RSF Conference Proceeding Series: Engineering and Technology, Vol. 3 No. 1 (2023) https://doi.org/10.31098/cset.v3i1.731

Research Paper

Analysis of the Occurrence of Combustion Failure in the Steam Boiler at KM. Nggapulu

Amad Narto[1], Andi Prasetiawan[1], Mochamad Syaefudin[1]*
[1] Politeknik Ilmu Pelayaran Semarang, Indonesia

Received : August 22, 2023	Revised : September 10, 2023	Accepted : September 15, 2023	Online : October 5, 2023

Abstract

The availability of steam is crucial for the smooth operation of devices requiring hot steam. The operational activities of a ship can be hindered if the production of hot steam is insufficient due to problems arising from inadequate maintenance or other reasons, leading to the failure of combustion in the steam boiler. This research aims to identify the factors influencing the failure of combustion in the steam boiler on KM Nggapulu, to understand the consequences of the combustion failure in the steam boiler on KM Nggapulu, and to ascertain the measures taken in the event of combustion failure in the steam boiler on KM Nggapulu. The research method employed in this thesis is qualitative. The data sources include primary and secondary data. Data collection techniques encompass observation, interviews, and documentation, ensuring the validity of the data. Based on the research conducted, the following conclusions can be drawn: The causes of combustion failure include irregular implementation of the Planned Maintenance System (PMS), contamination of main burner components (automizer, electrode, solenoid valve), clogged exhaust gas pipes due to soot, excessive air composition in the furnace due to exhaust gas pipe blockage, poor fuel quality, and irregular cleaning practices. The impacts of boiler combustion failure involve operational difficulties for systems dependent on hot steam, inadequate hot steam supply for passenger or crew accommodation, and viscosity issues in MFO (Marine Fuel Oil) due to inadequate hot steam. Remedial actions that can be taken include checking and maintaining the automizer, inspecting and maintaining the main burner (electrode and nozzle), cleaning the fuel heater, replacing the solenoid valve, reducing fuel viscosity, and cleaning the steam boiler exhaust gas duct.

Keywords *Analysis, Disturbance, Combustion, Boiler*

INTRODUCTION

In the current era of development, maritime transportation is of significant importance, with cruise ships being one example. These vessels are used to transport passengers across seas and rivers to reach their destinations. Apart from passenger transportation, cruise ships can also carry various goods from one region to another. As a result, shipping companies and sailors strive to develop their maritime operations to compete in the modern age. The engine that propels a ship is commonly referred to as the "main engine," which derives its power from a combustion system. This power is generated from a mixture of fuel and air within the combustion chamber. To meet the needs and desires of passengers and consumers in maritime transportation, shipping companies and sailors continuously prepare their ships to be in good condition and ready for operation whenever required. Several aspects need to be considered and implemented to ensure the smooth operation of activities on board ships. These include proper, routine, and periodic maintenance of the main engine, which serves as the primary propulsion system, as well as auxiliary equipment that supports the main engine's performance. This maintenance ensures maritime operations operate smoothly, normally, and without disruptions. If auxiliary equipment on a ship, such as boilers, experiences malfunctions that prevent the ship from operating as usual, it can result in losses for both the shipping company and the ship's passengers. Auxiliary equipment, like boilers, supports the performance of the main engine. One of these auxiliary

Corresponding author's email: mochamadsyaefudin75@gmail.com

systems is the steam boiler, which plays a vital role in producing hot steam used for various purposes, such as heating fuel, stabilizing temperatures in cold areas, heating cargo in tanker ships, accommodating passengers, and more. In today's era, most ships are equipped with auxiliary boilers. An auxiliary boiler is a closed vessel that can produce steam with a pressure greater than one atmosphere. The steam produced is typically generated by heating fresh water. This heating process can occur either inside pipes (water tube type) or outside pipes (fire tube type), depending on the specific type of boiler. The resulting hot steam from the boiler is used to fulfil heating requirements, warm lubricating oil, heat water for accommodations, and heat fuel. Hot steam is crucial for supporting the performance of auxiliary systems that require it. Operational activities on a ship can be disrupted if the demand for hot steam is not met due to irregular maintenance or other causes.

