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# MAINTAINING THE QUALITY OF STEAM BOOTEL WATER USING BOILER WATER TREATMENT (BWT) IN AN EFFORT TO PREVENT CORROSION SO THAT THE BOOTTE PIPE IS NOT DAMAGED ON THE PASSENGER SHIP

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***Abstract*— *Steam boiler is a closed vessel that can produce hot steam with a pressure greater than one atmosphere. Leaks in fire pipes will affect the operation of the steam boiler. One of the pipe leaks in steam boilers is caused by corrosion on the boiler walls which is caused by inadequate boiler water quality. Boiler water must be maintained so that the contents that cause corrosion are removed, the chloride salt content is kept as low as possible, does not contain gases that cause corrosion - the SiO2 content is as low as possible and the boiler water is kept alkaline. The aim of this research is to maintain the quality of steam boiler water using Boiler Water Treatment (BWT) in an effort to prevent corrosion so that boiler water pipes are not damaged on passenger ships. The presence of dissolved oxygen gas causes corrosion in the boiler. BWT is able to maintain the quality of boiler water by reducing dissolved oxygen and reducing gases that cause corrosion and maintaining the alkalinity of boiler water so that it can prevent corrosion in boiler pipes. The oxygen-repellent substances in BWT are sodium sulfite (Na2SO3) and hydrazine (N2H4).***

***Keywords*— *Boiler Water, Boiler Water Treatment, Corrosion***

## I. INTRODUCTION

A boiler is a type of auxiliary device on a ship that is used to produce water steam which will be used to heat fuel, cargo, auxiliary equipment that uses steam power or as propulsion on the ship.

The boiler/boiler is one of the aircraft that is very important in supporting the smooth operation of the ship. Cargo carried by tanker will be meaningless if the cargo cannot be unloaded into storage tanks on land. To be able to unload this liquid cargo, there is a need for a pump which is generally driven by a steam turbine. Steam under certain conditions is needed to drive this turbine so that pumping is as optimal as possible. Although a small number of small tankers do not use steam-driven pumps but use electricity or hydraulics.

Boiler water that is not properly treated and monitored can worsen corrosion and result in the boiler exploding. Water quality is determined by the substances dissolved in it, such as organic and inorganic materials and gases, for example CO2 and O2. All of this can cause scale and corrosion in the steam boiler, which in turn will cause losses.

A steam boiler is a device whose function is to convert water into steam by heating through burning fuel in the combustion chamber. Damage to steam boilers, especially damage to the pipes, namely pipe leaks or pipe ruptures which cause the ship to not work optimally.

Rusnoto (2006) discusses that boiler damage is mostly caused by corrosion and scale deposits from the water filling the boiler. By considering the problem of corrosion and its impact on steam boilers, in this research we provide the title: Maintaining Boiler Water Quality Using Boiler Water Treatment (BWT) So that Boiler Pipes Are Not Damaged on Passenger Ships.

The objectives of this research are:

- To find out why corrosion occurs in steam boiler pipes

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- To find out how to prevent corrosion on steam boiler walls by maintaining boiler water quality using Boiler Water Treatment (BWT).

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## II. LITERATURE REVIEW

### *A. Understanding Boilers and How Boilers Work*

The boiler in the engine room of a ship is one of several auxiliary devices on the ship. The function of a boiler is a closed vessel, which can form steam with a pressure of more than 1 atmosphere, namely by heating the boiler water inside from the hot gases from combustion. In general, 2 boilers are installed on ships with the aim that if one of the boilers is damaged or under repair, there is another one that can replace it.

There are two types of boilers on ships, namely:

- Fire tube boilers where the ignition process occurs in the pipe, then the heat produced is sent directly into the boiler which contains water.
- Water pipe boilers where the ignition process occurs outside the pipe, then the heat produced heats the pipe containing water, where in this water pipe the flowing water must be conditioned for minerals or other contents that dissolve in the water.

### *B. Boiler Working Principles*

Basically, the working principle of a boiler is that if water is heated at one atmosphere of pressure, the temperature will gradually rise to 100° C. But further heating will not raise the temperature any higher. The water will boil and all that is added is used to generate steam. So the resulting vapor pressure is 1 atmosphere and the temperature is 100°C. However, if water is heated to a pressure greater than 1 atmosphere, the temperature will rise to higher than 100°C and the water will boil at a temperature proportional to the pressure. After boiling, the temperature will not increase by further heating and all the heat is only used to form steam.

