

high-alloyed NiCrFe-alloy like UNS N08825 on the outside was developed to increase the corrosion resistance and decrease the susceptibility to cracking. The new composite tube showed resistance against SCC and thermal fatigue that was superior to the previous composite tubes based on UNS S30400.⁷

Achieving higher efficiency in recovery boilers required the tubes to operate at higher temperatures and pressures and in more corrosive fire-side environments, especially in the lower boiler areas and new airport designs. As nickel alloys are more corrosion-resistant and less susceptible to SCC, a new composite tube with UNS N06690 (alloy 690) on the outside was developed. UNS N06690 was chosen because it has shown extremely good resistance against SCC in other corrosive environments.

UNS N06690 has a lower thermal expansion than stainless steel, previously used in composite tubes. The lower thermal expansion results in a volume change during heating closer to the properties of ferritic carbon steel, making the product less susceptible to cracking during thermal cycling. UNS N06690 also shows better structure stability and lower work-hardening rates than other nickel alloys, such as UNS N06625. Corrosion tests⁸ compared the resistance of UNS N06690 and other alloys to SCC.

Installation Examples:

Composite tubes with a corrosion-resistant layer of UNS N08825

The first "full floor" installation in a black liquor recovery boiler has been in service since 1996. The tubes have been in operation for 27 years.

Composite tubes with a corrosion-resistant layer of UNS N06690

Alloy 690 composite tubes were installed in 2014 in a pulp and paper mill.

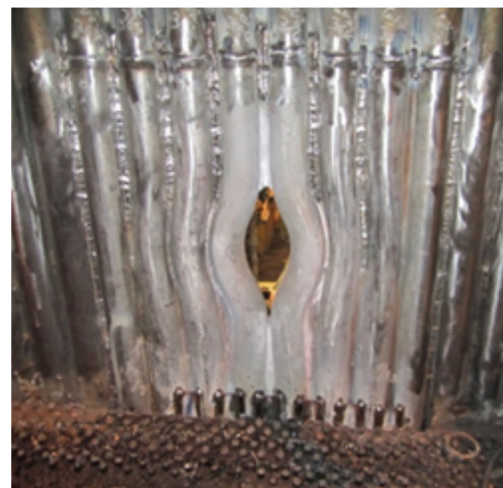


FIGURE 4 Left—full floor installation UNS N08825 composite tubes; Right—airport two inner UNS N06690 and six UNS N08825 composite tubes.

They replaced cracked and corroded 304L composite tubes originally installed in airports.

Conclusions

In recent years, many innovative steel grades or products have been developed for the industry to avoid corrosion problems, increase process efficiency, reduce costs, and increase safety. To develop these products, a high level of material and product development expertise is necessary. However, only long-term customer relationships with leading actors in different industries make these success stories possible.

References

- 1 J.O. Nilsson, "The Sandvik Handbook to physical metallurgy—stainless steels and special metals," Sandvik AB, S-GE038-B, 2013; p.14.
- 2 K. Tersmeden, P. Kangas, "Successful use of special stainless steels in nitrogen-based fertilizer plants," Sandvik R&D Center, S-52-87-Eng, March 1996.
- 3 T. Eilersson, A. Leijonberg, "Recovery boiler furnace floor-melt side damages," Proceedings of the 7th International Symposium on Corrosion in the Pulp & Paper Industry, held November 1992 (Atlanta, GA: TAPPI Press, 1992), pp. 259–265.
- 4 S. Ingevald, L. Kiessling, "Stress and corrosion induced damages in the lower fur-

nace of recovery boilers," Proceedings of the 7th International Symposium on Corrosion in the Pulp & Paper Industry, held November 1992 (Atlanta, GA: TAPPI Press, 1992), pp. 285–297.

- 5 L.P. Karjalainen, "Cracking failures in composite tubes in kraft recovery boilers," Proceedings of the 7th International Symposium on Corrosion in the Pulp & Paper Industry, held November 1992 (Atlanta, GA: TAPPI Press, 1992), pp. 243–250.
- 6 M. Mäkipää, et al., "Case studies on corrosion and material problems in black liquor recovery boilers," Proceedings of the 7th International Symposium on Corrosion in the Pulp & Paper Industry, held November 1992 (Atlanta, GA: TAPPI Press, 1992), pp. 277–283.
- 7 A. Wilson, U. Forsberg, "Sanicro38/4L7—a new composite tube for recovery boiler floors (Swedish)," Proceedings from the Swedish Black Liquor Recovery Conference, held 1994 (Stockholm, Sweden).
- 8 J. Kish, D.L. Singbeil, "Corrosion resistance of next-generation composite tube alloys for recovery boilers," CORROSION 2009, paper no. 09176 (Houston, TX: NACE International, 2009).

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