



DESIGN AND IMPLEMENTATION OF COMPUTER AIDED SYSTEM FOR QUALITY IMPROVEMENT INSPECTION AND TESTING FOR BOILER IN THERMAL ELECTRIC POWER STATION

ABSTRACT

There is a problem, in Iraq, due to the multitude of malfunction after the overall annual maintenance has been achieved, and that raises the cost of continuous repairs, one of the reasons of this problem, is the absence of planned testing and automation for testing devices, the second reason is the neglect of concentrating on a database, the third one is not following an integrated testing system for all parts, as well as, there are no documented reports for inspected parts. Most of various nondestructive inspection techniques have been achieved random selection steps.

The lack of a documentation system leads to lack of historical information about failures parts of a boiler that affect inspection decision process.

This paper summarizes Programmed system designing and computerized for internal inspection of boiler heatsurfaces (IIBHS) at Nassyriah power station as an example.

KEYWORDS

Internal Inspection of Boiler, Inspection and test for boiler in thermal power station, Inspection of Heat surfaces in thermal power.

الخلاصة

في العراق هناك مشكلة في كثرة الأعطال بعد القيام بالصيانة السنوية الشاملة وزيادة كلفة التصليح باستمرار وكان أحد أسباب هذه المشكلة غياب الفحص المبرمج والأتمتة في أجهزة الفحص مع عدم التركيز على قاعدة معلومات وعدم إتباع نظام فحص متكامل لكل أجزاء المنظومة وغيرها من الأسباب الكثيرة جداً والتي لا مجال لذكرها أو ذكر أهميتها. في هذا البحث تم التركيز على وضع نظام فحص داخلي واختبار للسطوح الحرارية في مرجل محطة كهرباء الناصرية.

INTRODUCTION

There are a wide range of reasons that cause failures to occur in the critical parts of a boiler in TPS, the type and amount of inspection needed for repairs will be determined on an individual system

basis. The internal surfaces of a boiler in contact with water and steam which cause many problems lead to failures. Basic problems due to scale, generally the critical parts are those whose failure will directly affect the reliability of the boiler. The critical parts include:

- Drum.
- Furnace – tubes.
- Supperheater – tubes.
- Economizer tubes [M.N. Hoving and GLNakoneczy , 2000].

The main problems caused by boiler scales are:

- Increase in tube wall temperature, hence, boiler tube ruptures.
- Decrease in overall boiler efficiency, hence, increase in energy cost and loss of reliability [MoD. Majnouni and Arif E. jaffer, 2003]

Every part contains components which need an internal inspection system which includes.

- Knowledge of environment of working conditions.
- Historical, current, and manufacturing data for boiler.
- Expected failure based on lessons learned from failure history.
- Selection of nondestructive test (NDT) & destructive test (DT) methods of inspection[ASME Sec . V, 1980].
- Failure analysis and recovery with recommendation for correct actions.
- determination of time frame consuming through the inspection process.
- Documentation involving reports, and recordings for future analysis.

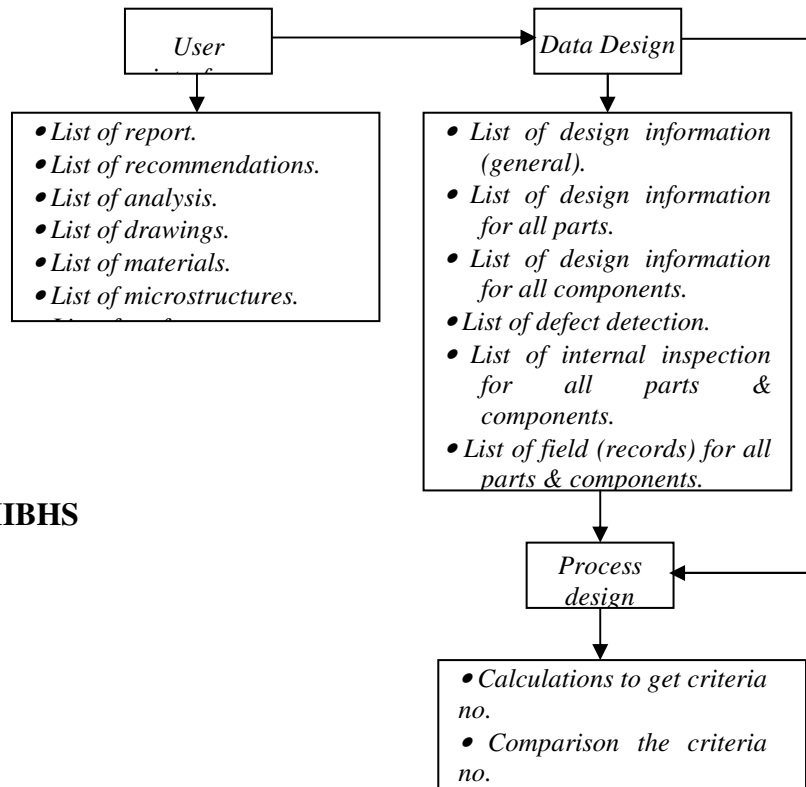
EXPECTED FAILURES:

