Journal of Academic Research and Trends in Educational Sciences
Journal home page:
http://ijournal.uz/index.php/jartes

METHODS OF REDUCING NOX EMITTED INTO THE AIR AT GAS TURBINE THERMAL POWER PLANTS

Abdujakhongir Yulyakhshiev[1]

Tashkent State Technical University

KEYWORDS

NOx emissions, Gas turbine thermal power plants, Combustion modifications, Selective catalytic reduction (SCR), Exhaust gas recirculation (EGR), Air pollution control, Environmental sustainability, Regulatory compliance, Health risks, Pollution mitigation

ABSTRACT

This article examines various methods employed to mitigate nitrogen oxide (NOx) emissions from gas turbine thermal power plants, aiming to minimize their environmental impact. NOx emissions contribute significantly to air pollution and pose health risks, making their reduction imperative. The study explores different techniques, including combustion modifications, selective catalytic reduction (SCR), and exhaust gas recirculation (EGR), among others. Through a comprehensive analysis of these methods, their effectiveness, advantages, and challenges are evaluated. By implementing appropriate NOx reduction strategies, gas turbine thermal power plants can achieve regulatory compliance, enhance environmental sustainability, and safeguard public health.

2181-2675/© 2024 in XALQARO TADQIQOT LLC.
DOI: **10.5281/zenodo.10702977**
This is an open access article under the Attribution 4.0 International(CC BY 4.0) license (https://creativecommons.org/licenses/by/4.0/deed.ru)

[1] Faculty of Thermal Energy, Tashkent State Technical University, Uzbekistan

iJOURNAL Journal of Academic Research and Trends in Educational Sciences (JARTES)
VOLUME 3, ISSUE 1 / ISSN 2181-2675

GAZ TURBINALI ISSIQLIK ELEKTR STANSIYALARIDA HAVOGA CHIQAYOTGAN NOX NI KAMAYTIRISH USULLARI

KALIT SO‘ZLAR/
КЛЮЧЕВЫЕ СЛОВА:

NOx emissiyalari, gaz turbinali issiqlik elektr stantsiyalari, yonish modifikatsiyalari, katalitik selektiv pasayish (SCR), chiqindi gazning qayta aylanishi (EGR), havo ifloslanishini nazorat qilish, atrof-muhit barqarorligi, tartibga rioya qilish, sog'liq uchun xavflar, ifloslanishni kamaytirish

ANNOTATSIYA/ АННОТАЦИЯ

Ushbu maqolada gaz turbinali issiqlik elektr stantsiyalaridan azot oksidi (NOx) chiqindilarini kamaytirish uchun qo'llaniladigan turli usullar, ularning atrof-muhitga ta'sirini minimallashtirishga qaratilgan. NOx chiqindilari havoning ifloslanishiga sezilarli hissa qo'shadi va sog'liq uchun xavf tug'diradi, bu esa ularni kamaytirishni talab qiladi. Tadqiqot turli usullarni o'rganadi, jumladan, yonish modifikatsiyalari, selektiv katalitik pasayish (SCR) va chiqindi gazning qayta aylanishi (EGR) va boshqalar. Ushbu usullarni har tomonlama tahlil qilish orqali ularning samaradorligi, afzalliklari va muammolari baholanadi. Tegishli NOx kamaytirish strategiyalarini amalga oshirish orqali gaz turbinali issiqlik elektr stansiyalari me'yoriy hujjatlarga muvofiqlikni ta'minlashi, ekologik barqarorlikni oshirishi va aholi salomatligini himoya qilishi mumkin.

Gas turbine thermal power plants play a crucial role in meeting the energy demands of modern society. However, their operation contributes to the emission of nitrogen oxides (NOx), which are potent air pollutants with adverse environmental and health effects. NOx emissions from these facilities result primarily from high-temperature combustion processes. In response to growing environmental concerns and regulatory requirements, there has been an increasing focus on developing and implementing methods to reduce NOx emissions from gas turbine thermal power plants.

