Application note

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Real-time zinc-nickel coating measurements

Thickness and composition analysis using the Niton XL5 Plus Handheld XRF Analyzer

Keywords

Non-destructive testing

HHXRF

Coating thickness

Zinc-nickel coatings

Quality control

Zinc-nickel (Zn-Ni) coatings are the result of an electroplating process that deposits a layer of zinc-nickel alloy onto the surface of a metal substrate, typically steel. Zn-Ni coatings offer superior corrosion resistance compared to pure zinc coatings and often replace cadmium coatings, as they provide comparable or better properties while complying with regulations such as REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals) and RoHS (Restriction of Hazardous Substances). Commonly used in the automotive, aerospace, and electronics industries, Zn-Ni coatings are often applied to fasteners, connectors, and structural parts exposed to corrosive environments.

Zn-Ni coatings typically consist of 85-93% zinc (Zn) and 7-15% nickel (Ni). The exact composition may vary depending on the application's specific requirements. The coating process involves electroplating, which consists of immersing the metal substrate in an electrolyte solution containing zinc and nickel ions. An electric current is then passed through the solution, causing the zinc-nickel alloy to deposit onto the substrate. To ensure that specifications for coated parts are met, metal finishing companies must verify both the coating thickness and composition.

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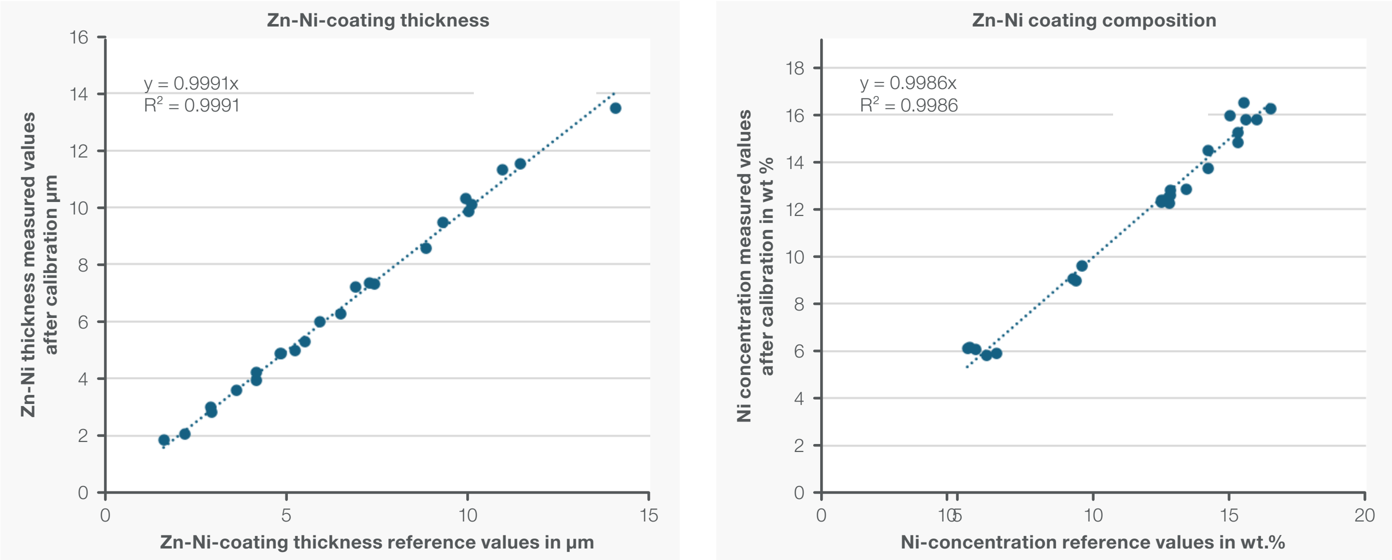

Figure 1. Calibration data and results of the calibration for the determination of a) Zn-Ni-coating thickness and b) Ni-concentration in the coating layer.

Instrumentation

X-ray fluorescence spectrometry (XRF) is the technology of choice for quality control of Zn-Ni plating, as it is the only analytical method that can determine the thickness and composition of the coating layer non-destructively. The use of handheld X-ray fluorescence spectrometry (HHXRF) instruments enables near-line analyses of finished products, which can be analyzed directly without being cut and brought to a separate chamber with benchtop instruments.

In previous work [1], the Thermo Scientific™ Niton™ XL5 Plus Handheld XRF Analyzer was demonstrated to be capable of measuring the coating weight or coating thickness of up to 4 layers of metal coatings on a substrate, using a proprietary standardless “fundamental parameters” algorithm. The layers and the substrate can be pure elements or alloys. Although the fundamental parameters algorithm can determine the thickness of Zn-Ni plating standardless, it delivers partial information, as the composition of the layer is not measured. To measure the composition and the thickness of the coatings simultaneously, another approach using empirical calibration can be deployed. The Niton XL5 Plus User Mode enables the operators to create their own calibration curves based on the measurements carried out on reference materials of Zn-Ni plated samples with known coating thickness and composition.

