if one or more of the input events exist.** 
The triangles are used as a transfer symbols. A line from the apex of the triangle indicates a transfer in and a line from the side or bottom denotes a transfer out. 	**INHIBIT gates describes a causal relationship between one fault and another. The input event directly produces the output event if the indicated conditional input defines a state of the system that permits the fault sequence to occur, and may be either normal to the system or result from failures.** 
The diamond describes a fault event that is considered basic in a given fault tree. The possible causes of the event are not developed further because the event is of insufficient consequences or the necessary information is unavailable. 	
The circle within the diamond indicates a sub-tree exists, but that sub-tree was evaluated separately and the quantitative results inserted as though a component. 	

3. The Functional Description of Steam-Power Unit with the Application of Fault Tree Analysis Technique

Through the studying of the operating nature of steam-power generation unit, one recognized that the unit operational system could be classified into three major operational subsystems. These subsystems are interconnected with each other in a specified manner to give the required output of the entire unit's system, which is the planned capacity of electrical power. These major subsystems are the Mechanical, Electrical, and Control, and each one of them is consisting of a combination of components and subsystems, which are working dependently on each other to obtain the required function. In the following, a description to each one of the major subsystems is given.

3.1 The Mechanical System

This system consists of the following major components: [4]

- The *Boiler* contains the furnace where burning fuel (oil, natural gas, and crude oil) and heats water to make steam. The boiler is the device meant for producing steam under pressure.
- The *Super-heater* is used to superheat the steam before passing through the boiler to the prime mover.
- Forced Draft Fans, for efficient combustion enough air has to be supplied. The chimney provides natural draught, and additional draught by forced draft (F.D.s) fans.
- The *Economizer*, where the gaseous products of combustion give most of their heat to the water in the tubes of the boiler and super-heater, and in order to make use of the remaining heat thereby heating the feed water in the economizer tubes.
- *Air-Heaters* arrangement used to provide initial heat to the air before it is admitted to the furnace.
- The *Turbine* changes steam's heat energy into mechanical energy. Steam pushes blades rotating on a bar, causing it to spin at high speed.

  The generator changes the mechanical energy into electrical energy. The spinning bar of the turbine causes a huge magnet in the generator to rotate past copper bars producing electric current.
- The *Condenser,* where steam after expansion through the turbine goes through the condenser. The use of condenser improves the efficiency of power plant by decreasing the exhaust pressure of the steam below atmosphere. Another advantage of the condenser is that condensed steam can be recovered and this provides a source of good and pure feed water to the boiler.
- *Circulating Water Pumps*, to provide the required quantity of cooling water for condensing steam in the condenser. Where these pumps are normally installed on the source of water (river) to supply water throughout the year.
- The *Hydraulic System,* it is an important system that used for controlling the quantity of steam supplied to the turbine. This system used to supply the hydraulic oil with high pressure directly to an electric motor, which controls the automatic motion (open and closed) of the supplied steam valves to the turbine.
- The *Serve Valve* controls the quantity of hydraulic oil that pumped by the hydraulic pump.

All failure modes of the mechanical system have been analyzed through the application of Fault Tree (FT) technique to describe the logical relationships among the failure events reached to the top event of this system, which is the turbine operating failure. The fault tree analysis of this system is shown in Fig. (1), where the failure symbols are explained in table-B.

3.2 The Electrical System

The electrical system of steam power unit is consists of the following major components: [5]

- *Turbine-Generator Shaft*, the turbine has single shaft with several stages (may be 17 stages), rotates with a velocity reaching to 3000 rpm, by input steam of temperature 482^{0}C with pressure of 58 bar. The generator shaft is connected directly with turbine shaft so that it rotates with velocity of 3000 rpm and the generated voltage is usually 11kV. The generator is 3-phase AC.
- The *11kV Circuit Breaker (C.B)*, is designed to control the generated voltage of 11kV, which is supplied to the electrical system.
- *11/132kV Main Transformer*, this transformer is used for the transformation from 11/132kV that supplied to the 132kV C.B when the generator is generating and vise versa when the generator is stopped.
- *Rectifier*, to convert the 125V A.C into 125V D.C that is required for the 125V D.C system to supply D.C voltage for some important equipment such as protection, control, and emergency oil pumps.
- *11/3.3kV Auxiliary Transformer*, this transformer is used for the transformation from 11 to 3.3kV that required for operating of some auxiliary units (high & low voltage equipment).
  - *3.3kV C.B*, to control the power that fed to the 3.3kV Bus-Bar (B.B).
  - *3.3kV B.B*, to supply the required voltage for operating of high voltage motors in the system.
  - *3.3/0.38kV Load Center Transformer*, to obtain 0.38kV that is fed to the 0.38kV B.B.
  - *0.38kV C.B*, to control the power that is fed to the 0.38kV B.B.
  - *0.38kV B.B*, to supply the required voltage for operating the low voltage motors in the system.

The failure modes of the electrical system have been analyzed with the application of the FT technique as described in Fig. (2), and the failure symbols are explained in table-C.

3.3 The Control System

The control system of the steam power unit could be divided into three subsystems as follows:

- The *Steam Turbine Control (STC)* system, this part of control system is responsible for the speed and load of the turbine.

The circuit board assemblies of this system contain the electronic printed-circuit boards (cards), which are provide the operational control and turbine-generator protective features in the system. The STC system consists of the following parts:

a- Sp/Ov Sp/O Sp Board: it is sensitive to the speed of turbine through their probes, which are connected to the turbine.

b- Interface and Set-point Select Boards: these boards are responsible for the setting sensitivity of the speed, load and load limiting.

c- Dual Set-point Board: is used to give final signals for speed and load.

d- Speed Summer Board: it takes the above signals as inputs and gives one signal as an output, which enters the Servo Amplifier Board.

e- Ipl Summer Board: it is sensitive to the boiler pressure and gives signal that indicates the proper pressure.

f- Servo Amplifier Board: used to control the operating activity of servomotor until executing the order.

g- 3 kHz Board: it amplifies the signal coming from the Servo Valve to the Servo Amplifier Board.

Almost all types of faults, which occur in this part of control system, are the failures of cards for the above components due to the failure of the integrated circuits boards. Then, a trip signal are resulted from these failures such as the failure of Set-point Select Board, or the Dual Set-point Board, or the Servo Amplifier Board, or the 3kHz Board. And all of these trip signals lead to the failure of Servo valve.

The Servo valve controls the output high-pressure hydraulic fluid flow in proportion to the magnitude and polarity of the input direct current command signals, which control the regulation valves to control the steam that goes to the turbine.

- *Spec 200 control system*, this system is used to control most of operating processes during the running of the power generation unit. This system consists of several important units or subsystems, which forming the basics of control functions, such as:

a- Drum Level Control System, which control the normal level of water in the boiler drum.

b- Airflow Control System, which controls the flow of air that is entering to the boiler for combustion process, through its control on the forced draft fans (FD fans).

c- Oil Pressure Control System: this system controls the oil pressure, which is supplied to the boiler furnaces and required for combustion process.

d- DA Level Control System, which controls the water level in DA drum and makes it in a normal level.

- *Furnace Safety and Supervisory System*, this system is known by the abbreviation (FSSS). It is responsible for the boiler running process and the boiler safety operation, through its controlling the fast closing valves for the fuel lines, which are supplied to the boiler.

The running of any protection system of the unit is due to the resulted orders from this system. Since this system has several types of trip signals, so that if any of these signals results, the system will immediately emit a signal to the protection system of boiler to stop operating. Also any fault signal, which results from the electronic boards (cards) of this system, will lead to stopping the boiler.

The faulty signals, which are produced from the FSSS, do comprise the following:

a- Turbine trip signal.

b- Flame failure trip signal.

c- Loss of fuel trip signal.

d- High furnace pressure trip signal.

e- Loss of F.D fans trip signal.

f- High or low level trip signal.

g- Airflow low trip signal.

h- Loss of 125V D.C trip signal.

Fig. (3) shows the fault tree construction of components failure and the faulty signals for the three parts of control system, and the symbols of this figure are explained in table-D.

The top events of the three systems (mechanical, electrical, & control) are related with each other in OR-gate leading to top event of whole unit system (unit shutdown).

4. The Designing of Knowledge-Based Representation for the Reasoning Programs of the Power Unit Fault Trees

The *state-space search* is an important kind of control strategies that could be used to represent the level of procedural knowledge control.

