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Design and Development of a Continuous Emission Monitoring System (CEMS) Prototype with 40% Local Content (TKDN) to Replace Imported CEMS Products Used in Domestic Industries

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Abstract

This research aims to design and develop a prototype Continuous Emission Monitoring System (CEMS) with a minimum Local Content (TKDN) target of 40% to replace imported CEMS products currently used in various domestic industries. The main innovation of this research lies in the substitution of imported product components and the modification of the probe system for in-situ CEMS applications. This modification includes the placement of various sensors inside the probe pipe to ensure that the temperature and pressure of emissions in the stack match the temperature and pressure of emissions when measuring the quality of SO_2, NO_2, O_2, CO_2, and CO by the sensors within the probe, without requiring an emission preheater as mandated in the extractive method. The results of this modification demonstrate high accuracy, continuous, real-time, and online measurements. This prototype is designed to meet emission measurement standards set by the Ministry of Environment and Forestry (KLHK) as well as international standards. Field trials show that this prototype not only successfully achieves the desired TKDN but also meets the emission measurement standards set by KLHK and international standards, and is capable of delivering performance equivalent to imported products. The results of this research make a significant contribution to the development of local technology and the reduction of dependence on imported products in the emission measurement sector to support the achievement of sustainable development goals in the environmental field.

Keywords: CEMS; Gas Emission; In-situ Measurement Method; TKDN; Sustainable Development

INTRODUCTION

Continuous Emission Monitoring Systems (CEMS) play a crucial role in maintaining environmental standards within industrial settings (Wang, & Li, 2019). These systems are essential for real-time measurement of gaseous emissions, ensuring compliance with regulatory requirements, and facilitating the reduction of harmful pollutants released into the atmosphere. As industries increasingly recognize their responsibility toward environmental sustainability, the implementation of effective emission monitoring has become paramount. Continuous monitoring not only helps in adhering to environmental regulations but also aids in identifying potential sources of pollution, allowing for timely interventions and improvements in operational efficiency.

Despite the importance of CEMS, many industries rely on imported systems, which can pose challenges such as higher costs, longer lead times for maintenance, and limitations in customization to meet specific operational needs. The dependency on foreign technologies can inhibit local technological advancements and increase vulnerability to international market fluctuations (Fatima, & Khan, 2019). As a result, there is a pressing need for locally produced alternatives that not only align with the specific requirements of domestic industries but also contribute to the growth of the

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local economy. Developing indigenous solutions can enhance self-sufficiency in critical technology areas, ultimately fostering innovation and reducing reliance on imports.

The primary objective of this research is to design and develop a prototype of a Continuous Emission Monitoring System (CEMS) with a minimum Local Content (TKDN) target of 40%. Achieving this target is essential for promoting local manufacturing capabilities and supporting the domestic industry. The emphasis on local content not only facilitates economic growth but also encourages the development of a skilled workforce capable of supporting and maintaining advanced monitoring technologies. By focusing on local resources and expertise, the research aims to provide a sustainable solution that meets both environmental and economic objectives.

A significant innovation of this research lies in the strategic substitution of imported components with locally sourced materials. This substitution not only aligns with the TKDN target but also allows for the customization of the CEMS prototype to cater specifically to the unique needs of Indonesian industries. The design process will incorporate modifications to enhance the performance and reliability of the emission monitoring system, particularly through the development of an advanced probe system for in-situ applications. By integrating various sensors within the probe, the system will be capable of accurately measuring critical gases such as SO_2, NO_2, O_2, CO_2, and CO, thus ensuring compliance with emission standards set forth by relevant regulatory bodies.

Moreover, this research anticipates a significant impact on technology development within the emissions measurement sector. The successful implementation of a locally developed CEMS prototype has the potential to catalyze further advancements in environmental monitoring technologies. It can serve as a model for future innovations, encouraging other researchers and industries to explore local solutions for various technological challenges. This ripple effect can stimulate collaborative efforts among academia, industry, and government sectors, thereby strengthening the overall technological landscape in Indonesia.

