X-RAY FLUORESCENCE

Accurate Grade Control of Chromium Ores and Concentrates with EDXRF

Lab Report 190

Introduction

Chromium is widely used in steel and alloy production, and the global demand is steadily growing. It is a critical metal to produce stainless steel and other corrosion-resistant alloys. Chromium containing metal products are essential for high-performance applications in construction, automotive, and aerospace. Chromium compounds also play a significant role in chemical manufacturing, pigments, and leather processing. Most of the chromium produced today originates from chromite $FeCr_2O_4$ bearing ore deposits.
Chromite ore concentrates need to fulfil stringent quality requirements to achieve good prices and avoid penalties. Hence, accurate and fast elemental analysis of ores and concentrates plays a pivotal role for process monitoring, quality assurance and an overall cost-effective mining operation. Miners seek reliable tools to determine not only Cr and Fe but also for accurate assessment of key minor and trace elements. For example, Al_2O_3, SiO_2, MgO, CaO, and TiO_2 contents are of interest as they affect the smelting behavior and slag formation. And phosphorus (P) is a penalty element for which strict limits apply due to its negative impact on steel quality.

Energy-Dispersive X-ray Fluorescence (EDXRF) enables fast and reliable elemental analysis of geological samples like chromite ores. The **S2 PUMA Series 2** EDXRF spectrometer combines high analytical precision with intuitive operation and robustness, making it ideal for many applications in mineral mining. In this report we demonstrate the performance of the S2 PUMA for rapid and accurate grade control of chromium-bearing ore and ore concentrate.

Optimal spectrometer configuration

The S2 PUMA Series 2, a versatile, high-performance benchtop EDXRF spectrometer, is an excellent solution for demanding industrial applications. The optimized **HighSense™** beam path, the 50-Watt power X-ray tube, and the HighSense silicon drift detector (SDD) ensure short time-to-results in combination with outstanding analytical performance.

The **XY-Autochanger** enables high sample throughput, while remaining completely flexible (Figure 1): You can load mixed batches (liquids, powders, solids …) and load, unload, or prioritize new samples at any time. The **vacuum mode** results in best sensitivity for lighter elements and lowest cost of operation.

Bruker's unique **SampleCare™** technology protects vital system components, guaranteeing high instrument uptime and ensuring low cost of ownership even in dusty environments (Figure 2). In case of a power outage, delicate samples are retrieved from the sample chamber, before safely shutting down the spectrometer – thanks to **SMART UPS** (uninterruptable power supply).

The intuitive **TouchControl** allows users to operate the S2 PUMA after minimal training and without external PC.

Figure 1
XY-Autochanger with 20 positions on a removable tray and 2 fixed positions for QC samples.

Reference Materials, Sample Preparation, Calibration

A set of 10 certified chromium ore and chromium ore concentrate reference samples from African Mineral Standards (AMIS) was used to calibrate the S2 PUMA. The concentration ranges covered by the reference materials are listed in Table 1.

Thirteen (13) grams of sample material were mixed thoroughly with two (2) grams of binder and pressed into 40 mm pellets. Pressed powder pellet preparation was chosen because it is faster, easier, and cheaper than fused bead preparation. State-of-the-art XRF matrix correction algorithms enable precise and accurate analysis of ores and concentrates despite relatively large matrix variation. Noteworthy, original ore samples and concentrations need to be crushed, ground and dried before they can be pressed into pellets.

Vacuum mode was selected to ensure optimal light element performance (e.g. Mg, Al). Sample rotation was used in combination with a large, 34 mm spot size to obtain most

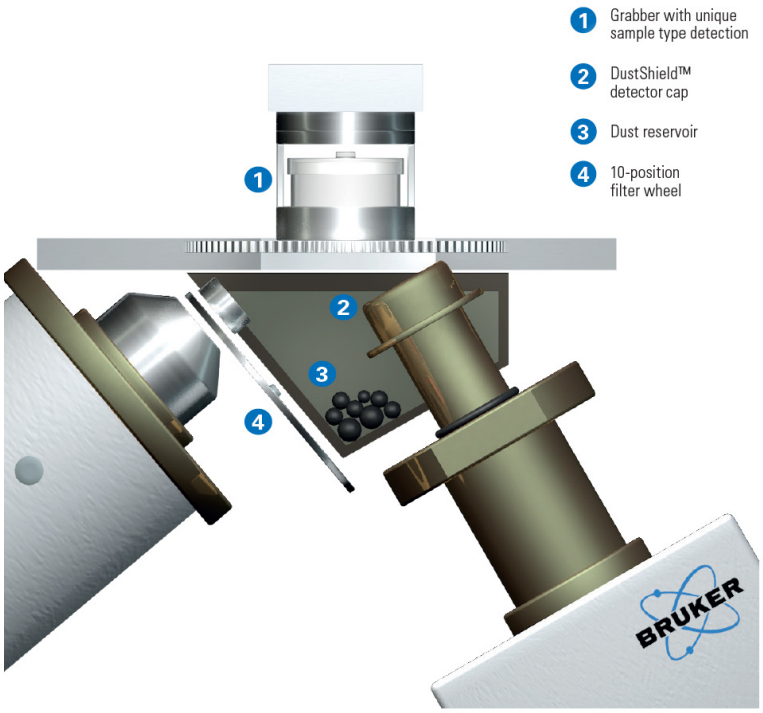

Figure 2
HighSense™ beam path with SampleCare™ for optimal performance and highest uptime.

representative analyses. All measurement parameters are summarized in Table 2. The exceptional counting statistics and signal to noise ratios led to excellent calibration coefficients (Table 3).