"State spaces can either be searched in a *forward* direction (or *forward chaining*) by starting at the initial states and applying the operators to find a path to a goal state, or in a *backward direction* (or *backward chaining*) by starting with goal and applying the inverse of the operators to find a path to the initial state.” (6)

The level of knowledge-based can be represented by some means such as the *production rules*, and the *logical representations*. “ The production rules are often simply called production. A production is a *condition-action* pair and defines a single chunk of problem-solving knowledge. The *condition part* of the rule is a pattern that determines when that rule may be applied to a problem instance. The *action part* defines the associated problem-solving step.”(6) Also the knowledge-based level can be represented in “first order predicate logic, if the formulas are suitably interpreted. The program may contain several different ways to establish predicate statements corresponding to the AND/OR graph. The solution of a problem is presented as a set of statements that are found by doing a depth-first search of the corresponding AND/OR graph until an instantiation of a set of assertions is found that provides a solution graph.” (7)

To control the fault tree procedural knowledge, the state space search of forward direction (forward chaining) has been utilized at the level of knowledge control representation of the unit-systems fault trees. Then, the production of *if-then* rules based on the AND/OR graph have been used to represent the knowledge-based system.

Figures (5, 6, & 7) show the state spaces search to identify the top events from the procedural knowledge-based representation of mechanical, electrical, and control systems fault trees, respectively. The set of production rules of isolating the mechanical system failure causes reaching to the system top event (MF1) that could inferred from Fig. (5), would be represented as follows:

$$\left.\begin{array}{l} MF4 \vee MF5 \vee MF6 \vee MF7 \vee MF8 \vee MF9 \vee MF10 \Rightarrow MF3 \\ MF12 \vee MF13 \vee MF14 \vee MF15 \Rightarrow MF11 \\ MF20 \vee MF21 \Rightarrow MF19 \\ MF17 \vee MF18 \vee MF19 \Rightarrow MF16 \\ MF2 \vee MF3 \vee MF11 \vee MF16 \Rightarrow MF1 \end{array}\right\} \quad (1)$$

where the symbol $\vee$ means *OR* .

From Fig. (6), the inferred set of production rules to isolate the electrical system failure causes reaching to the top event (EF1) would be represented as follows:

$$\left.\begin{array}{l} EF5 \vee EF6 \vee EF7 \vee EF8 \Rightarrow EF4 \\ EF10 \vee EF11 \Rightarrow EF9 \\ EF13 \vee EF14 \Rightarrow EF12 \\ EF9 \wedge EF12 \Rightarrow EF9.12 \\ EF3 \vee EF4 \vee EF9.12 \Rightarrow EF2 \\ EF18 \vee EF19 \Rightarrow EF17 \\ EF16 \vee EF17 \Rightarrow EF15 \\ EF2 \wedge EF15 \Rightarrow EF1 \end{array}\right\} \quad (2)$$

where the symbol $\wedge$ means *AND*.

And the set of production rules, which inferred from Fig. (7) to isolate the control system failure causes reaching to the top event (CF1) would be represented as follows:

$$\left.\begin{array}{l} CF5 \vee CF6 \vee CF7 \vee CF8 \Rightarrow CF2 \\ CF9 \vee CF10 \vee CF11 \vee CF12 \vee CF13 \vee CF14 \vee CF15 \vee CF16 \Rightarrow CF3 \\ CF17 \vee CF18 \vee CF19 \vee CF20 \Rightarrow CF4 \\ CF2 \vee CF3 \vee CF4 \Rightarrow CF1 \end{array}\right\} \quad (3)$$

The three systems top events (MF1, EF1, & CF1) are connected with each other reaching to the whole unit-system top event (UF) through the production rule as represented by:

$$MF1 \vee EF1 \vee CF1 \Rightarrow UF \quad (4)$$

Function (4) could be deduced from the knowledge-based representation of the unit-system fault tree as that shown in Fig. (8).

5. The Programmable System that Designed for the Failure Mode and Effect Analysis

"The failure mode and effect analysis (FMEA) can be described as a systematic way of identifying failure modes of a system, item or function, and evaluating the effects of the failure modes on the higher level. The objective of FMEA is to determine the causes for the failure modes and what could be done to eliminate or reduce the chance of failure. This technique is an effective way to identify component failures or system malfunctions, and to document the system under consideration."(8)

The programmable system is designed to be used as an expert system to help the specialist user (power plant engineers) in identifying the failure modes and to analyze their reasons and effects on whole unit system. The designed system consists of a set of programs, and all are written in Matlab programming system. In the following a brief explanation for some of the designed programs with their flowcharts:

- The first program is known by "RCS" since it works as a *reasoning control structure* for the unit-system fault trees to cognizing the failure causes and the effect analysis for whole system of the steam-power unit reaching the unit-system top event the (Unit Shutdown). Fig. (9) shows the flow chart of this program.
- The second program is denoted by "FTREE", which is specialized in explaining the logical relationships among the failure modes for the whole unit-system as described in the fault tree diagrams. Also the running of this program gives the minimal cut sets of failure events, where such events should given more attention since the occurrence of any one of the will leading to the failure of whole system (Top Event). Fig. (10) shows the flow chart of this program.
- "DBp" denotes another program that is contained in the programming system and it is designed to be use as an input-output *database program*. This program contains all the necessary input database (failure & repair rates) that is required to quantify the reliability and availability of all individual components or events of the unit-system fault trees. Then, the output results of this program could be used as an output database that is required for other analytical programs of the system. The analytical procedures of this program are out the range of this research.
- Another sets of programs are designed in a systematic way such as the backward chaining of the unit-system fault trees that is beginning from higher level (top event) reaching to lower level (primary events). The running of these programs is appeared in a shape of windows, which are controlled by different types of pushbuttons. All these windows are set in the programming system that is specialized to perform the function of FMEA of the steam-power plant.

Some of the system windows of the failure mode analysis for the steam-power plant are shown in Figs. (11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, & 22).

6. Discussion and Conclusion

- For complex type of industrial systems such as the power plant, the Fault Tree Analysis (FTA) has a respective importance in recognizing all types of failure modes, which affect their performance efficiency, and deducing the reasons of system malfunctions.
- The effectiveness of the designed programmable system for FMEA is mainly depending on the precision of knowledge, which were obtained from the expertise of operating staff in the power plant. Therefore, there is substantial need to involve a large number of experts (engineers and specialists) who are operating in the different departments of the power plant as consultants in constructing the knowledge-based system of the FMEA programming system.
- The knowledge of the designed programmable system could be modified to be applied in other types of complex industrial systems to identify their failure modes and analyzing their reasons and effects to improve the maintenance activities and then enhancing the reliability of the system performance.
- The FMEA may be considered as a reasoning technique of a diagnostic expert system. This technique describes the logical relationships among the failure events of the system fault tree.
- The Matlab programming system could be considered as an effective tool in designing such programming systems to solve the different types of industrial engineering problems, since it has the ability of programming with both of linguistic and analytic statements.

7. Suggestion for Future Work

- The designed programmable system of this work could be developed to be working on line with systems of the power plant. Such development requires the connection of the systems and components with appropriate sensors for sensing any error that might occur in the operating systems of the power plant, then converting them into signals to be translated into commands in a central control unit. Such control unit should comprise computers network that is programmed on the FMEA programming system to have the ability of translating of the error commands into failure modes, and to analyze the reasons and all possible effects of each failure mode.
- The programmable system is designed specifically for the failure modes analysis of the steam type power units, and could be developed to cover other types of thermal power units depending on the extension of the constructed knowledge-based system.

