

STUDYING OF BOILER CORROSION AT KUWAIT OIL AND GAS COMPANIES

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ABSTRACT

Kuwait is one of the major producers and exporter of crude oil around the world, which is used as fuel for energy during the steam generation in the industrial boilers. However, due to presence of the various chemical substances, in boiler surface it creates corrosion problem. The corrosion problem has led to billions of dollars' worth of loss every year in various organizations. Many researchers and practitioners have put a lot of effort to find out efficient solutions. Every industry has different responsibilities and structure, so it is difficult to apply one solution for every industry. To fill this research gap and build up a new prevention system, this research work was carried out. Systematic literature reviews formed the preliminary research work in the context of corrosion, all the factor and source of corrosion have been found out and the prevention system is presented. After finding out the list of all element and anomalies of previous work, created a five-point Likert scale boiler corrosion survey and to get empirical validation, convenience sampling survey conducted at various oil and gas industry of Kuwait. We used SPSS 2.0 to find the skewness and the set of main factors for the problem. With the help of design science approach, a new corrosion prevention management framework that can be applicable at each industry has beendeveloped.

KEYWORDS: *Boiler Corrosion, Kuwait, Boiler, Prevention Management*

Article History

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INTRODUCTION

A boiler is a vessel, which generally made of steel or alloy steel in a closed form, and the primary purpose of boiler is to heat the fluid (usually water). The fluid does not necessarily boil; it is also used to heat or vaporized the existing liquid, and it has been using in a various heating process and application such as central heating, boiler-based power generation, cooking and sanitation (Frederick M. Steingress,2001). So, the boiler is also termed as a steam generation unit, and designed in such way that it can use the chemical energy present in a fuel, which raises the energy content of water that will be used for power application and heating purpose. In a boiler, many different kinds of fuels are boil; it may be either fossil and non-fossils fuels. The most common types of fuels include coal, oil and natural gas. By heating of water in the boiler above the atmospheric pressure, steam could be generated (Alazemi et al., 2019). Many industries such as food factory, oil field, textile factory, dairy factory, garment factory, paper mill, commercial building, brewery is extensively using the industrials boilers. Whereas other types of boilers like commercial and industrials are used for many other applications, including an office building, apartment, hotels, restaurant, schools, hospitals, government building and airport. A boiler is classified based on the use of the content in the tubes, several tubes, the position of a furnace, an axis of

shells, methods of circulation of water and steam. All types of boilers are suffering from the problem of corrosion, which generally termed as the boiler corrosion.

Boiler corrosion is defined as the ongoing destruction of the surface of boiler metals by the pitting action of dissolved oxygen, which presents in the boiler water. It heavily defects the inner metallic exterior of the boiler that lead to the deep holes in the metal, which maybe self-protected by further corrosion products such as scab or blisters over the holes, which allow the chemical reaction to continue further. Generally, the surface of the boiler is built of the heavy metals that consist of many layers, but oxygen pitting site can be developed by a deep penetration hole, through boiler metal that causes ultimate failure. Oxygen dissolved in the water, which is present inside the boiler is many times untreated that is highly corrosive to the steam boiler. Deaerator and preheated water will reduce the dissolved oxygen content of raw water, so it is necessary to attain adequate chemical reserve of an effective oxygen scavenger to avoid the damage of costly boiler metal corrosion and downtime. Boiler corrosion leads to damage in term of operation as well as financial, profoundly.

Kuwait is a significant producer of crude oil in the world and also the exporter. Due to the extensive presence of oil, they have been using the oil sources for generation of electricity and other application. To perform the various operation with the help of crude oil, there always be a requirement of industrial boiler for that process. Boiler ability to use the oil as source of energy in evaporating the water and converting into the steam allows generating electricity, and also performing different application process. Therefore, in Kuwait, an industrial boiler is excellent lit, used for different process and application in the field of food, oil and gas, chemical, textile, pharmaceutical and in the power plant sector for the energy generation (Tuffner, 2014).

