

The Effect of Implementing SI PETIR (An Innovative Boiler Lance Tube Straightening Solution) on Sootblower Maintenance Efficiency at the 660 MW Adipala Coal-Fired Power Plant in Central Java

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| ARTICLE INFO | ABSTRACT |
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| <p>Article history:</p> <p>Received 05.03.2026 Revised 25.03.2026 Accepted 29.03.2026</p> | <p>This study aims to analyze the impact of the implementation of the SI PETIR system on the efficiency of sootblower maintenance at the 660 MW Adipala Coal-Fired Power Plant in Central Java through improvements in time efficiency, reductions in maintenance costs, and enhancements in operational reliability. The methodology employed is a descriptive-comparative approach using a case study design. Data were obtained through field observations, documentation, and interviews with maintenance technicians, then analyzed by comparing conditions before and after the implementation of the SI PETIR system based on MTTR, maintenance costs, and operational reliability indicators. The research results show that SI PETIR was able to reduce MTTR from 7,200 minutes to 720 minutes, cut maintenance costs from Rp 95,070,000.00 to Rp 9,970,000.00, and improve operational reliability from 83.33% to 96.67%, thereby proving to be effective and economical in improving sootblower maintenance performance.</p> |
| <p>Keywords:</p> <p>SI PETIR, Maintenance, Sootblower, Efficiency</p> | |

1 Introduction

Coal-fired power plants remain one of the main sources of electricity supply in Indonesia; therefore, the reliability and operating efficiency of their supporting equipment must be maintained optimally. One of the primary components in a coal-fired power plant is the boiler, which produces steam through the coal combustion process. Boiler performance is strongly influenced by the effectiveness of heat transfer on the surface of boiler tubes. The accumulation of ash and soot deposits on tube surfaces can inhibit heat transfer because it forms an insulating layer that reduces boiler thermal efficiency [1]. Accordingly, periodic boiler cleaning is an important part of maintaining generating unit performance and operational efficiency [2].

One of the pieces of equipment used to remove ash deposits in boilers is the sootblower. This device uses high-pressure steam to clean ash and soot deposits from boiler tube surfaces so that heat transfer remains optimal. Sootblower performance plays an important role in combustion efficiency and overall boiler performance because cleaning effectiveness affects heat transfer quality during plant operation [3]. In a sootblower system, the lance tube is a main component that functions as the cleaning-steam channel and moves forward and backward into the boiler during the cleaning process [4].

A frequent problem in the lance tube is deformation or bending caused by high operating temperature, operating pressure, and friction during operation. This condition prevents the sootblower from operating normally and requires maintenance or component replacement. Lance tube replacement is challenging because the component is heavy, approximately 500-600 kg, and is installed at a certain elevation in the boiler area. Consequently, mobilization requires special tools, additional workers, and relatively long maintenance time. This condition increases sootblower downtime, reduces boiler maintenance efficiency, and raises maintenance operating costs [5].

An increase in the frequency of lance tube damage also affects the overall effectiveness of boiler operation. High sootblower downtime may cause ash-deposit cleaning to be suboptimal, decreasing combustion efficiency and increasing fuel consumption. Therefore, a more effective and innovative maintenance strategy is required to address lance tube deformation without always replacing the component with a new one [6].

Based on these operating conditions, SI PETIR was developed as a maintenance support tool for straightening lance tubes directly at the installation location. The implementation of SI PETIR enables faster repair without requiring a new component, thereby reducing sootblower downtime and improving cost efficiency. In addition, SI PETIR is expected to improve sootblower operational reliability and support the overall effectiveness of the boiler system.

Previous studies have discussed the importance of sootblower maintenance effectiveness for boiler efficiency [3], [6]. However, empirical studies specifically analyzing the effect of an innovative lance tube straightening device on sootblower maintenance efficiency in Indonesian coal-fired power plants are still limited. Therefore, this study analyzes the effect of SI PETIR implementation on sootblower maintenance efficiency at Power Plant in Central Java by comparing conditions before and after implementation based on maintenance time, maintenance cost, and operational reliability indicators.

2 Method

2.1 Research Design

This research used a descriptive-comparative method with a case study approach. The study compared conditions before and after SI PETIR implementation to determine its effect on sootblower maintenance efficiency.

2.2 Time and Place of Research

The research was conducted at PT PLN Indonesia Power Unit Bisnis Pembangkit (UBP) Adipala, Cilacap Regency, Central Java. The research period was from 1 July to 31 December 2025.