Calibration

The calibration has been performed using a set of 24 reference samples of low alloy steel coated with Zn-Ni and previously analyzed in a laboratory. The intensities of elements of interest, such as Fe, Zn, and Ni, as well as of additional elements and background regions, have been collected across the entire sample set.

The reference values have been computed to create a mathematical model that calculates both the Ni-Zn coating thickness and the Ni concentration as functions of the measured intensities. The blue curves in Figure 1a and 1b are the calibration results, which show a good correlation between the measured and reference values.

The calibration model equations are then entered into the program for each analyte, as shown in Figure 2 for Nickel.

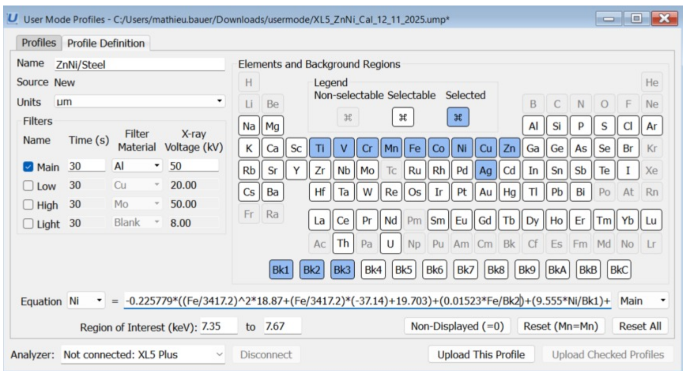

Figure 2. User mode configuration.

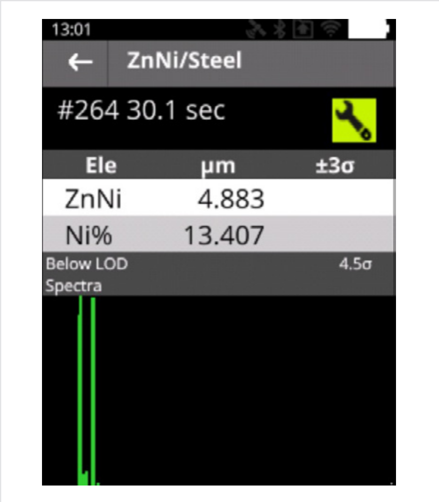

Figure 3. Exemplified results of analysis for Zn-Ni coatings of a sample with reference values of plating of 4.91 µm Zn-Ni and a coating layer containing 13.27% Ni.

Sample	Reference values		Measured values (30s)	
	Zn-Ni thick. (µm)	Ni content (wt.%)	Zn-Ni thick. (µm)	Ni content (wt.%)
A	4.91	13.27	4.88	13.41
B	2.27	12.68	2.42	12.26
C	7.92	13.3	8.04	13.08
D	9.12	6.02	9.06	6.17
E	4.01	9.34	3.85	9.39
F	8.39	8.94	8.94	8.80
G	11.80	15.9	11.86	16.66
H	10.00	14.8	10.07	14.99
I	8.50	14.2	8.43	14.03
J	6.20	13.45	6.35	13.26

Table 1. Results of Validation for the determination of Zn-Ni coatings thickness over steel and the Ni-concentration of the coating layer.

Validation

The calibrated instrument is then validated using samples that have also been analyzed in the laboratory but were not part of the calibration process. As shown in Figure 3, the Niton XL5 Plus handheld XRF analyzer provides accurate, real-time results for analyzing Ni-Zn coatings.

Table 1 summarizes the results of the analysis obtained for the samples analyzed in the validation process. There is excellent agreement between the reference and measured values for both the determination of the Zn-Ni coating thickness and the Ni composition.

Conclusion

Performing quality control of Zn-Ni coatings is essential for metal finishers to ensure the corrosion resistance of critical parts used in the automotive and aerospace industries. The Niton XL5 Plus analyzer calibrated with user mode for this application has demonstrated its ability to deliver accurate results and numerous benefits to the metal finishing industry, including but not limited to these:

- **Increased productivity** thanks to real-time, near-line results for faster process control and reduced rework.
- **Preservation of high-value parts** due to non-destructive testing that requires no cutting or damage.
- **A lower operational burden** with easy deployment and low total cost of ownership.

Reference

M. Bauer, Measuring Metal Coating Thickness at Line Using the Thermo Scientific Niton XL5 Plus XRF Analyzer, Thermo Fisher Scientific 2021