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A Review Paper on Fire Side Erosion of Economizer Tubes

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ABSTRACT: Economizers are essential components in industrial processes and power generation systems, responsible for recovering waste heat from flue gases. However, economizer tube erosion poses a significant challenge, compromising the efficiency and longevity of these systems. Economizer tube erosion is a significant concern in industrial settings, fire side economizer tube erosion, also known as fire side erosion, is a specific type of economizer tube damage that occurs due to the effects of high-temperature and high-velocity combustion gases on the surfaces of the economizer tubes. This review paper explores the various reasons behind fire side erosion of economizer tube and offers solutions to mitigate this issue.

Keywords: Fire side erosion, erosion, baffle plates, abrasive particles

I. INTRODUCTION

Fire side economizer tube erosion, also known as fire side erosion, is a specific type of economizer tube damage that occurs due to the effects of high-temperature and high-velocity combustion gases on the surfaces of the economizer tubes. This phenomenon is particularly relevant in industrial boilers and power plants where economizers are used to recover heat from flue gases before they exit through the stack.

Fire side economizer tube erosion typically appears in the form of pitting, grooving, or thinning of the tube walls. The severity of erosion may vary depending on factors like the fuel used, combustion conditions, and the design of the economizer.

Erosion of economizer tubes reduces their effectiveness in transferring heat from the flue gases to the feed water, diminishing the overall thermal efficiency of the boiler or power plant.

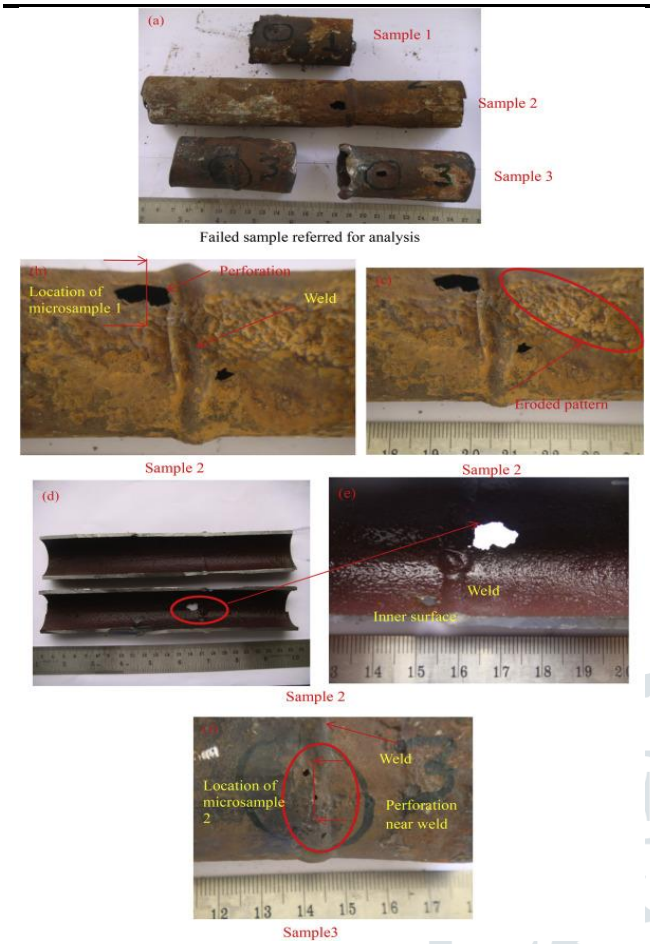

Fig.1: Sample of fire side erosion

II. CAUSES OF FIRE SIDE EROSION

Erosion of economizer tubes in a boiler can occur due to various factors, and fire side erosion is one of them. Fire side erosion of economizer tubes refers to the wear and deterioration of these tubes on the side exposed to the hot gases and flames from the combustion process. Several reasons can contribute to fire side erosion of economizer tubes:

1. High Gas Velocity

High gas velocities in the flue gas path can lead to erosion of the economizer tubes. Fast-moving gases can carry abrasive particles like ash, soot, and other contaminants that can impact the tube surfaces. Flue gas velocity can play a significant role in causing economizer tube erosion due to several interrelated factors:

Abrasion: High flue gas velocities can carry abrasive particles such as ash, soot, and unburned carbon at a much higher speed. When these particles impinge on the economizer tube surfaces at high velocities, they can cause mechanical wear and abrasion, gradually eroding the tube material.

Turbulence: Increased gas velocity can result in turbulence within the flue gas path. Turbulent flow can lead to the erratic and chaotic movement of particles, making them more likely to impact and erode the tube surfaces.

Localized Erosion: Erosion is not uniformly distributed across the tube surfaces. Areas where the gas flow changes direction, encounters bends, or is obstructed by other components can experience more severe erosion due to abrupt changes in velocity. These localized areas may be particularly vulnerable to erosion.

Increased Impact Energy: The kinetic energy of the gas particles is directly proportional to their velocity. Higher gas velocities mean that particles have more energy when they strike the tube surfaces, increasing their erosive potential.