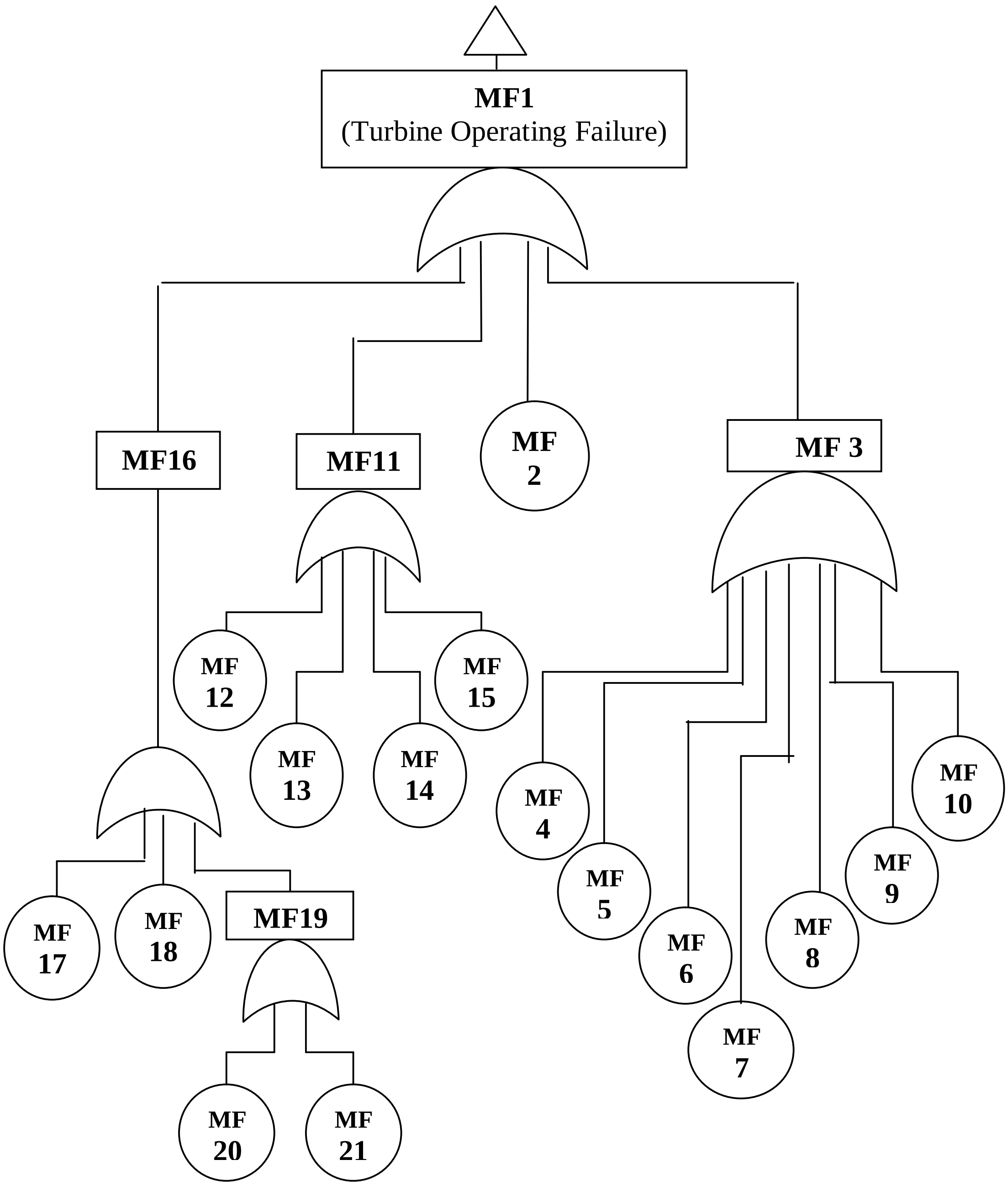


Fig. (1) The Fault Tree Construction of Mechanical System Failure Modes

Table-B:

Symbols explanation of failure modes or events of the **mechanical** system fault tree of Fig. (1):

Event Symbol	Explanation	Event Symbol	Explanation
MF1	Mechanical System Top Event (Turbine Operating Failure)	MF12	Air Removal Pumps Failure
MF2	Boiler Feed Water Pumps Failures	MF13	Circulating Water Pumps Failure
MF3	Boiler Failure	MF14	Condenser Tubes Dirty
MF4	Loss of Air Combustion Fans	MF15	Condensate Water Pumps Failure
MF5	Max. or Min. Water Level	MF16	Hydraulic System Failure
MF6	Boiler Tubes Leakage	MF17	Hydraulic Oil Pressure Pumps Failure
MF7	Heavy Oil Control Valve Failure	MF18	Oil Level Low
MF8	Air Combustion Register System Failure	MF19	Servo Valve Failure
MF9	Rotating Air Heater Failure	MF20	Servo Valve Filter Dirty
MF10	Heavy Oil Pressure Pumps Failure	MF21	Hydraulic Oil Control Valve Closed
MF11	Condenser Failure		

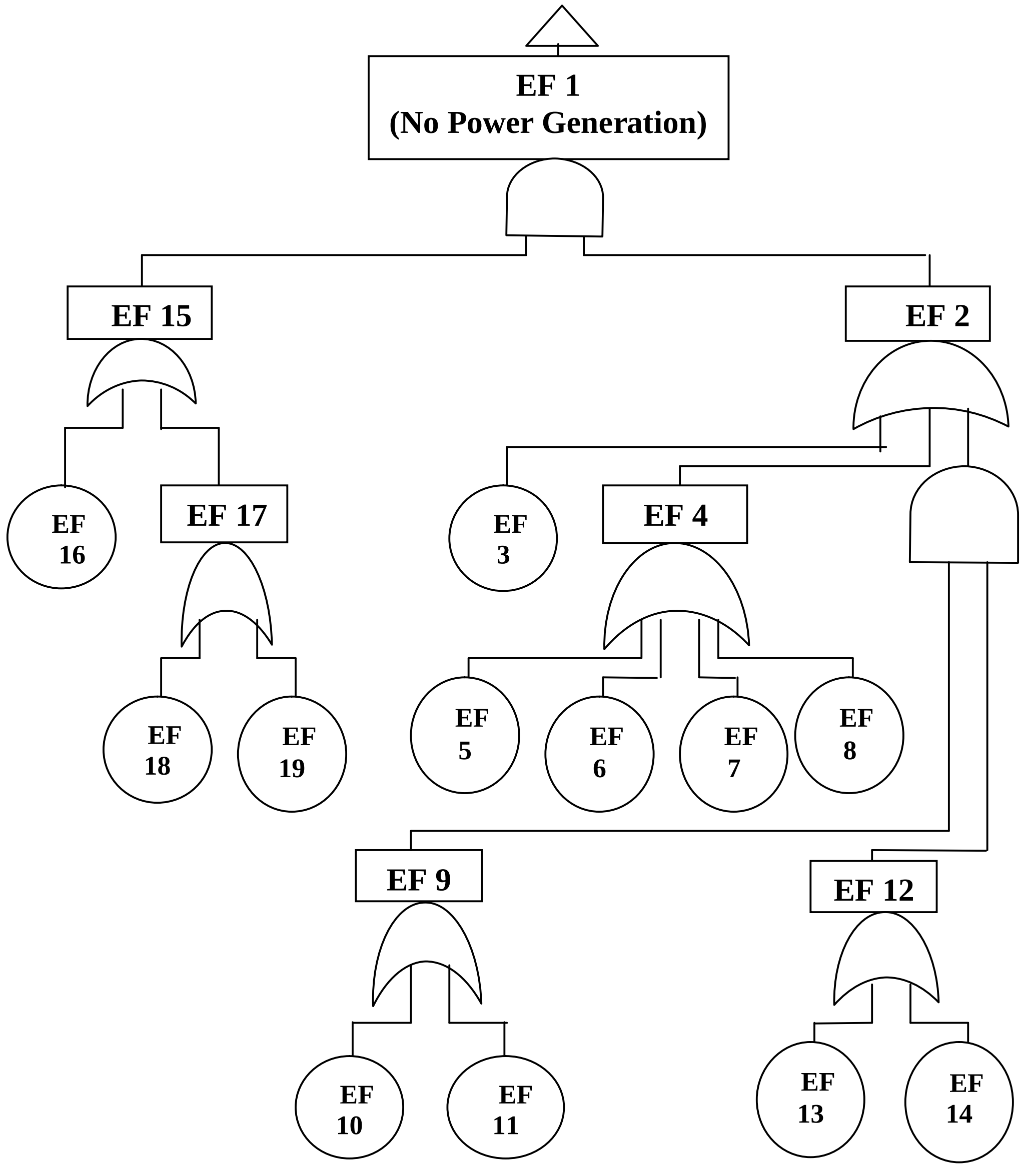


Fig. (2) The Fault Tree Construction of Electrical System Failure Modes

Table-B:

Symbols explanation of the failure modes or events of the **electrical** system fault tree of Fig. (2):

Event Symbol	Explanation	Event Symbol	Explanation
EF1	**Electrical System Failure (Top Event)**	**EF11**	**Trip of Differential Relay 1**
EF2	**The Generator Stop of Power Generation**	**EF12**	**Auxiliary TRR Failure**
EF3	**Stator Earth Fault**	**EF13**	**Trip of Differential Relay 2**
EF4	**Loss of Excitation**	**EF14**	**Auxiliary TRR Earth Fault**
EF5	**Rotor Failure**	**EF15**	**132 kV C.B Failure**
EF6	**Excitation C.B Failure**	**EF16**	**Failure in Pressure of Gas "SF6"**
EF7	**Rectifier Failure**	**EF17**	**Air Compressor Unit Failure**
EF8	**Carbon Brushes Failure**	**EF18**	**Leakage in the Compressor Unit Pipes**
EF9	**Main TRR Failure**	**EF19**	**Compressor Failure**
EF10	**Main TRR Earth Fault**		

