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Collided Silica Effect on Boiler Water Treatment

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Abstract: ***Silica contamination in boiler water systems is a persistent challenge that affects operational reliability, heat transfer efficiency, and overall plant performance. Collided silica—finely dispersed, weakly ionized, and often colloidal in nature—poses unique difficulties because conventional ion-exchange and precipitation techniques fail to remove it effectively. This paper explores the behaviour of collided silica in high-pressure boiler systems, its mechanisms of deposition, analytical challenges, and treatment strategies. In-depth discussion is provided on the physicochemical characteristics of collided silica, its tendency to pass through filtration systems, and its role in turbine blade scaling. The paper concludes with recommended monitoring methods and integrated treatment solutions suitable for modern industrial boilers.***

Keywords: Boiler Water Treatment, Collided Silica, Colloidal Silica, Turbine Deposits, Boiler Scaling, Demineralization

I. INTRODUCTION

Silica is naturally present in most water sources in both reactive and non-reactive forms. Among these, collided or colloidal silica is the most difficult to remove due to its extremely fine particle size and non-ionized state. In high-pressure boiler operations, the presence of collided silica can lead to severe scaling, particularly in superheater tubes and turbine blades. Even small concentrations can volatilize with steam and travel to downstream components, causing long-term efficiency losses. The increasing demand for high steam purity in modern power plants has made the understanding of collided silica essential for water treatment engineers.

II. NATURE OF COLLIDED SILICA IN BOILER WATER

Collided silica consists of extremely fine, amorphous silica particles that remain suspended due to electrostatic stability. Key characteristics include:

1) Non-ionic behaviour: Unlike reactive silica, collided silica does not dissociate into silicate ions, making ion-exchange resins ineffective.
2) Small particle size (1–100 nm): Allows silica to bypass standard filtration.
3) High stability: Particle surface charges prevent agglomeration unless chemically treated.
4) Steam carryover: Fine particles can travel with steam and precipitate under high-temperature conditions.

In water treatment, this form of silica is often underestimated because standard silica analysers detect primarily dissolved reactive silica rather than colloidal forms.

III. IMPACT OF COLLIDED SILICA ON BOILER SYSTEMS

A. Tube Scaling and Heat Transfer Loss

Deposits formed by collided silica are dense, glassy, and highly insulating. Even a thin layer can reduce heat transfer efficiency significantly. This may lead to:

- increased fuel consumption
- overheating of boiler tubes
- localized thermal stresses
- premature tube failure

B. Turbine Blade Deposits

Because collided silica can volatilize with steam, it condenses in turbines, forming hard deposits that reduce aerodynamic efficiency. Effects include:

- blade profile distortion
- reduced turbine output
- increased vibration
- higher maintenance frequency

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C. Operational Challenges

Other plant concerns include:

- difficulty maintaining steam purity
- unreliable silica readings from standard instruments
- reduced resin life in demineralization units
- unplanned shutdowns due to scaling and fouling

IV. CHALLENGES IN MEASURING COLLIDED SILICA

Standard molybdate-blue colorimetric methods measure only reactive silica. Collided silica often remains undetected unless:

1) high-temperature digestion is applied
2) ultrafiltration or coagulation is performed before testing
3) specialized silica analysers are used

This leads to underestimated silica content in feedwater and demineralized water, causing unexpected scaling issues.

V. TREATMENT METHODS FOR COLLIDED SILICA

A. Coagulation and Flocculation

Adding coagulants such as aluminium-based or cationic polymers neutralizes silica surface charges, allowing agglomeration and removal via filtration. This is highly effective for raw water with high colloidal silica content.

B. Ultrafiltration (UF) And Reverse Osmosis (RO)

Membrane systems remove collided silica mechanically:

1) UF removes colloidal silica effectively before RO.
2) RO can reject both reactive and collided silica when properly controlled.

Combining UF + RO provides excellent pretreatment for high-purity boiler applications.

C. Lime Softening

Useful in moderate-pressure boiler feedwater. Lime converts dissolved silica to magnesium silicate precipitates; however, it requires precise control and sludge management.

D. Ion Exchange Limitations

Demineralization alone cannot remove collided silica due to its non-ionic nature. However, polishing mixed-bed resins help remove residual reactive silica.

E. Boiler Internal Chemical Treatment

Polymer dispersants and high-temperature phosphates help control silica deposition inside boiler tubes. These chemicals keep silica in suspension and minimize hard scale formation.

