Design of Computerized Fault Data Collection and Analysis System for Boilers Systems

Kiffaya Abood AlSaffarm **Layla Muhsan Hasan Bdeir**
College of Engineering, Al-Mustansiriya University
Materials engineering department

Abstract

In this research a computerized fault data collection and analysis system has been developed. The system described is called Computer Aided Failure Mode and Effects Analysis (CAFMEA)

CAFMEA modular structure consists of the following four modules:

1- Steam Boiler Troubles 2- Reports. 3- Graphics. 4- Tables.

CAFMEA shows how to find the latent roots responsible for the break down. These latent roots are the management system weakness; once these roots found it means to solve many other potential problems that haven't occurred yet and to expect the places of future failure events.

CAFMEA can be used to develop a maintenance strategy based on fact rather than opinion. One of the main benefits to be gained from CAFMEA is that to reduce chronic failures which happen more than once for the same reason. Furthermore, 20 % of these failures represents 80% of losses these failures are called "significant few failures" (Pareto Analysis) this means when these significant few failures are reduced, the maintenance cost will be reduce as well. This system has been developed using Visual Basic (version 6) which has the capability and flexibility of accepting customization according to the specific needs of the plant.

الخلاصة

في هذا البحث تم تطوير نظام حاسوبي لجمع البيانات وتحليلها (CAFMEA) .ان الحزمة البرمجية CAFMEA تضم النظم الفرعية الأربعة الآتية :

1. مشاكل المراجل البخارية 2. التقارير 3. الرسوم البيانية 4. الجداول

ان الحزمة البرمجية CAFMEA تبين كيفية تحديد الاسباب الكامنة وراء التوقفات والتي تمثل مناطق الضعف في منظومات المراجل البخارية عندما تحدد هذه الاسباب اصبح بالامكان معالجة العديد من اسباب المشاكل التي لم تحدث بعد والتكهن بمواقع الفشل المستقبلية. كما وتستخدم وبنجاح للحصول على نظام صيانة قائم على الحقائق وليس على الاراء. من اهم الفوائد المستحصلة من الحزمة البرمجية CAFMEA انه يساعد في تقليل حدوث الأعطال المزمنة التي تحدث لعدة مرات لنفس السبب علاوة على ذلك فقد وجد ان 20% من هذه الأعطال يشكل 80% من كلفة الصيانة(Pareto Analysis) , هذا يعني عندما تعالج هذه الأعطال فأن كلفة الصيانة سوف تقل.

تم انشاء هذا النظام بأستخدام لغة Visual Basic (version 6) . ان المرونة المتوفرة في البرنامج تتيح للمستخدم تطويره على حسب احتياجات المصنع .

1- Introduction:

The increasing capabilities and functionality of many products make it more difficult for manufacturers to maintain the quality and reliability. Traditionally, reliability has been achieved through extensive testing and the use of techniques such as probabilistic reliability modeling(Pree, 2000; Latino, 1997; William, 2000).

Failure Mode and Effects Analysis (FMEA) is commonly defined as a systematic process for identifying potential design and process failures before they occur, with the intent to eliminate them or minimize the risk associated with them(Narayanagounder & Gurusami, 2009) .It is methodology for analyzing potential reliability problems, it has been in use for several decades and has proven to be one of the best methods for finding potential problems in a system. FMEA is used to identify potential failure modes, determine their effect on the operation of the product, and identify actions to mitigate the failures it transform risk management from a reactive process to proactive one(Latino, 2000; Kales, 1998; Dieter, 1990; Crow, 2002) .

FMEA shows how to find the latent roots responsible for the break down. These latent roots are the management system weakness; once these roots are found it means to solve many other potential problems that haven't occurred yet(Wavespec & Wavespec, 1999; Bonnefoi, 1990; Latino, 2000).

The primary objective of most boiler operations is maintaining availability, or uptime. Many facilities have more than one boiler on-site running in parallel. To get the boiler back on line and reduce or eliminate future forced outages due to failure, it is extremely important to determine and correct the root cause(Kenneth, 2000; Kmenta & Ishii, 1998).

CAFMEA it is computerized identification for potential parts failure before they occur, with the intent to eliminate them or minimize the risk associated with them. Its purpose is to identify the ways in which that parts might potentially fail, to eliminate or reduce the likelihood and/or outcome severity of such a failure.