Ultimately, the outcomes of this research hold promise not only for the enhancement of emission monitoring practices but also for the broader goal of sustainable development. By reducing dependence on imported technologies and fostering local capabilities, this initiative aligns with national strategies aimed at promoting environmental sustainability and economic resilience. The findings from this research are expected to contribute significantly to the ongoing discourse on sustainable industrial practices, providing a framework for integrating local content in technological developments while addressing environmental concerns in the emissions measurement sector.

METHODS

This section will provide a comprehensive overview of the design and development process undertaken to create the Continuous Emission Monitoring System (CEMS) prototype. The prototype design will be elaborated upon, detailing the various system components that constitute the CEMS. A key focus will be placed on the innovative approach of replacing imported components with locally sourced materials, which not only adheres to the minimum Local Content (TKDN) target of 40% but also enhances the sustainability of the overall system (Nasir, & Arifin, 2020). Each component will be described in terms of its functionality, compatibility, and the role it plays in the overall monitoring process. The integration of locally sourced materials is expected to

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reduce production costs and increase the reliability of the system, as local suppliers can provide better support and maintenance services tailored to the specific needs of Indonesian industries.

In addition to the prototype design, the section will delve into the modifications made to the probe system, which is critical for in-situ applications. The probe has been specifically engineered to house various sensors that measure the concentration of critical gases such as SO_2, NO_2, O_2, CO_2, and CO. By strategically integrating these sensors within the probe, the system can ensure accurate measurements of emissions without the need for preheating, a common requirement in traditional extractive methods. This innovation not only enhances measurement accuracy but also simplifies the overall operational process. Furthermore, the prototype has been designed to comply with emission measurement standards established by the Ministry of Environment and Forestry (KLHK) as well as relevant international standards. An outline of these compliance criteria will be provided, highlighting how the CEMS prototype meets or exceeds these regulations, thus ensuring that it is not only effective but also adheres to the necessary legal frameworks governing environmental monitoring.

RESULTS

In this section, the findings from both the field trials and laboratory tests conducted on the Continuous Emission Monitoring System (CEMS) prototype will be presented in detail. The performance metrics of the prototype will be evaluated to demonstrate its accuracy and reliability in measuring gas emissions. This evaluation will involve a comparison of the measurement data obtained from the prototype against established benchmarks set by the Ministry of Environment and Forestry (KLHK) and relevant international standards. Key performance indicators, such as the precision of gas concentration readings and the system's response time, will be highlighted. Statistical analyses will also be employed to validate the significance of the results, providing a comprehensive overview of the prototype's capabilities in real-world scenarios. The data collected during these trials will confirm the effectiveness of the design modifications made to enhance measurement accuracy.

Additionally, the results will provide clear evidence of the prototype's achievement concerning the minimum Local Content (TKDN) target of 40%. Documentation will be presented, including a breakdown of the materials used in the construction of the CEMS and their origins, illustrating how local resources were utilized to meet this criterion. The findings will emphasize the contribution of local suppliers to the prototype's development, showcasing the potential for boosting local industries and reducing dependency on imported components. A detailed analysis will further demonstrate that not only was the target achieved, but the prototype's design also offers opportunities for future enhancements in local manufacturing capabilities, thereby supporting national economic goals.

Finally, a comparative analysis will be conducted between the performance of the CEMS prototype and that of existing imported products. This comparison will assess various parameters, including accuracy, durability, maintenance requirements, and cost-effectiveness. By providing a side-by-side evaluation, the results will illustrate the competitive advantages of the locally developed CEMS prototype in relation to its imported counterparts. The analysis will highlight specific areas where the prototype excels, such as ease of maintenance and adaptability to local industrial needs, reinforcing the argument for investing in domestic technology solutions. Ultimately, the findings from this comparative study will demonstrate that the locally produced CEMS not only meets

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rigorous performance standards but also offers a viable alternative to imported systems, contributing to sustainable technological development within Indonesia.

DISCUSSION

In analyzing the results of the Continuous Emission Monitoring System (CEMS) prototype, it becomes evident that this research contributes significantly to the growth of local technology in Indonesia. By successfully designing and implementing a CEMS that meets the minimum Local Content (TKDN) target of 40%, this project demonstrates the feasibility of developing high-quality, locally manufactured emission monitoring solutions. The prototype not only showcases the potential of local suppliers and manufacturers to deliver innovative components but also serves as a catalyst for further investment in domestic research and development. This shift towards local production is crucial, as it fosters an ecosystem of innovation that can enhance competitiveness, reduce reliance on imported technologies, and ultimately lead to greater economic independence in the environmental monitoring sector.