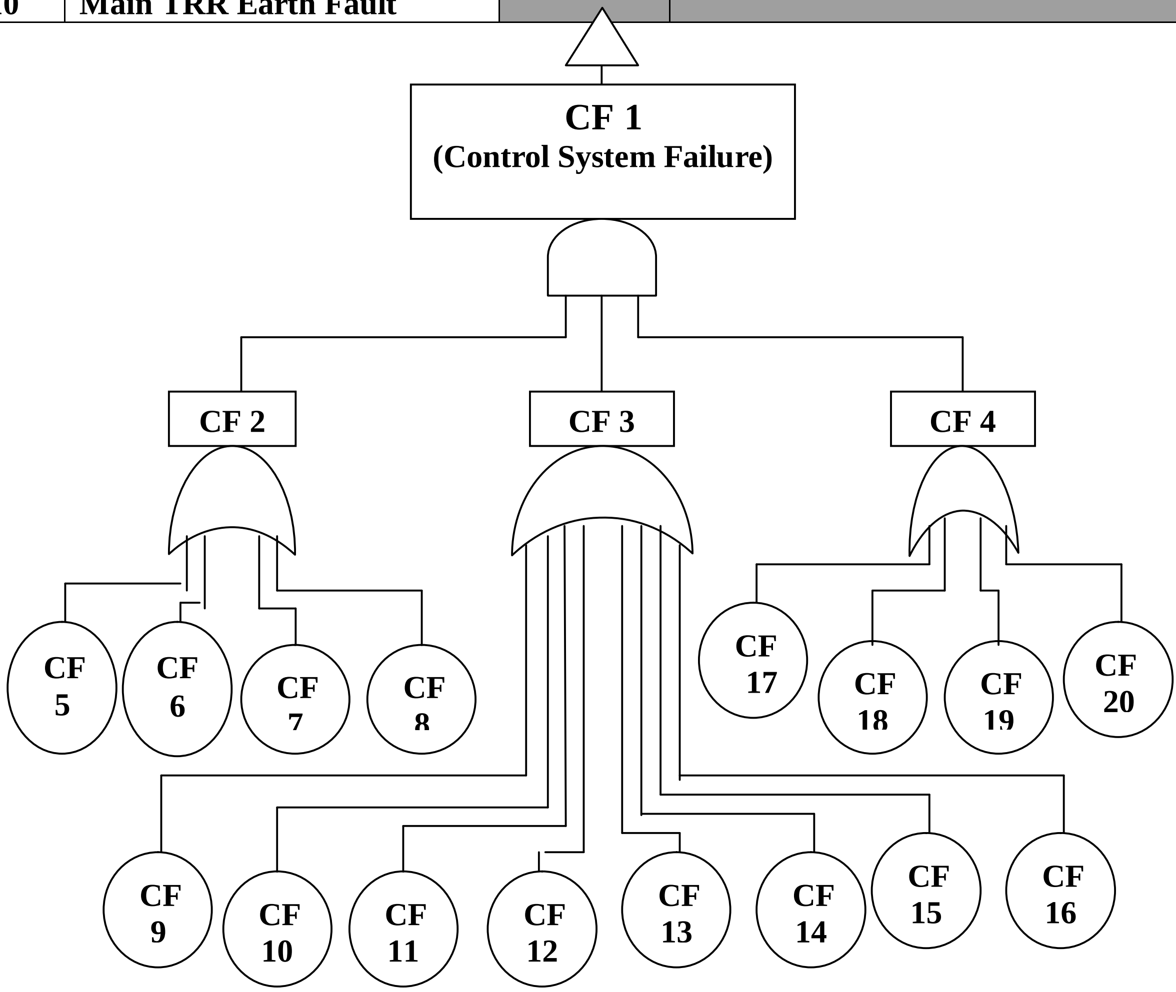


Figure (3) The Fault Tree of Control System Failure Modes

Table-C:

Symbols explanation for the failure modes or events of the **control** system fault tree of Fig. (3):

Event Symbol	Explanation	Event Symbol	Explanation
CF1	**Control System Failure (Top Event)**	**CF11**	**Loss of Fuel Trip Signal**
CF2	**STC System Failure**	**CF12**	**High Furnace Pressure Trip Signal**
CF3	**FSSS Failure**	**CF13**	**Loss of FD Fan Trip Signal**
CF4	**Spec.200 System Failure**	**CF14**	**High & Low Drum Level Trip Signal**
CF5	**Setpoint Select Board Failure**	**CF15**	**Low Air Flow Trip Signal**
CF6	**Dual Setpoint Board Failure**	**CF16**	**Loss of 125V DC Trip Signal**
CF7	**Servo Amplifier Board Failure**	**CF17**	**Drum Level Control System Failure**
CF8	**3 kHz Board Failure**	**CF18**	**Air Flow Control System Failure**
CF9	**Turbine Trip Signal**	**CF19**	**Oil Pressure Control System Failure**
CF10	**Flame Trip Signal**	**CF20**	**DA Level Control System Failure**

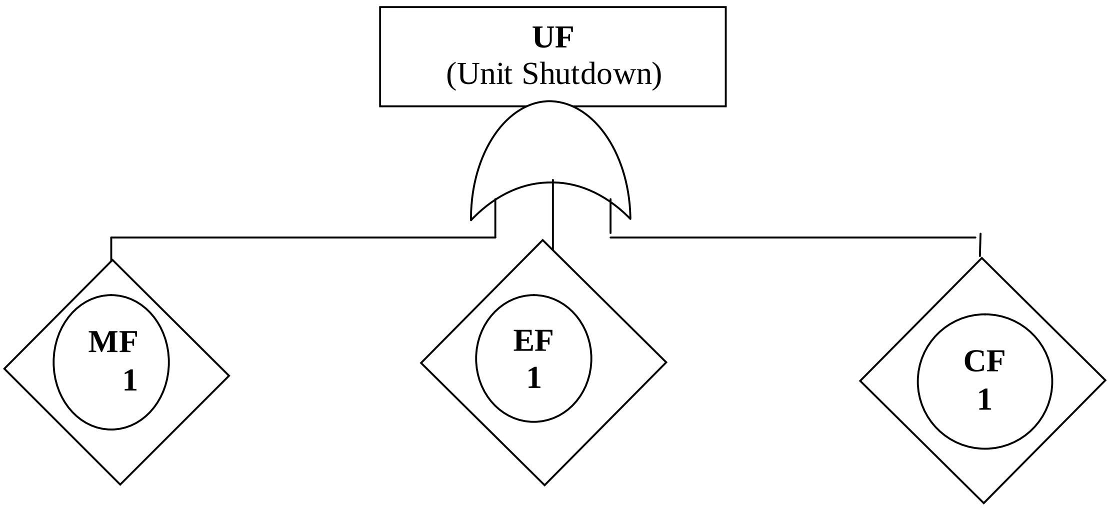


Figure (4) Unit System Fault Tree

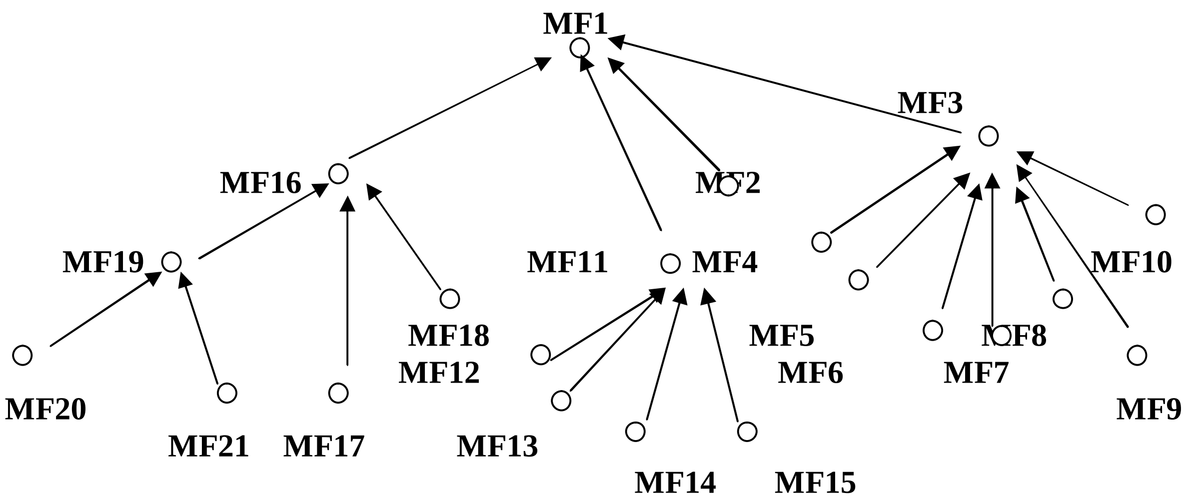


Fig. (5) The State Space Search to Identify the Top Event from the Knowledge-Based Representation of the Mechanical System Fault Tree

