Application Note

Instrument: GDS900

Bulk Analysis of High-Speed and Cold-Working Tool Steel

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Key Words: High speed, Cold-working, Tool Steel, GDS900 Atomic Emission Spectrometer

Introduction

Tool steels are alloyed steels with varying combinations of resistance to softening upon heating, wear resistance, and toughness. These properties are desirable in tools which must withstand repeated blows or punching, maintain a sharp edge, and hold up to high temperatures. High-speed tool steels include group "M" (Mo containing), and group "T" (W containing) materials that are used to make cutting tools. Other tool steels such as group "H" are designed to work in hot environments without deforming or softening. Group "D" tool steels demonstrate wear resistance at low temperatures. Group "A" air-hardening, cold-working tool steels are characterized by low distortion during heat treatment and have a balance of wear resistance and toughness.

Physical tests such as hardness, tensile yield, and elongation are not sufficient by themselves to classify tool steels. Chemical composition can be used as a definitive technique for classifying tool steels. The tool steel producer should control alloying composition of the heat to be sure it meets chemical specification and thereby have the desired properties for the targeted grade of tool steel. Expensive alloying ingredients are added to bring the heat into grade based upon the chemical analysis of the raw material. Control of the composition therefore offers a way of controlling cost and increasing the quality of the final product. Manufacturers that use tool steels should also verify the material before it is used. Tools are created for very specific use and if the chemical composition of the material is not correct then the tool will not withstand the stresses for which it was designed. The tool may fail prematurely adding additional replacement cost of the tool and any damages that may have been incurred.

Glow discharge atomic emission spectrometry (GDS) is a chemical analysis technique that is well suited for routine determination in a wide variety of materials including tool steels. It has the power to determine not only the amount of iron and carbon present, but the levels of alloying constituents such as Cr, V, W and Mo, as well as many other constituents. Tool steel producers can tailor the mechanical properties, hardness, abrasion resistance, and ability to hold a cutting edge at elevated temperatures of the tool steel by varying the levels of these elements.

Instrument Model

The LECO GDS900 is an atomic emission spectrometer that determines the elemental content of solid conductive materials by measuring the intensity of characteristic light emitted from the sample when excited. The glow discharge source uniformly removes (sputters) material from the sample surface, outperforming other excitation sources. Excitation of the atoms occurs in the glow discharge plasma discretely apart from the sample surface thereby reducing the metallurgical and chemical history inherent in all samples. Neutral atomic emission lines predominate the glow discharge spectra. While singly ionized transitions are observed in the glow discharge, the spectra are notably less complex than those produced by most other atomic emission techniques, resulting in few spectral interferences. In addition, the response of the typical glow discharge analytical line is linear and thus fewer wavelengths are required to determine the full range of concentrations.

The GDS900 offers state-of-the-art technology designed specifically for routine elemental determination in most ferrous and nonferrous materials. LECO's exclusive CCD-based design ensures measurement stability, flexibility, and analytical performance in a production environment.

Sample Preparation

Tool steels are prepared using a 120-grit zirconium oxide belt or disc.

Accessories

For sample surface preparation: Belt Grinder (LECO BG) or polisher (LECO PX).

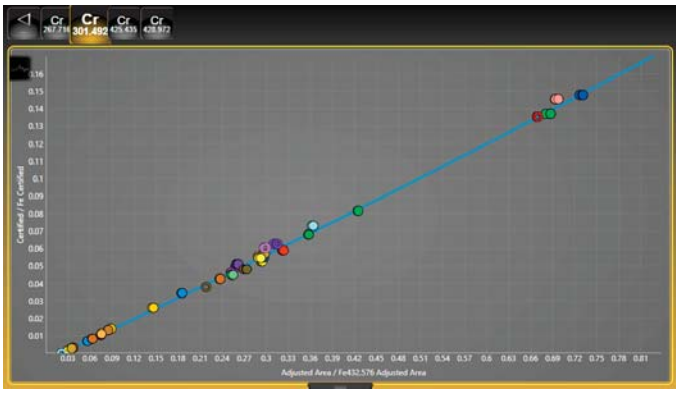
Calibration Curves

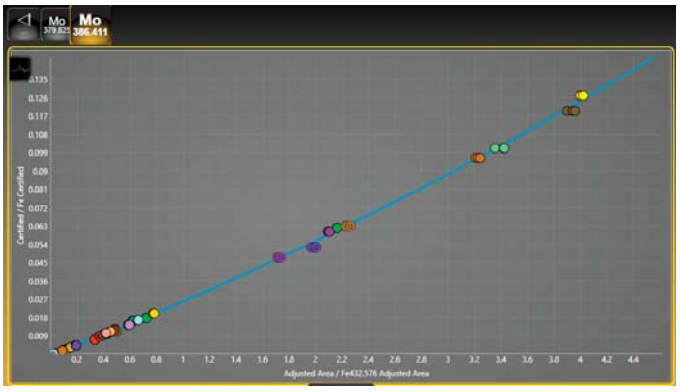
The chromium calibration curve includes high concentrations needed for Grade “D” high carbon, high chromium alloys, in addition to mid-level concentrations required for many other grades.

