A Novel Analysis Framework for Particle Morphological Classification of Mineral Ore Using A Statistical Raman Analysis and X-ray Diffraction Analysis.

*Daisuke Sasakura[1], Yuichiro Uemura[2]

1. Malvern Japan ,Div of Spectris Co.Ltd,., 2. PANalytical Div. Spectris Co,. LTD

[Introduction]

Mineral ores extracted by mining go through a milling process before ore dressing. An important factor in both milling and ore dressing operations is the determination of the particle size distribution of the materials being processed, commonly referred to as particle size analysis. An elemental analysis technique such as X- ray based analytic technics and destructive wet chemical analysis can determine the quantity of mineral species present in the ore. Especially, X ray diffraction analysis (XRD) is commonly used as non-destructive and high sensitive analysis to investigate of a component analysis of minerals in ore based on the assumption methodologies such as Rietveld quantitative analysis. However, these existing chemical and elemental analysis methods do not allow the study of the composition of individual particles of different size and shape. Our group had been reported for capability of the statistical Raman spectroscopic method (SRS) is novel approach which can resolve this problem [1]. Using this method the Raman spectra of several hundred particles is determined after size and shape classification of each individual particle by an automated particle image analysis (APIA). Raman spectroscopy can be used to acquire the spectra of any inorganic compounds such as metal oxides and nitrides which are Raman active. Many mineral resources are mined as inorganic compounds. Therefore, Raman spectroscopy can be used for the identification of the chemical composition of mineral ores. Using SRS method described herein, it is possible to calculate the particle size distribution and proportion by mass or volume of each chemical component or mineral species based on Raman spectroscopic information. However, most of drawback of SRS method is not allow to determine for the absolute vale of component in mineral ore, therefore, XRD is needed as complementally method. This study will report and discuss the capability about a combined novel analytical framework of SRS method and XRD using iron ore as a model material.

[Material and Method]

Iron ore samples were purchased from a vendor. These samples had been through the ore dressing process. XRD was carried out using an Empyrean (PANalytical, Netherland) equipped Cu Kα X ray source, performed over a range of $20^{\circ}<2\theta<100^{\circ}$, with a step size was 0.026. To make sure averaging sample information due to a powder segregation, a sample spinner was used. SRS analysis was carried out using a Morphologi G3-ID instrument (Malvern Instruments, UK) equipped with a dry powder sample dispersion unit (SDU) and Raman module. The laser wavelength of Raman excitation was 785nm the laser power was less than 5mW. Iron ore dry powder samples were dispersed using the SDU using a short duration pulse of compressed air. Measurements were made automatically using Standard Operating Procedures (SOPs) which define the software and hardware settings used. Measurement sample was dispersed on to glass plate as sample carrier which was minimized environmental exposure by the enclosed sample chamber unit. Particle identification by Raman analysis used the spectrum correlation coefficient approach.

[Results and Discussion]

A qualitative analysis by XRD profile had suggested for that sample were including of a polymorphic Iron oxides such as Fe_2O_3, F_3O, Fe_3O_4 and hydroxide $F_3O(OH)$. Population of component were Iron Oxide 93.7%, Magnetite 1.5% , Goethite 1.7% and Quartz 3.1% were investigated which were calculated based on Rietveld quantitative analysis. Raman spectrum SRS analysis was performed to investigate of the

population analysis on several size fractionated based on Raman spectrum classification and APIA analysis.

[Summary]

This report illustrated the application and capability of a combined novel analytical framework of SRS method and XRD.

[1] Sasakura D, Hayauchi A., “A Novel Approach for the Classification of Mineral Ore Particles by A Statistical Raman Spectroscopic Method” ., SCG-6-11, JpGu Annual Conference 2017, Yokohama,

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