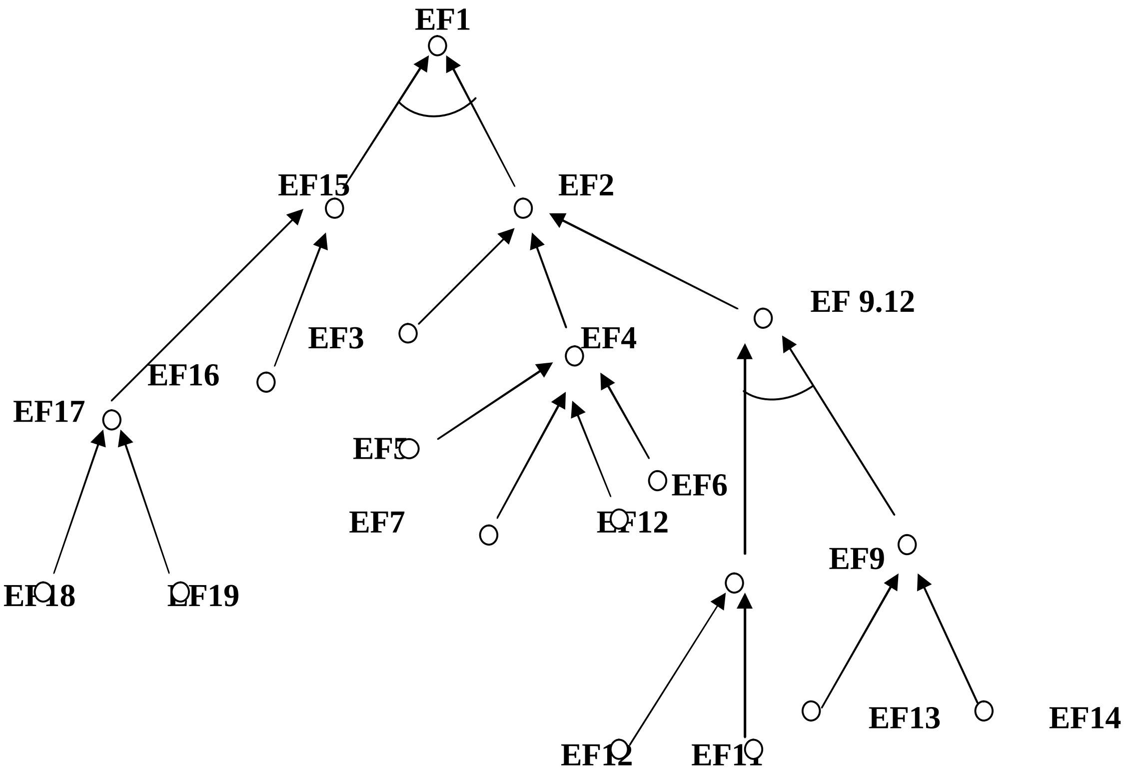


Fig. (6) The State Space Search to Identify the Top Event from the Knowledge-Based Representation of the Electrical System Fault Tree

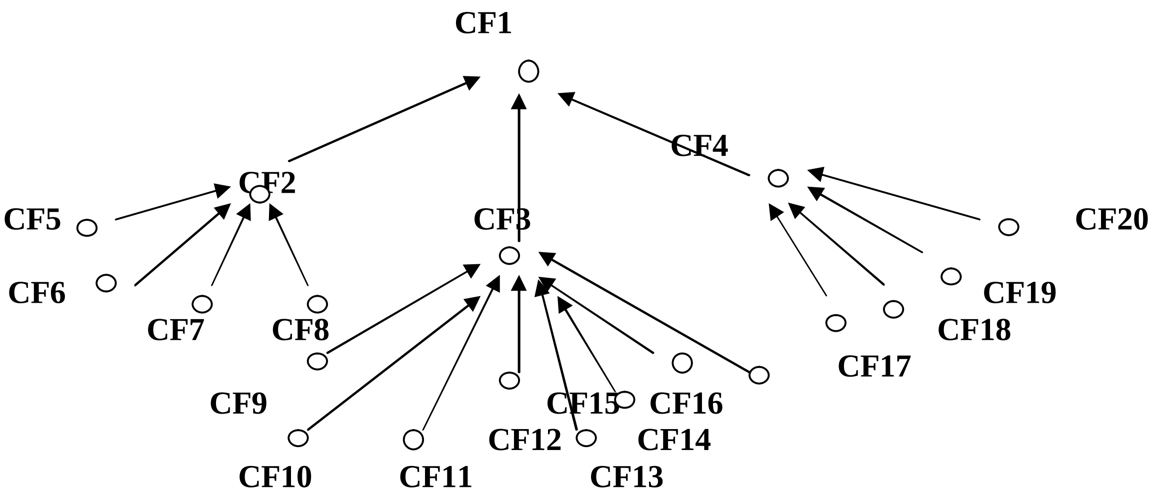


Fig. (7) The State Space Search to Identify the Top Event from the Knowledge Based Representation of the Control System Fault Tree

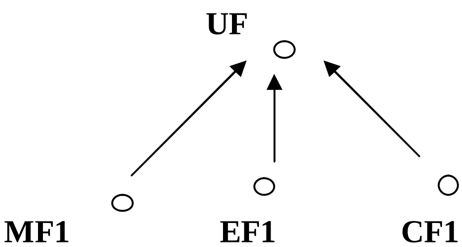
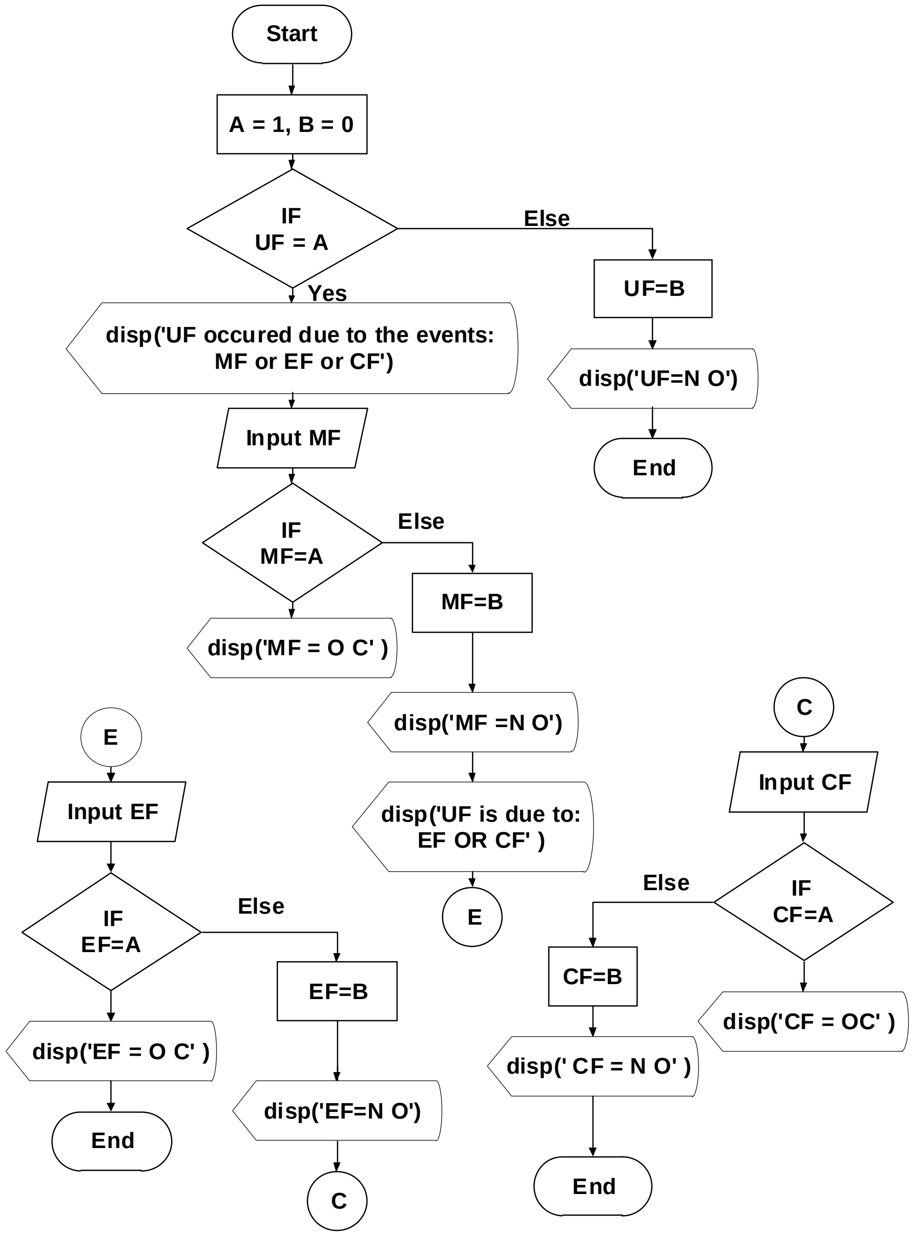


