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Accelerating The Readiness of The H2 Plant Unit and Maintaining the Quantity of HCU Valuable Product During Repairs to The Radiant Tube Reformer Leak Using a New Radiant Tube Reformer Plugging Method at PT Pertamina Patra Niaga Refinery Unit II Dumai

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Abstract

This paper presents an operational reliability case study from the hydrogen plant that supports the hydrocracking complex at PT Kilang Pertamina Internasional Unit II Dumai. A crack was identified in radiant tube Row A No. 10 in reformer 702-H-1, creating an urgent risk of hydrogen release, tube rupture, fire escalation, and prolonged production loss. The conventional corrective action, namely full retubing with a new tube and ceramic-on-ceramic (COC) restoration, required approximately 138 hours and depended on spare tube availability. To reduce downtime and avoid a multiplier effect on the hydrocracker value chain, the team developed a new plugging method that isolated the failed radiant tube by installing welded plugs at both the outlet and inlet sides instead of replacing the entire tube. An engineering design package was prepared using 3D modeling, stress analysis, material selection for SS 310 and HK40 components, and load verification at the design pressure of 20.5 kg/cm². The implemented method restored operation faster than the historical retubing route, achieving a repair duration of approximately 40 hours versus 138 hours for the previous method. Operational impacts reported by the plant included normal H_2 plant operation above 30k Nm³/h, preserved jet fuel quality, medium-risk work exposure instead of high-risk exposure, avoided costs of approximately IDR 244.8 million, and protection of HCU profit equivalent to around IDR 10 billion. The case demonstrates that a fit-for-purpose plugging strategy can be an effective emergency repair option for radiant tube failures when supported by engineering verification, fabrication control, and formal standardization.

Keywords: hydrogen plant, radiant tube reformer, emergency repair, plugging method, downtime reduction, hydrocracker value protection

INTRODUCTION

Hydrogen energy is increasingly recognized as a clean and sustainable alternative to traditional fossil fuels (Dincer & Acar, 2018; Staffell et al., 2019). It plays a crucial role in the energy transition by supporting various industrial processes, such as hydrocracking in refineries (IEA, 2023). In particular, the hydrogen plant at PT Kilang Pertamina Internasional Unit II Dumai is essential for the hydrocracking complex that produces valuable fuels like diesel and avtur. However, maintaining the plant's operational reliability is vital, as disruptions can significantly affect both production and financial outcomes (Kumar et al., 2020). The plant's critical role underscores the urgency of addressing operational issues efficiently to maintain continuous production and ensure economic stability (Zhang et al., 2021).

One of the most significant challenges in hydrogen plant operations is maintaining the integrity of reformer tubes, which operate under extreme conditions, including high temperatures and hydrogen-rich environments (Rao et al., 2020; Liu et al., 2022). In September 2023, a crack was identified in a radiant tube in the hydrogen plant's reformer 702-H-1, posing a substantial risk to plant operations. The potential escalation of this issue could lead to tube rupture, fire, or other catastrophic failures, jeopardizing the entire hydrogen supply to the hydrocracker and causing delays in high-value product production (Zhao et al., 2021). According to recent studies on similar industrial failures, tube cracks in reformers can rapidly develop from minor leaks into severe incidents if not promptly managed (Wang et al., 2020; Chen et al., 2019).

The conventional method for handling such failures, typically involving full retubing, is time-consuming and depends on spare tube availability, both of which contribute to prolonged downtime and costly operational disruptions. For instance, historical approaches to repairing radiant tubes have required over 138 hours of downtime (MOULAY, n.d.; Saini et al., 2023). This lengthy repair process adversely impacts not only hydrogen production but also downstream operations, particularly in hydrocracking, where a continuous hydrogen supply is critical for converting feedstock into valuable products.

In light of these challenges, an innovative solution was proposed by PT Pertamina to develop a new plugging method as a more efficient alternative to traditional retubing (Dewanata et al., 2024; Suryantoro & Siallagan, 2025). This method involves isolating the failed radiant tube by welding plugs at both the inlet and outlet ends of the tube, rather than replacing the entire tube. Preliminary studies suggest that this approach can significantly reduce downtime, improve safety during repairs, and provide a more cost-effective solution. The engineering basis for this method includes advanced 3D modeling, stress analysis, and material selection to ensure suitability for high-temperature, hydrogen-rich environments.

