Corrosion Rate Analysis of An Excavator Bucket (A Case Study at the Heavy Equipment Workshop Unit of the Public Works and Spatial Planning Agency (PUPR) of Bengkalis Regency)

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Abstract.
Corrosion is a common issue affecting heavy equipment components, particularly excavator buckets that operate in open environments and frequently come into direct contact with water, mud, soil, and abrasive materials. Continuous corrosion can lead to reduced material thickness, mass loss, and diminished mechanical strength, ultimately shortening the excavator bucket's service life. This study aims to determine the corrosion rate of excavator buckets at the Heavy Equipment Workshop Unit (UPT) of the Bengkalis Regency Public Works and Spatial Planning Agency (Dinas PUPR). The study employed a quantitative method using the weight-loss approach. Data were obtained through direct measurement of excavator bucket dimensions, measurement of initial and actual thicknesses, and calculations of volume, material density, mass loss, and exposure time during the service period. The collected data were then analyzed using the corrosion rate formula to quantify the extent of corrosion on the excavator buckets. The results indicate that the excavator bucket has a surface area of 14,712 cm², a volume of 99,360 cm³, and a material density of 8.05 g/cm³. The reduction in bucket thickness from 50 mm to 41 mm represents a loss of 9 mm (or 0.9 cm). Calculations revealed a material volume loss of 13,240.8 cm³ and a mass loss of 106,588.44 grams. The total exposure time for the excavator bucket during its service period was 6,300 hours. Analysis using the weight-loss method yielded a corrosion rate of 12.50 mm/year. In conclusion, the excavator buckets at the Bengkalis Regency PUPR Agency's Heavy Equipment Workshop are experiencing a relatively high rate of corrosion. This condition is driven by the bucket's operating environment, which involves frequent exposure to water, mud, and high humidity, as well as material friction during operations. Therefore, routine maintenance, periodic thickness inspections, and the application of anti-corrosion coatings are necessary to slow the corrosion rate and extend the service life of the excavator buckets.

Keywords: *corrosion, excavator bucket, corrosion rate, weight loss and heavy equipment.*

I. INTRODUCTION

The Heavy Equipment Workshop Unit of the Public Works and Spatial Planning Agency (PUPR) of Bengkalis Regency is responsible for the maintenance, servicing, and repair of heavy equipment used to support infrastructure development and maintenance activities within Bengkalis Regency. The workshop handles various types of heavy equipment, including excavator buckets used in operations in aquatic areas and flood-prone regions.

Based on preliminary observations conducted at the workshop, the excavator bucket exhibited significant signs of corrosion. The observed corrosion included surface rust, deterioration of the protective coating, and material thinning in several parts of the bucket. These conditions are believed to result from intensive equipment usage, aggressive working environments, and inadequate post-operation corrosion prevention practices.

If corrosion problems affecting the excavator bucket are not systematically analysed and addressed, they may lead to an increased frequency of repairs, higher maintenance costs, and a reduced service life of the component. Furthermore, delays in repairing heavy equipment due to bucket damage may hinder infrastructure development projects and public service activities.

Therefore, a comprehensive analysis of corrosion on the excavator bucket is required, including the identification of the type of corrosion, the factors contributing to its occurrence, and its effects on the performance and service life of the component. The findings of this analysis are expected to provide a basis for determining more effective corrosion prevention and mitigation strategies through improvements in material selection, maintenance methods, and protective coating applications.

Based on the above background, this research is entitled **"Analysis of the Corrosion Rate of an Excavator Bucket (A Case Study at the Heavy Equipment Workshop Unit of the Public Works and Spatial Planning Agency (PUPR) of Bengkalis Regency)"**. This study aims to provide a comprehensive understanding of corrosion problems and to identify appropriate solutions to support the sustainable operation of heavy equipment.

Research Problems

Based on the background described above, the research problems in this study entitled "Analysis of the Corrosion Rate of an Excavator Bucket (A Case Study at the Heavy Equipment Workshop Unit of the Public Works and Spatial Planning Agency (PUPR) of Bengkalis Regency)" are formulated as follows:

1. What type of corrosion and corrosion rate occur on the excavator bucket at the Heavy Equipment Workshop Unit of the Public Works and Spatial Planning Agency (PUPR) of Bengkalis Regency?
2. What factors contribute to the corrosion rate of the excavator bucket, and how do they affect the operational performance and service life of the bucket?

Research Objectives

Based on the research problems stated above, the objectives of this study entitled "Analysis of the Corrosion Rate of an Excavator Bucket (A Case Study at the Heavy Equipment Workshop Unit of the Public Works and Spatial Planning Agency (PUPR) of Bengkalis Regency)" are as follows:

1. To identify the type of corrosion and determine the corrosion rate occurring on the excavator bucket at the Heavy Equipment Workshop Unit of the Public Works and Spatial Planning Agency (PUPR) of Bengkalis Regency.
2. To identify the factors that contribute to the corrosion rate of the excavator bucket and to analyse their effects on the operational performance and service life of the bucket at the Heavy Equipment Workshop Unit of the Public Works and Spatial Planning Agency (PUPR) of Bengkalis Regency.