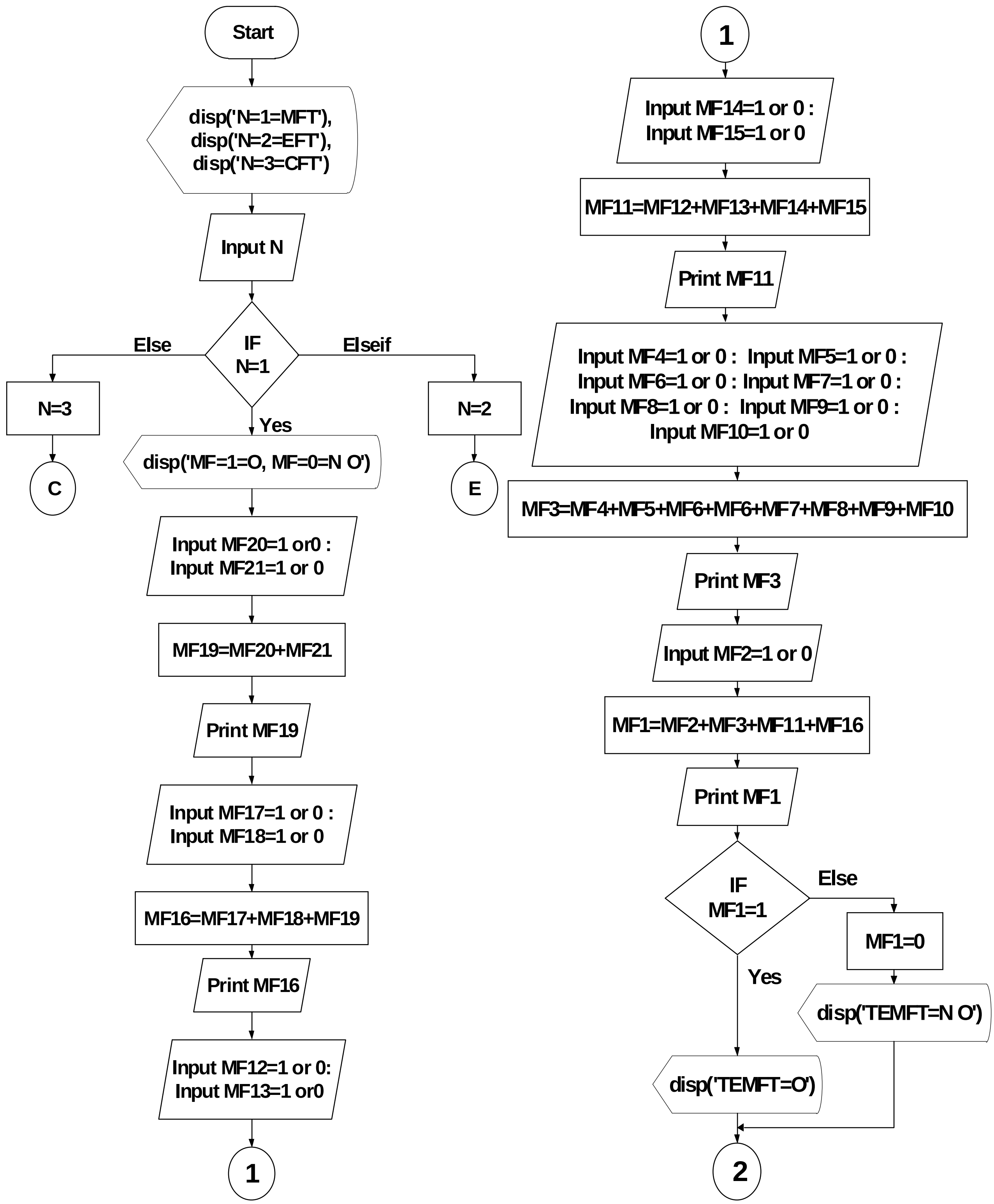
Figure (8) The Knowledge Based Representation of the

Unit System Fault Tree

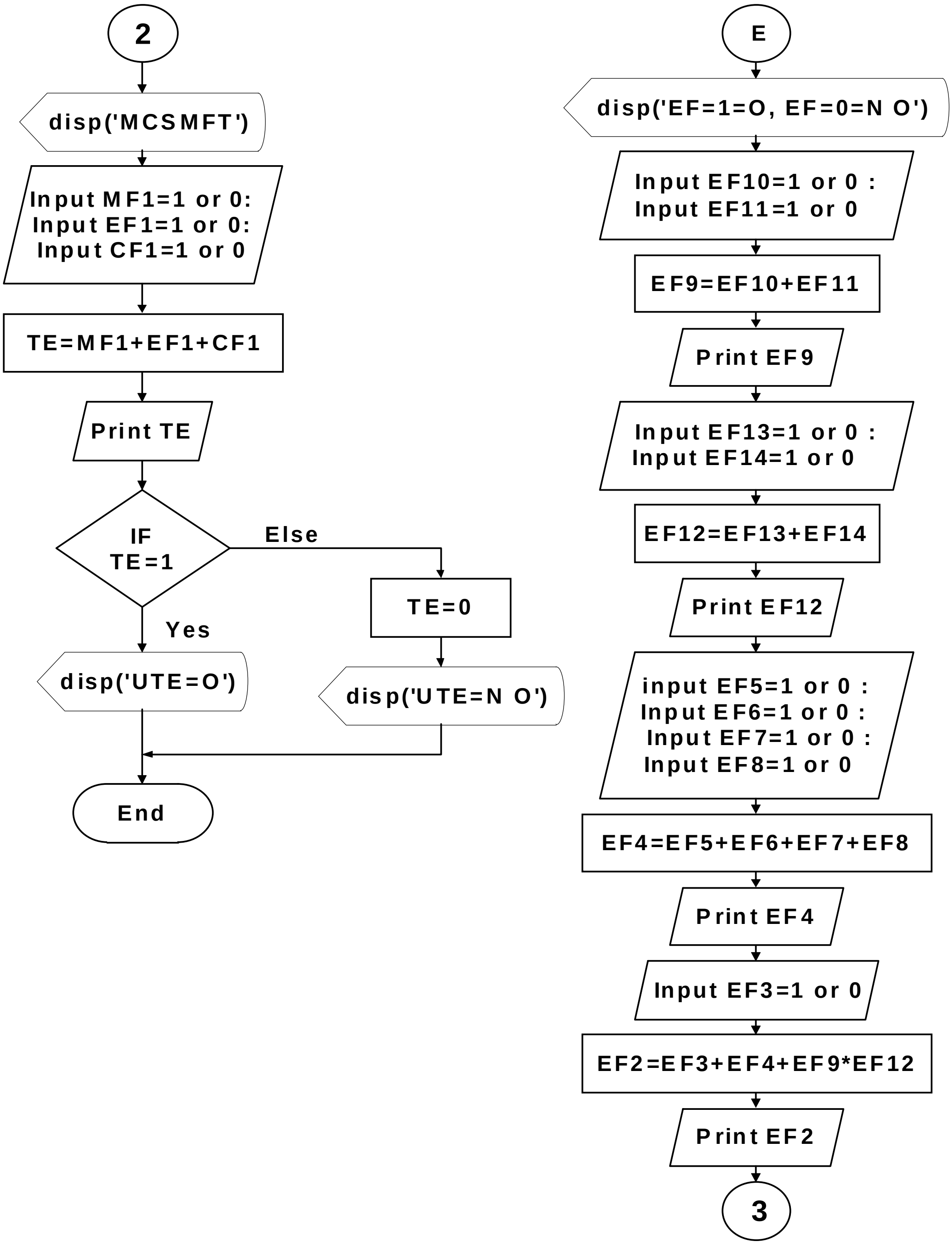


O C = Event Occurred ; N O = Event Not Occurred ; MF = Mech. Syst. Failure;
EF = Electrical Sys. Failure ; CF = Control Sys. Failure