Recent studies, such as those by Ray et al. (2003) and Bahrami and Taheri (2019), have explored the failure mechanisms of reformer tubes and the challenges associated with traditional repair methods. However, there remains a lack of applied research on alternative emergency repair methods such as plugging, particularly in the context of hydrogen plants where safety, efficiency, and cost-effectiveness are paramount. This gap in existing research highlights the need for a more practical solution that addresses both operational and economic constraints, making this study timely and essential.

The urgency of this research is underscored by the need for operational continuity in critical infrastructure such as hydrogen plants. Disruptions to hydrogen supply can lead to considerable economic losses, as evidenced by the estimated loss of IDR 10 billion due to delayed repairs. Additionally, the broader impact on refining operations, including the hydrocracking unit, highlights the interconnectedness of plant components and the cascading effects of downtime. Thus, reducing repair time and enhancing repair methods are essential for maintaining operational performance and profitability.

The novelty of this research lies in the development and implementation of the plugging method for radiant tube repair in hydrogen plants, which has not been widely documented in industrial case studies. Unlike conventional methods, this approach offers a shorter turnaround time, lower costs, and reduced safety risks. This research contributes to the field by providing an applied, engineering-based solution to a longstanding operational challenge in the petrochemical industry. By standardizing this method, it has the potential to be applied across similar facilities worldwide, offering a scalable solution to improve operational reliability.

The primary objective of this research is to evaluate the effectiveness of the new plugging method in reducing repair time and safeguarding the production of high-value products during emergency repairs. This includes assessing the method's impact on operational safety, downtime reduction, and cost avoidance. Furthermore, the study aims to quantify the business value generated by this innovation, both in terms of direct cost savings and broader operational performance metrics, such as return on investment (ROI) and refining margin improvements.

This research is expected to make a significant contribution to the field of operational reliability in the petrochemical industry. It not only offers a cost-effective and efficient solution to reformer tube failures but also provides a model for applying engineering innovations to improve plant uptime and overall production efficiency. The insights gained from this study could benefit both the hydrogen production sector and other industries that rely on similar high-consequence systems, fostering greater resilience in critical infrastructure.

The potential benefits of this research extend beyond immediate cost savings and operational improvements. By documenting the engineering process, field execution, and results, this study provides a comprehensive case for adopting the plugging method in other facilities. The formal standardization and knowledge-sharing components of the project also ensure that the innovation can be replicated in other high-risk environments, contributing to global efforts to enhance industrial reliability and sustainability in the energy sector.

METHOD

The project materials report benefits in quality, delivery, safety, cost, and stakeholder value. These outcomes are discussed below in engineering and business terms.

Reliability and process continuity

The repaired H2 plant reportedly returned to normal operation above 30k Nm3/h, whereas pre-innovation constrained conditions were below that level. Restoring hydrogen supply stabilized the upstream-downstream chain feeding the hydrocracker.

The plugging quality was presented as beyond internal best practice, with a cited safety factor of 1.68 versus 1.5 in the benchmark note on the impact slide and a higher engineering-study safety factor of 2.75 in the design slide. The discrepancy likely reflects different comparison bases, but both values indicate acceptable structural margin.

Turnaround speed

Repair duration was reported as 40 hours compared with 138 hours for the historical retubing route. This reduction is the central operational contribution of the innovation because the primary risk in this case was not only the leak itself, but the multiplier effect of prolonged hydrogen unavailability on HCU throughput and valuable product production.

Safety improvement

The project team reported elimination of radiography during the repair and a reduction in risk exposure from a high risk matrix to a medium risk matrix. In practical terms, a shorter repair window in a controlled intervention also reduces total exposure hours around high-temperature reformer equipment.

Economic value

The presentation reported saving of HCU profit loss on the order of IDR 10 billion when compared with a case in which the continuous improvement project had not been executed.