A SYSTEM DESIGN FOR IHSB:

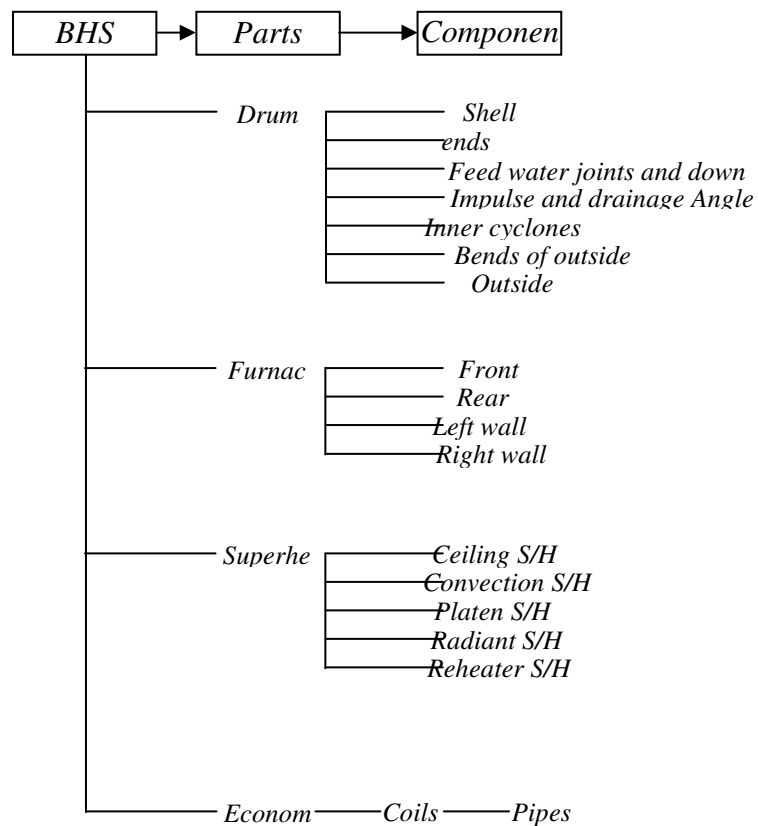
In general, system design means deciding what information is needed by the end user. It includes logical and physical design activities, and user's interface, data, and process design activities. Also what procedure system requirements developed in the stages of system analysis[James A. Obrien, 1997].

A system design for IHSB by analyzing in details the process which includes the activities of IIBHS and deals with all problems, then puts the systematic solution programmed by writing a set of instructions that cause a computer to perform a particular task.

In the fig. (1) the system design concept is applied on IIBHS process in TPS of Nassirya in south of Iraq.

**Fig. (1)****A system design of IIBHS**

The system covers the main parts and components as in fig. (2)

**Fig (2) The tree diagram of BHS illustrates parts & components**

FEATURES OF PARTS:

Features of parts or components and the condition of operation define the factor which governs the designing of lists.

- Drum shell is inspected in longitudinal and circumference tial welds. All welded attachment in the inner drum and the ends.
- Furnace tubes on the lists are inspected in levels to consider the area near burners which has suffered from exposure to direct impinged fire-or dissimilar materials which defines the level of pipe.
- Superheater has tubes made of alloy steel and subjected to creep failure, the lists include **OD** measurement to help the inspector if there is any failure caused by creep effect in the metal.
- Economizer, external water tubes are subjected to damage of erosion on tube surface[David N. French, 1993].

DOCUMENTS IN SYSTEM DESIGNING:

Two types of documents are used for designing a system of inspection and testing to cover principles and requirements of process.

The first type is the information documents as specifications, design information and defect detection.

The second type is the documents which express the process of (I & T) with decision making for each inspected part and components throughout lists such as:

- List of internal inspection & testing.
- List of internal inspection & testing (record) as in fig. (3).
- List of reports of internal inspection & testing.
- List of defects code.
- List of recommendations.
- List of analysis.
- List of work time.

In each part or component the list designed according to Russian and American which consider the feature of parts.