2- Fault Tree Analysis

Fault tree analysis (FTA) is a reliability assessment technique, which is widely used to hazard identification that focuses on the causes of an undesired event in the engineering system [(14)]. It is a top–down approach to the identification of process hazards [(15)]

Fault Tree Analysis diagrams show how the data developed by FMEA should be interrelated to lead to specific event. FMEA is very effective when applied to a single unit or single failure. When it is applied to a complex system, however, the number of failure modes can become very voluminous, so that economics and/or human frailty make it difficult to identify all potential failures. The logical structure is depicted as an upside-down tree with the hazard (called top-event) at its root [(16)]. Figure 1 shows types of FTA symbols(Cheng and Zhang, 2005; Kales, 1998; Snell & Jaitly, 2001)

3-CAFMEA System Architecture:

The system architecture consists of four modules(Bdeir, 2005):

1.Boiler troubles 2.Reports 3.Graphics 4.Tables

3-1Boiler Troubles Database:

This part keeps technical database which concerns failure modes in the boiler systems. It is subdivided into:

3-1-1 Waterside Problems Database:

This part keeps technical database which concerns waterside problems and their causes as shown in Figure (2)

3-1-2 Tubing System Problems Database:

This element provides the common failure modes that occur in the tubing systems, Figure (3).

By choosing hydrogen damage for example, the hydrogen damage window will appear which includes the following options:

- Symptoms: This will display the symptoms of hydrogen damage, Figure(4)
- Susceptible material: This will display the susceptible material to hydrogen damage, Figure (5).
- Hydrogen damage causes: This will display a fault tree analysis of the cause of Hydrogen damage, Figure (6).
- Hydrogen damage prevention: This will display the suggested ways to prevent Hydrogen damage ,Figure (7).

3-1-3 Draft System Problems Database:

This window provides the user with the following options, Figure (8):

- Types of draft system: This will display the types of draft system.
- Improper draft system: This will display the problems caused by improper draft system.
- Problems in draft system parts: This will display the common problems that occur in each part.

3-1- 4 Combustion Control Equipment Problems Database:

This will display the common problems that occur in the combustion control equipment, Figure (9). By choosing one of these problems, the treatment of this problem will appear.

3-2 Reports Module:

This part can be subdivided into:

3-2-1 Add New FMEA Report:

This screen allows the user to enter the data necessary for FMEA report. To do this the user must click on “add new” then all information are inserted after that the user must click on “update” to save the information in the database .This screen helps the user to delete the current record by click “delete” or print by click on “print” It consists of:

1. Boiler number: The number of the failed or affected boiler.
2. MCU: The failed or affected Main Construction Unit (MCU).
3. SCU: The failed or affected Sub Construction Unit (SCU).
4. Operation stop: This consists of:
   - Date: The date of operation stops (day/month/year).
   - Time: The time of operation stops (hour: minuets).
5. Operation restart: This consists of:
   - Date: The date of operation restarts (day/month/year).
   - Time: The time of operation restart (hour: minuets).
6. Date: Date of writing the report is inserted.
7. Down time: Total ideal time of repair is inserted.
8. Delay time: Total delay time is inserted.
9. Action code: The maintenance action taken as a result of the fault is inserted from the code.
10. Number of workers: The number of workers in the maintenance action is inserted.
11. Total cost: The total maintenance cost which is labor plus material…, etc. is inserted.
12. Inspection: The Inspection method used is inserted.
13. Fault mode: The specified fault mode is inserted.
14. Type of fault : Three basic types of fault are inserted
   - Random: a fault occurring without apparent pattern and regardless of preventive maintenance.
   - Initial: a fault developing immediately after maintenance work.
   - Wear out: a fault caused by a component coming to the end of its useful life.
15. Class of fault: Class of fault is identified e.g. mechanical, electrical.
16. Effect of failure: The effect of fault on plant performance e.g. shut down.
17. Cause known: “Yes” or “No” is inserted according to whether the true cause of the fault has or has not been identified.
18. Fault cause: The specific failure cause is inserted e.g. operator error.
19. Severity: The severity of failure is inserted in five classes
   - Catastrophic: This category is for disastrous effect such as permanent loss of property.
   - Critical: This category is for disastrous but restorable damage.
   - Major: This category is for serious malfunction of the system.

