5th Asia-Pacific Conference on Plasma Physics, 26 Sept-1Oct, 2021, Remote e-conference

Carbon and flyash analyses of pulverized coal using laser-induced breakdown spectroscopy

Nilesh J. VASA[1], Hemalaxmi RAJAVELU[1], Satyanarayanan SESHADRI[2]
[1] Department of Engineering Design, [2] Department of Applied Mechanics, Indian Institute of Technology Madras, Chennai, 600036 India
e-mail (speaker): njvasa@iitm.ac.in

Online coal analysis is useful in power plants to improve the overall combustion efficiency. The prior knowledge about the chemical composition of coal helps to optimize the combustion process, thereby improves efficiency. Further, to achieve a required coal quality, coal from different origins is blended before combustion. For this reason, it is essential to develop an online coal quality sensor. Various laboratory-based techniques are available, but there is a growing interest in developing the Laser-Induced Breakdown Spectroscopy (LIBS) technique for online sensing applications [1].

LIBS is an elemental characterization technique that captures the characteristic emission from a laser-generated plasma over the target. It allows simultaneous measurement of multiple elements with minimal/without sample preparation. LIBS has been reported as an effective analysis tool for the elemental characterization of coal and ash. LIBS analysis of powder samples is challenging due to the laser-induced shockwave during the ablation result in forming a particle cloud. The particle cloud formation shields the successive laser pulses to the target and plasma emission to the spectrometer and adversely affects the damage threshold of optical components. The challenge is overcome by introducing inert gas flows combined with a controlled suction to remove particle cloud from the region interest, enhancing the LIBS signal. Overall it is demonstrated that the LIB system combined with the proposed approaches is useful for an analysis of raw and pulverized coal. In this research work, the feasibility of the LIBS system to perform online coal monitoring in an open atmosphere is studied via a micro-size inert environment [1, 2]. The technique is extended for an online/direct analysis of power targets without sample preparation by combining a flow-gas and vacuum unit [3].

Figure 1 shows the schematic of the experimental setup. It was demonstrated that the flow of various gases like He, N_2, Air, and Ar gas (1 liter per minute flow rate) could create a corresponding micro atmosphere around the ablation region. The plasma growth and enhanced line emission intensity in the case of Ar gas-environment were observed. Various inorganic elements such as Si, Al, Fe, Ca, Mg, Na, and K present in coal contribute to coal ash formation. Hence, a good correlation with a negative linear trend was observed between the total emission intensities of the inorganic elements and the carbon content in the coal samples. The simultaneous measurement of decay characteristics of C_2 emission was measured by feeding the plasma emission to the monochromator and PMT (Photo Multiplier Tube) assembly that is coupled with the LIBS setup shown in Fig. 1. The emission persistence time (τ) of molecular C_2 of various samples was increased linearly with an increase in carbon wt%. The emission persistence time of the prominent molecular C_2 emission was included in the calibration model to account for the dynamic variation of the emission intensities of the atomic and molecular signals originate from the coal samples. Further, the experimental studies with the loosely packed powder targets showed that Ar gas flow combined with vacuum suction around the ablation region effectively removed particle cloud and enhanced the LIBS measurement.

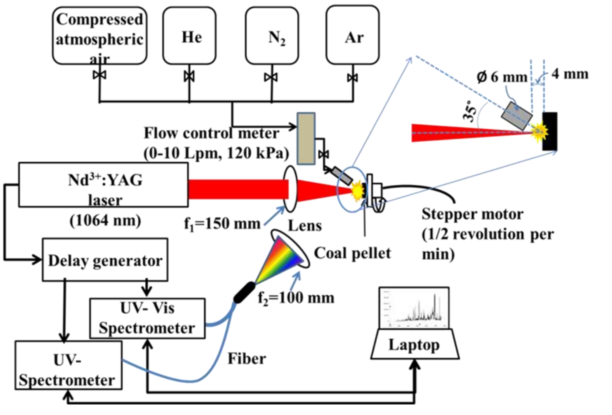

Figure 1: Schematic diagram of the LIBS experimental setup for spectral and temporal measurements.

Overall the present study proved that the LIBS technique could be a potential analytical to for the online monitoring of coal. Apart from coal, the applications of the proposed technique can be extended for geology, food industry, metal industry, pharmaceutical industry, etc., to monitor precursors and products.

Acknowledgment

The Grant-in-Aid supported the project from the Ucchattar Avishkar Yojna and Bharat Heavy Electricals Limited (BHEL), India.

References

[1] H. Rajavelu, N. J. Vasa and S. Seshadri, Spectrochimica Acta Part B: Atomic Spectroscopy, 181, 106215 1-9 (2021).
[2] H. Rajavelu, N. J. Vasa and S. Seshadri, Applied Spectroscopy, 75, 7, 893 - 900 (2021).
[3] H. Rajavelu, N. J. Vasa and S. Seshadri, Applied Physics A, 126:395, 1-10 (2020).