INTRODUCTION - INDUSTRIAL BOILER

Heat is an essential element for heating building and the many operations in the industrial process. For transferring heat from one place to another place, there will always be the availability of a particular process. Water or steam is to be considered as one of the best forms of transfer of heat, because it contains some desirable properties such as higher energy absorption or easy transportability. It is readily available everywhere and not harmful to the environment. The atmospheric pressure of water is also lower. An industrial boiler is working on the same principle of a cooker, but the capability of boiler is much higher than the cooker in every term so it can cope much higher pressure than a pressure cooker. An industrial boiler is welded with many layers of thick steels plates up to 35mm thickness, able to take the pressure of 30 bar or more. Reliable or robust design for the boiler is necessary. Otherwise, there are always chances to collapse of the boiler take place, explosive force comparable to the explosive power of a ton of gelatinate would be released. As per different design measurement, it is possible for the single boiler is to generate about 38 MW of thermal output, which is approximately equal to the power of 500 average VW golf car. The basic design of hot water or steam boiler are relatively similar in design. The boiler pressure vessel is a horizontal, cylindrical tube closed at both sides with an endplate and insulated all around. There is a flame tube (1st pass) in this pressure vessel, which is fire through a burner and an internally situated reversing chamber that reverses the flue gases and leads them back in the 2nd smoke tube pass. On the front of the boiler is an external reversing chamber, which again reverses the flue gases and leads them to the end of the boiler in the 3rd smoke tube pass. Hot water boilers are usually filling with water during the operation process.

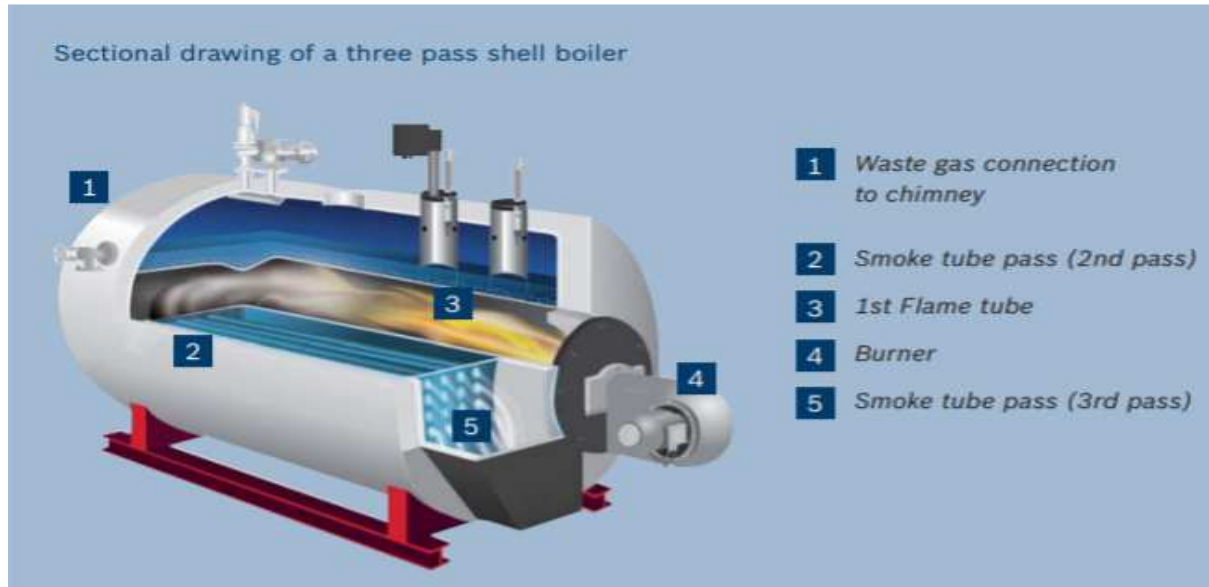


Figure1: Industrial Boiler (MarkusTuffner, 2014).

Steam boilers, on the other hand, are only 3/4 filled with water; the upper quarter is the steam space. Due to this vast design that can able to store a massive amount of water and multi-stage lead through the flue gases, this also terms as the three-pass shell boiler.