- Minor: This category is for resaved for fault that lead to marginal inconveniences to system or its user.
- Trivial: This category is for inconsequential faults that cause no more than a nuisance to the user of the system.

20. State of plant: This indicates the operational condition of the plant when the fault occurs.
21. Delay cause: The cause of delay in maintenance is recorded as shown Figure (10).

3-2-2 Historical Report:

This element displays the historical FMEA reports during a time interval inserted by the user depending on the database saved by the “add new FMEA report” screen.

3-2-3 Number of Failures Occurred, Down Time and Total Maintenance Cost Concerning Certain Fault Mode:

This element displays number of failures times, down time and total cost of each fault mode within a time interval inserted by the user.

3-2- 4 Significant Few Failures:

This element displays the significant few failures (20% or less of the failures events causes 80% or greater of the losses) (Pareto Analysis) at a time interval inserted by the user, as shown in Figure (11).

3-2- 5 Number of Failures Occurred, Down Time and Total Maintenance Cost Concerning Certain Boiler Number

This element displays number of failures times, down time and total maintenance cost of each boiler within a time interval inserted by the user.

3-2- 6 Failure Mode Concerning Certain Type of Fault

This element displays the type of fault of each failure mode within a time interval inserted by the user.

3-3Graphic Modules:

This will display all historical data according to the database saved by the “add new FMEA report” screen graphically. It will provide the following graphs:

- Main Construction Unit (MCU) with total down time.
- Main Construction Unit (MCU) with total maintenance cost.
- Sub Construction Unit (SCU) with total down time.
- Sub Construction Unit (SCU) with total maintenance cost Figure (12).

3-4 Tables Modules:

This module provides the user with all data necessary for working with the system; see Figure (13).This module consists of the following tables:

1. Type of fault. 2. Severity of fault. 3. Fault mode

4- Conclusions

The following points are concluded from the present research:

1- A computerized system is developed in this study to help the engineers in industrial plant to collect the data necessary to detect the weak points in the boilers systems and expect the places of future failure events by collecting all information about failures frequencies, down time and total maintenance cost….,etc.

2- CAFMEA utilizes a knowledge base to:

1. Keep records. 2.Efficient feedback. 3. Analyze the failure and cost data.

3- The analysis of data collected under CAFMEA enables management problems themselves to be analyzed, as follows:

- The identification of a problem.
- The relationship between these problems and other problems.

- The relationship between the problem and production factors with specific reference to profit loss and maintenance cost.
- The effectiveness of a solution on the problem.

4- The design of future boiler systems can benefit considerably from the bank of operational data available as compared with the often subjective data used at present.

5- CAFMEA shows how to find the latent roots responsible for the break down. These latent roots are the management system weakness once these roots are found it means to solve many other potential problems that haven't occurred yet.

6- Using the modified FMEA process to identify 20% or less of failure events that causes 80% or greater of the losses "significant few failures" (Pareto Analysis) this will reduce the overall maintenance cost.

7- CAFMEA promotes reduction of chronic problems, increases mean time between failure and increases reliability. Other benefits derived from CAFMEA are the maintenance staff that will be able to do more work through proper planning and scheduling proactive rather than reactive maintenance. Spare parts should be reduced which will bring a recurring saving on carrying costs still the biggest saving will come from increasing the use of assets.

8- CAFMEA provides the engineers with data necessary to:

1.Report failure causes 2. Failure modes.

3.Failure mechanism 4. Critically impacts of failures.

9- The visual basic program version 6 is used for the development of CAFMEA because of its flexibility and its excellent user interface facilities.

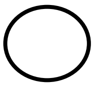
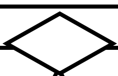
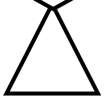
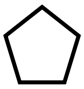
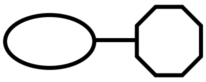
	Intermediate event an event resulting from combinations of more basic events
	Basic event
	Undeveloped event
	Transfer symbol
	Normal event that is expected to occur during system operation
	Inhibit gate
	And gate indicates that the output occurs if and only if all of the input events occur.
	Or gate indicates that the output occurs if and only if at least one of the input events occurs.