Results

A repeatability test was performed using the certified reference material AMIS 0665 to determine the analytical precision and accuracy. Between each measurement, the sample was loaded and unloaded automatically by using the XY-Autochanger. The time-to-result is about 6 minutes, including sample handling. The results of repeatability test are summarized in Table 4, revealing excellent precision and accuracy.

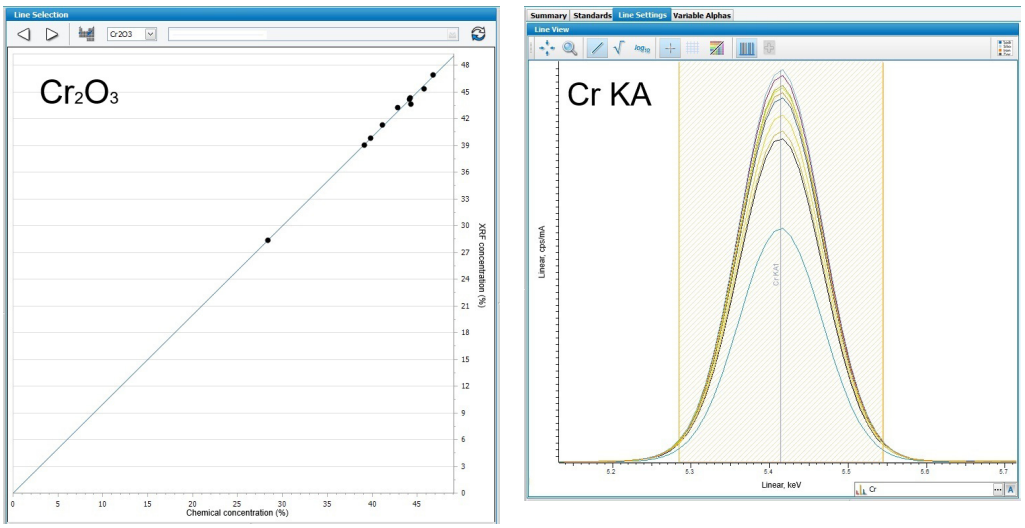

Figure 3
Calibration curve for Cr_2O_3 (left) and Cr KA peaks with integration range (right).

Table 1
Concentration ranges covered by 10 secondary reference materials.

Compound	Min content, wt%	Max content, wt%
Cr_2O_3	28.4	46.74
Fe_2O_3	22.9	29.9
MgO	8.8	14.09
Al_2O_3	11.1	15.1
SiO_2	1.27	19.4
P_2O_5	0.004	0.032
CaO	0.215	1.22
TiO_2	0.49	0.76
V_2O_5	0.143	0.432
Mn_3O_4	0.226	0.275

Table 2
Measurement parameters.

Elemental Line	Voltage	Current	Filter	Sample Rotation	Rotation
Mg, Al, Si, P	20 kV	Automatic	none	Vacuum	Yes
Ca, Ti, V, Cr, Mn, Fe	40 kV	Automatic	500 µm Al	Vacuum	Yes

Table 3

Calibration statistics.

Elemental lines	Squared correlation coefficient (R^2)	Standard deviation
Cr_2O_3	0.9965	0.31%
Fe_2O_3	0.9967	0.14%
MgO	0.9879	0.17%
Al_2O_3	0.9857	0.17%
SiO_2	0.9997	0.11%
P_2O_5	0.9903	0.001%
CaO	0.9993	0.01%
TiO_2	0.9947	0.01%
V_2O_5	0.9901	0.01%
Mn_3O_4	0.9487	0.003%

Conclusion

The data shown in this lab report highlights the outstanding analytical performance of the S2 PUMA for the analysis of chromium ore and ore concentrate. Accurate results for key major, minor, and trace elements are obtained within few minutes, enabling fast and reliable decision-making across the upstream mining and mineral beneficiation workflow: From ore extraction to final grade control of concentrates prior to shipment for downstream smelting.

The S2 PUMA with 22-position XY-Autochanger and the HighSense technology combines high sample throughput with flexibility: Sample can be added, removed or prioritized at any time.

Equipped with Bruker's unique SampleCare technology and SMART UPS the S2 PUMA comes prepared for harsh and dusty mining environments – ensuring high uptime and low maintenance.

Table 4

Repeatability test for reference material AMIS 0665. Measured as pressed pellet.

wt%	Cr_2O_3	Fe_2O_3	MgO	Al_2O_3	SiO_2	P_2O_5	CaO	TiO_2	V_2O_5	Mn_3O_4
Rep-1	41.15	26.46	11.27	14.68	6.29	0.0170	0.478	0.651	0.355	0.248
Rep-2	41.14	26.49	11.32	14.64	6.28	0.0171	0.476	0.650	0.351	0.248
Rep-3	41.12	26.47	11.32	14.65	6.26	0.0172	0.476	0.654	0.356	0.248
...	...	...	...	...	...	...	...		...	...
Rep-10	41.14	26.47	11.28	14.63	6.23	0.0167	0.474	0.652	0.354	0.244
Average	**41.14**	**26.48**	**11.29**	**14.65**	**6.25**	**0.0171**	**0.477**	**0.652**	**0.354**	**0.246**
Std.Dev.	**0.02**	**0.02**	**0.02**	**0.01**	**0.02**	**0.0002**	**0.003**	**0.002**	**0.001**	**0.002**
Rel.Std.Dev.	**0.04%**	**0.09%**	**0.20%**	**0.10%**	**0.32%**	**1.17%**	**0.64%**	**0.25%**	**0.40%**	**0.93%**
Difference to certified value	**0.01**	**0.04**	**-0.32**	**0.18**	**-0.15**	**n.a.**	**-0.007**	**0.008**	**-0.004**	**-0.020**
Certified (AMIS 0665)	41.15	26.52	10.97	14.83	6.10	n.a.	0.47	0.66	0.35	0.226

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