Wear on Tube Material: Over time, the constant impact of high-velocity flue gas particles can wear down the tube material, causing thinning and eventual perforation. As the tube material becomes thinner, it becomes even more vulnerable to erosion.

2. Abrasive Particles

The presence of abrasive particles in the flue gas, such as ash, fly ash, or soot, can cause erosion when they impinge on the economizer tubes over time. This is particularly common in coal-fired and biomass boilers. Here's how abrasive particles can cause erosion of economizer tubes:

Impact Energy: Abrasive particles, such as ash, soot, dust, and other solid contaminants, are carried by the flue gas at varying velocities. When these particles collide with the economizer tube surfaces, they transfer kinetic energy, leading to localized stress on the tube material.

Material Removal: The repeated impacts from abrasive particles gradually remove small amounts of material from the tube surface with each collision. Over time, this results in thinning of the tube wall, making it more susceptible to further erosion and eventually perforation.

Localized Erosion: Erosion is not uniformly distributed across the entire tube surface. Instead, it often occurs more significantly in areas where the gas flow or particle concentration is higher. These localized areas may experience accelerated wear and thinning.

Increased Gas Velocity: Higher gas velocities can exacerbate the erosive impact of abrasive particles. As the gas velocity increases, the kinetic energy of the

particles also increases, making their impact more forceful and erosive.

Surface Roughening: Erosion can lead to surface roughening, which further accelerates erosion. The roughened surface provides irregularities where abrasive particles can become trapped and cause more rapid material removal.

3. Low tube material

The hardness of the tube material is essential to resist erosion. Using materials with low hardness can make the economizer tubes more susceptible to erosion.

4. Tube Geometry

Tube geometry can play a role in causing fire side erosion of economizer tubes. While tube geometry itself may not be the direct cause of erosion, certain tube designs and configurations can contribute to localized erosion by influencing the flow of hot gases and particulate matter in the flue gas path. Here's how tube geometry can be a factor in fire side erosion:

Sharp Bends: Tubes with sharp bends or tight angles can disrupt the smooth flow of flue gases. As the gases navigate these sharp bends, they can become turbulent, leading to higher velocities and changes in direction. The turbulence can cause abrasive particles to impact the tube surfaces with greater force, leading to erosion at these locations.

Sudden Changes in Direction: Similar to sharp bends, sudden changes in the direction of economizer tubes can create turbulence, which can result in localized erosion. Abrasive particles in the flue gas may not follow the altered flow path smoothly, increasing their erosive potential.

Obstructions: If there are obstructions or protrusions inside the economizer that affect the flow of flue gas, it can cause localized turbulence and erosion in the vicinity of these obstacles. These obstructions can disrupt the flow pattern and lead to more significant erosive forces in certain areas.

Residence Time: The geometry of economizer tubes can influence the residence time of flue gases in the system. Areas with extended residence time may experience more exposure to abrasive particles, which can exacerbate erosion in those locations.

5. Insufficient Tube Thickness

If the economizer tubes are too thin, they may not withstand the erosive forces from the hot gases and abrasive particles, leading to premature erosion.

6. Low Tube Material Hardness

The hardness of the tube material is essential to resist erosion. Using materials with low hardness can make the economizer tubes more susceptible to erosion.

7. Lack of Adequate Maintenance

The lack of adequate maintenance can significantly contribute to fire side erosion of economizer tubes in a boiler system. Maintenance plays a crucial role in preventing and addressing erosion-related issues. Here's how the lack of maintenance can lead to fire side erosion:

Accumulation of Deposits: Over time, economizer tubes can accumulate deposits of ash, soot, and other particulate matter from the combustion process. These deposits can create a layer on the tube surfaces, which acts as an insulator. As a result, the economizer tubes may become less efficient at transferring heat from the flue gas to the feed water. This reduced efficiency can lead to localized overheating and, in extreme cases, lead to tube deformation or rupture.

Erosion Due to Deposits: Deposits on the tube surfaces can trap abrasive particles, and as the hot gases flow over these deposits, the abrasive particles can create localized erosion. The erosive forces are intensified in the presence of deposits because the particles can become embedded and cause more rapid wears.

Reduced Efficiency: A lack of maintenance can lead to reduced thermal efficiency of the economizer. Reduced efficiency can result in higher flue gas temperatures, which, in turn, can increase the erosive potential of the hot gases on the economizer tubes. Higher gas temperatures can lead to more severe erosion.

Corrosion and Material Degradation: Inadequate maintenance can also result in the build-up of corrosive materials or chemicals on the tube surfaces. Corrosion can weaken the tube material, making it more susceptible to erosion. Corrosion can lead to pitting and thinning of the tube walls.

Missed Inspections: Routine inspections are necessary to identify areas of erosion or thinning on economizer tubes. The lack of inspections can result in missed opportunities to detect and address erosion issues before they become severe.