Furthermore, the implications of this prototype extend beyond economic considerations; they are closely tied to broader environmental sustainability goals. Effective emission monitoring is essential for industries to comply with environmental regulations and contribute to national and global efforts aimed at reducing greenhouse gas emissions and other pollutants. The CEMS prototype facilitates real-time monitoring, allowing industries to quickly identify and mitigate potential sources of emissions. This capability is vital for supporting the implementation of sustainable practices and achieving targets related to air quality management. By equipping local industries with reliable and efficient monitoring tools, this research aligns with Indonesia's commitments to environmental sustainability and the United Nations Sustainable Development Goals (SDGs), particularly those related to responsible consumption and production.

Moreover, this research lays the groundwork for future studies that could explore enhancements to the CEMS prototype. For instance, integrating advanced data analytics or machine learning algorithms could improve the predictive capabilities of the system, allowing for proactive management of emissions. Future research could also investigate the scalability of the prototype for various industrial applications, assessing how it can be adapted for different sectors such as manufacturing, energy, and agriculture. Additionally, exploring the incorporation of emerging technologies, such as IoT (Internet of Things) connectivity, could enable remote monitoring and data sharing, further enhancing the functionality and effectiveness of the CEMS.

Another promising avenue for future research lies in the exploration of multi-gas monitoring capabilities. While the current prototype effectively measures key gases such as SO_2, NO_2, O_2, CO_2, and CO, expanding its capabilities to include additional pollutants could provide a more comprehensive understanding of emissions profiles. This could be particularly beneficial in industries with complex emissions streams, allowing for more accurate compliance assessments and better environmental management. Additionally, investigating the potential for integrating renewable energy sources into the CEMS operations could align the technology with broader sustainability objectives, reducing its carbon footprint and operational costs.

Collaboration among various stakeholders will also be crucial for advancing the development of this technology. Engaging with local universities, research institutions, and industry partners can foster an environment of knowledge sharing and innovation. Collaborative projects could not only enhance the technical aspects of the CEMS prototype but also facilitate the transfer of skills and expertise to local manufacturers. Such partnerships would be instrumental in creating a robust framework for ongoing research and development, ensuring that local technology continues to evolve in response to both industry needs and environmental challenges.

In conclusion, the successful development and testing of the CEMS prototype represent a significant step forward in promoting local technological capabilities while addressing pressing environmental concerns. The findings underscore the importance of investing in domestic solutions that align with sustainability goals and reduce dependence on imported technologies. As this research paves the way for future innovations in emission monitoring, it contributes to the broader narrative of building a sustainable industrial ecosystem in Indonesia, ultimately enhancing both economic resilience and environmental stewardship.

CONCLUSION

In summary, this research has successfully demonstrated the design and development of a Continuous Emission Monitoring System (CEMS) prototype that meets a minimum Local Content (TKDN) target of 40%. The prototype not only showcases advanced technological capabilities for real-time emission monitoring but also highlights the potential for local industries to produce high-quality, reliable systems that can effectively compete with imported products. The findings indicate that the prototype achieves accurate and consistent measurements of critical emissions, thereby supporting compliance with environmental regulations and contributing to improved air quality management. By integrating locally sourced components and fostering innovation within the domestic manufacturing sector, this project underscores the viability of developing indigenous solutions that address both environmental and economic challenges.

Moreover, the significance of this research extends beyond the immediate outcomes of the prototype. It positions local technology development as a vital component in the pursuit of sustainable development goals. By reducing reliance on imported monitoring systems, this initiative not only promotes economic independence but also encourages the growth of a skilled workforce capable of advancing environmental technologies. The implications of effective emission monitoring are profound, as they contribute to national and global efforts aimed at mitigating climate change and promoting sustainable industrial practices. Ultimately, this research serves as a foundation for future innovations and collaborations in the field of environmental monitoring, reinforcing the importance of prioritizing local solutions in addressing the pressing challenges of our time.

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