AN APPLICATIONS BRIEF FROM
SPECTRO ANALYTICAL INSTRUMENTS

Analyzing light elements in aluminum alloys for improved scrap recycling

Introduction

Alloys combining aluminum with metals such as copper, zinc, magnesium, manganese, silicon, and lithium are used extensively in applications from aerospace, automotive, and construction to utensil manufacturing. Since recycling of these alloys requires 95% less energy than primary aluminum production, mounting costs plus environmental concerns have made such recycling a major global industry.

A key consideration: recyclers may need to process hundreds of specialized aluminum alloys, each with different performance characteristics — and price points. Spectrometers utilizing multi-element analysis play critical roles in differentiating these alloy components. Handheld X-ray fluorescence (XRF) analyzers are the metal recycling industry's instruments of choice for many such applications.

This paper covers the use of one such instrument to analyze elements in varying recycling samples — even those incorporating the difficult-to-measure light elements aluminum, magnesium, and silicon. With improved light element performance plus easy calibration, flexible ease of use, high productivity, and a large metals database, it proved a powerful analytical tool for aluminum alloy recycling.

The scrap sorting challenge

To be economically practical, aluminum scrap metal consignments for recycling must be analyzed for sorting on the spot, quickly and easily.

Analysis by laboratory instruments is too time-consuming and expensive. So instrumentation makers have developed solutions embodied in various handheld XRF analyzers.

However, until recently, a major challenge remained. Many aluminum alloys incorporate light elements like magnesium and silicon for functions across a wide variety of industries that require lightweight strength. Thus more and more samples containing these alloys were appearing in the recycling stream. The amount of expensive processing, including remelting and re-refining, necessary depended on the exact composition of the alloy. So operators needed to sort incoming samples into a large number of specific wrought alloy and cast alloy grades.

Problem: handheld XRF analyzers had difficulty in measuring light elements such as magnesium and silicon. Readings were potentially at or below their limits of detection (LODs). Some instruments required substantial time — perhaps 60 seconds — to reliably measure light elements at all.

Fortunately, SPECTRO Analytical was able to increase the scope of capabilities of its SPECTRO xSORT analyzer. As detailed below, LODs were lowered to meet the light element alloy challenge.

Analyzer

The measurements discussed in this paper were made using a SPECTRO xSORT AlloyPlus handheld XRF spectrometer from SPECTRO Analytical Instruments. The company has supplied X-ray spectrometers to the metallurgical industries for many years; that experience is built into the xSORT line. This analyzer is an improved member of the xSORT family of instruments, which offers reliable on-site identification, analysis, and screening for every budget. It's designed to take the uncertainty out of scrap sorting, positively identifying alloy grades in seconds.

This AlloyPlus model utilizes a miniaturized, low-power X-ray tube rated at 50 kilovolts (kV), with a rhodium anode, providing exactly defined excitation for excellent stability and precision. This is complemented by a new high-count readout system and a high-resolution, high-sensitivity silicon drift detector (SDD). (These technologies are versions of those used in high-performance laboratory instruments like the top-of-the-line SPECTRO XEPOS analyzer.) They're combined to enable the handheld SPECTRO xSORT to furnish accurate, high-productivity spectrochemical analysis and screening of numerous elements in aluminum and aluminum alloy recycling and scrap metal sorting.

The SPECTRO xSORT used is field-proven to deliver metal grade identification in only 7 seconds for most aluminum alloys. (For light element performance, see "Detection limits" below.)

Efficient ergonomics plus simple, user-friendly displays help make the instrument extremely easy to use. Complete with battery pack, SPECTRO xSORT weighs less than 4 pounds (1.64 kilograms). To operate, the user grips the comfortable handle, presses the flexible X-ray safety gasket onto the sample, and pulls the trigger. The procedure is the same for almost all samples, and requires no method switching, helium purge, or vacuum. (Optional adapters can be added to handle, for example, small samples or wires; an optional docking station also provides extended analysis capabilities.)

The instrument's unique iCAL logic supplies easy one-sample, one-time standardization. Analytical results are clearly displayed on an integrated touchscreen. They can also be saved simultaneously to USB drive, network, or printer in XML or PDF form (WiFi capability is standard). An optional integrated camera for precise spot testing can also pair each result with an image of the subject sample. A large, flexible metals database easily accommodates new alloys, and lets the user extend prepackaged libraries or create customized grade libraries.