Consequently, the combustion process in the steam boiler might not proceed as smoothly as expected, leading to a decrease in the generated steam pressure. Given the importance of maintaining adequate pressure steam, the boiler needs to operate normally and without complications. Thus, understanding and skills related to boilers, particularly knowledge of components prone to fouling, damage, or leakage, are essential to ensure an uninterrupted combustion process. To keep the boiler in good condition, periodic maintenance, according to the manufacturer's manual, is crucial. Based on the aforementioned background, the following problem statements can be formulated:

1. What are the factors causing combustion failure in the steam boiler on KM Nggapulu?
2. What are the impacts resulting from combustion failure in the steam boiler?
3. What efforts are undertaken to address these issues?

LITERATURE REVIEW

Theoretical Description

Numerous researchers have examined the combustion failure in steam boilers or auxiliary boilers. However, each ship may have distinct engine conditions regarding this problem formulation. This includes causes of combustion failure and factors influencing such failure. Additionally, this discussion focuses on a less-explored issue—clogged exhaust gas ducts in steam boilers. In this context, the author delves deeper into the reasons behind burner ignition failure in steam boilers or auxiliary boilers, encompassing not only material factors such as low fuel temperature, dirty automizers, improper electrode spacing, fouled heaters, and poor fuel quality.

a. Steam Boiler or Auxiliary Boiler

1. Definition of Steam Boiler or Boiler

   To facilitate operation, a more detailed explanation of boiler parts and materials is required. Before delving into boiler specifics, it's necessary to understand the scientific theory behind steam boilers. This theory is then developed into a functional system to optimize high-pressure steam production, serving the operational needs of auxiliary equipment aboard the ship, accommodating passengers, and other functions. Boilers are structurally divided into two types: a) Fire Tube Boilers and b) Water Tube Steam Boilers

2. Functions of Steam Boiler

   A steam boiler's primary function is to produce hot steam or steam used for various purposes onboard. Some functions of the generated steam are: a) Heating fuel in tanks, b) Heating heaters within the engine room, and c) Heating seawater in freshwater generators to produce fresh water.

3. Steam Boiler Requirements

   Steam boilers have specific requirements, including: a) The ability to produce steam with

a pressure exceeding 1 atmosphere (atm) within a specific time, with minimal water content in the steam. b) The boiler must have a secondary heating system to ensure consistent steam temperature during changing load conditions. This is crucial when the ship is maneuvering, as steam pressure needs to remain constant. c) Balanced usage and production of steam to meet demand.

4. Boiler Appendices

Appendices are vital components of boilers that impact their operation. Proper maintenance is crucial to ensure smooth operation. Boiler appendices include components related to both steam and water chambers.