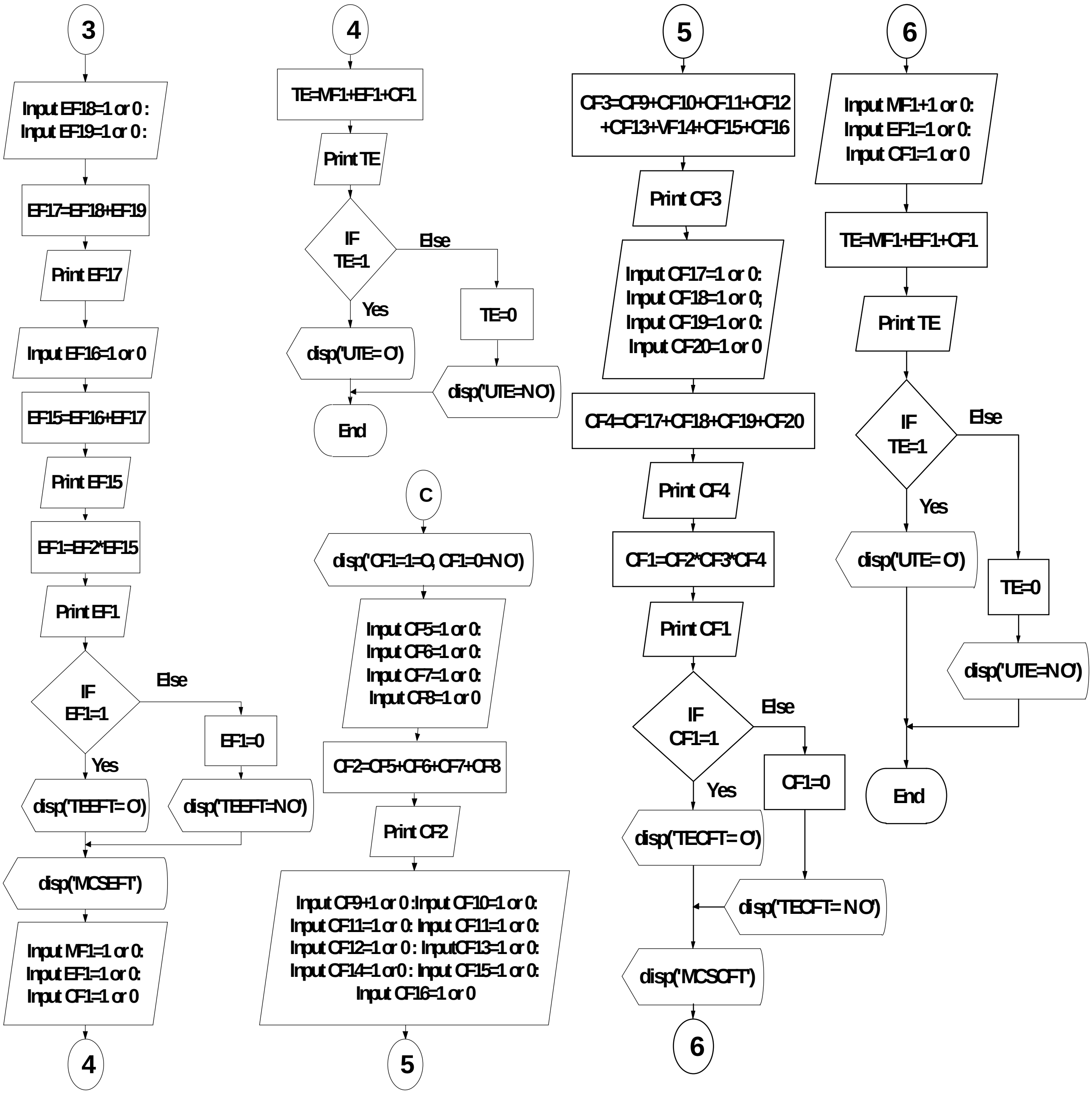
Figure (9) The Flow Chart of " RCS" Program



TEMFT = Top Event of Mech. Sys. F T ; O = Occurred ; N O = Not Occurred



MCSMFT = Minimal Cut Set of Mech. Sys. FT ; UTE = Unit Top Event



MCSEFT = Minimal Cut Set of Elect. Sys. F T ; MCSCFT = M. C. S of Cont. Sys. FT
TEEFT, TECFT = Top Event of Elect. & Cont. Systems. F T respectively