Finally, the instrument's automatic shutter fulfills two purposes: to protect internal components, and also to serve as sample material for the iCAL standardization. No separate sample or tedious operator standardization routine is required.

(Note that SPECTRO Analytical also offers an even more powerful solution for aluminum recycling analysis. The SPECTRO SPECTROTEST analyzer employs arc spark optical emission spectrometry (OES) in a larger but still mobile, field-ready form factor. It's designed for superior performance when even more precise metal analysis is required, or when materials are more difficult to identify — as in the case of trace lithium in aluminum alloys.)

Detection limits

As mentioned above, the presence of light elements in aluminum alloys to be recycled can prove problematic for handheld XRF analyzers. Some instruments required substantial time — on the order of 60 seconds per measurement — to reliably determine light elements.

SPECTRO Analytical Instruments recently included several technological innovations in its SPECTRO xSORT handheld analyzer, as detailed above. One primary goal: lowering LODs in the analysis of light elements, for speedy, reliable measurement.

Performance was then tested with samples containing a number of aluminum/light element alloys of differing grades. See tables below.

Results

As the results show, SPECTRO xSORT now possesses LODs that mean light elements no longer pose a serious challenge to identifying and sorting aluminum alloys.

SPECTRO xSORT was able to provide reliable identification and measurement of previously difficult light element components with twice (2X) the precision of previous models — and in half the time. The instrument can now successfully sort wrought alloys in the 2014/2024, 7050/7075, 6061/6063,

Tables: Identification and analysis of various aluminum alloys. Average of five measurements carried out with SPECTRO xSORT.

2014

Element	Measurement time	Measured Value [%]	Standard Deviation [%]	Actual Value [%]
Al	20s	92.9	0.1	92.89
Bi	2s	0.028	0.003	0.025
Cr	2s	0.028	0.002	0.05
Cu	2s	4.48	0.01	4.26
Fe	2s	0.459	0.004	0.46
Mg	5s	0.49	0.10	0.45
	20s	0.41	0.10	
Mn	2s	0.775	0.006	0.81
Ni	2s	0.043	0.002	0.028
Pb	2s	0.023	0.001	0.023
Si	5s	0.81	0.02	0.88
	20s	0.75	0.02	
Sn	2s	0.031	0.002	0.037
Ti	2s	0.035	0.001	0.03
V	2s	0.02	0.003	0.018
Zn	2s	0.033	0.001	0.029

2024

Element	Measurement time	Measured Value [%]	Standard Deviation [%]	Actual Value [%]
Al	20s	92.7	0.13	92.51
Bi	2s	0.008	0.002	0.008
Cr	2s	0.031	0.003	0.028
Cu	2s	4.55	0.07	4.55
Fe	2s	0.26	0.006	0.25
Mg	5s	1.47	0.15	1.57
	20s	1.3	0.11	
Mn	2s	0.65	0.008	0.66
Ni	2s	0.045	0.003	0.031
Pb	2s	<0.005		
Si	5s	0.18	0.03	0.25
	20s	0.21	0.017	
Sn	2s	0.013	0.003	0.015
Ti	2s	0.039	0.001	0.032
V	2s	0.016	0.004	0.022
Zn	2s	0.075	0.007	0.073

6061

Element	Measurement time	Measured Value [%]	Standard Deviation [%]	Actual Value [%]
Al	20s	97.31	0.09	97.23
Cr	2s	0.25	0.002	0.229
Cu	2s	0.314	0.002	0.3
Fe	2s	0.353	0.001	0.35
Mg	5s	1.01	0.09	1
	20s	0.95	0.08	
Mn	2s	0.053	0.001	0.052
Ni	2s	0.063	0.001	0.053
Si	5s	0.58	0.03	0.64
	20s	0.56	0.02	
Ti	2s	0.038	0.008	0.037
Zn	2s	0.089	0.001	0.08