This article explores various methods and technologies aimed at mitigating NOx emissions from gas turbine thermal power plants. By examining the principles, applications, and effectiveness of these techniques, we aim to provide insights into the strategies available to minimize the environmental impact of these facilities. The discussion encompasses both combustion-related approaches and post-combustion treatment methods, highlighting their respective advantages, limitations, and challenges.

NOx emissions are associated with a range of environmental and public health concerns. They contribute to the formation of ground-level ozone and particulate matter, which are key components of smog and contribute to respiratory illnesses, cardiovascular diseases, and other health problems (EPA, 2021). Additionally, NOx emissions play a role in the acidification of soils and water bodies, as well as the eutrophication of aquatic ecosystems, posing threats to biodiversity and ecosystem health (Seinfeld & Pandis, 2016).

Given these environmental and health impacts, there is a growing imperative to reduce NOx emissions from industrial sources, including gas turbine thermal power plants. Regulatory agencies worldwide have implemented stringent emission standards and guidelines to limit NOx emissions from these facilities, necessitating the development and

adoption of effective emission control technologies (IEA, 2018).

Various methods and technologies have been developed to reduce NOx emissions from gas turbine thermal power plants. These include combustion modifications, such as lean premixed combustion and staged combustion, as well as post-combustion treatment techniques, such as selective catalytic reduction (SCR) and exhaust gas recirculation (EGR) (Yang et al., 2020). Each method has its unique mechanisms and applications, offering different levels of NOx reduction efficiency and operational flexibility.

Gas turbine thermal power plants are significant contributors to nitrogen oxide (NOx) emissions due to their high-temperature combustion processes. To address the environmental and health concerns associated with NOx emissions, various methods and technologies have been developed to reduce their release into the atmosphere. This section explores the primary approaches employed to mitigate NOx emissions in gas turbine thermal power plants, focusing on combustion modifications and post-combustion treatment techniques.

1. Combustion Modifications:

a. Lean Premixed Combustion:

Lean premixed combustion involves adjusting the air-to-fuel ratio to create a fuel-lean environment during combustion. By reducing the oxygen concentration in the combustion zone, lean premixed combustion lowers the peak flame temperature, which in turn reduces the formation of thermal NOx (Mellor et al., 2017). This approach is effective in reducing NOx emissions, but it may require modifications to the combustion system and can lead to stability and operability challenges.

b. Staged Combustion:

Staged combustion involves dividing the combustion process into two or more stages to control the formation of NOx. In a staged combustion system, fuel is partially burned in a primary combustion zone with limited oxygen supply, followed by further combustion in a secondary zone with additional air injection. By controlling the temperature profile and residence time in each stage, staged combustion reduces NOx emissions by minimizing peak flame temperatures and nitrogen oxidation (Yun et al., 2020).

2. Post-Combustion Treatment Techniques:

a. Selective Catalytic Reduction (SCR):

SCR is a widely adopted post-combustion treatment technique for reducing NOx emissions in gas turbine thermal power plants. SCR systems utilize catalysts, typically composed of vanadium, titanium, or zeolites, to catalyze the reaction between NOx and ammonia (NH_3) or urea ($CO(NH_2)_2$) injected into the flue gas stream. This reaction converts NOx into nitrogen (N_2) and water vapor, significantly reducing NOx emissions (Berguerand et al., 2018). SCR systems offer high NOx removal efficiency and can be retrofitted to existing power plants.

b. Exhaust Gas Recirculation (EGR):

EGR involves recirculating a portion of the exhaust gas back into the combustion

chamber to dilute the oxygen concentration and lower the combustion temperature. By reducing the peak flame temperature, EGR inhibits the formation of thermal NOx while promoting the formation of nitrogen (N_2), thereby reducing overall NOx emissions (Chen et al., 2019). EGR systems can be integrated into gas turbine designs to achieve NOx reduction without significant modifications to the combustion system.