### *C. Steam Bootel Water Boiler*

Water is a useful and inexpensive medium for heat conduction to a process. The quality of the steam produced in a boiler system is influenced by proper water treatment.

According to Handoyo (2016:118), the best water used to fill steam boilers is distilled water and condensate water. Distilled water is water produced from an Evaporator (Fresh Water Generator), this type of water is best used for boiler water, but chemicals still need to be added to neutralize the properties of the water. Condensate water is water formed from used steam which is cooled in the condenser and becomes condensate water. This condensate water is also almost the same as distilled water which is considered the best for use as boiler water, because it is part of the process of the boiler water travel system itself (circular circulation).

### *D. Corrosion in Boiler*

1) Corrosion is caused by boiler water
   Corrosion will occur in parts where water is continuously evaporated if the smoke funnel is above the combustion chamber and shows a water pipe leading to the combustion chamber. When some corrosion occurs, immediately treat it with a chemical reaction. When the reaction occurs quickly, the corrosion does not take root. However, washing using a chemical reaction will slow down the occurrence of corrosion. Some of the causes of corrosion are negligence in blowing off, not cleaning the boiler properly, insufficient boiler water circulation and excessive use.
2) Corrosion caused by other substances
   Iron rusts or corrodes due to immersion in water or high temperatures and the use of materials that are easily corrosive. In this case, the oxygen contained in the water supply is very good for drilling or perforating, this happens in the steam room where there is a lack of water changes, the passage of water from the boiler drum and pipes, water pipes and economizer. Carbonic acid results from carbon dioxide when dissolved in water and reacts with iron to produce ferrous carbon. The iron carbon reacts with oxygen to produce a second iron oxide. Since this reaction process takes place in which carbon dioxide is liberated, thereby accelerating other corrosion cycles.
3) Corrosion by nature
   One part of the drilling or perforation, the expansion of the corrosion area is caused by the separation of acids in the boiler water and the separation of large/fat acids from woven animals or plants in the boiler water.

d) Corrosion by salt
   Magnesium chloride corrosion in boilers occurs until it takes root. This occurrence is due to the separation of hydrochloric acid resulting in boiler water and this does not stop in the hole but stops in the form of fish scale rust expanding, which often occurs in parts due to strong heat where air bubbles are difficult to release.

e) Corrosion by excessive hot steam.
   Steam is separated in hydrogen and oxygen when the temperature of the steel surface rises to 400 degrees centrigrade or higher. Oxygen is a corrosive of steel cross-sections

The raw water used must be kept as clean as possible from factors that accelerate damage or contamination of the steam boiler. Apart from that, several types of impurities and severe corrosion on steam boiler components can also be dangerous considering that steam boilers operate at high pressure and temperature. In practice, the main difficulty in the steam generation process lies precisely in the preparation of the raw material, namely the water to be evaporated. This is mainly because the steam boiler and steam pipes must be tight and withstand pressure during the production process. Rusnoto (2006) discusses that boiler damage is mostly caused by corrosion and scale deposits from the water filling the boiler. So boiler operators must be really careful and diligent in maintaining the boiler.

Handoyo (2016:120) explains that boiler water must meet the requirements, namely: free from impurities, free from gases that trigger corrosiveness, free from

violence, free from salt levels, free from acidity and must be alkaline (basic).

Handoyo (2016:120) explains that boiler water must meet the requirements, namely: free from impurities, free from O2 and CO2 gases which trigger corrosiveness, free from violence, free from salt content, free from acidity and must be alkaline (alkaline) with a pH ranging from 9.5 – 11.

## *III. RESEARCH METHODOLOGY*

This research method is used using a case research design to analyze existing problems. A case research design is carried out if the question "How" becomes the main research problem with the necessity of making a descriptive or analysis that is limited to a particular case to answer the problem so that it can become a question contained in the author's problem formulation by observing the production and maintenance process of the boiler on the ship. The types of data obtained were Primary and Secondary using data collection techniques from Interview, Observation and Literature Study. Then the discussion technique in this research is a descriptive discussion, namely a technique for creating a systematic, factual and accurate picture or description of an object being studied. This research was conducted on the Km Kelud passenger ship in the period January – March 2024.