Figure (1) Types of FTA symbols [14, 17, 18]

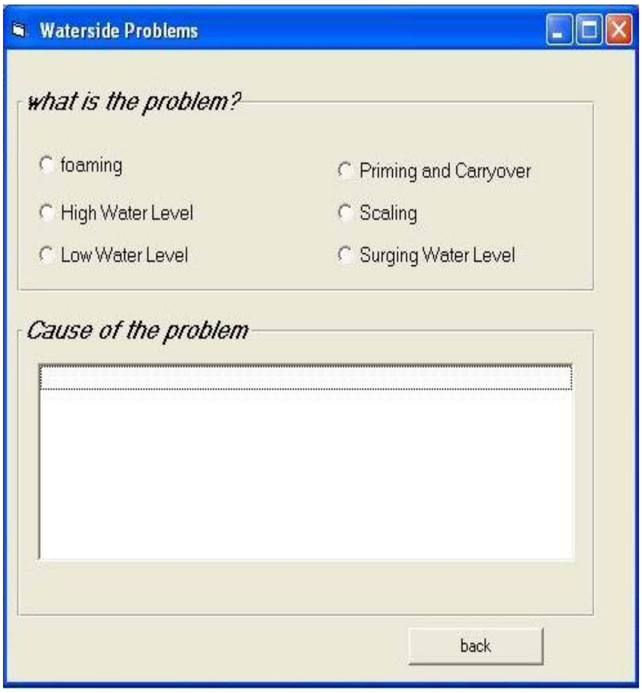


Figure (2) Waterside problems

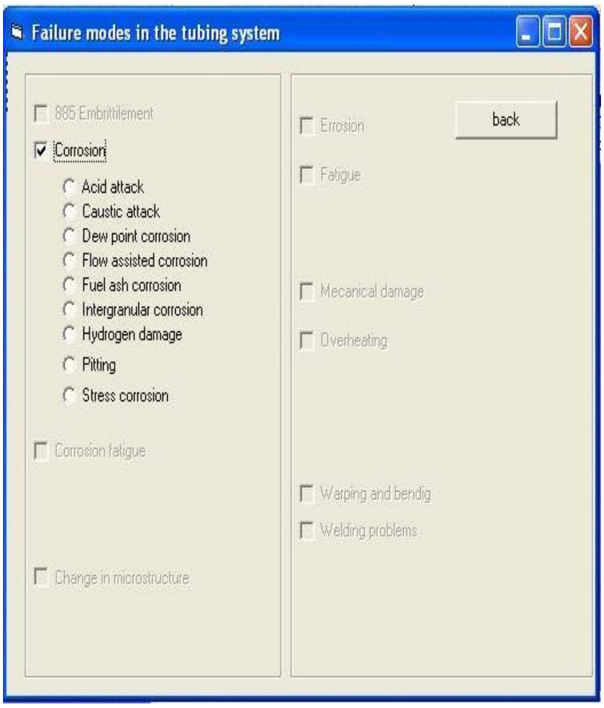


Figure (3) Failure modes of the tubing system/corrosion