III. PREVENTIVE MEASURES

Mitigating and preventing fire side erosion of economizer tubes in a boiler is crucial for maintaining the efficiency and longevity of the system. Here are

some solutions and preventive measures to address fire side erosion of economizer tubes:

1. Prevention against high gas velocity

To mitigate economizer tube erosion caused by flue gas velocity, you can take several actions, as mentioned earlier:

Control and optimize the flue gas velocity to reduce the erosive impact on the tubes.

Use erosion-resistant materials for the tubes.

Install baffle plates and flow deflectors to distribute the gas flow more evenly.

Consider refractory coatings or erosion-resistant coatings to provide a protective barrier.

Implement regular inspection and maintenance practices to identify and address erosion in its early stages.

Controlling gas velocity is a key factor in reducing the erosive forces acting on economizer tubes. Proper design and operational adjustments can help minimize the negative impact of flue gas velocity, ultimately extending the life of the tubes and maintaining the efficiency of the boiler system.

2. Prevention against abrasive particles

To prevent and mitigate the erosion of economizer tubes by abrasive particles, several strategies can be employed:

Material Selection: Use materials for economizer tubes that have higher resistance to erosion, such as alloy steel materials.

Regular Maintenance: Implement routine cleaning and inspection to remove deposited particles and identify areas of erosion.

Gas Velocity Control: Adjust flue gas velocities to minimize the impact of abrasive particles. Lower gas velocities can reduce the erosive forces acting on the tubes.

Baffle Plates and Flow Deflectors: Install components within the economizer to evenly distribute the flow of flue gas, which can reduce localized erosion.

Refractory Coatings: Apply refractory or erosion-resistant coatings to the tube surfaces to create a protective barrier against abrasive particles.

3. Tube geometry

To address fire side erosion related to tube geometry, it's essential to consider the following strategies:

Design Optimization: When designing economizer tubes, minimize the use of sharp bends and abrupt changes in direction. Use smoother curves and designs that promote laminar flow and reduce turbulence.

Flow Deflectors and Baffle Plates: Install flow deflectors and baffle plates within the economizer to evenly distribute the flow of flue gases. These components can help reduce localized turbulence and erosion.

Material Selection: Choose tube materials that are resistant to erosion and can withstand the abrasive forces generated by changes in gas flow patterns.

Regular Inspection: Implement routine inspections to identify areas of erosion and tube wear. Address erosion promptly to prevent it from progressing.

By optimizing tube geometry and flow patterns within the economizer, you can minimize the potential for fire side erosion and extend the life of economizer tubes in a boiler system.

4. Adequate maintenance

To prevent fire side erosion of economizer tubes due to the lack of adequate maintenance, consider the following actions:

Establish a Maintenance Schedule: Develop a comprehensive maintenance schedule that includes routine cleaning, inspections, and preventative measures to remove deposits and address erosion-related issues.

Regular Cleaning: Implement periodic cleaning procedures to remove deposits and contaminants from the economizer tubes.

Inspection and Monitoring: Conduct regular inspections to identify areas of erosion and thinning. Implement non-destructive testing methods, such as ultrasonic testing, to assess the condition of the tubes.

Prompt Repairs and Replacements: Address erosion-related issues promptly by repairing or replacing damaged economizer tubes to prevent further deterioration.

Proper Record Keeping: Maintain detailed records of maintenance activities, inspections, and repairs for reference and trend analysis.

By ensuring that maintenance is a priority and that economizer tubes are kept in optimal condition, you can mitigate the risk of fire side erosion and extend the lifespan of the tubes, ultimately contributing to the overall efficiency and reliability of the boiler system.

5. Use of Erosion-Resistant Materials

When designing or replacing economizer tubes, consider using erosion-resistant materials. These materials are better suited to withstand abrasive conditions. High-alloy materials or coated tubes are often used to resist erosion.

6. Proper Soot blowing

Regular and effective soot blowing is essential to remove ash and soot deposits from the economizer tubes. It helps prevent the build-up of abrasive materials that can lead to erosion. Ensure that soot blowing is carried out according to a well-defined schedule and is performed correctly to cover all parts of the economizer tubes.

7. Regular Inspections

Regularly inspect the economizer for signs of erosion, including thinning tube walls, pitting, or other damage. Early detection allows for preventive action to be taken before extensive erosion occurs.

IV. CONCLUSION

In conclusion, economizer failure and tube erosion on the fire side are critical challenges in industrial boiler and HVAC systems that can lead to energy inefficiency, operational issues, and safety concerns. To prevent these failures and maintain the optimal performance of economizers, it's crucial to:

Regularly inspect and maintain economizer systems to identify potential issues early.

Ensure proper design and installation, following manufacturer's specifications and industry standards.

Address economizer tube erosion through proper soot blowing, adjusting fuel combustion, and using erosion-resistant materials.

Optimize gas flow, inspect for erosion regularly, and consider protective coatings and advanced monitoring systems.

By implementing these preventive measures and addressing potential failures promptly, we can enhance energy efficiency, extend the lifespan of our equipment, and ensure the safety of your systems and personnel.

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