In addition two types of documents required for the calculations which give the number to achieve the process, such as:



Calculations of criterion number to limit the dependent thickness or allowable thickness, number of hardness allowable and other mechanical properties, out diameter (OD) allowable calculations, and time standard for all activities in each part.

Field works List (Record) over haul
Inspection and test annual non-destructive

Unit No.
Part name drum
Date.....
Inspector name.

Inspection No.
Inspector Accuracy.....

No.	Sheet Shell						Drum ends		Feed Water Joint & Down Comer		Impulse & Drainage angle Joint		Inner Cyclones Actual Cond.		Bends part of out side cyclones admitting pipe		Out side cyclones angle Joint		
	1	2	3	4	5	6	left	Right	Hole No.zone	Act Cond.	w.j no.	Act Cond	No.	left	Right	Bend no.	Act Cond	Anglej. No.	Act Cond.
Acc.																			
Def.																			
									1		1		1			1		1	
									2		2					2		2	
									3		3					3		3	
											16								
																24		24	
													42						
									76										

List of field record for drum

A SYSTEM BUILDING STEPS:

The steps to build the system are as follows:

1. Identifies the data needed from a huge data pool which include: parts, material, dimensions, drawing specification, working hours... etc, then designs lists for all informations to all parts.
2. Identifies the expected defects in all parts in a separate list.
3. Selecting a dependent procedure of nondestructive test and destructive, and designing lists of inspection & test which include the list of mechanical test.
4. Design lists of field (records) for all parts.
5. Finding the criteria number and allowable limit of all parts, by calculation, as thickness or OD allowable.
6. The lists of reports designing easy form to user which separates the rejected component, and fitting the lists of recommendations to repairs or treatments.
7. Designs analysis lists after type defect classifications.
8. Calculations of the standard time to estimate the performance of each activity are achieved.
9. Setting the materials compositions for all parts to help the inspector to take a decision and setting microstructure in picture with limits of work hours to help the inspector to achieve the comparisons and take a decision for validity as in.
10. Identifies the methods of water chemical analysis with designing the lists of chemical analysis.

CALCULATIONS:

The calculations involve equations to define the numbers needed by inspector after comparison to take a decision for repairing or changing or leaving the inspected part in the work.

1. According to Russian standard the equation was used to define the allowable thickness of pipe for furnace, superheater, and economizer is [Dr.Markov , Dr.plastoy]:

$$t_{\min} = \frac{P_w \times D_m}{200 \psi \sigma_{\text{act}} + P_w}$$

Where:

t_{\min} = minimum thickness allowable (mm).

P_w = working pressure kgf / mm².

D_m = Nominal diameter (OD) mm.

ψ = Welding coefficient.

= 1 for seamless pipe.

σ_{act} = Ultimate stress at working temperature kgf / cm².

For example:

The allowable thickness for water wall pipe of front wall of furnace:

First step the material defines, the pipe made of 15XM.

From the standards the minimum thickness is:

$$t_{\min} = \frac{155.5 \times 60}{200 \times 1 \times 13.085 + 155.5} = 3.36 \text{ mm} = 3.4 \text{ mm}$$

This number means the criterion number to inspect the thickness of all pipes made of alloy steel 15XM, under working pressure 155.5 kgf / mm² and out side diameter 60 mm, design thickness 6mm – and accepted thickness number after working hours > 3.4 mm.

2. According to American standard the equation was used to define the criterion number of (OD) in sperheater, which gives the indication about thermal effect on the metal (creep failure)[ASME, 1971].

$$\text{OD criterion} = \frac{\text{OD original} \times 3.5}{100 + \text{OD}}$$

Where

OD criterion = out side diameter of pipe.

OD original = out side diameter of pipe in design condition.



Then OD allowable < OD criterion

For example:

The pipe of platen superheater which is made of alloy steel (12X IMΦ) with dimension of OD = 42 mm.

$$\text{OD criterion} = \frac{42 \times 3.5}{100 + 42} = 43.47 \text{ mm}$$

OD allowable < 43.47 mm

3. Stresses in the drum shell calculated from hardness number of test.

By measuring hardness Brinell number (HB) (used portable digital hardness tester) then calculate σ number from equation:

$$\sigma = \left(\frac{\text{HB}}{3 \text{ or } 3.5} \right)$$

Then σ allowable > 50 kgf / mm² accepted.

4. According to Japanes standard the equation which gives the indication about the scale in the water of boiler[JIS, 1966]:

$$W2 - W1 < 400 \text{ g / mm}^2$$

Where

W2 = the weight of pipe with scale.

W1 = the weight of pipe without scale (after washing).

Then (w2 – W1) allowable < 400g / mm²

This test helps the inspector to give his decision about washing the boiler.

5. Time standard calculation:

Time consumer in all types of (I & T) NDT and DT calculates by means of data numbers after analysis in normal distributed curve.

The data numbers divided to classes [G.M. Clarke and D. Cooke , 1978].

$$\text{Length of class} = \frac{\text{HV} - \text{LV}}{6}$$

Where

HV – LV = range

HV = high value number in data

LV = Low value number in data

6 = number of classes

then apply the equation.

$$\bar{X} = \frac{\sum f \bar{x}}{\sum f}$$

Where

f= frequency (data numbers)

X = mean value

The equation of $S = \sqrt{\frac{\sum fx^2}{\sum f} - (\bar{X})^2}$

Where S standard deviation

The analysis covers all type of DT & NDT like ULT, RL, MPT, PT... etc.

For example ultrasonic data submitted to analysis as below

$$\text{Range} = \text{HV} - \text{LV}$$

$$= 5.33 - 4.88$$

$$= 0.45$$

$$\text{Length of class} = \frac{\text{Range}}{\text{Number of classes}} = \frac{0.45}{6} = 0.075$$

No.	class	Freq.	mid point X	(X) ²	fx	fx ²
1.	4.88-4.955	3	4.91	24.10	14.73	72.32
2.	4.956-5.031	5	4.99	24.90	24.95	124.50
3.	5.032-5.107	7	5.06	25.60	35.42	179.22
4.	5.108-5.183	6	5.14	26.41	30.84	158.51
5.	5.184-5.259	5	5.21	27.14	26.05	135.72
6.	5.26-5.335	4	5.29	27.98	21.16	111.93
		30			153.15	782.20

$$= \frac{153.15}{30} = 5.10$$

$$S = \sqrt{\frac{\sum fx^2}{\sum f} - (\bar{X})^2}$$

$$= \sqrt{\frac{782.20}{30} - (5.10)^2} \quad (1361)$$



= 0.25165

IMPLEMENTATION (DBMS) COMPUTER AIDED OF IIBHS IN TPS

The software involves three basic activities:

1. Updating and maintaining common data base to reflect new events requiring changes to an organizations record.
2. Providing information needed for end users application by using application programs that share the data in common databases. This sharing of data supported by the common software interface provided by (DBMS) package.

Thus, end users and programmers do not have to know where or how data are physically stored.

3. Providing an inquiry / response and reporting capability through a DBMS package, so that endurance can easily interrogate data bases, generate reports, and receive quick responses to their special requests for information.

The software of a database management system (DBMS) is implemented to record and supervise the IIBHS in Al- Nassryiah power station in south of Iraq. Since all four units of power station, have the same type of boiler then the options in this system applies for all four boiler.

Computer specification for system requirements:

Central process unit (CPU): Pentium III 633 MHz or higher.

RAM memory: 128 MB, 256 MB recommended.

Hard disk space: 200 MB

Operating system: windows XP.

For printing a laser with A4 paper size is recommended.

As in fig. (8) these options are:

1. Boiler specifications: displays the boiler specifications window.
2. Drum: displays the drum list.
3. Furnace: displays the furnace list.
4. Super heater: displays the super heater list.
5. Economizer: displays the economizer list.
6. Materials: displays the window containing the materials used in the boiler and there chemical composition.
7. Help: to execute this help file.
8. Exit: to end the system and return to windows.

Shell sheets and drum ends	Feed water joints and down comer	Impuls and drainage angle joints	Left inner cyclones	Right inner cyclones	Bend parts of outside cyclones admitting pipe	Outside cyclones angle joints
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After having a good look on the existing option with high + light which moves to choose any required one.

If the user selects the drum second menu will appear which contains four options, then if the user selects list option the third menu will appear etc. for example the list in fig. (3) in the computer will appear as in fig (9-a) fig. (9-b), and fig. (9-c), also the list of report in fig. (4) it will appear by the window of computer as in fig. (10).



Drum field work list

Drum Field work List of inspection recording and testing

Inspection No. : Inspector name :

Unit No. : Part name : Drum Inspector Reliability : % Date :

Shell sheets and drum ends	Feed water joints and down comer	Impuls and drainage angle joints	Left inner cyclones	Right inner cyclones	Bend parts of outside cyclones admitting pipe	Outside cyclones angle joints
----------------------------	----------------------------------	----------------------------------	---------------------	----------------------	---	-------------------------------

Shell sheets

No.	Defective
1	<input type="checkbox"/>
2	<input type="checkbox"/>
3	<input type="checkbox"/>
4	<input type="checkbox"/>
5	<input type="checkbox"/>
6	<input type="checkbox"/>

Drum ends

	Defective
Left	<input type="checkbox"/>
Right	<input type="checkbox"/>

Save Reset Delete Remark: Click only on the defect parts Back to Main

Fig(8)

All the system will display as window in the computer to achieve the activities of IIBHS and give the user results, and recommendations in a simple method.