All functions of an industrial boiler system work based on hot water or steam boiler, which creates uses of the specific kind of fuel. Fuel is going through a certain kind of combustion process, which able generates some energy that has been used for evaporating the water, then transfer steam to the consumer via the pipe system. When all steam used, the remaining water transferred back through the pipe for reheating. Flue gases are created with the combustion of fuels that are transferred back to the atmosphere, through the chimney

BOILER CORROSION

The main reason for corrosion occurs on surface of the boiler, due to the presence of the atmospheric oxygen in the air or water that reacts with a metallic surface and performs the oxidation reaction. Whereas, corrosion in the industrial boiler happens due to oxygen, which dissolves into water that is present inside the boiler, reacts with the metals of the steam boilers. The surface of the boiler is built of various metal or alloy metals, and a ferrous component of metals react with atmospheric oxygen in the water and undergo into the oxidation reaction. This oxidation chemical reaction leads to the formation of ferrous oxides. Ferrous oxides result in the formation of cavities and deep holes into the surface of metals. The formation of deep holes and cavities on the surface of the metallic element is termed as pitting. Pitting is the primary host for the corrosion.

Main Causes of Boiler Corrosion

- Boiler maintenance is unscheduled and improper.
- Presence of CO₂ in boiler water.
- pH level of boiled water is unbalanced.
- Presence of oxygen in boiler water.

- Exposure of metals to the dissolved gases.

The main problem of corrosion is cracking of metal surface, whereas cracking in the boiler metal may occur due to two of a different mechanism. First of all, cyclic stresses are due, through the process of rapid heating and cooling that are processed on the metallic surface of the boiler. If the process is concentrated at only certain point, then it results in corrosion, place which is roughened or pitted at the metallic surface. It generally occurs due to improper corrosion prevention. The second type of corrosion fatigue, which started due to the presence of thick protective oxide film present on the surface of metals, and that part continue with the cyclic stresses. The result of corrosion fatigue is creating up the cracks, which is generally blunt and thick in shape. Based on the different type of chemical reaction, corrosion is classified further.

Types of Corrosion in Industrial Boiler

- Acidic corrosion
- Caustic corrosion
- Hydrogen embrittlement
- Oxygen attack
- Carbon dioxide attack
- Galvanic corrosion

Effects of Boiler Corrosion

Corrosion can damage the boiler in two possible ways; general and pitting. General corrosion damages the overall system, whereas pitting only damage the smaller part of the boiler surface. Corrosion of boiler AFFECTS the operation process as well as financial loss to the processing holder. Some of the effects of the boiler corrosion are,

Lost Efficiency: Corrosion and scale deposit directly or indirectly affect the efficiency of an operation. Product of corrosion also leads to the scale deposit so, if we do not scale up the amount of corrosion, there shall be more chances of corrosion in the future. More likely into the pulled off the metal that will cause efficiency-robbing deposit. Corrosion that damage the surface of boiler lead into the reducing of the system efficiency. Holes in the metals cause leaks that can cause various operational problems and result in the shutdown of the boiler.

Shorter System Lifespan: Fail in controlling corrosion will lead in shorten the lifespan of the entire system. If chemical composition within the water system does not receive attention timely, then corrosion will worsen with time and lead to the overall loss in efficiency experience continue to degrade until the system shuts down.

Higher Costs: The cost required to militance the damage of parts due to corrosion is excessively costly or replacing the damaged part. In many cases, it required to replace the overall system or maybe pitted tubes instead of repairs. To replace damage, the part OF it will need to shut down the system for some time, which affects the overall productivity of the system. Even after replacing damaged parts of the system, the previous level of productivity is not able to attain.

Holes: Holes generally happen when continue to keep using the boiler for further process when pitting already occurred on it, and any other prevention not taken. A hole will be damaging the whole surface of the boiler.

Pitting: Pitting is the major problem of the corrosion; it generally occurs on the surface part, where the presence of a high level of oxygen, oxygen reacts with metals cause pits in the surface. If any maintenance or prevention not undertaken, then pitting become more worsened and cause the hole on the surface.