2.3 Population and Sample

The population in this study comprised all sootblower maintenance activities, particularly lance tube straightening work on boiler units at PT PLN Indonesia Power UBP Adipala. The population included repair time, number of workers, MTTR, downtime, and availability recorded in the maintenance system. The research sample consisted of sootblower maintenance activities involving lance tube straightening during the observation period.

2.4 Operational Definition of Variables

The independent variable was SI PETIR implementation, namely the application of a mechanical support tool in the sootblower lance tube straightening process. This implementation was compared with the previous conventional method to evaluate its ability to improve time effectiveness and reduce workforce requirements. The dependent variable was sootblower maintenance efficiency, measured through maintenance time, number of workers, MTTR, downtime, and availability.

2.5 Data, Instruments, and Data Collection Techniques

Data collection instruments included observation, documentation, and interviews. Direct observation was conducted on the sootblower system at Power Plant in Central Java to identify equipment conditions before and after SI PETIR implementation. Documentation was used to collect data on lance tube damage, repair time, and downtime from maintenance reports. Interviews with maintenance technicians were conducted to obtain information on work constraints, workforce needs, repair time, and occupational safety aspects during maintenance activities.

2.6 Data Analysis Technique

The data were analyzed using descriptive-comparative analysis based on field observations, with MTTR, downtime, and availability as main indicators. The data were reduced by grouping the conditions before and after SI PETIR implementation, then presented in comparative tables and narrative descriptions. The analysis compared time efficiency using MTTR, maintenance cost, and operational reliability through downtime and availability. The results were interpreted to determine changes in sootblower performance after SI PETIR implementation.

3 Result and discussion

This study aimed to analyze the effect of SI PETIR innovation on sootblower maintenance efficiency at the 660 MW Adipala Coal-Fired Power Plant in Central Java. Before SI PETIR implementation, repair of deformed lance tubes was carried out using the conventional method by replacing the pipe with a new component. This method required dismantling, lifting, reinstallation, and a relatively long working process, which resulted in high downtime and high maintenance cost. In addition, lance tube deformation disturbed the stability of the sootblower steam jet, making boiler deposit cleaning less optimal and increasing the potential for fouling.

After SI PETIR implementation, repairs were conducted directly on-site using a hydraulic mechanical system consisting of a hydraulic jack and supporting frame. This process enabled the lance tube to be straightened faster and more efficiently without replacing it with a new component. SI PETIR also improved occupational safety by reducing heavy component lifting activities and the need for a large workforce. Based on field observation and technician interviews, the implementation produced a significant change in sootblower maintenance efficiency, as shown in Table 1.

Table 1. Comparison of conditions before and after SI PETIR implementation

| Parameter | Conventional method | SI PETIR method |
|-----------------------|---------------------|------------------|
| Work duration | 5 days | 12 hours |
| Maintenance cost | IDR 95,070,000 | IDR 9,970,000 |
| Number of workers | 8-10 people | 3-4 people |
| Safety risk | High | Low |
| Sootblower downtime | 5 days | 1 day |
| Success rate | 100% | 90% |
| Pipe service life | New pipe | 12-24 months |
| Documentation and SOP | Not standardized | Supported by SOP |

3.1 Maintenance Time Efficiency Analysis

Maintenance time efficiency was analyzed using mean time to repair (MTTR). MTTR indicates the average time required to complete a repair process. In this study, MTTR was calculated using equation (1).

$$\text{MTTR} = \text{downtime} / \text{repair incidents} \quad (1)$$

The data show that MTTR before SI PETIR implementation was 7,200 minutes, equivalent to 5 days. After implementation, MTTR decreased to 720 minutes, equivalent to 12 hours. The reduction of 6,480 minutes indicates that SI PETIR significantly improved the effectiveness of the maintenance process. This improvement occurred because lance tube

straightening could be carried out without complete dismantling or replacement with a new component.