II. LITERATURE REVIEW

Previous studies indicate that corrosion in excavator buckets is a significant issue that can reduce material strength, operational efficiency, and the service life of heavy equipment. Various studies employing methods such as Scanning Electron Microscopy (SEM)**,** Energy Dispersive X-ray Spectroscopy (EDX), spectral analysis, and wavelet analysis have demonstrated that corrosion causes changes in both the microstructure and chemical composition of metallic materials. In addition, research on hardfacing, protective coatings, and material selection has shown that the use of more corrosion-resistant materials and appropriate surface treatments can effectively reduce the degradation rate of bucket components operating in aggressive environments.

From a theoretical perspective, corrosion is an electrochemical process involving oxidation and reduction reactions on metal surfaces, which are accelerated by humid environments, water, mud, and electrolyte substances. Corrosion may occur in several forms, including uniform corrosion**,** pitting corrosion**,** crevice corrosion**,** and galvanic corrosion. The corrosion rate is influenced by several factors, such as the type of material, working environment, temperature, humidity, exposure time, and maintenance quality. Excavator buckets are generally manufactured from carbon steel or alloy steel, each of which has different levels of corrosion resistance. Therefore, material selection plays a crucial role in improving the durability and service life of bucket components.

The conceptual framework of this research is based on the relationship between the working environment, material characteristics, and the intensity of bucket usage and their influence on the corrosion rate. The analysis is conducted using the weight loss method to determine the extent of material degradation caused by corrosion. The findings of this study are expected to provide a scientific basis for establishing effective maintenance strategies, including routine cleaning, the application of anti-corrosion coatings, periodic inspections, and the use of more corrosion-resistant materials. These measures are expected to extend the service life of excavator buckets, reduce maintenance costs, and maintain the optimal operational performance of excavators.

III. RESEARCH METHODOLOGY

The research methodology plays an essential role as a structured and systematic guideline to ensure that the objectives of the study are achieved scientifically and that the results are reliable and accountable. In this study entitled "Analysis of the Corrosion Rate of an Excavator Bucket (A Case Study at the Heavy Equipment Workshop Unit of the Public Works and Spatial Planning Agency (PUPR) of Bengkalis Regency)", a quantitative experimental approach was employed, focusing on measurement, testing, and numerical analysis. The research was conducted at the Heavy Equipment Workshop Unit of the Public Works and Spatial Planning Agency (PUPR) of Bengkalis Regency because it serves as the official maintenance facility with actual operating conditions that are representative of the research object. The excavator bucket was selected as the primary object of study because it is continuously exposed to aggressive media such as soil, mud, sand, and water, making it highly susceptible to corrosion and mechanical wear.

The research was carried out through a series of systematic stages, beginning with problem identification, literature review, preparation of equipment and materials, and field data collection. Primary data were obtained by measuring the bucket material thickness using an Ultrasonic Thickness Gauge (UTG), recording environmental parameters such as temperature and pH, and conducting visual observations to identify the type of corrosion present. The collected field data were then analysed using the weight loss method to calculate the corrosion rate and determine the amount of material loss expressed in millimetres per year (mm/year). In addition, the study identified several factors influencing the corrosion rate, including equipment operating time, environmental humidity, and the material characteristics of the excavator bucket.

The results of this analysis are expected to provide a comprehensive understanding of the extent of material degradation caused by corrosion in the excavator bucket. The findings are intended to serve as a scientific basis for developing effective maintenance strategies, scheduling periodic inspections, and implementing appropriate preventive measures to extend the service life of the bucket component. Consequently, the operational efficiency of heavy equipment can be improved, maintenance and repair costs can be reduced, and the risk of unexpected equipment failure that may disrupt construction and infrastructure maintenance activities carried out by the Public Works and Spatial Planning Agency (PUPR) of Bengkalis Regency can be minimised.

IV. RESEARCH RESULTS AND DISCUSSION

This research was conducted on an excavator bucket at the Heavy Equipment Workshop Unit of the Public Works and Spatial Planning Agency (PUPR) of Bengkalis Regency. The excavator operates in muddy, waterlogged, and highly humid environments, exposing the bucket continuously to corrosive media that may cause corrosion and a reduction in material thickness. The research object was a carbon steel excavator bucket that had been in operation for approximately three years.

Data were collected through field observations, documentation, bucket dimension measurements, and thickness measurements using an Ultrasonic Thickness Gauge (UTG). Before the measurements were carried out, the bucket surface was thoroughly cleaned to ensure accurate readings. The collected data were subsequently used to calculate the surface area, volume, mass loss, and corrosion rate using the weight loss method.