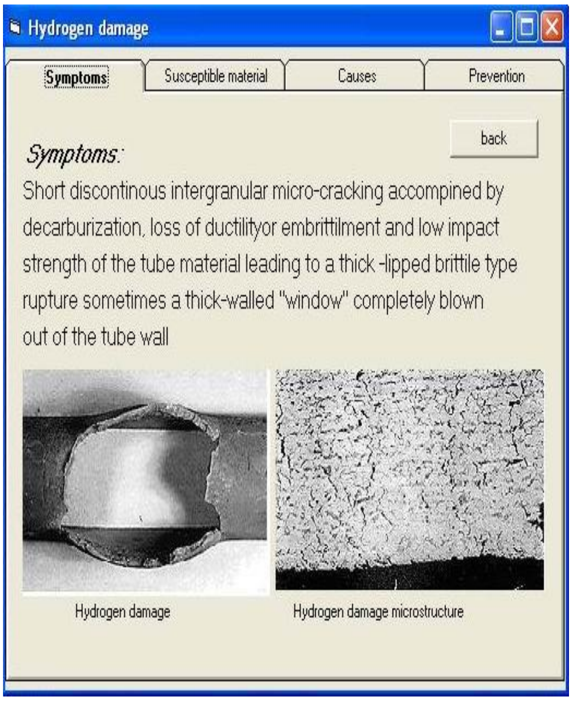


Figure (4) Hydrogen damage symptoms

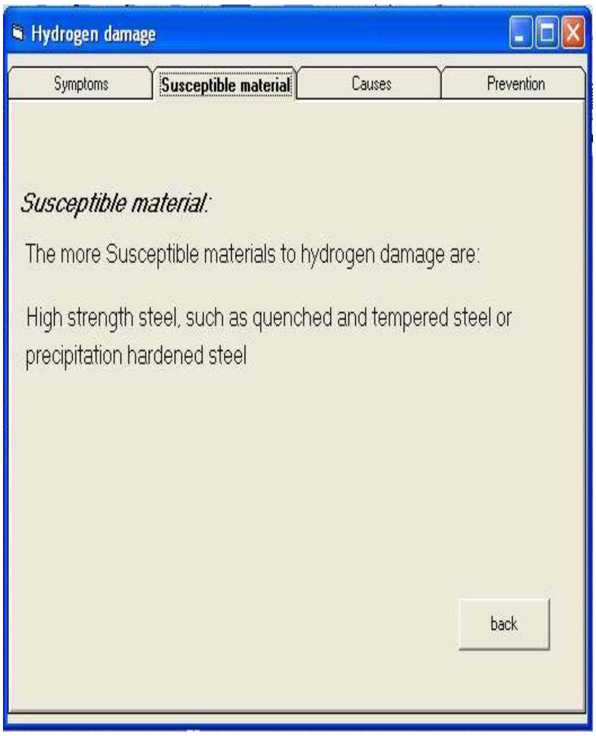


Figure (5) Susceptible material to hydrogen damage

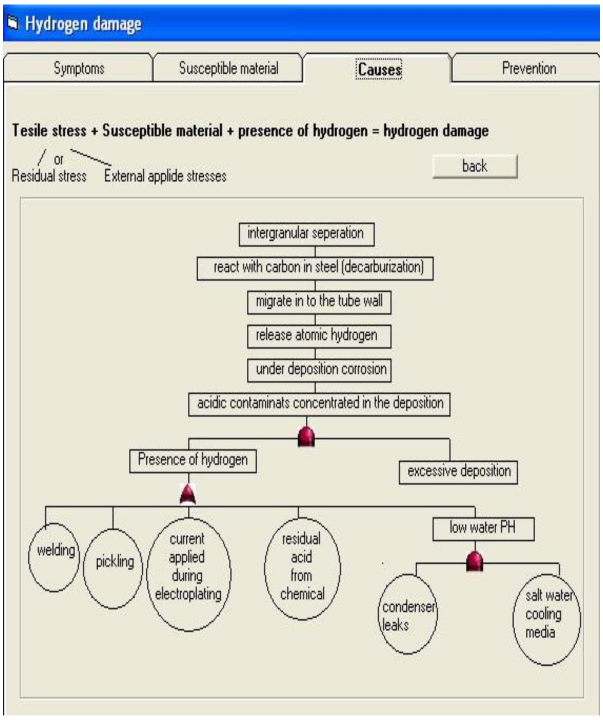


Figure (6) Hydrogen damage causes