6063

Element	Measurement time	Measured Value [%]	Standard Deviation [%]	Actual Value [%]
Al	20s	98.4	0.06	97.63
Cr	2s	0.013	0.001	0.006
Cu	2s	0.008	0.001	0.011
Fe	2s	0.21	0.003	0.19
Mg	5s	0.79	0.1	0.64
	20s	0.74	0.06	
Mn	2s	0.023	0.002	0.013
Pb	2s	0.019	0.002	0.011
Si	5s	0.47	0.02	0.42
	20s	0.45	0.02	
Ti	2s	0.024	0.001	0.014
Zn	2s	0.021	0.001	0.012

1100				
Element	Measurement time	Measured Value [%]	Standard Deviation [%]	Actual Value [%]
Al	20s	99.1	0.01	99.11
Cr	2s	0.029	0.003	0.021
Cu	2s	0.148	0.002	0.14
Fe	2s	0.503	0.002	0.5
Mg	5s	<0.19		-
	20s	<0.1		
Mn	2s	0.028	0.001	0.032
Si	5s	0.17	0.011	0.1
	20s	0.081	0.008	
Ti	2s	0.032	0.003	0.027
V	2s	0.008	0.002	0.02
Zn	2s	0.0351	0.0004	0.029

7050/7075					
Element	Measurement time	7050 Measured Value [%]	Standard Deviation [%]	7075 Measured Value [%]	Standard Deviation [%]
Al	5s	89.5	0.17	89.2	0.08
	20s	89.4	0.13	89	0.07
Cr	2s	0.015	0.002	0.26	0.003
Cu	2s	2.18	0.009	1.63	0.01
Fe	2s	0.13	0.002	0.19	0.003
Mg	5s	1.98	0.18	2.19	0.2
	20s	2.09	0.1	2.3	0.13
Mn	2s	0.007	0.001	0.035	0.002
Ni	2s	0.021	0.003	0.024	0.002
Si	5s	0.11	0.015	0.17	0.02
	20s	0.1	0.007	0.17	0.005
Ti	2s	0.036	0.002	0.047	0.004
Zn	2s	5.89	0.01	5.99	0.017
Zr	2s	0.11	0.001	0.041	0.001

For the identification and separation of 7050 and 7075, determining the correct Mg level is critical. The differentiation of these two very similiar grades can then be carried out based on the Zr content.

and even 1100 grade series, where magnesium is a critical component, sometimes in combination with other elements, in only 7 seconds!

So recyclers can now separate more grades in less time.

Conclusion

The SPECTRO xSORT handheld XRF analyzer provided good results in a timely fashion for all tested grades of aluminum and aluminum alloys, including wrought and cast alloys. Of particular note was xSORT's enhanced performance with alloys containing light elements. Basically, the instrument lets users identify and sort more alloys, faster, with increased precision.

The instrument proved itself an easy-to-use, dependable, and highly accurate tool for analyzing, identifying, and sorting aluminum-based metallic scrap. It can add value and increase profitability in the recycling process.

Choosing a handheld XRF analyzer

Handheld XRF spectrometers are not created equal. Make sure the instruments you consider can meet the needs of your specific PMI tasks with the right mix of proven performance, innovative features, and tested convenience. Look for the following benefits:

Field-proven performance and speed. Consider models that have proved they can perform well in challenging plant or field locations. One key for highly reliable yet high-volume PMI: the ability to deliver dependable results in seconds.

Operating flexibility. Some older models require time-consuming procedures such as switching analytical methods between samples, or demand helium purges or vacuum for accurate operation. Find an instrument that lets you analyze the alloys you need: simply, easily, and quickly.

Documentation/connection flexibility. Why get stuck with limited choice of results formats to document compliance? Flexible SPECTRO xSORT lets you save results in different formats at different destinations simultaneously. Save to USB drive, network, or printer as XML or PDF, and (via an integrated camera) combine with images of the sample measured.

Easy standardization and built-in protection. Try to find instruments that avoid tedious multiple-sample standardization. Example: SPECTRO xSORT provides unique one-sample, one-time standardization. The shutter even functions as the system's standardization sample, while also offering built-in protection of detector and tube, even when analyzing light elements.

Large metals database. Choose devices that can easily accommodate new alloys (e.g., with light elements) or materials. For instance, SPECTRO xSORT lets you extend prepackaged libraries and/or create new customized grade libraries.

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