Fig (9)

Drum field work list

Drum Field work List of inspection recording and testing

Inspection No. : 1 Inspector name : salah beram

Unit No. : 1 Part name : Drum Inspector Reliability : 93 % Date : 1/1/2000

Shell sheets and drum ends	Feed water joints and down comer	Impuls and drainage angle joints	Left inner cyclones	Right inner cyclones	Bend parts of outside cyclones admitting pipe	Outside cyclones angle joints
----------------------------	----------------------------------	----------------------------------	---------------------	----------------------	---	-------------------------------

No.	Defective	No.	Defective	No.	Defective	No.	Defective	No.	Defective	No.	Defective
1	<input type="checkbox"/>	14	<input type="checkbox"/>	27	<input type="checkbox"/>	40	<input type="checkbox"/>	53	<input type="checkbox"/>	66	<input type="checkbox"/>
2	<input type="checkbox"/>	15	<input type="checkbox"/>	28	<input type="checkbox"/>	41	<input type="checkbox"/>	54	<input type="checkbox"/>	67	<input type="checkbox"/>
3	<input type="checkbox"/>	16	<input type="checkbox"/>	29	<input type="checkbox"/>	42	<input type="checkbox"/>	55	<input type="checkbox"/>	68	<input type="checkbox"/>
4	<input type="checkbox"/>	17	<input checked="" type="checkbox"/>	30	<input type="checkbox"/>	43	<input type="checkbox"/>	56	<input checked="" type="checkbox"/>	69	<input checked="" type="checkbox"/>
5	<input type="checkbox"/>	18	<input type="checkbox"/>	31	<input type="checkbox"/>	44	<input type="checkbox"/>	57	<input type="checkbox"/>	70	<input type="checkbox"/>
6	<input checked="" type="checkbox"/>	19	<input type="checkbox"/>	32	<input checked="" type="checkbox"/>	45	<input checked="" type="checkbox"/>	58	<input type="checkbox"/>	71	<input type="checkbox"/>
7	<input type="checkbox"/>	20	<input type="checkbox"/>	33	<input type="checkbox"/>	46	<input type="checkbox"/>	59	<input type="checkbox"/>	72	<input type="checkbox"/>
8	<input type="checkbox"/>	21	<input type="checkbox"/>	34	<input type="checkbox"/>	47	<input type="checkbox"/>	60	<input type="checkbox"/>	73	<input type="checkbox"/>
9	<input type="checkbox"/>	22	<input type="checkbox"/>	35	<input checked="" type="checkbox"/>	48	<input type="checkbox"/>	61	<input type="checkbox"/>	74	<input type="checkbox"/>
10	<input type="checkbox"/>	23	<input type="checkbox"/>	36	<input type="checkbox"/>	49	<input type="checkbox"/>	62	<input type="checkbox"/>	75	<input type="checkbox"/>
11	<input type="checkbox"/>	24	<input type="checkbox"/>	37	<input type="checkbox"/>	50	<input type="checkbox"/>	63	<input type="checkbox"/>	76	<input type="checkbox"/>
12	<input type="checkbox"/>	25	<input type="checkbox"/>	38	<input type="checkbox"/>	51	<input type="checkbox"/>	64	<input type="checkbox"/>		
13	<input type="checkbox"/>	26	<input type="checkbox"/>	39	<input type="checkbox"/>	52	<input type="checkbox"/>	65	<input type="checkbox"/>		

Save Reset Delete Remark: Click only on the defect parts Back to Main

CONCLUSION:

By using the computerized system, the efforts and time will be saved, also the successful results which introduce by implementing the system gives the benefits as follows:

- Standardization of methods, procedures, for selection the NDT and DT.
- Reducing of paper work and form.
- Providing database from a huge data in a short time.
- Better documentation by recording the stages of inspection and reports.
- Historical data is given with time which assists both manager and inspection staff.
- Enlarging the capabilities of analysis.
- Avoiding the undeliberating errors.
- Training become more easy by using the programmed system.

The recommendations listed in this system are minimum guideline for inspecting the critical components of the boiler island. Based on problems encountered during the day-to-day boiler operation, additional inspections may be recommended.

The steps in this system will help to know the amount, type and specific location of inspection performed at any outage, either planned or forced.

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