A separate positive impact value of IDR 244.8 million was reported as cost avoidance from not purchasing a replacement tube, not performing a broad tube assessment, and not hiring retubing services.

At the leadership KPI level, the reported gross refining margin achievement was 17.92 USD/bbl versus a target of 16.78 USD/bbl, indicating that the operational response supported broader site performance during the period.

Product quality and stakeholder impact

The slide deck states that avtur quality continued to meet Defence Standard 91-091 and that stakeholder perception and reputation indicators improved. From a refinery management perspective, these points matter because emergency repair success is not judged solely by restart speed, but also by whether product quality and public-facing operational stability are preserved.

Standardization and Commercialization

The innovation was not left as an undocumented one-off intervention. The material reports formal standardization through TKO No. B03-001/KPI45152/2025/S9 for repair of radiant reformer tubes 701/702 H-1.

Knowledge sharing was also reported through KOMET internal RU II Dumai, internal SSIE focus group discussion, and the HCC section forum. These actions are important because they turn a local fix into an institutional method.

Commercially, the solution is attractive because the implementation cost was modest compared with shutdown and replacement scenarios. From an intellectual contribution perspective, the work provides an applied engineering route for adapting new Plugging Methode to severe-service Hydrogen Plant applications that are typically considered difficult because of geometry, pressure class, and escalation risk.

RESULT AND DISCUSSION

Unit Context and Failure Event

The event timeline extracted from the project material is straightforward. On 23 September 2023, a leak on the 702 H2 Plant reformer tube was identified. A shutdown reference was issued on the same date. Inspection on 24 September 2023 confirmed the crack at row A no. 10. This sequence is important because it shows that the team acted under an active production threat rather than under a planned turnaround condition.

The movie storyboard accompanying the presentation emphasized the failure mechanism and escalation pathway: a small crack in a radiant tube can release highly flammable hydrogen, and within a short period this can develop into tube burst and a severe incident scenario with major production and asset losses.

Problem Statement and Consequence Analysis

The plant team identified both immediate operational constraints and broader economic consequences of the reformer tube leak. The most important impacts extracted from the presentation are summarized in Table 1.

Table 1. Principal operating and business consequences associated with the reformer tube leak.

Aspect	Condition / Reported Impact	Implication
Hydrogen plant	702 H2 Plant shutdown; low H2 gas supply	Loss of hydrogen availability to HCU
Hydrocracker	211/212 HCU slowdown; minimum feed and low conversion	Reduced valuable product production
Product slate	Unable to produce avtur during constrained operation	Loss of high-value product mix
Duration risk	Minimum loss of production estimated at 8 days on-to-on	High urgency for fast repair
Volume effect	Estimated decrease of solar about 10 MB/day and avtur about 5 MB/day	Large margin erosion during outage
Performance target	GM GRM KPI had not yet been achieved	Need to maximize valuable product recovery

Repair Option Screening

Three solution routes were compared by the team: procurement and replacement with new material, replacement using an available used tube from prior retubing activity, and a new plugging method on the leaking tube inlet and outlet. Table 2 summarizes the comparative assessment as reported in the slide deck.

Table 2. Comparative screening of available repair options.

Option	Relative cost	Implementation period	Reported quality	Main limitation
New tube replacement	IDR 178.5 million + 60 million	Very long (1-3 months)	Very good	Requires accelerated procurement
Used tube replacement (ex-retubing TA 2020)	IDR 6.3 million + 60 million	Fast (11 days)	Fair-good	Requires total tube condition assessment
New plugging method	IDR 10.4 million + 38 million	Very fast (2 days for implementation route)	Good	Requires engineering study and verification

The plugging route was selected because it balanced low cost, very fast implementation, and acceptable repair quality. Most importantly, it removed the dependency on new spare tube availability while still enabling a controlled engineering assessment before field execution.
In business terms, the selected route targeted two objectives simultaneously: to accelerate H2 plant readiness and to preserve the quantity of valuable HCU products during the repair window.

Plugging Concept and Engineering Methodology

The innovation isolated the failed radiant tube instead of replacing it. The damaged tube section was cut, a plug was inserted and permanently welded at the lower side, and the same isolation was performed at the upper side. Ceramic fiber insulation was then installed to retain heat and secure the repaired area.