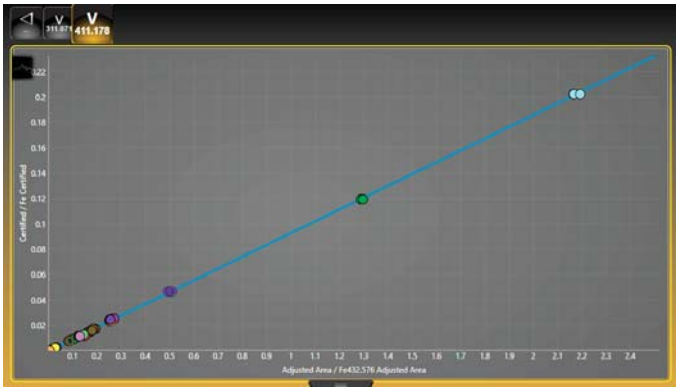
The molybdenum calibration curve includes alloy concentrations from low levels to high concentrations required for Grade “M” high-speed tool steels.

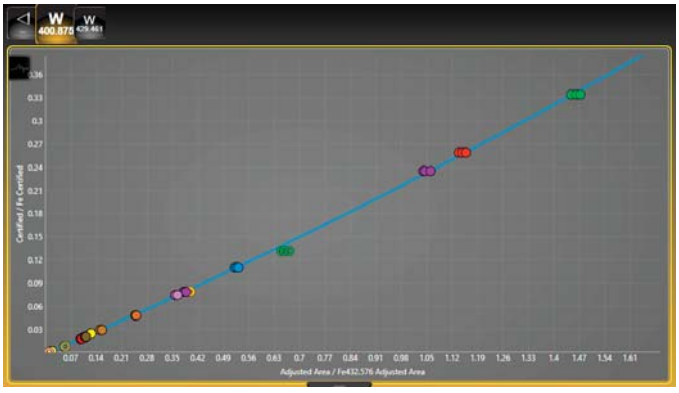
The vanadium calibration curve includes alloy concentrations from low levels to high concentrations required for Grade “A” air-hardening cold-working tool steels.

The tungsten calibration curve includes alloy concentrations from low levels to high concentrations required for Grade “T” high-speed tool steels.









Calibration Standards

A factory-installed tool steel calibration is offered based upon specific customer requirements. Working curves are comprised of Certified Reference Materials (CRM's) and Reference Materials (RM's), and may include standards from the following manufacturers: BAS, Brammer, and ARMI. Customer supplied calibration pieces are useful to complement the calibration

Drift Control of Calibration

Homogenous non-certified set-up standards (SUS's) are used to drift correct calibration curves. When necessitated by customer ranges or lack of suitable SUS material, RM's and CRM's may be substituted.

Analysis Times

The GDS900 has the ability to perform multiple analyses without dropping the sample. This is possible due to the sputtering away of material to reveal new untouched sample. Three analyses can be completed in a minute and a half when using the “analyze all in one spot” option in the software.

	Single Burn	Three Burns w/o Dropping
Start-up and Pre-burn	60 s	60 s
Analyze	10 s	10 s
Analyze	—	10 s
Analyze	—	10 s
Total	**70 s**	**90 s**

Typical Results

A-11 GRADE TOOL STEEL: BRAMMER BS10V

ELEMENT	CERT	AVG	STDEV	RSD	Run #1	Run #2	Run #3
Fe	79.57	79.64			79.66	79.62	79.64
C	2.46	2.43	0.01	0.50	2.42	2.43	2.44
Cr	5.41	5.40	0.01	0.25	5.39	5.40	5.41
Cu	0.076	0.075	0.001	0.77	0.076	0.075	0.074
Mn	0.52	0.52	0.005	1.05	0.515	0.523	0.513
Mo	1.30	1.30	0.001	0.08	1.297	1.299	1.298
Ni	0.080	0.089	0.0003	0.31	0.0893	0.0888	0.0891
P	0.019	0.017	0.0002	0.97	0.0172	0.0172	0.0169
S	0.079	0.074	0.001	0.72	0.074	0.073	0.073
Si	0.89	0.86	0.003	0.38	0.865	0.861	0.858
V	9.50	9.56	0.01	0.15	9.56	9.57	9.54
W	0.013	0.016	0.001	6.47	0.017	0.015	0.015