Research Framework

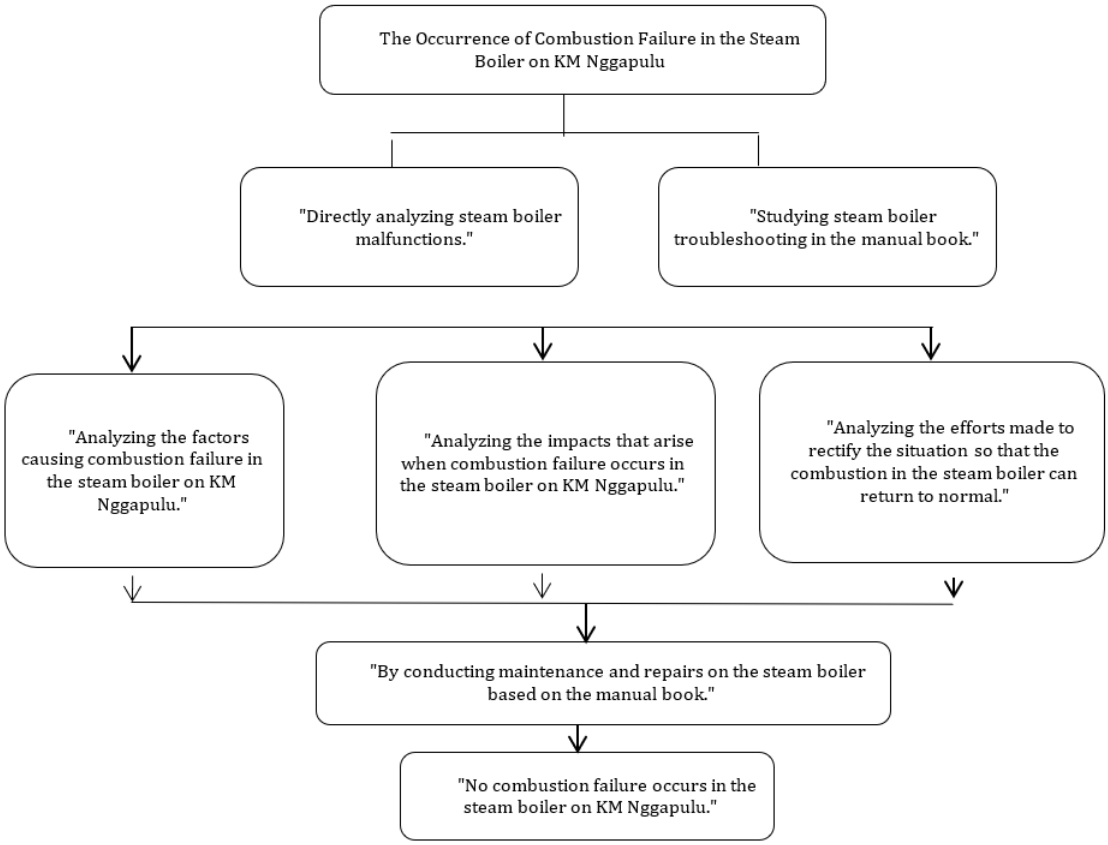

Figure 1. Research Framework

Source: Private document, 2023

RESEARCH METHOD

Research Site

a. Research Period

The research was conducted during the researcher's sea practice on the vessel KM. Nggapulu. The researcher engaged in sea practice on the ship for over a year. This research was carried out during the researcher's sea practice on the ship from June 8, 2021, to August 9, 2022. The research involved applying the materials and theories acquired from the academic instructors at the university to real-life situations on the ship, aiming to directly correlate and align practical experiences with theoretical knowledge. The activities performed on the ship

encompass not only addressing the challenges that arise during the completion of this thesis but also participating in the duties of an engine cadet who must take responsibility for superiors in the engine room (KKM), as well as assisting the operation and supervision of the engineers on board under the direct guidance of the first engineer as the head of the engine room. The cadet also has obligations to fulfil for the purpose of resuming studies at the university after the sea practice, with all tasks recorded in the cadet record book.

b. Research Site

The researcher conducted the study on board the ship during the sea practice. The following are the ship's data and company information during the researcher's sea practice:

Name of Vessel: KM. Nggapulu
Call Sign: YGRG
IMO Number: 9226499
Type Of Ship: Passenger Ship
Owner: PT. PELNI
Gross Tonnage: 14,739
DWT: 3,175 MT
Net Tonnage: 4,644 NT

The researcher observed objects, gathered materials, and collected data sources as the foundation for composing the thesis while on board the KM. Nggapulu.

Research Data Sources Sample

a. Primary Data Source

Primary data serves as a direct source of data for data collection, as stated by Sugiyono (2018: 456). The researcher gathers information directly from primary sources or the area where the investigation is conducted. During the researcher's practice on board the KM. Nggapulu ship, both primary and secondary data were obtained. The issue addressed in this thesis pertains to steam boilers, and primary data was acquired. A steam boiler is a closed vessel under pressure, where water is transformed into steam through the application of heat.

b. Secondary Data

Secondary data refers to data sources that do not directly provide data to the data collector, such as through other individuals or documents, as defined by Sugiyono (2018: 456).

Method Collecting Data

To obtain data, the way to collect data that the author uses is:

a. Observation Method

Tersiana (2018: 12) explains observation as the process of generally watching and monitoring behaviour in specific situations. Observers are individuals who conduct observations. The observation data collection method, also referred to as the observation method in general, is a way to gather research data by recording data using the problem formulation to be studied. In this case, the researcher will conduct direct observation regarding the occurrence of combustion failure in the steam boiler on KM. Nggapulu, in line with the title chosen for this thesis, during the researcher's sea practice from August 8, 2021, to August 9, 2022.

b. Interview Method

The interview is a communication interaction between two individuals, involving one person asking specific questions to obtain information from another party for a specific purpose, as Sugiyono (2009: 231). Interviews can be used as a technique for collecting research

data. They can be conducted when the researcher wants to conduct preliminary studies on the problem under investigation. Interviews can also be carried out to provide evidence to explore problem discussions.

c. Literature Review

The literature review is a data collection technique that examines books, literature, notes, and various reports related to the problem to be solved. The researcher searched for several book sources to support the issue of combustion failure in the steam boiler on KM. Nggapulu. In the compilation of this thesis, the researcher needs references from library books, internet sources, as well as a combination of theories obtained from library books, ship guidelines, and the author's experience in maritime training on ships. Everything needed by the researcher in creating the thesis is found through solutions based on the research conducted to address the issues discussed in the study.