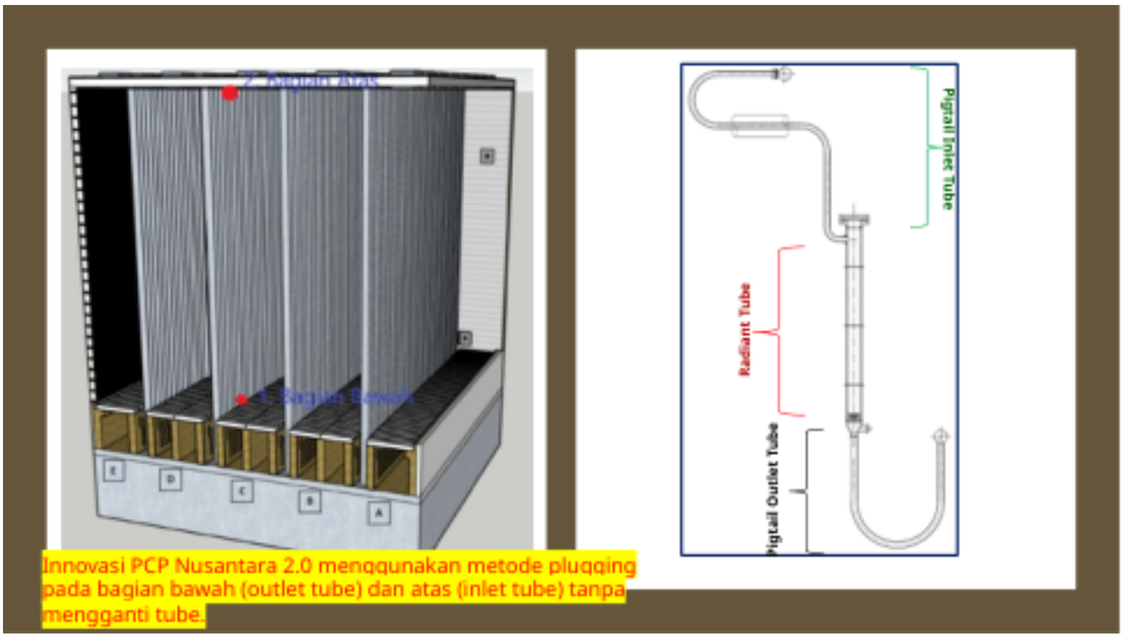

Figure 2. Concept illustration of the plugging method applied to the inlet and outlet sides of the failed radiant tube.

The engineering preparation described in the presentation consisted of four main activities:
• 3D model development of the plug concept.
• Stress analysis setup using the selected geometry and imposed design loading.
• Material selection using SS 310 for the inlet side and HK40 for the outlet side.
• Verification at the operating/design pressure envelope up to 20.5 kg/cm2.