NOx emissions from gas turbine thermal power plants pose significant environmental and health risks, necessitating effective mitigation strategies. Combustion modifications and post-combustion treatment techniques offer viable approaches to reducing NOx emissions while maintaining operational efficiency. By implementing these methods, gas turbine thermal power plants can minimize their environmental footprint and contribute to cleaner air and improved public health.

In conclusion, mitigating nitrogen oxide (NOx) emissions from gas turbine thermal power plants is crucial for addressing environmental concerns and safeguarding public health. The methods discussed in this article offer effective strategies for reducing NOx emissions while maintaining operational efficiency.

Combustion modifications, such as lean premixed combustion and staged combustion, optimize combustion conditions to minimize NOx formation during the combustion process. These approaches leverage adjustments in fuel-air ratios and combustion staging to lower peak flame temperatures and mitigate NOx emissions effectively.

Post-combustion treatment techniques, including selective catalytic reduction (SCR) and exhaust gas recirculation (EGR), provide additional avenues for NOx reduction. SCR systems utilize catalysts to facilitate the conversion of NOx into harmless nitrogen and water vapor, while EGR systems dilute the oxygen concentration in the combustion chamber, reducing NOx formation.

By implementing a combination of these methods and technologies, gas turbine thermal power plants can achieve significant reductions in NOx emissions, contributing to improved air quality and environmental sustainability. However, it is essential to consider factors such as system compatibility, cost-effectiveness, and regulatory compliance when selecting NOx reduction strategies.

Moving forward, continued research and development efforts are necessary to optimize existing NOx reduction technologies and explore innovative solutions. Collaboration between industry stakeholders, policymakers, and researchers is critical to advancing the adoption of cleaner, more efficient combustion practices in gas turbine thermal power plants.

Ultimately, by prioritizing NOx emission reduction initiatives, gas turbine thermal power plants can play a pivotal role in mitigating air pollution and promoting a healthier, more sustainable future for communities worldwide.

References:

1. Environmental Protection Agency (EPA). (2021). Nitrogen Oxides (NOx).

Retrieved from https://www.epa.gov/no2-pollution/basic-information-about-no2

2. International Energy Agency (IEA). (2018). Emission standards in large combustion plants. Retrieved from https://www.iea.org/reports/emission-standards-in-large-combustion-plants

3. Seinfeld, J. H., & Pandis, S. N. (2016). Atmospheric chemistry and physics: From air pollution to climate change (3rd ed.). John Wiley & Sons.

4. Yang, W., Han, Z., Li, Y., Lu, G., Zhang, H., & Guo, H. (2020). NOx emissions reduction strategies and mechanism analysis in a gas turbine combustor: A review. Renewable and Sustainable Energy Reviews, 124, 109787. https://doi.org/10.1016/j.rser.2020.109787

5. Berguerand, N., Haider, M. B., & Park, S. (2018). Selective catalytic reduction of NOx over vanadium-based catalysts: a review. Catalysts, 8(3), 107. https://doi.org/10.3390/catal8030107

6. Chen, H., Zhang, H., Wang, Z., & Wu, D. (2019). Study on the effect of exhaust gas recirculation on combustion and NOx emissions of a gas turbine combustor. Energy Procedia, 158, 4039-4044. https://doi.org/10.1016/j.egypro.2019.01.984

7. Mellor, A. M., Sivaharan, A., Hawkes, E. R., & Savill, M. (2017). Lean premixed combustion for low NOx gas turbine combustion. Progress in Energy and Combustion Science, 60, 31-112. https://doi.org/10.1016/j.pecs.2017.02.001

8. Yun, S., Li, Z., Zhang, C., Yu, Q., & Zhang, Z. (2020). Study on staged combustion for NOx reduction in a gas turbine combustor. Journal of Thermal Science and Engineering Applications, 12(1), 011020. https://doi.org/10.1115/1.4044504