Data Analysis Technique

Meanwhile, according to Neolakan (2014:173), data analysis involves processing data statistically and non-statistically to obtain research results. Based on the research findings, discussions are conducted based on the conclusions drawn from the research results. In composing this thesis and conducting this study, the author employs the data analysis method known as SHEL (Software, Hardware, Environment, Liveware).

FINDINGS AND DISCUSSION

Problem Analysis

The analysis in the thesis writing regarding the occurrence of combustion failure in the steam boiler on KM. Nggapulu is based on the data analysis method in Chapter 3. The author employs a data collection technique called SHEL to assist in determining and analyzing the elements that cause combustion failure in the steam boiler. Based on observations, interviews, and literature reviews conducted during the sea practice, the author's approach to a problem will be discussed, and the analysis of this issue will be linked to the problem formulation that the author will elaborate on.

Problem Discussion

a. What are the factors causing combustion failure in the steam boiler on KM. Nggapulu?

Below is the SHEL method table that has been obtained based on the issues identified during the researcher's sea practice on the ship, along with its explanation:

Table 1. Research Findings

SHEL	Factor
Software	• The Planned Maintenance System (PMS) is not conducted periodically.
Hardware	• Some components of the main burner are dirty • Exhaust gas discharge is blocked due to soot.
Environment	• The air composition in the furnace is too high due to blockage in the exhaust gas pipe. • Poor fuel quality.
Liveware	• The implementation of steam boiler component cleaning is not carried out regularly.

Source: Private Document (2023)

1. Software

The Planned Maintenance System (PMS) software is a continuous or scheduled maintenance system for ships' equipment and accessories to ensure the ship's seaworthiness and operational readiness. The ISM Code in SOLAS Chapter IX is designated in Element 1.4 of the Functional Requirement for Safety Management System, and ISM Code Chapter 5 Section 10 discusses the maintenance of ships and equipment.

During a sea practice session, the researcher encountered an issue involving a steam boiler that refused to ignite. Eventually, Engineer 3 inspected the fuel system and checked the main burner. Further inspection was carried out on the exhaust gas pipe through the dexcel located above the boiler. The problem's root cause was the fouling of steam boiler components and a blockage in the exhaust gas pipe due to soot accumulation.

2. Environment

In complete combustion, the reactants burn with the appropriate amount of oxygen to produce several products. When hydrocarbons combust with oxygen, the primary reaction yields carbon dioxide and water. Incomplete combustion occurs when there is either a lack of oxygen or an excess of oxygen, resulting in incomplete fuel conversion to carbon dioxide and water. Due to blockages in the exhaust gas pipe from combustion, the combustion air gases cannot be expelled. This causes an excess of air within the steam boiler. As a consequence, the components of the fire triangle are not properly balanced due to the excessive air content, preventing the combustion process from occurring as the air conditions within the steam boiler are disproportionate or excessive.

3. Liveware

While conducting maritime practice and encountering an issue of combustion failure in the steam boiler on the vessel KM Nggapulu, it was discovered that the root cause of this combustion failure was the blockage of the exhaust gas pipe resulting from soot accumulation.

b. The impacts resulting from steam boiler combustion failure are as follows:

1. Difficulty in Operating Auxiliary Machinery

Operating the main engine or other auxiliary machinery requires steam from the boiler. If the steam boiler experiences issues, it becomes challenging to meet the steam demand on the ship. This can hinder the smooth operation of auxiliary machinery.

2. Interruption in Steam Production:

Based on observations and examinations of incidents experienced during maritime practice on a passenger ship, when the combustion in the steam boiler fails to ignite, steam production halts. Consequently, the need for hot steam for passengers and other auxiliary equipment goes unmet. If the vessel uses a type of fuel oil known as MFO, this fuel cannot be used for the initial operation of the main engine, which also affects other auxiliary machinery requiring hot steam to function. Additionally, losses can be incurred when switching from MFO to MDO during operations like deck crane usage due to the lack of available hot steam required for the process.

c. Efforts taken to address the issue are as follows:

1. Checking and Maintenance of the Atomizer

During maritime practice on the vessel KM. Nggapulu, the researcher discovered a clogged atomizer due to carbon deposits, which were residues of combustion adhering to the atomizer. It is essential to keep the atomizer clean because any blockages on the atomizer can prevent optimal fuel atomization or spraying. If the fuel is not properly atomized, the fuel injection process will not function effectively, leading to disruptions in the combustion process.