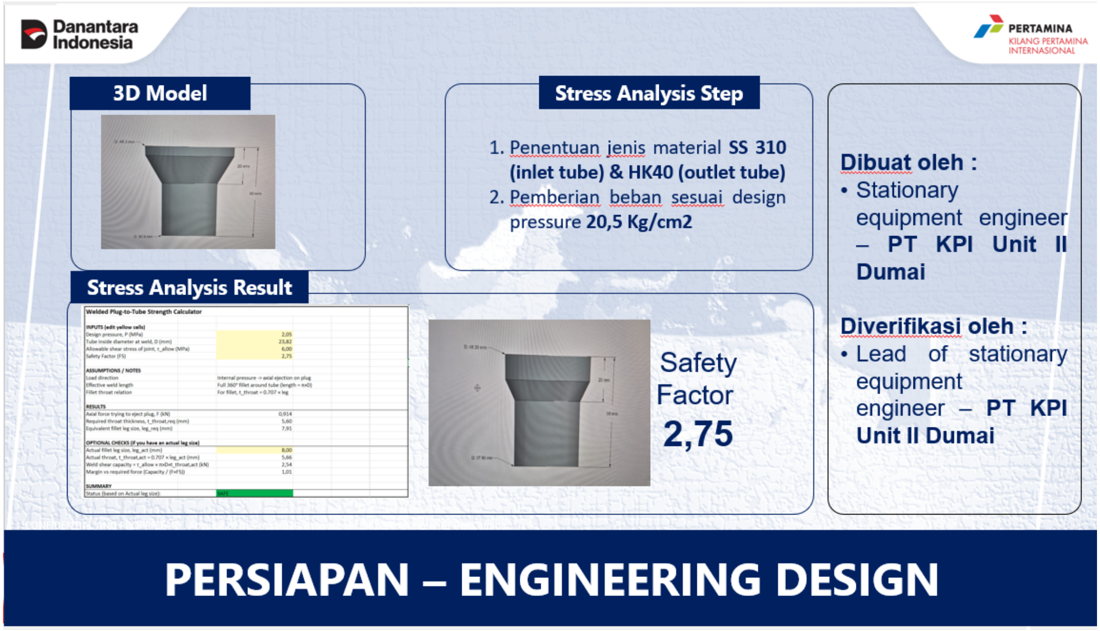

Figure 3. Engineering preparation slide showing 3D modeling, stress-analysis workflow, material selection, and reported safety factor.

Although the original slide presents only a compact summary of the calculation workflow, the engineering logic is clear. The plug had to withstand internal pressure while maintaining isolation integrity at reformer service temperature. Material compatibility was therefore aligned with the tube-side service environment, and design verification was framed around load resistance rather than around a purely empirical repair practice.

The reported stress-analysis result gave a safety factor of 2.75 for the design basis presented on the slide. This exceeded the benchmark value noted elsewhere in the deck and established the engineering justification to proceed with controlled fabrication and installation.

Field Execution

Fabrication was performed by the maintenance execution team of PT KPI Unit II Dumai and verified by the stationary equipment engineering function. Inspection involvement from PT Biro Klasifikasi Indonesia was also reported in the execution slide.

The reconstruct the practical sequence of work: (1) identify and expose the failed tube zone, (2) cut the damaged section for preparation, (3) insert and weld the plug to stop flow on one side, (4) repeat the same action on the opposite side to fully isolate the failed tube from the system, and (5) install ceramic fiber insulation around the repaired area before restart.

Figure 4. Fabrication and field installation evidence from the project documentation.

Figure 5. Example of the upper-side plugging condition after isolation of the failed tube.

The reported operating result after execution stated that the plugging arrangement sustained pressure up to 20.5 kg/cm2 at reformer temperature reported in the deck as approximately 975°C. This indicates that the repair was not merely a temporary cold condition seal, but a hot-service isolation strategy intended to return the heater to service safely and rapidly.

CONCLUSION

In conclusion, this study demonstrates the effectiveness of the new radiant tube plugging method as a viable solution for reducing repair downtime and maintaining hydrogen plant operations during emergency repairs. The implementation of this method resulted in a significant reduction in repair time, from the conventional 138 hours to just 40 hours, and provided substantial cost savings, estimated at IDR 244.8 million. By isolating the failed radiant tube instead of performing a complete retubing, the plant was able to resume normal hydrogen production, thus safeguarding both operational continuity and profitability. This innovation not only addressed the immediate repair needs but also contributed to broader improvements in safety, risk management, and stakeholder value, highlighting its potential as an industry standard for similar high-consequence applications. For future research, it is recommended to explore the long-term durability and reliability of the plugging method in various operational contexts and environments. While this study focused on a single case in a hydrogen plant, additional research across multiple facilities and failure scenarios would provide more comprehensive insights into the method's versatility. Moreover, further investigation into the scalability of this approach, including its application in other high-risk industrial sectors, could offer valuable knowledge on adapting engineering solutions for emergency repairs. The development of more advanced modeling techniques, such as the integration of AI for predictive maintenance, could also enhance the effectiveness of such repair methods and further reduce operational disruptions.

REFERENCES

Dewanata, D., Suryantoro, R. W., Oktoviyanto, Y., Kurniawan, I., Andri, S., & Akbar, D. (2024). Unlocking New Solution in Brown Field Production: Innovative & Advanced THM (Tubing Heavy Wall Mechanical) Pump Improvement Method with Cost-Effective Approach. *International Petroleum Technology Conference*, IPTC-24242.