PROBLEM STATEMENT

A lot of research work has already been done in the field of boiler corrosion and also for prevention. Every method has some number of anomalies in their method, and finds out which method is the best way to use for prevention, that's why it became a requirement for studying boiler corrosion. This research tried to study boiler corrosion in the boiler, which has been used by the oil and gases industry of Kuwait. Kuwait is giant producer and exporter of crude oil, and various organisations has been using the industrial boiler for different application and processes, where the source of the process is crude oil. One of the significant problems is corrosion affects boiler efficiency by damaging the metallic surface of the boiler. In this damaging affect, overall productivity of industry is affected. So, this research focused on studying the boiler corrosion, find out the gaps in the previous method of prevention and propose a new framework for this problem.

RESEARCH SCOPE

This project is on studying the boiler corrosion used in oil and gas industries of Kuwait. The study focused on identifying the various factors which result in corrosion of boiler and find out gaps in the previous prevention method which has been adopted in Kuwait, and overcome this problem by providing some framework and steps for maintenances of boilers in Kuwait. The project underwent the following process.

- Studying and identifying the working condition, temperature, pressure etc. through proper investigation in Kuwait oil and gas industry.
- Studying the different type of corrosion, and identifying the factors which negatively affect the boiler.
- Studying the various maintenance processes and identify the problems in that process.
- Propose a framework and necessary steps to overcome this problem.

The research philosophy adopted in this study is 'positivism' research philosophy for further research. In this method, knowledge is built on the basis of natural observation and gives a new perspective view for their relationship and property of topic. Corrosion is natural phenomena, which is studied for many years and solution come from the study but not sufficient, and much more is required to identify a better solution, because there is a huge amount loss occurs due to the corrosion problem. Realism is the best way to analyze the natural phenomena of corrosion and identify the various factors which affect the corrosion and what is the problem in current maintenance method for corrosion and to overcome this problem. The framework and step for future process has been provided.

RESEARCH OBJECTIVES

A lot of research work has been done in the field of boiler corrosion; still, there is a broad scope of improvement in this filed. Different research methodologies are considered to perform this work and provide a specific suitable method to overcome this problem. After analysing of work done yet on boiler corrosion, a wide range of scope for improvement is

required. It is the purpose of this research; to identify the various factors for boiler corrosion and find out the gaps in the previous one, using the maintenance process, purpose and obtained a better method than the existing one. The overall goal of this research work is to identify anomalies in the prevention method of corrosion through proper survey, and with the help of design science approach, provides a framework. The following objectives have been formulated.

- Identify the factor which is main reason for corrosion through literature review.
- Identify the prevention method of corrosion using in Kuwait.
- Find out the anomalies present in the previous process using survey method
- Design science approach used to build up a new framework or set of guidelines for doing practice with the boiler those are using the oil and gas industry of Kuwait.

The following are the research questions:

- What are the main reasons for boiler corrosion?
- What are the common effects of boiler corrosion?
- What are the preventive ways of boiler corrosion?
- Is there any significant difference in main reasons for boiler corrosion according to demographic data?
- Is there any significant difference in common effects of boiler corrosion according to demographic data?
- Is there any significant difference in preventive ways of boiler corrosion according to demographic data?
- Is there is a relation between main reasons for boiler corrosion and its effects?

RESEARCH METHODOLOGY

A total sample of (60) filled questionnaires were collected. All incomplete responses were exempted. The collected data were analyzed using (SPSS v.25) program: "Statistical Package for Social Sciences", as follow: Cronbach's alpha used to determine the reliability for the questionnaire and its dimensions. Descriptive statistics used to describe the basic features of the total in the study (60), such as frequencies, Percentages, Mean and Stander Deviation. Relative Importance Index (RII) method is used to determine the relative importance of the study dimensions. With large enough sample sizes (> 30 or 40), the violation of the normality assumption should not cause major problems (Pallant.2007); this implies that we can use parametric procedures even when the data are not normally distributed (Tavakol,Dennick, 2011). If we have samples consisting of hundreds of observations, we can ignore the distribution of the data according to the central limit theorem (Bland., & Altman.,1995.); therefore, T- independent sample test and ANOVA were used to find the difference in the study dimensions according to demographic; if ANOVA test were significant, the post hoc (Scheffe) test will be useful.