Fig. (10) The Flow Chart of "FTREE" Program

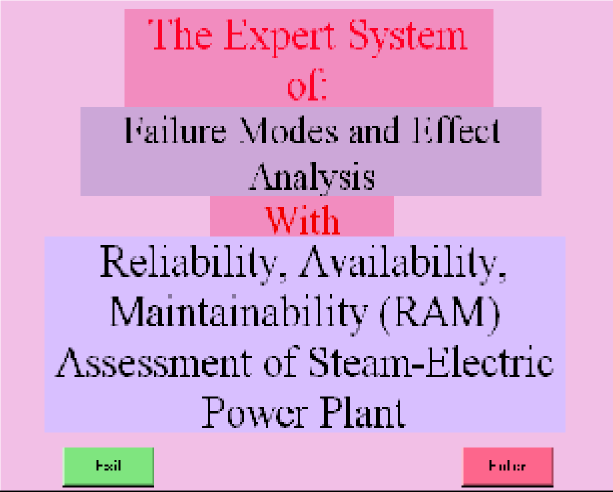


Fig. (11) Introduction Window of the Designed system

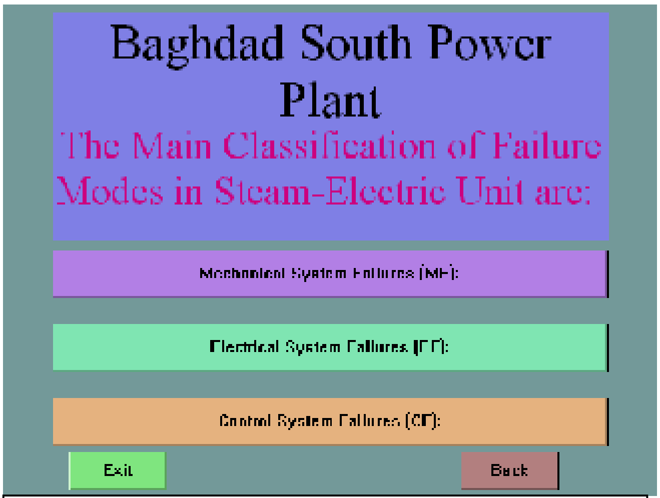


Fig. (12) The Second Window of the System for Basic Failure Mode Identification

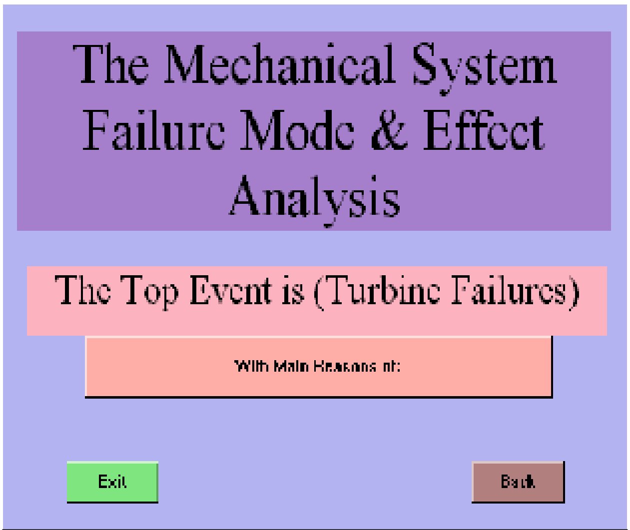


Fig. (13) The Basic Definition Window Mechanical System Failure Mode

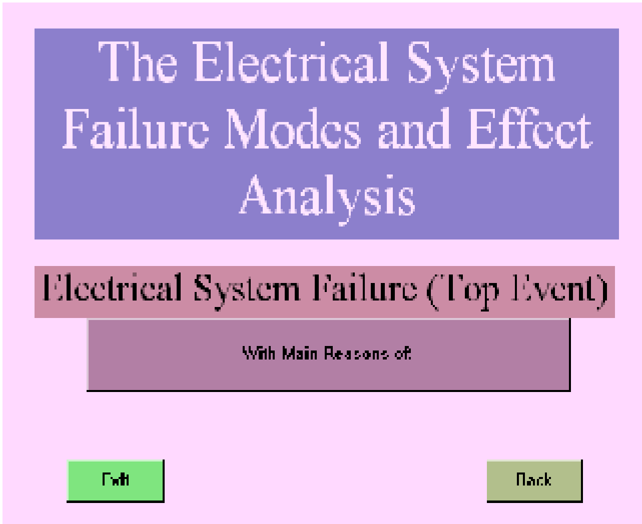


Fig. (14) The Basic Definition Window of Electrical System Failure Mode

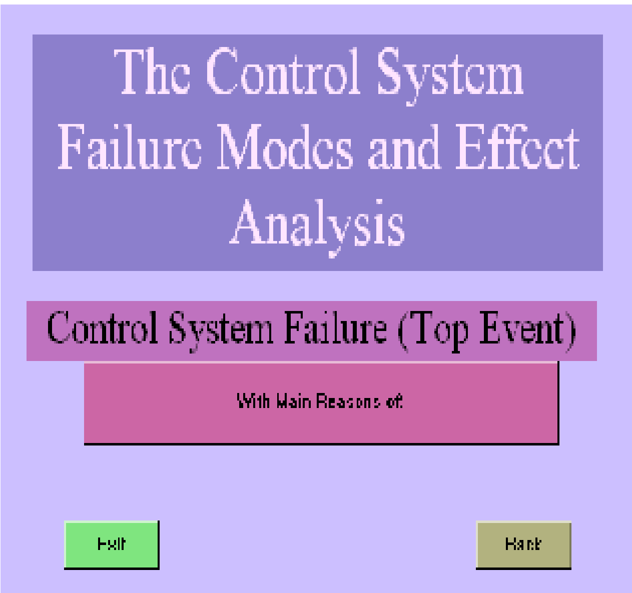


Fig. (15) The Basic Definition Window of Control System Failure Mode

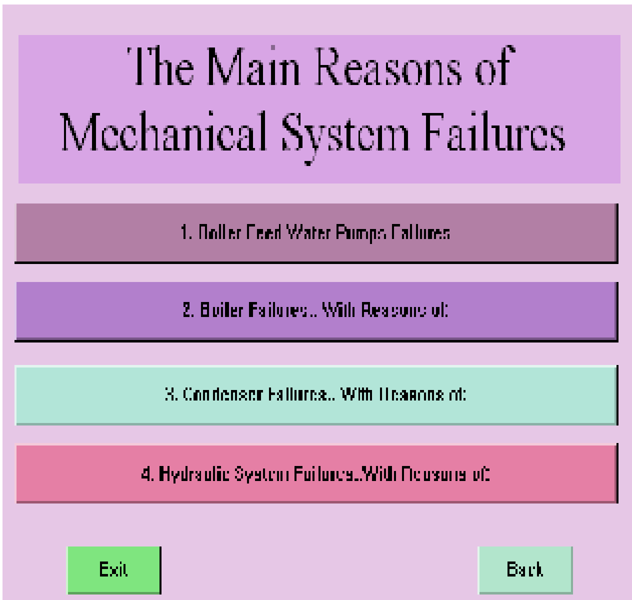


Fig. (16) Main Reasons Window for the Mechanical System Top Event

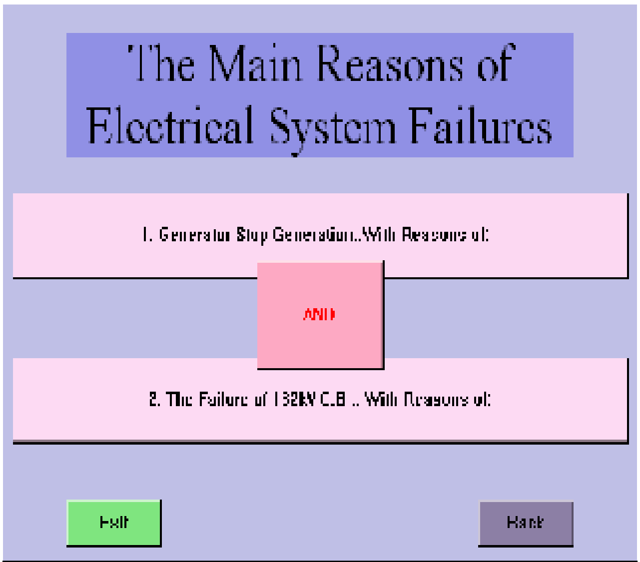


Fig. (17) The Main Two Reasons Window of Electrical System Failure

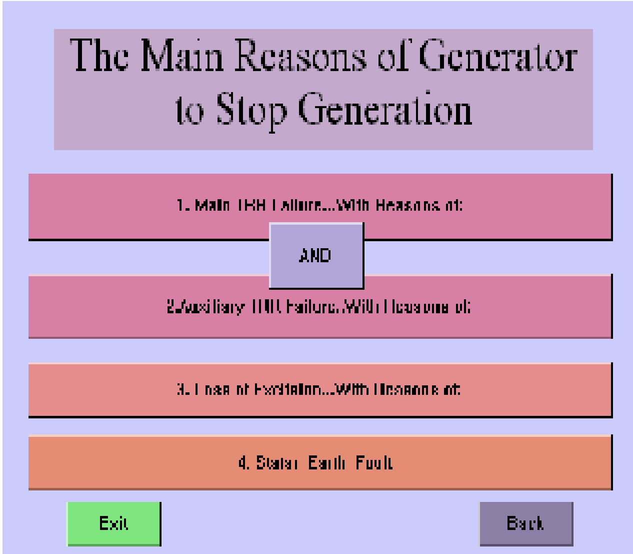


Fig. (18) The Main Reasons Window of Generator Failure

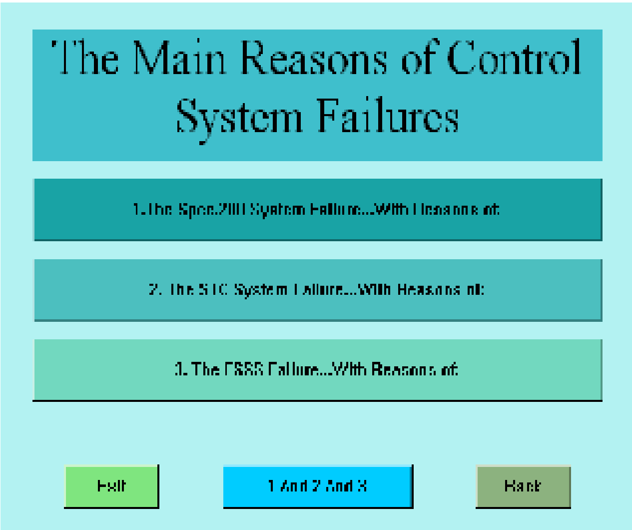


Fig. (19) The Main Three Reasons Window for the control System Failure

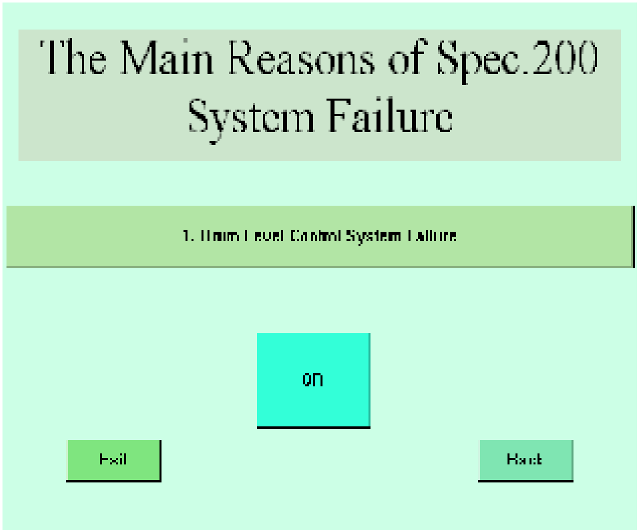


Fig. (20) The First Reason Window of the Spec.200 System Failure

Fig. (21) The First Reason Window of the STC System Failure

Fig. (22) The First Reason Window of the FSSS Failure

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تصميم نظام مبرمج لتمييز أنماط الفشل وتحليل التأثيرات لمحطة بخارية لتوليد الطاقة الكهربائية اعتمادا على انشاء شجرة تحليل الخطأ

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الخلاصة:

يهدف البحث الى إنشاء نظام مبرمج يمكن أن يستخدم في تمييز أنماط الفشل (العطلات) الرئيسة التي يمكن أن تحدث في محطة بخارية لتوليد الطاقة الكهربائية. كما ومن خلال استخدام هذا البرنامج يمكن تحليل التأثيرات والأسباب لكل نوع من أنواع العطلات وصولا الى ما يعرف بالأحداث الأساسية المسببة للعطل.

لقد تم إنشاء هذا النظام الخاص بعملية تمييز أنماط العطلات وتحليل أسبابها أي ما يعرف بـ (FMEA)، وذلك اعتمادا على إنشاء شجرة تحليل الخطأ (FT- analysis) الخاصة بكل نظام من الأنظمة المكونة لمحطة توليد الطاقة.

ان تصميم مثل هذا النظام المبرمج يمكن أن يستخدم من قبل مهندسي الطاقة في المحطة كوسيلة مساعدة في تسهيل عملية تمييز نوع العطل مع تحليل أسبابه وتأثيراته على النظام الشامل لوحدة إنتاج الطاقة وهذا يساعد على الإسراع في عملية تشخيص العطلات وإصلاحها وبالتالي تحسين كفاءة عمل المنظومة من خلال تطوير قابلية صيانة أنظمتها والتي تعتبر دالة من دوال موثوقية الأداء. ومن خلال التعديل في برمجة المعرفة الخاصة بهذا النظام يمكن تطبيقه في أنظمة صناعية أخرى.