## *IV. RESULT AND DISCUSSION*

### *A. Occurrence of Corrosion in Steam Boilers*

Corrosion is the destruction of the boiler walls from the wall surface inwards. Corrosion on ship steam boilers can be divided into:

- Internal wall corrosion (part exposed to water).
- Corrosion of the outer wall (the part affected by the fire).

On this occasion we will only describe internal wall corrosion caused by steam boiler water containing dirt.

Internal wall corrosion can take the form of:

a.. Hole (*Pitting*).
Pitting is a form of corrosion in the form of holes ± holes, mainly caused by boiler water whose pH is between 6 and 9 and contains dissolved oxygen. This event is actually an electrochemical process. Metal surfaces when in contact with the atmosphere, tend to change to their natural state. When oxygen dissolves in water, red iron oxide is formed on the surface and this oxide will continue to form so that all the iron becomes rusty. If dissolved oxygen levels are limited, oxide will not occur but the iron surface will become dull. This dull color is actually the formation of a thin layer of iron oxide on the surface of the metal which is not fully oxidized as occurs with red iron oxide. At a certain alkalinity, this thin layer becomes more stable and can provide better protection for the iron.

b. Thinning (General Wasting).
This form of corrosion occurs when boiler water is contaminated with sea water which tends to become slightly acidic. This may be due to the decomposition of the magnesium chloride salt at high temperatures. $MgCl2 + 2H2O \pm Mg(OH)2 + 2HCl$

c. Other forms of corrosion such as corrosion due to metal fatigue, corrosion due to excess caustic soda and others are not directly a result of the condition of the boiler water.

Corrosion or rust problems in boilers often occur which results in damage to the boiler pipes. Corrosion problems in pipes cause negative impacts in the form of:

a. The thickness of the pipe decreases and the pipe becomes more brittle
b. Blockage and buildup of corrosion deposits
c. Broken pipe.

Corrosion in steam boilers usually occurs on the water side and can also occur on the fire side. The impacts caused by leaking fire pipes in steam boilers are as follows

a. The steam pressure produced by the steam boiler is not achieved. The normal steam pressure of 6.0 kg/cm2 drops to 4.0 kg/cm2 when a fire pipe leak occurs.
b. The shipping time is longer for anchoring due to stopping the ship's engine during repairs and maintenance of steam boiler fire pipe leaks.
c. Requires additional costs to maintain leaks in pipes that are no longer suitable.

### *B. Boiler Water Treatment (BWT)*

BWT is a single chemical substance or mixture that is added to the boiler water that is already in a ship's steam boiler, one of the functions of which is to prevent corrosion on the boiler walls..

By adding BWT to the boiler water, it is hoped that the boiler will last longer because corrosion of the boiler walls is inhibited and fuel consumption is not wasteful. because there is no scale on the kettle walls. Boiler water used on ships can come from:

a. Evaporated seawater (distilled on board)
b. Fresh water taken on board

From the results of the analysis above, it is clear that if seawater enters the boiler, corrosion will immediately occur, especially if there is dissolved oxygen gas. When using distilled boiler water, it is impossible to get pure water in the sense that it is free of minerals, therefore it is necessary to have additional substances to prevent corrosion, in this case the additional substance used to prevent corrosion in ship steam boilers is Boiler Water Treatment (BWT).

The main function of BWT is to prevent corrosion, namely being able to reduce dissolved oxygen levels to a minimum. BWT component substances include oxygen repellent substances. Oxygen repellent substances include sodium sulfite (Na2SO3) and hydrazine (N2H4). The amount of oxygen dissolved in boiler water has a significant influence on the corrosion process, especially at pressures above 300 lb/Sq.

The chemical that can be used in steam boiler water treatment to prevent corrosion is Sulfite. Function: To

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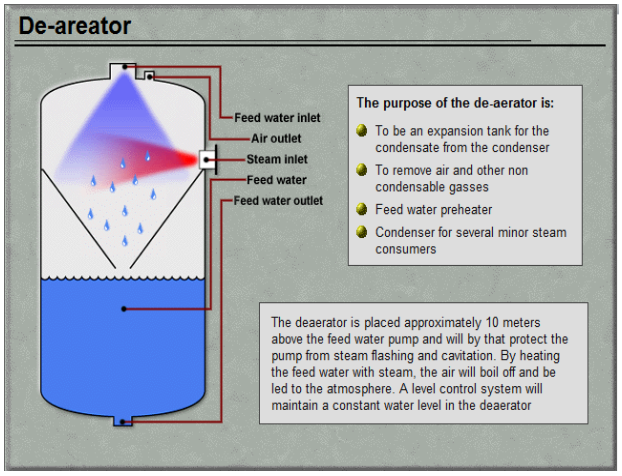
remove dissolved oxygen from boiler feed water. Working Principle: Sodium Sulfite reacts directly with O2 17. Reaction: 2 Na2SO3 + O2 2 Na2SO2.