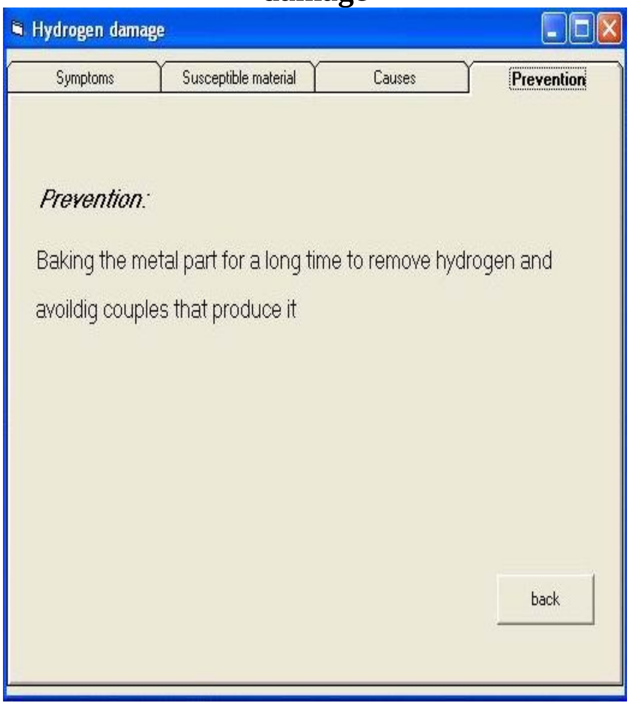


Figure (7) Hydrogen damage prevention

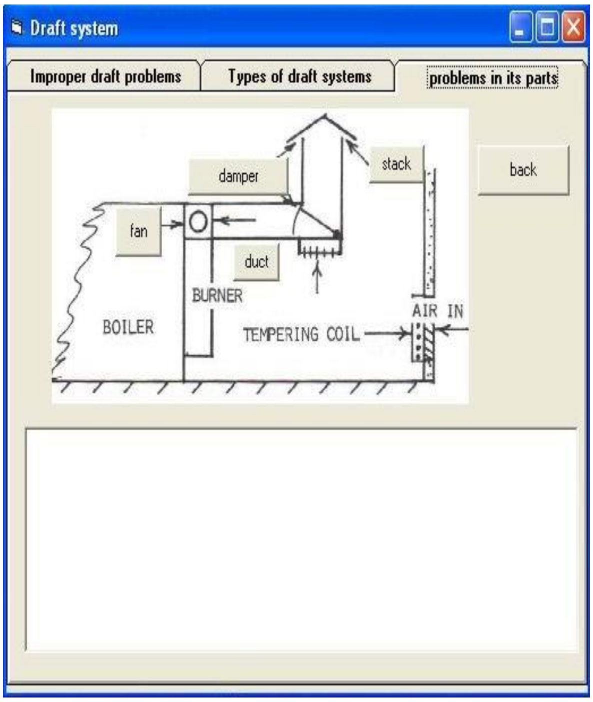


Figure (8) Draft system/problems of its parts

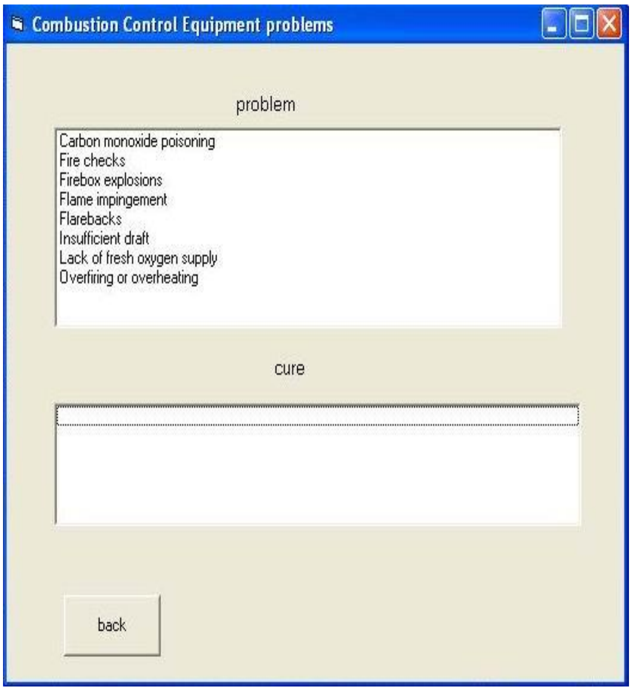


Figure (9) Combustion control equipment problems