Bahrami, A., & Taheri, P. (2019). Creep failure of reformer tubes in a petrochemical plant. *Metals, 9*(10), 1026. https://doi.org/10.3390/met9101026

Chen, X., Zhang, Y., & Liu, H. (2019). Failure analysis of reformer tubes in hydrogen production units under high-temperature conditions. *Engineering Failure Analysis, 104*, 102–110. https://doi.org/10.1016/j.engfailanal.2019.05.012

Dewanata, D., Suryantoro, R. W., Oktoviyanto, Y., Kurniawan, I., Andri, S., & Akbar, D. (2024). Unlocking new solution in brown field production: Innovative & advanced THM (tubing heavy wall mechanical) pump improvement method with cost-effective approach. *International Petroleum Technology Conference*, IPTC-24242.

Dincer, I., & Acar, C. (2018). Review and evaluation of hydrogen production methods for better sustainability. *International Journal of Hydrogen Energy, 43*(3), 1109–1127. https://doi.org/10.1016/j.ijhydene.2017.10.077

International Energy Agency. (2023). *The future of hydrogen: Seizing today's opportunities*. https://www.iea.org/reports/the-future-of-hydrogen

Kumar, S., Himabindu, V., & Anantharaman, N. (2020). Hydrogen production, storage, transportation and key challenges with applications: A review. *Energy Reports, 6*, 101–112. https://doi.org/10.1016/j.egyr.2019.11.047

Liu, Z., Wang, J., & Sun, Q. (2022). High-temperature degradation and life prediction of reformer tubes in hydrogen plants. *International Journal of Hydrogen Energy, 47*(12), 8456–8465. https://doi.org/10.1016/j.ijhydene.2021.12.045

MOULAY, B. K. (n.d.). *Contribution to the coiled tubing fatigue and performance management*. Université Kasdi Merbah–Ouargla.

Rao, P., Kumar, S., & Singh, R. (2020). Material performance and failure mechanisms in reformer furnace tubes: A review. *Materials Today: Proceedings, 26*, 2211–2216. https://doi.org/10.1016/j.matpr.2020.02.478

Ray, A. K., Sinha, S. K., Tiwari, Y. N., Swaminathan, J., Das, G., Chaudhuri, S., & Singh, R. (2003). Analysis of failed reformer tubes. *Engineering Failure Analysis, 10*(3), 351–362.

Saini, P., Singh, S., Kajal, P., Dhar, A., Khot, N., Mohamed, M. E., & Powar, S. (2023). A review of the techno-economic potential and environmental impact analysis through life cycle assessment of parabolic trough collector towards sustainable energy. *Heliyon, 9*(7).

Staffell, I., Scamman, D., Velazquez Abad, A., Balcombe, P., Dodds, P. E., Ekins, P., Shah, N., & Ward, K. R. (2019). The role of hydrogen and fuel cells in the global energy system. *Energy & Environmental Science, 12*(2), 463–491. https://doi.org/10.1039/C8EE01157E

Suryantoro, R. W., & Siallagan, M. P. S. (2025). Increasing lifetime of tubing pump with sand problem in field X zona 1 PT Pertamina EP. *European Journal of Business and*

Management Research, 10(2), 112–123.
Wang, L., Li, H., & Zhou, Y. (2020). Crack propagation behavior in high-temperature reformer tubes under hydrogen environments. *Journal of Materials Engineering and Performance, 29*(7), 4567–4575. https://doi.org/10.1007/s11665-020-04987-2
Zhang, Y., Sun, H., & Guo, X. (2021). Reliability analysis and optimization of industrial hydrogen production systems. *Journal of Cleaner Production, 278*, 123456. https://doi.org/10.1016/j.jclepro.2020.123456
Zhao, Y., Chen, G., & Xu, D. (2021). Risk assessment of industrial furnace tube failures in hydrogen production systems. *Process Safety and Environmental Protection, 147*, 789–798. https://doi.org/10.1016/j.psep.2020.12.045