D-2 GRADE TOOL STEEL: BRAMMER BS37E

ELEMENT	CERT	AVG	STDEV	RSD	Run #1	Run #2	Run #3
Fe	84.18	84.21			84.21	84.19	84.24
C	1.51	1.54	0.01	0.48	1.54	1.53	1.54
Cr	11.54	11.53	0.01	0.10	11.52	11.54	11.54
Cu	0.053	0.056	0.0004	0.63	0.0555	0.0562	0.0558
Mn	0.29	0.30	0.01	3.69	0.30	0.30	0.28
Mo	0.79	0.81	0.003	0.33	0.809	0.813	0.813
Ni	0.34	0.34	0.001	0.27	0.337	0.337	0.338
P	0.024	0.022	0.0003	1.22	0.0221	0.0218	0.0224
S	0.0020	0.0019	0.0001	5.82	0.0020	0.0018	0.0020
Si	0.37	0.37	0.003	0.88	0.368	0.362	0.365
V	0.78	0.80	0.03	3.14	0.81	0.82	0.77
W	0.021	0.021	0.0003	1.60	0.0209	0.0208	0.0214

M-2 GRADE TOOL STEEL: IARM 44C

ELEMENT	CERT	AVG	STDEV	RSD	Run #1	Run #2	Run #3
Fe	80.93	80.91			80.890	80.950	80.890
Al	0.050	0.044	0.002	3.41	0.044	0.043	0.046
C	0.82	0.90	0.006	0.69	0.901	0.895	0.907
Co	0.25	0.25	0.002	0.65	0.247	0.251	0.249
Cr	4.04	4.06	0.01	0.27	4.06	4.05	4.07
Cu	0.12	0.12	0.001	0.53	0.115	0.116	0.115
Mn	0.30	0.30	0.01	3.35	0.31	0.29	0.31
Mo	5.02	5.02	0.01	0.14	5.02	5.03	5.02
Ni	0.13	0.13	0.001	0.43	0.134	0.134	0.135
P	0.027	0.029	0.0002	0.69	0.0293	0.0290	0.0294
S	0.004	0.002	0.0002	13.65	0.0014	0.0018	0.0017
Si	0.31	0.29	0.001	0.23	0.293	0.292	0.293
V	1.91	1.87	0.02	0.82	1.88	1.85	1.87
W	6.00	6.06	0.004	0.07	6.064	6.061	6.056

T-1 GRADE TOOL STEEL: IARM 48C

ELEMENT	CERT	AVG	STDEV	RSD	Run #1	Run #2	Run #3
Fe	74.52	74.79			74.81	74.79	74.78
C	0.77	0.80	0.001	0.12	0.799	0.800	0.800
Co	0.22	0.22	0.001	0.28	0.221	0.222	0.221
Cr	4.24	4.12	0.01	0.18	4.12	4.12	4.13
Cu	0.13	0.13	0.0002	0.12	0.1267	0.1269	0.1266
Mn	0.39	0.39	0.004	1.16	0.382	0.388	0.391
Mo	0.17	0.19	0.0003	0.14	0.1950	0.1946	0.1951
Ni	0.20	0.20	0.0002	0.07	0.2043	0.2046	0.2045
P	0.029	0.031	0.0002	0.71	0.0306	0.0306	0.0310
S	0.018	0.02	0.0001	0.39	0.0158	0.0159	0.0159
Si	0.45	0.45	0.001	0.17	0.446	0.445	0.445
V	1.27	1.23	0.01	0.65	1.23	1.23	1.24
W	17.50	17.38	0.01	0.06	17.39	17.38	17.37

M-1 GRADE TOOL STEEL: IARM 304A

ELEMENT	CERT	AVG	STDEV	RSD	Run #1	Run #2	Run #3
Fe	83.39	83.53			83.58	83.50	83.52
C	0.857	0.83	0.004	0.45	0.832	0.833	0.839
Co	0.28	0.29	0.001	0.05	0.286	0.285	0.286
Cr	3.55	3.55	0.01	0.20	3.55	3.54	3.54
Cu	0.14	0.13	0.001	0.53	0.133	0.132	0.132
Mn	0.26	0.25	0.01	3.74	0.24	0.25	0.25
Mo	8.04	8.05	0.02	0.30	8.08	8.04	8.03
Ni	0.13	0.13	0.001	0.49	0.130	0.130	0.131
P	0.019	0.014	0.0002	1.05	0.0142	0.0144	0.0145
Si	0.36	0.33	0.003	0.80	0.333	0.330	0.328
V	1.23	1.20	0.01	1.23	1.19	1.21	1.21
W	1.65	1.68	0.05	2.76	1.63	1.72	1.7

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