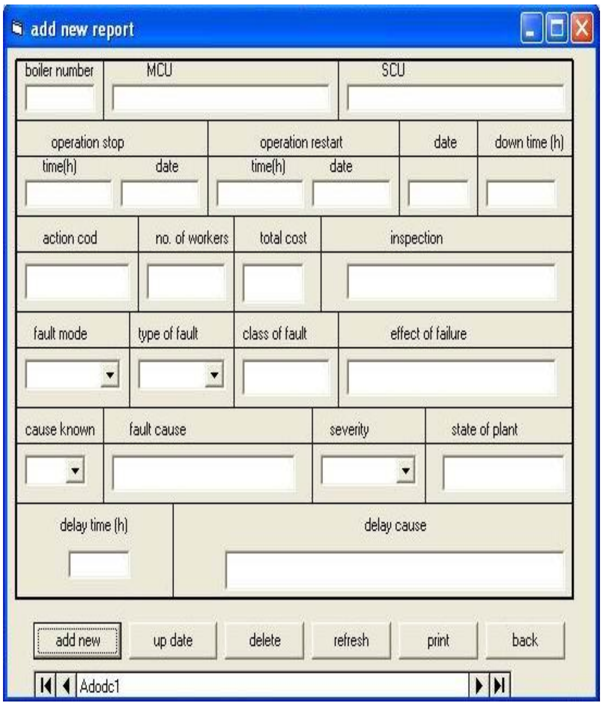


Figure (10) Add new FMEA report

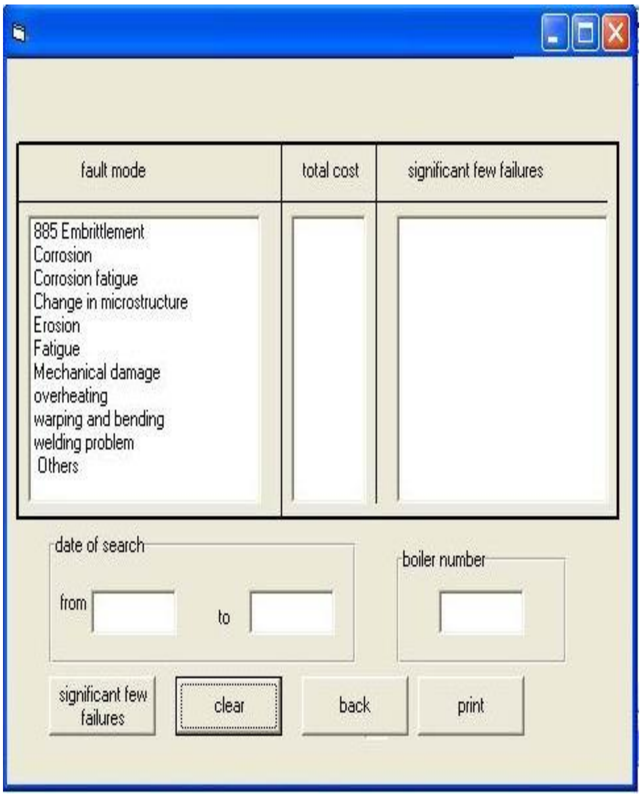
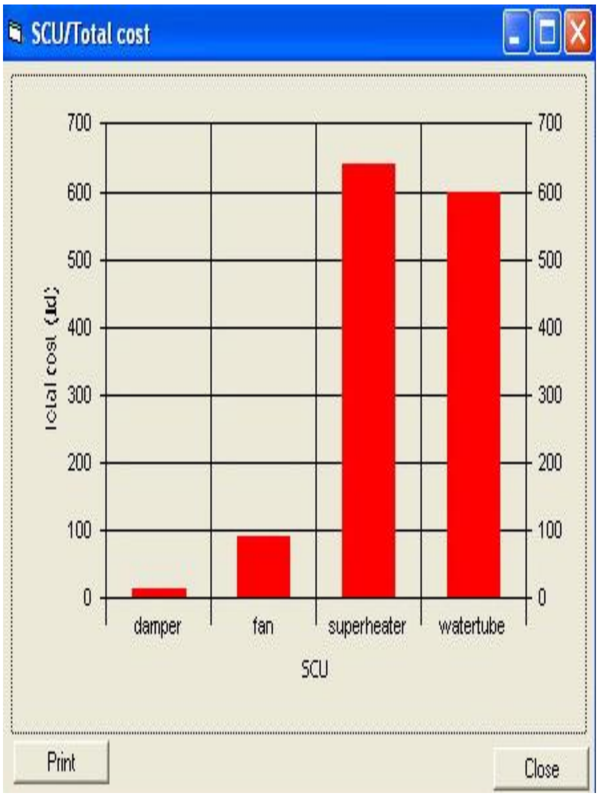


Figure (11) Significant few failures (Pareto Analysis)