The following hypotheses have been framed in this study:

- There is no significant difference in (main reasons for boiler corrosion, common effects of boiler corrosion, and preventive ways of boiler corrosion) from the viewpoint of the participants, according to demographic data (Job)
- There is no significant difference in (main reasons for boiler corrosion, common effects of boiler corrosion, and preventive ways of boiler corrosion) from the viewpoint of the participants, according to demographic data (Age)

- There is no significant difference in (main reasons for boiler corrosion, common effects of boiler corrosion, and preventive ways of boiler corrosion) from the viewpoint of the participants, according to demographic data (Education)
- There is no significant difference in (main reasons for boiler corrosion, common effects of boiler corrosion, and preventive ways of boiler corrosion) from the viewpoint of the participants, according to demographic data (Experience)

RESULTS

The Demographic Characteristics

Demographics data for participants (N=60), shows that 58.3% of the participants were Technical while 41.7% were Engineer, the highest group 58.3% were 24 to 44 years old, 38.3% were at Bachelor as academic level, 35% had 6 to 10 years working in this industry. (Table 2)

Table 1: Demographic Characteristics (N=60)

Demographics Characteristics		N	%
Job	Engineer	25	41.7
	Technical	35	58.3
Age	24- 44 years	31	51.7
	45- 55 years	18	30.0
	Over 55 years	11	18.3
Education Level	Bachelor	23	38.3
	Master	22	36.7
	PhD	15	25.0
How long have you been working in this industry?	1 – 5 years	20	33.3
	6- 10 years	21	35.0
	> 10 years	19	31.7

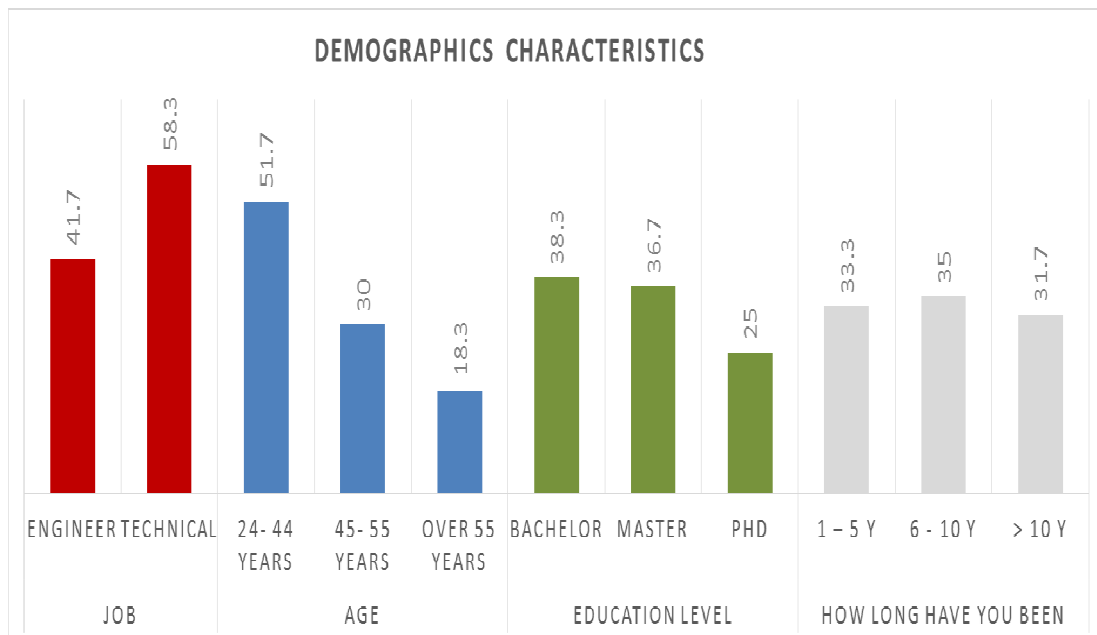


Figure 2: Demographic Characteristics.