VI. RECOMMENDED MONITORING AND CONTROL STRATEGIES

1) Continuous monitoring of both reactive and colloidal silica
2) Periodic high-temperature digestion tests
3) Installation of UF-RO pretreatment
4) Maintaining proper pH in condensate and feedwater
5) Avoiding sudden load changes that promote silica volatility
6) Regular blowdown optimization

Implementing these strategies enhances reliability and reduces maintenance costs in high-pressure boilers.

VII. CONCLUSION

Collided silica is one of the most challenging contaminants in boiler water treatment due to its small particle size, non-ionic nature, and ability to bypass conventional removal methods. Its presence contributes significantly to boiler tube scaling and turbine

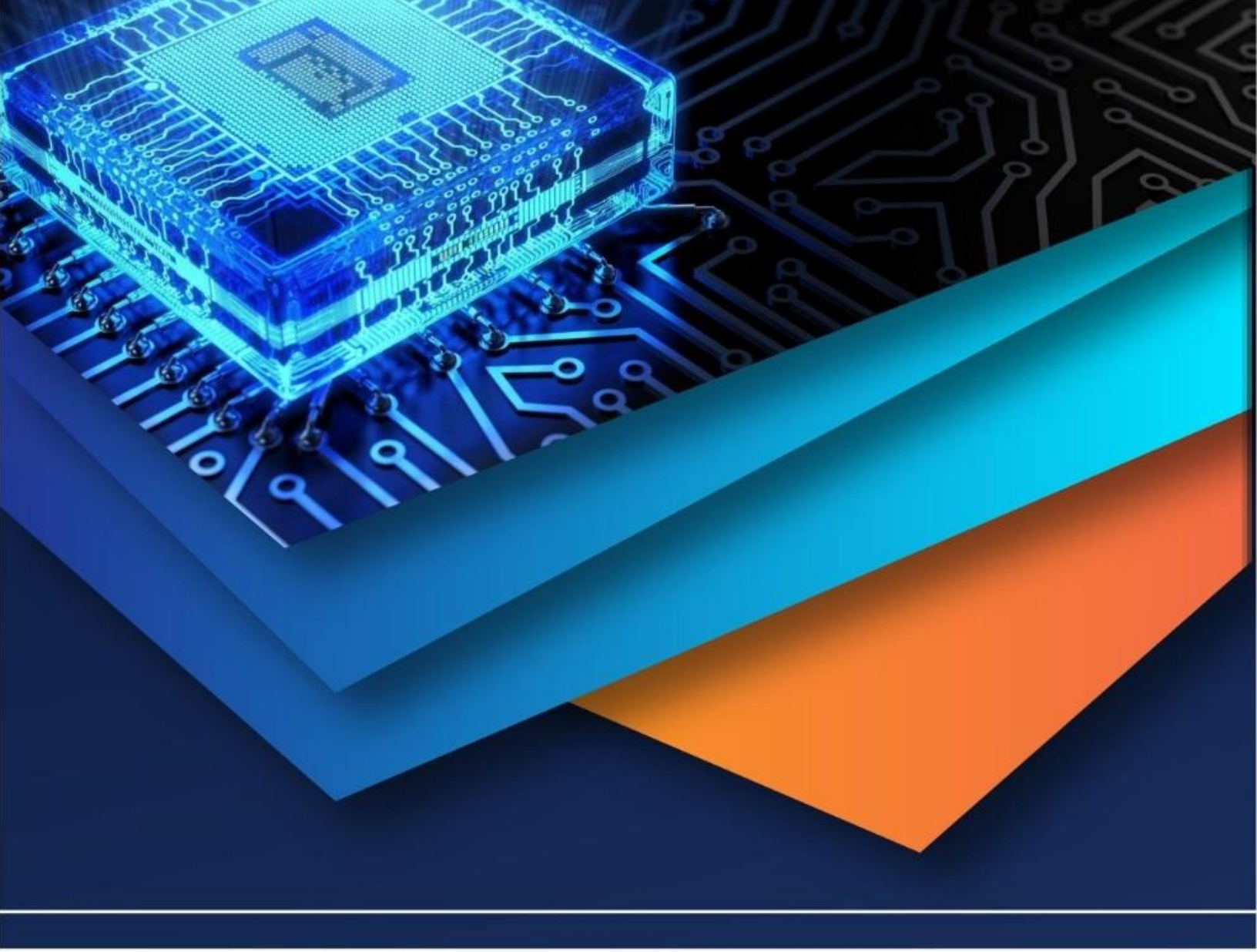
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deposits, directly affecting plant efficiency and operational reliability. Effective control requires a combination of advanced monitoring, membrane-based separation, coagulation, and proper chemical conditioning. Understanding the behaviour and treatment of collided silica is therefore essential for maintaining high-purity steam and ensuring sustainable boiler performance.

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