MTTR Comparison Before and After SI PETIR

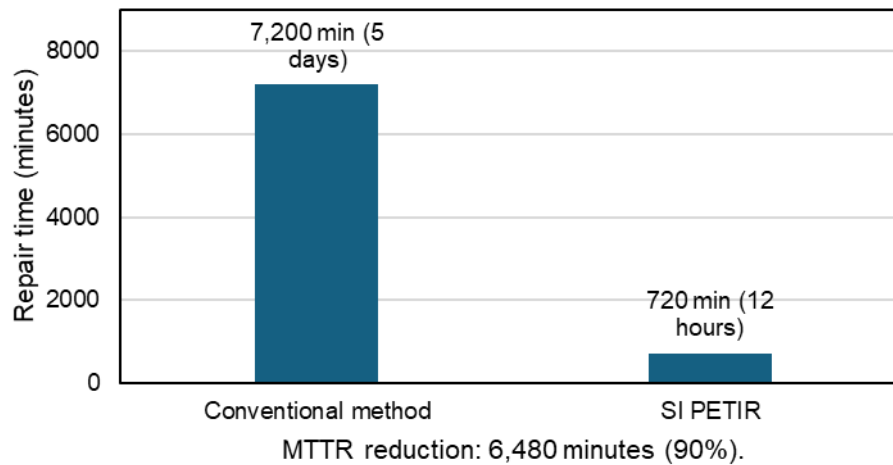


Figure 1. MTTR comparison before and after SI PETIR implementation

3.2 Cost Efficiency Analysis

SI PETIR implementation reduced maintenance cost significantly. The conventional method required IDR 95,070,000 because it involved purchasing a new lance tube, material distribution, and a larger workforce. After SI PETIR implementation, maintenance cost decreased to IDR 9,970,000 because repair was performed only on the deformed pipe area. The cost efficiency achieved per repair was IDR 85,100,000. If SI PETIR is used 52 times in one operational period, the potential benefit opportunity reaches IDR 4,933,670,000. This result shows that SI PETIR provides substantial long-term financial benefits for the company.

Sootblower Maintenance Cost Comparison

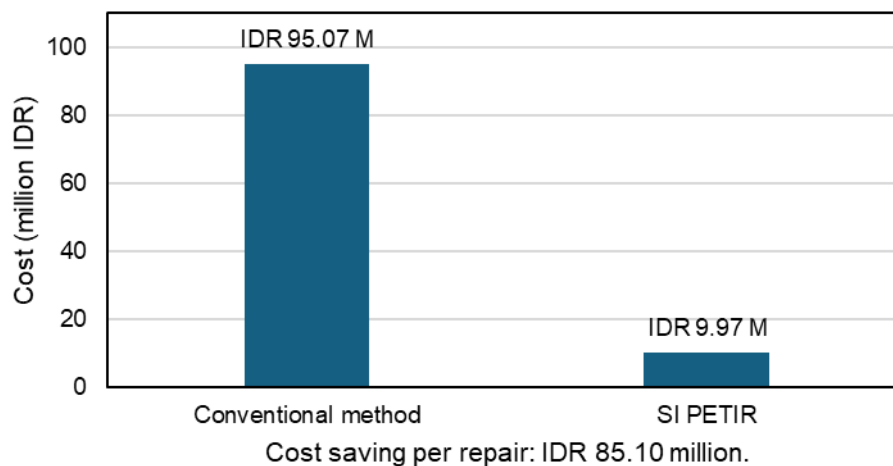


Figure 2. Maintenance cost comparison between the conventional method and SI PETIR

3.3 Operational Reliability Analysis

Operational reliability was analyzed using availability, which indicates the readiness level of equipment to operate. Availability was calculated using equation (2).

$$\text{Availability} = \text{uptime} / \text{operating time} \times 100\% \quad (2)$$

Before SI PETIR implementation, sootblower availability was 83.33% due to 5 days of downtime during a 30-day observation period. After SI PETIR implementation, downtime was reduced to 1 day, and availability increased to 96.67%. The increase of 13.34 percentage points

indicates that SI PETIR improved sootblower operational reliability and supported stable boiler operation.

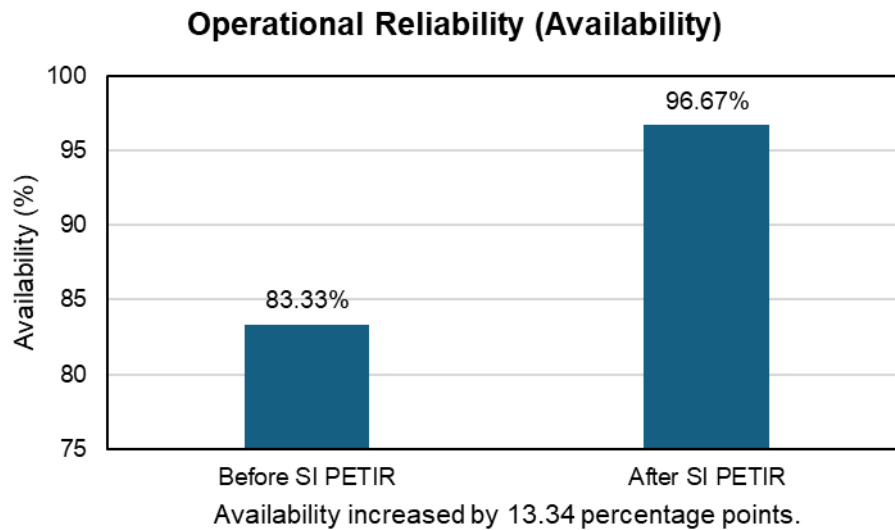


Figure 3. Operational reliability comparison based on availability

3.4 Supporting Factors of SI PETIR Implementation

SI PETIR also produced positive effects on workforce requirements, occupational safety, lance tube service life, and documentation readiness. The workforce requirement decreased from 8-10 people to 3-4 people because the repair process became simpler and more focused. The safety risk also decreased because several heavy-lifting activities could be eliminated.

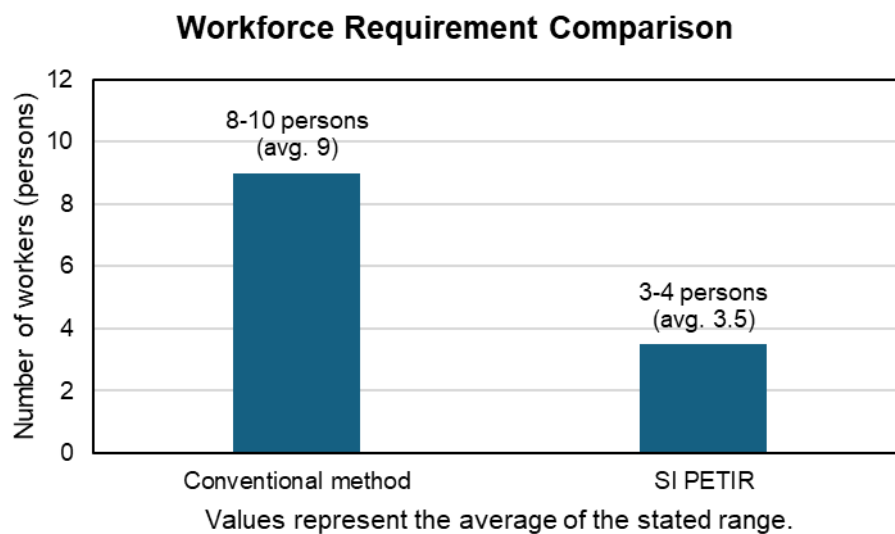


Figure 4. Workforce requirement comparison

From the occupational safety perspective, SI PETIR reduced the need for component mobilization at height and minimized manual handling of heavy components. Although the risk assessment was qualitative, the comparison indicates that the conventional method had higher risk than the SI PETIR method because it involved more lifting, dismantling, and installation activities.

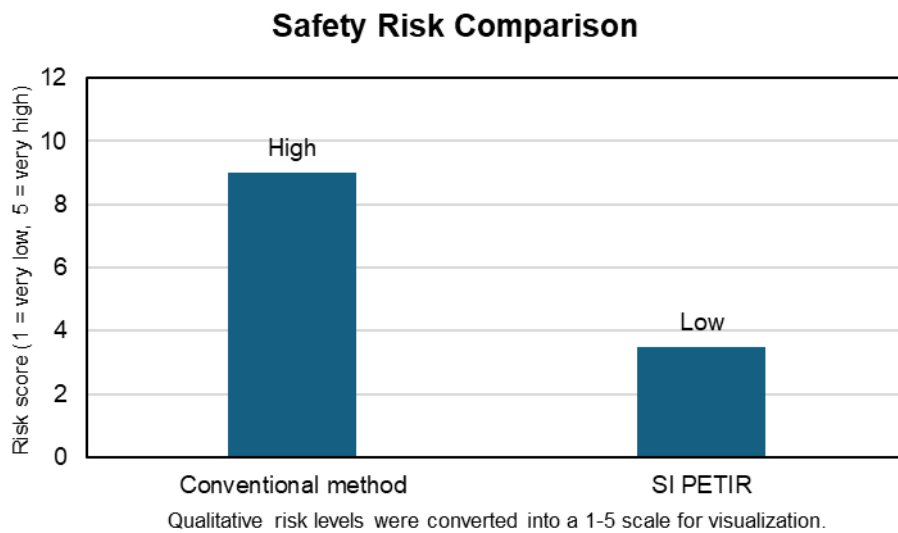


Figure 5. Safety risk comparison

In addition, SI PETIR can extend the usable period of repaired lance tubes for approximately 12-24 months. Although the success rate of SI PETIR was about 90%, this result is considered effective and feasible as an alternative maintenance strategy compared with the conventional method, which requires higher cost and longer downtime.