Note: the graph is drawn with assumed values

Figure (12) Graphic result/ SCU with total maintenance cost

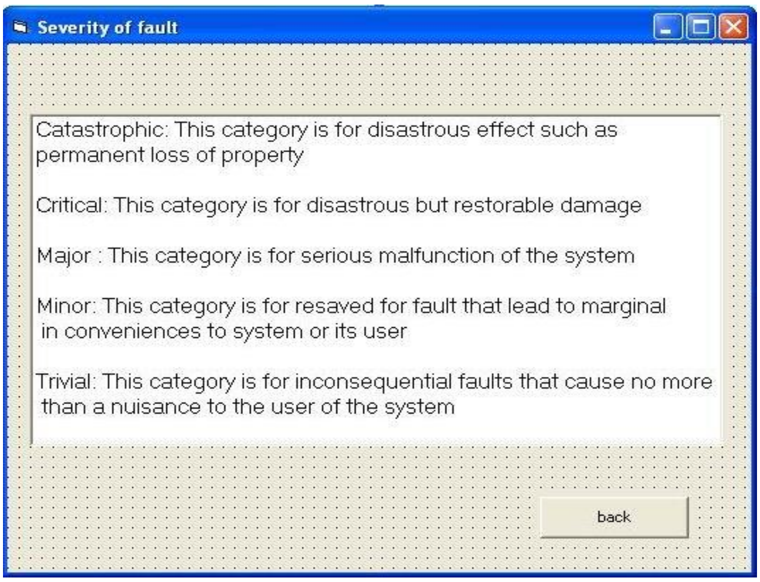


Figure (13) Severity of fault table

5-References:

Bdeir, L. M. (2005) .Development of Computer Aided Failure Mode and Effects Analysis for Boiler Systems. M.Sc. thesis, Al-Mustansiriya University.

Bonnefoi,P., (1990). Introduction to Dependability Design. Merlin Gerin Sevice Information, France,

Cheng, G. and Zhang, Y. (2005). Reliability Analysis Techniques Based On FTA for Reactor –Regenerator System. 18th International Conference on Structural Mechanics in Reactor Technology.

Crow ,K,(2002). Failure Modes and Effects Analysis (FMEA). DRM Associates, from http: //www.npd-solutions.com/fmea.html.

Dieter, G.E., (1990). Engineering Design A Materials and Processing Approach. Second addition, McGraw-Hill, Inc,

Kaiser ,B. (2003).A Fault-Tree Semantics to Model Software-Controlled Systems. Hasso-Plattner-Institute for Software Systems Engineering,.

Kales ,P.(1998) .Reliability for technology ,Engineering and management. prentice-Hall ,Inc.

Kales, P., (1998). Reliability for Technology, Engineering and Management. prentice-Hall ,Inc.

Kenneth, C.L. (2000) .Failure Modes and Effects Analysis “A modified Approach”. Tw, Press, from http: // www.reliability.com.

Kmenta ,S. and Ishii, K.(1998) . Advanced FMEA Using Meta Behavior Modeling for Concurrent Design of Products and Controls. ASME Design Engineering Technical Conferences.

Latino , J., (2000) .The Failure Dilemma. Reliability center, Inc.

Latino, Ch. J. (1997) .The Power of Failure Analysis to Eliminate Process Interruptions. Reliability center, Inc., from http://www.reliability.com.

Latino, Ch. J., (2000) .Is Analysis An Engineering Function?. TWI Press, Inc., from http://www.reliability.com.

Narayanagounder,S. and Gurusami, K. (2009) .A New Approach for Prioritization of Failure Modes in Design FMEA using ANOVA. Proceedings of World Academy of Science, Engineering and Technology , (37) :2070-3740

NASA, (2000). Failure Mode and Effect Analysis, A Bibliography., NASA Scientific and Technical Information Program.

Pree ,J., (2000) .Root Cause Failure Analysis .TWI Press,Inc.

Snell, V.G. and Jaitly, R. (2001) .Probabilistic Safety Analysis. Safety & Licensin CANDU.

Wavespec ,J.T. and Wavespec ,R.C., (1999). FMEA Studies – How Deep Should We Go?.Dynamic Positioning Conference,

William ,C.W., (2000) .Criteria for CMMS to Satisfy Facility Reliability Needs. Tw, Press.