2. Checking and Maintenance of the Main Burner (Electrode and Nozzle)

The electrode or burner igniter is crucial for igniting the fuel in the steam boiler. If any issues arise, immediate repairs are necessary. To address such problems, the approach involves detaching the burner from the steam boiler and then adjusting the electrode according to the Instruction Manual Book.

The steps outlined appear to describe the correct procedure for measuring electrode spacing. Here is a refined version:

a. Close all fuel valves leading to the burner.
b. Ensure that all panels are turned off, open, and safe.
c. Disconnect the burner from the main burner hole.
d. Remove the electrode and proceed with the measurement. Additionally, clean the fuel heater.

3. Replacing the Solenoid

The solenoid valve is a crucial component in the steam boiler combustion process, serving as an electrically operated valve that utilizes magnetic coil principles to control the fuel flow to the main burner.

a. Lowering the fuel viscosity
b. Cleaning the steam boiler exhaust gas channel

CONCLUSIONS

Conclusion

a. Factors leading to combustion failure in the steam boiler on the KM Nggapulu are irregular implementation of the Planned Maintenance System (PMS), fouling of main burner components (atomizer, electrode, solenoid valve), clogging of the exhaust gas pipe due to soot, excessive air composition in the furnace due to blockages in the exhaust gas pipe, poor fuel quality, and irregular cleaning practices.
b. The impacts of steam boiler combustion failure include difficulty operating equipment that relies on hot steam, unmet demand for hot steam for passenger accommodations or ship crew, and, when using MFO-type fuel, an inability to lower fuel viscosity due to insufficient hot steam.
c. In the event of initial combustion failure in the steam boiler, the efforts taken include checking and maintaining the atomizer, inspecting and maintaining the main burner (electrode and nozzle), cleaning the fuel heater, replacing the solenoid valve, lowering fuel viscosity, and cleaning the steam boiler exhaust gas channel. These measures are crucial to address the issues causing combustion failure and to ensure the boiler's proper operation.

Suggestion

a. Implementing a well-structured plan for periodic repair and maintenance through the Plain Maintenance System (PMS) is advisable. This ensures that maintenance activities are carried out systematically and regularly to prevent issues and maintain optimal performance.
b. Maintain fuel viscosity at a low level by carefully regulating the fuel temperature to ensure stability, following the guidelines provided in the Instruction Manual Book. This helps prevent fuel-related combustion problems and ensures smooth operation.
c. Regularly and systematically maintain the main burner in accordance with the Instruction Manual Book. Conduct routine inspections, cleanings, and replace components as necessary to ensure the main burner functions optimally and avoids potential combustion

failure issues.

REFERENCES

Aalborg Industries Co, Ltd. (2018). *Pedoman Penyusunan Skripsi*. PIP Semarang.

Alfabeta. (2011). *Instruction Manual Book Auxiliary Boiler & Exhaust Gas Economizer.* Alfabeta.

Galih. (2012). *Metode Fault Tree Analysis.* Retrieved March 19, 2018 from http://galihekapriminta.blogspot.com/2012/05/metode-fault- tree-analysis.html.

Moleong, L. J. (2010). *Metode Penelitian Kualitatif.* Bandung: PT. Remaja Rosdakarya.

Narto, A., Suwondo, M. M., & Nasri, M. T. (2018). *Mesin Penggerak Utama Motor Diesel dan Turbin Gas.* PIP Semarang.

Prasetyo, D. (2017). *Sistem perawatan dan perbaikan permesinan kapal* (Edisi 2). Politeknik Ilmu Pelayaran Semarang.

Prasetyo, D. (2017). *Sistem Perawatan Dan Perbaikan Permesinan Kapal* (Edisi 1). Politeknik Ilmu Pelayaran Semarang.

Pratikto. (2008). *Ketel Uap Pipa Air Bi Drum*. Malang: CV. Asrori.

Soenoko, R. & Gunadiarta, I. M. (2009). *Bahasan Termal Bahan-Bahan Dan Ketel-Uap Jilid I, II.* Malang: CV. Citra.

Sugiyono. (2009). *Metode Penelitian Bisnis (Pendekatan Kuantitatif, Kualitatif dan R&D).* Bandung: Alfabeta.

Sugiyono. (2009). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D.* Bandung: Alfabeta.

Taufiq, R. (2016). *Pemeliharaan dan Rekayasa Keandalan.* Retrieved March 18, 2018 at https://taufiqurrachman.weblog.esaunggul.ac.id/