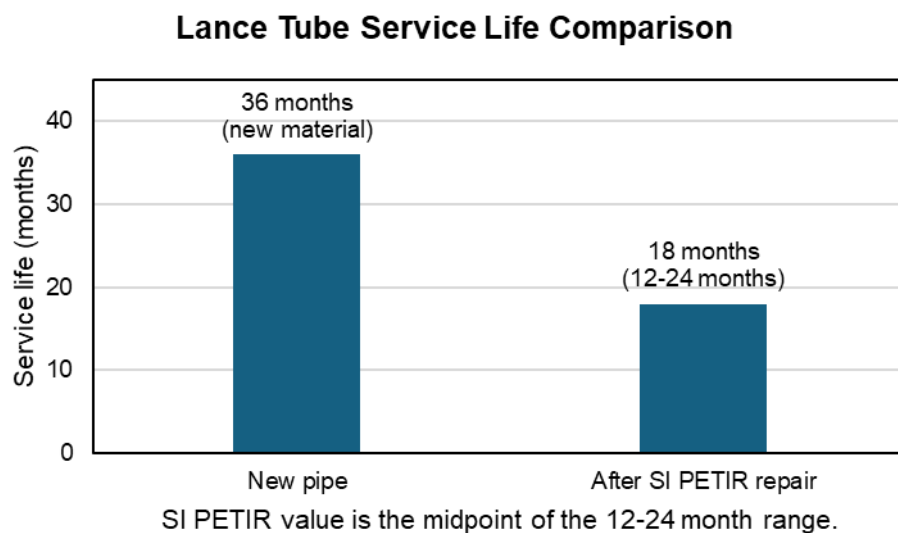


Figure 6. Lance tube service life comparison

The implementation of SI PETIR also encouraged better maintenance documentation and standard operating procedure (SOP) readiness. Standardized documentation makes the repair process easier to repeat, evaluate, and improve for future maintenance activities.

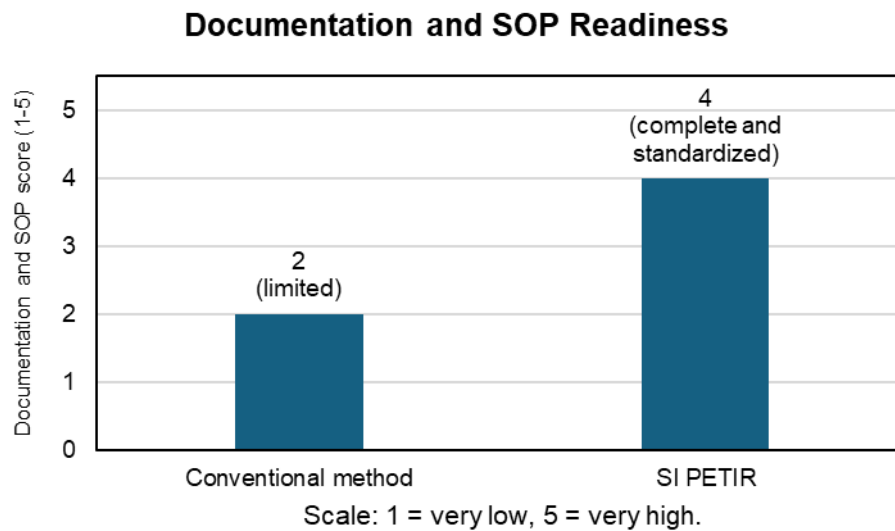


Figure 7. Documentation and SOP readiness comparison

4 Conclusion

Based on the results and discussion, SI PETIR implementation improved sootblower maintenance efficiency at Power Plant in Central Java. The innovation reduced maintenance cost from IDR 95,070,000 to IDR 9,970,000 and shortened maintenance time from 5 days, or 7,200 minutes, to 12 hours, or 720 minutes. This reduction accelerated the maintenance process and decreased sootblower downtime. SI PETIR also improved operational reliability by reducing downtime from 5 days to 1 day during the observation period and increasing availability from 83.33% to 96.67%. Therefore, sootblowers could return to operation more quickly and the risk of prolonged boiler cleaning disruption could be reduced.

For future work, SI PETIR should be replicated at other generating units to test its consistency under different operating conditions. Long-term monitoring is also recommended to determine the durability of repaired lance tubes over multiple sootblower operating cycles. Further design development can be directed toward digital integration, such as sensors or automatic monitoring systems. In addition, future studies should include a more comprehensive financial feasibility analysis using net present value (NPV), internal rate of return (IRR), and benefit-cost ratio (BCR) to evaluate the economic value of SI PETIR implementation more rigorously.

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Conflicts of Interest

The authors declare no conflict of interest.

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