Removing dissolved oxygen in feed water will reduce the possibility of corrosion in the boiler. Gases that can be dissolved in boiler water include oxygen O2, carbon dioxide CO2 – Nitrogen N2 – NH3 etc. Dissolved oxygen gas will cause corrosion on all ship equipment that is flooded with water. Oxidation of iron in the water medium will cause iron solubility. This reaction can also occur in a kettle. Carbon dioxide/CO2 then corrosion will occur as a result of carbonic acid wear (acid corrosion), in this case there will be holes like scratches along the pipe, but if the corrosion process other than carbon dioxide is also accompanied by the presence of dissolved oxygen or dissolved oxygen, then the corrosion will be more severe, this severity can occur throughout the pipe, which will not only be scratches but circular and elongated throughout the pipe, even worse if the results of carbonate corrosion enter the boiler through reverse condesate, then this will occur. iron rust which can cause rust deposits. Dissolved carbon dioxide can be blocked by providing a type of neutralizing amine which can bind a certain amount of carbon dioxide.

Removing gases is very important, namely removing the gases thermally in the preheating machine, where both O2 and CO2 can be released before the filling water enters the boiler.

There is a possibility that O2 will still be carried into the boiler, so to prevent this, chemical methods must be used, and for this you can use:

a. Natrium sulfit – $Na_2SO_3$
   This is a common ingredient used in the past 2Na2SO3 + O2 – 2Na2SO4. This method causes the concentration of Na2SO4 salt in the boiler water to increase, O2 goes with the steam to the turbine and condenser, while Na2 SO3 is only in the boiler, so outside the boiler there is still a danger of corrosion by O2.
b. Hydrazine – $N_2H_4$
   This material is widely used today N2H4 + O2◊ N2↑ + 2H2O + NH3↑. The weak substance N2 is neutral. This is a sketch of a Deaerator where the tool functions as an initial heater which can remove temporary hardness of Crbonate / CaCO3 and as an initial heater. This deaerator gets heat from the steam used by the auxiliary aircraft




This is a device whose function is to heat the water filling the boiler as well as to remove the gases contained in the water condensate. The deaerator heats the water by mixing the water with used steam so that the hot fresh water will rise and emit gases from the air exhaust pipe / water outlet.

The boiler water is maintained so that it remains alkaline with a pH value between 9.6 – 11. The pH value of the water is neutral at position 7 but the pH of the water is increased to 9.6. To increase it to 9.6, chemicals must be added according to the rules of the boiler manual. If the pH value exceeds the specified one, the boiler must be blown down to the specified limit. A pH value that is too low causes acid corrosion, while a pH value that is too high causes alkaline corrosion. Chemicals to maintain alkalinity can be phosphates, including: Tri Natrium Phosphate - Na3PO4 or Hexa Metaphosphate - (NaPO3)6 or Sodium Carbonate Na2CO3 and NaOH.

From the description above, to operate so as not to cause things that could cause damage to the kettle, it is best to use evaporator water or distilled water to fill the kettle. Boiler water must be maintained so that the contents that cause corrosion are removed, the chloride salt content is kept as low as possible, does not contain gases that cause corrosion - the SiO2 content is as low as possible and the boiler water is kept alkaline.

## *V.* CONCLUSION

- One of the pipe leaks in steam boilers is caused by corrosion on the boiler walls which is caused by inadequate boiler water quality.
- The presence of dissolved oxygen gas causes corrosion in the boiler.
- Boiler Water Treatment is able to maintain the quality of boiler water by reducing dissolved oxygen and reducing gases that cause corrosion and maintaining the alkalinity of boiler water so that it can prevent corrosion in boiler pipes.
- The oxygen-repellent substances in BWT are sodium sulfite (Na2SO3) and hydrazine (N2H4).

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