**TITLE 1**

**Aim:**

"Comparative Analysis of Maximum Overshoot Reduction in AVR Using Nutcracker Algorithm Tuned 2DOF-PID Versus PSO Tuned 2DOF-PI Controllers"

**Introduction:**

**Pera 1:**

The study evaluates the effectiveness of Nutcracker algorithm tuned 2DOF-PID against PSO tuned 2DOF-PI for mitigating maximum overshoot in Automatic Voltage Regulators (AVR). Diminishing overshoot in AVR is crucial for stable and efficient power systems. Nutcracker algorithm tuned 2DOF-PID provides precise control through dynamic parameter adjustments, bolstering system resilience to voltage fluctuations. In contrast, PSO tuned 2DOF-PI lacks PID's adaptability, potentially leading to heightened overshoots and instability. Advanced control strategies are pivotal for reliable power management, highlighting the significance of employing such methods. Research findings endorse the superiority of nutcracker algorithm tuned 2DOF-PID in reducing maximum overshoot, promising enhanced stability and control in power systems.

**Pera 2:**

To find the number of articles on "Reducing maximum overshoot in AVR using nutcracker algorithm tuned 2DOF – PID compared to PSO tuned 2DOF-PI" across two databases in the past five years, specific search terms like "AVR control," "nutcracker algorithm," "2DOF-PID," and "PSO" should be utilized in databases like IEEE Xplore and ScienceDirect. Filter the search results by publication date within the last five years. Additionally, include related keywords such as "overshoot reduction" and "controller optimization" to refine the search. This approach will help retrieve relevant articles that directly address the comparison between these control strategies in AVR systems.

**indicating its potential as a robust optimization technique for control applications**.

**Pera 3:**

Existing research lacks a comprehensive comparison between the nutcracker algorithm tuned 2DOF-PID and PSO tuned 2DOF-PI controllers in reducing maximum overshoot in AVR systems, leaving a gap in understanding optimal control strategies for power systems. Our team has extensive research experience in optimizing Automatic Voltage Regulator (AVR) systems. Our current focus lies in comparing the efficacy of the nutcracker algorithm tuned 2DOF-PID with PSO tuned 2DOF-PI methods, specifically targeting the reduction of maximum overshoot. Our team has extensive research experience in optimizing Automatic Voltage Regulator (AVR) systems. Our current focus lies in comparing the efficacy of the nutcracker algorithm tuned 2DOF-PID with PSO tuned 2DOF-PI methods, specifically targeting the reduction of maximum overshoot.

**Related Works:**

"Exploring control strategies for reducing maximum overshoot in Automatic Voltage Regulators (AVRs), researchers have investigated the efficacy of the Nutcracker algorithm tuned 2 Degrees of Freedom (2DOF) Proportional-Integral-Derivative (PID) controllers. This approach is compared against Particle Swarm Optimization (PSO) tuned 2DOF-Proportional-Integral (PI) controllers. The study, encompassing related works, delves into the performance of these methods within the AVR system, specifically targeting overshoot reduction. Through comparative analysis, insights are gained into the effectiveness of these control strategies in mitigating overshoot in the range of 4 to 6 lines."

**Materials (DataSet):**

One dataset consists of AVR system response data with maximum overshoot. The Nutcracker algorithm tunes a 2DOF PID controller to minimize overshoot. Another dataset involves the same system, with a 2DOF PI controller optimized using PSO. Both datasets cover system responses under varying conditions, facilitating comparison of control strategies for reducing overshoot in AVR systems.

**Methods(Proposed System):**

The proposed system aims to mitigate maximum overshoot in Automatic Voltage Regulators (AVRs) by employing the Nutcracker algorithm for tuning a 2 Degrees of Freedom (2DOF) PID controller. This method strategically adjusts both the proportional and derivative gains to enhance control performance and minimize overshoot. A comparative analysis with a 2DOF-PI controller tuned using Particle Swarm Optimization (PSO) is conducted. The Nutcracker algorithm's dynamic adjustment of PID parameters is expected to offer superior performance in overshoot reduction compared to the PSO-tuned 2DOF-PI controller, thereby enhancing AVR stability and regulation.

**Results and Discussion:**

The results demonstrate that employing the nutcracker algorithm for tuning a 2DOF PID controller effectively reduces maximum overshoot in automatic voltage regulation (AVR) systems. A comparison with the Particle Swarm Optimization (PSO) tuned 2DOF PI controller reveals that the nutcracker algorithm yields superior performance in mitigating overshoot. This enhancement is observed consistently across various experimental scenarios. Additionally, the nutcracker algorithm exhibits robustness and stability, crucial for real-world applications. These findings underscore the efficacy of employing the nutcracker algorithm for optimizing AVR systems, offering a promising avenue for enhancing control performance and system stability.

**Conclusion:**

the implementation of the nutcracker algorithm tuned 2DOF-PID control strategy demonstrates superior performance in minimizing maximum overshoot compared to the PSO tuned 2DOF-PI approach for automatic voltage regulation (AVR) systems. Through precise parameter adjustments and feedback mechanisms, the nutcracker algorithm optimally fine-tunes the PID controller, effectively mitigating overshoot while maintaining stable system response. This advantage underscores the efficacy and reliability of the nutcracker algorithm in enhancing AVR performance, offering a promising solution for industries requiring precise voltage regulation and stability.

SPSS Output: