ECONOMIC IMPACTS AND SOLUTIONS FOR WASTE TO ENERGY BOILER CORROSION MANAGEMENT

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ABSTRACT: For the past 15 years, field automated weld metal overlay technology has played a pivotal role in the cost-effective management of corrosion damage to furnace waterwalls. The next generation of economic impact is the utilization of weld overlay technology advancements for addressing upper furnace (superheater, etc.) corrosion management challenges.

GENERAL WTE BOILER CORROSION MECHANISMS

Municipal waste contains various constituents and impurities that induce corrosion attack on boiler tubing. Among the leading contributors are chlorine, sulfur, zinc, lead, sodium and potassium. During boiler combustion, various metallic chlorides and sulfates as well as HCl and SO_2 are formed and then deposited on the cooler surfaces, such as waterwall and superheat tubes. Based on the low melting point and high vapor pressures of many metallic chlorides, when carbon and low alloy steels are in contact with these chloride salts a severe corrosion attack can and will occur. Additionally, flue gas streams can contain HCl gas which also can create chloride attack on steel.

Superheater Tube Failure

The reason why low alloy steel is so susceptible to chloride attack via chloride salts (deposits and/or vapors) and HCl gas is because iron chlorides have very high vapor pressures. This translates into a situation in which as soon as the boiler tube metal reacts with chloride salt deposits/vapors and HCl, iron chlorides are formed and again vaporized, and so on.

METALLURGY/MATERIAL SELECTION PRINCIPLES

1st Principle: Reducing iron content in the boiler tube metallurgy will reduce iron chloride formation.

2nd Principle: Replace iron content with nickel. Nickel chlorides have much lower vapor pressures hence better resistance to chloride attack.

3rd Principle: Rely on an alloy that will create a corrosion protective scale formation. Chromium is excellent in the formation of a chromium oxide scale even in lower temperature ranges.

4th Principle: Utilize molybdenum for resistance to high temperature chloride attack at temperatures up to 1100° F

WHY AUTOMATED WELD OVERLAY?

Waterwalls

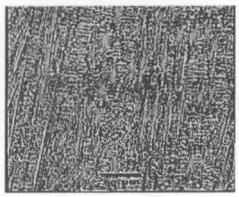
Once the proper material for a specific boiler application is selected, the technology for applying the specified metallurgy to the boiler tubes is equally critical to a long-term solution. Automated weld metal overlay has been utilized over the past 15 years in over 170 WTE projects using over 900,000 lbs. of Alloy 625 wire. The reason for the selection can be attributed to the following characteristics:

1) Full Fusion Bond to Base Metal

- Capable of restoring tube pressure boundary on tubes as low as .080"
- Excellent heat transfer

2) Homogeneous Dense Microstructure

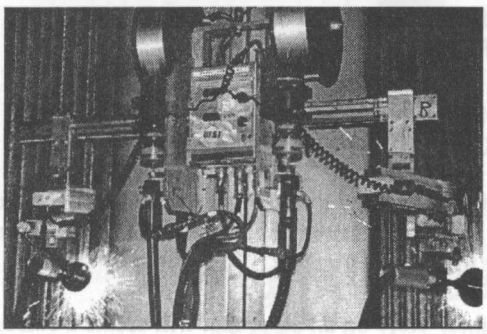
- Optimum Longevity
- Reduced maintenance/downtime



Microstructure
(50 um)

3) Schedule/Production Impacts

- 25 – 35% faster than replacement
- Shorter boiler outages



New Dual Head System

4) Field Application

- 30% - 40% Less ($) Than Replacement with Upgraded Metallurgy

The combination of these strengths has created significant economic improvements in the cost of waterwall corrosion management for the waste to energy industry over the past 15 years.

WHY AUTOMATED WELD OVERLAY?

Upper Furnace

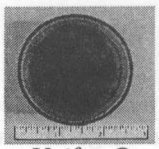
The same performance characteristics of weld overlay that have been successful in the waterwall section of the boiler have applicability to the upper furnace.

In order for automatic weld overlay to be feasible for loose tube replacements, ductility had to be improved to accommodate bending requirements. Hence, WSI developed a patent pending advanced shop weld overlay process that improves conventional weld overlay ductility by 40+%:

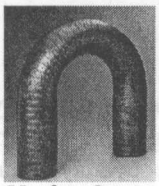
	PSGMAW	Unifuse 360°
HAZ Hardness*	35	24
O.D. Tolerance	±.030"	±.005"

*Rockwell C

A fully automated assembly line rotates and travels tubes up to 50' in length to provide 360° of Unifuse weld overlay protection. The improved ductility creates bending capabilities up to 1D radius bends on 1 ¼" tubing.



Unifuse® 360° tube

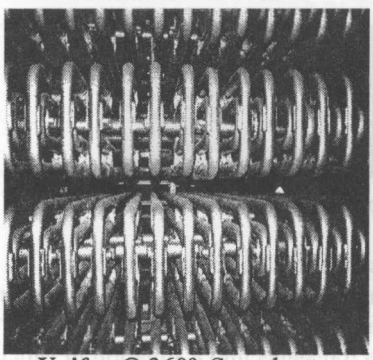


Unifuse® 360° bent tube

GMAW bent tube

TECHNICAL/ECONOMIC ADVANTAGES

- No dissimilar metal welds (Future Failure Mechanism)
- Less expensive than wrought high alloy tubes
- Significant reliability/maintenance improvement over shields
- Alloy versatility
- Start and stop weld overlay protection readily (i.e. If entire assembly did not need protection or different alloys were appropriate)
- Significant slag formation reductions leading to improved boiler efficiency



Unifuse® 360° Superheater

Detached Shields

ECONOMIC MODEL

A representation of the cost benefits achievable on a major waste to energy boiler utilizing conventional corrosion management practices is reflected below:

1st two superheater elements economic model

Model basis

- 1st two stages/elements of the superheater receive the most aggressive corrosion attack
- Boiler production value = $40,000/day
- Superheater element life expectancy = 5 years*
- Boiler tube failure downtime impact = 36 hrs/failure
- Maintenance cost per failure = $60,000/failure

(*NOTE: Every boiler has different operating conditions. Our experience indicates a 2X life expectancy of ***Unifuse®*** versus conventional techniques)

Economic Analysis

Cost Impact	Conventional T22 w/shielding	*Unifuse®* 360°
Installation Cost	$1,000,000	$1,787,500
Annual Maintenance	$ 100,000	$ 10,000
# Boiler Tube Failures/yr. (0 in year 1)	3	0.2
Downtime Costs (# Failures x 40,000/day x 36hrs)	$ 180,000/yr	$ 12,000/yr
Failure related maintenance costs ($60,000 x # failures)	$ 180,000/yr	$ 12,000/yr
Cumulative 2 year costs	$1,460,000	$1,821,500
Cumulative 4 year costs	$2,380,000	$1,889.500
Cumulative 6 year costs	**$3,840,000**	**$1,957,500**

FUTURE INITIATIVES

Based on the economic savings potential defined herein, initiatives are underway to provide commercial offerings which resolve the short term return on investment limitations and make available the significant long term value. Cooperative efforts are necessary to ensure optimum technical (metallurgy selection) and commercial packaging initiatives are facilitated to realize future financial savings in the upper furnace that have already been achieved over the past 15 years in the waterwalls.