Table 2: Descriptive Statistics for Participants' Responses towards Effects of Boiler Corrosion

Items	Mean	Std. Deviation	RII (%)
Products of corrosion contribute to scale deposits.	3.6667	1.12997	73.33
Corrosion and scale deposits ruin the efficiency of the system.	3.7667	1.25370	75.33
Scale build up cyclically contributes to more corrosion.	3.8667	1.12697	77.33
Corrosion affects the lifespan of the boiler.	3.5167	1.12734	70.33
Corrosion affects the overall organization productivity.	3.7000	1.29274	74.00
Corrosion affects the economic condition of an organization.	3.8667	1.11183	77.33
Corrosion can lead to excessive costs to repair the system or replace damaged parts.	3.7333	1.02290	74.67
Preventative maintenance affects production time	3.7833	1.12131	75.67
Corrosion cause gradual formation of cavities and holes in the metal which termed as pitting.	3.9000	1.17459	78.00
Corrosion usually starts at internal tube surfaces and are most often circumferential on the tube.	3.6500	1.03866	73.00
Effects of boiler corrosion	3.7450	0.62475	74.90

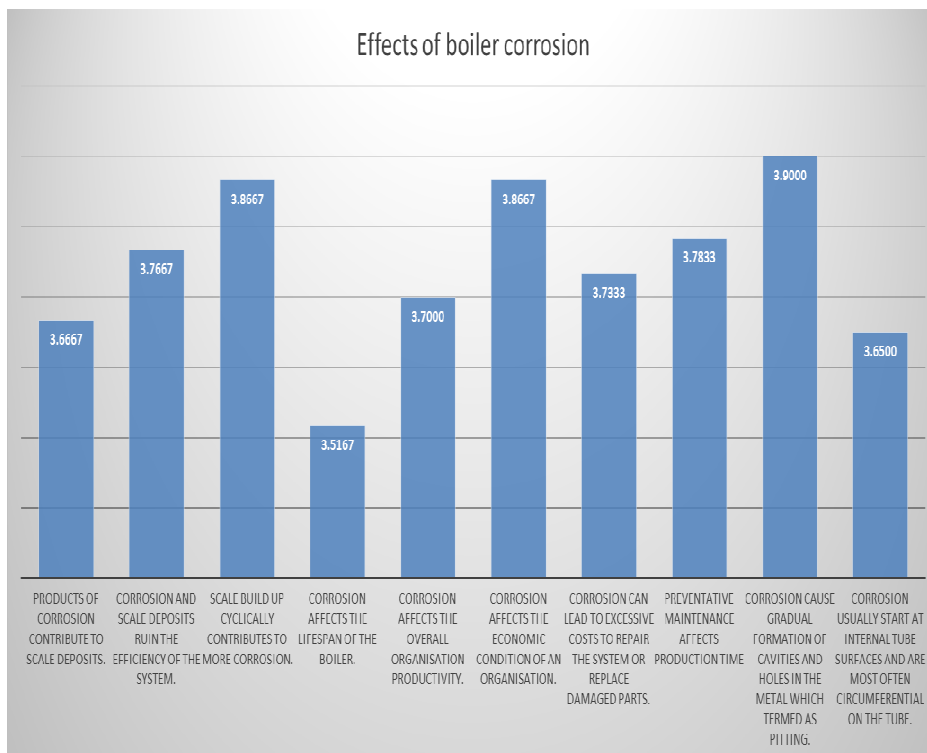


Figure 2: Descriptive Statistics for Participants' Responses towards Effects of Boiler Corrosion.

CONCLUSIONS

Boiler Corrosion is a major problem in Kuwait oil and gas industry, which has led to billions of dollars’ worth of loss every year. It has therefore become a necessity to find out efficient solutions of this problem. Many researchers and practitioners work from different areas have done a lot of work in this context to overcome this problem. The problem of corrosion is varying on the basis of context, so it is difficult to apply solution of one corrosion type in different type. Therefore, it

becomes necessity to fill up this research gap, and re-study the boiler corrosion at point of what is the main reason and source of corrosion in the boiler. What prevention technique and methodology is used by the organization and individual one, to overcome from these problems. Using systematic literatures review, identified the different factors and problems related to corrosion, and various prevention methods used; and completed a particular research work, however, it requires to be empirically validated.

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