The identification results showed that the excavator bucket was manufactured from carbon steel, which possesses high mechanical strength but is susceptible to corrosion when exposed to humid environments without adequate protection. During operation, the bucket comes into direct contact with soil, sand, mud, and water, resulting in a combination of corrosion and mechanical wear that gradually degrades the material throughout its service life.

Fig. 4.1 Initial Bucket Thickness Measurement

The thickness measurement results showed that the excavator bucket thickness decreased from 50 mm to 41 mm during the 2023–2026 period, resulting in a 9 mm reduction in thickness, equivalent to approximately 18% of the original thickness. This reduction occurred gradually each year, indicating that the material degradation progressed continuously due to prolonged exposure to the operating environment and abrasion caused by contact with excavated materials.

Fig. 4.2 Bucket Reduction Thickness Measurement Results

During the research period, follow-up thickness measurements showed that the bucket thickness decreased from 41 mm to 40 mm, indicating an additional 1 mm reduction in material thickness. Based on visual observations, the predominant type of corrosion identified was uniform corrosion, characterised by the formation of rust over nearly the entire surface of the bucket, resulting in gradual material thinning.

The calculated research parameters showed that the excavator bucket had a surface area of 14,712 cm^2, a volume of 99,360 cm^3, a material density of 8.05 g/cm^3, and a mass loss of approximately 106,588.44 g. Furthermore, the volume of material lost due to corrosion was calculated to be 13,240.8 cm^3, with a total operational exposure time of 6,300 hours.

Based on calculations using the weight loss method, the material thinning rate was determined to be 3 mm/year, while the corrosion rate was calculated at 12.50 mm/year. These results indicate that the excavator bucket experienced a relatively high rate of corrosion, requiring special attention to maintenance in order to prevent more severe damage and extend the service life of the component.

The discussion of the research findings revealed that corrosion was mainly influenced by several factors, including a humid working environment, direct exposure to water and mud, the use of carbon steel as the bucket material, prolonged operating time, and abrasive wear caused by continuous contact with soil, sand, and rocks. The combination of these factors accelerated the oxidation process and increased the reduction in the bucket's material thickness.

The corrosion observed in this study had a significant impact on the structural integrity of the excavator bucket by reducing its mechanical strength, increasing the risk of deformation and cracking, and raising maintenance costs due to the need for repairs or component replacement. These findings are consistent with corrosion theory and previous studies, which state that excavator buckets are among the heavy equipment components most susceptible to corrosion and wear when operating in aggressive environments.

Overall, the objectives of this research were successfully achieved, namely to identify the type of corrosion, determine the corrosion rate, and analyse the factors contributing to corrosion in the excavator bucket. Based on the summary of the experimental results, the bucket experienced significant mass loss and material thinning, with a corrosion rate of 12.50 mm/year. Therefore, periodic inspections using an Ultrasonic Thickness Gauge (UTG), routine cleaning after operation, the application of anti-corrosion

coatings, and preventive maintenance are strongly recommended to maintain the service life of the bucket and minimise the risk of operational failure.

V. CONCLUSION

Based on the results of this research, it can be concluded that the excavator bucket at the Heavy Equipment Workshop Unit of the Public Works and Spatial Planning Agency (PUPR) of Bengkalis Regency experienced corrosion, as indicated by the presence of rust and a reduction in material thickness caused by the combined effects of corrosion and mechanical wear during operation. The thickness measurements obtained using an Ultrasonic Thickness Gauge (UTG) and the calculations performed using the Weight Loss method demonstrated that the corrosion rate can be used to assess the level of material deterioration and to serve as a basis for determining the condition of the bucket and its maintenance requirements.

Corrosion of the excavator bucket was influenced by several factors, including a humid working environment, continuous exposure to water and mud, intensive equipment utilisation, and inadequate post-operation maintenance. The resulting effects include a reduction in the bucket's material thickness and structural strength, an increased risk of damage, higher maintenance costs, and a shorter service life of the component. Therefore, preventive measures such as periodic inspections, routine cleaning after operation, and preventive maintenance are essential to maintain the bucket's performance and operational reliability.

As part of corrosion control efforts, it is recommended that the bucket thickness be inspected regularly using an Ultrasonic Thickness Gauge (UTG), that the bucket be thoroughly cleaned after each operation, and that anti-corrosion coatings be applied periodically. Furthermore, buckets that have reached or exceeded the minimum allowable thickness should be repaired or replaced immediately to ensure the safety and reliability of heavy equipment. Future studies are also encouraged to expand this research by comparing different bucket materials, evaluating various anti-corrosion coating systems, and applying alternative corrosion testing methods in order to obtain more comprehensive results regarding corrosion prevention and control.

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