

Research on Control Measures for Coal Testing Accuracy

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ABSTRACT

Coal is a crucial resource in modern society, and improving the accuracy of coal testing is of great practical significance for avoiding trade disputes and optimizing coal usage. This paper provides a comprehensive analysis of the sources of error in coal testing, incorporating practical experience. It explores strategies for enhancing testing accuracy from two perspectives: the operational processes and the factors affecting accuracy. The study delves into aspects such as personnel qualifications, facility conditions, testing methods, equipment, reference materials and reagents, and quality control measures^[1]. The aim is to offer effective solutions for improving coal testing accuracy, ensuring the reliability and validity of results, and providing valuable references for practices in related fields.

KEYWORDS

Coal testing accuracy; Error sources; Laboratory management; Quality control

1 Introduction

Coal is a vital fundamental resource in both social production and everyday life, with extensive applications in fields such as metallurgy, chemical engineering, and power generation. China has abundant coal reserves, but the quality of coal varies significantly across different mines, and the requirements for coal quality differ across industries.

During coal sales, it is common to blend coals of varying quality, which often leads to trade disputes due to discrepancies in testing results.

Therefore, conducting accurate coal testing through scientific methods to obtain precise, comprehensive, and objective results is of great importance.

However, based on practical experience, the accuracy of coal testing is often compromised by various factors, resulting in test outcomes that do not objectively reflect the actual quality of the coal. To address this issue, it is essential to summarize relevant experiences and ensure that frontline workers adhere to specific testing requirements and accurately grasp key aspects of coal testing, thereby improving the accuracy of coal quality assessments.

Coal resources can generally be classified into thermal coal, injection coal, and coking coal based on their different uses. For thermal coal, the key testing parameters include ash content, total sulfur, volatile matter, and calorific value. Injection coal is typically tested for ash content, total sulfur, volatile matter, and fixed carbon. Coking coal requires testing for ash content, total sulfur, volatile matter, caking properties (caking index), and moisture.

Standard coal testing procedures usually encompass total moisture, proximate analysis (including moisture, ash, volatile matter, and fixed carbon), total sulfur, hydrogen content, and calorific value.

2 Improving coal testing accuracy based on sources of error

In the coal testing process, errors are an unavoidable issue. Errors refer to the difference between the actual value and the test result. Coal testing errors can generally be categorized into different types, including random errors, systematic errors, and gross errors.

Random errors refer to errors caused by uncertain factors that are characterized by randomness and variability, making it difficult to identify accurate patterns. These errors are typically variable and exhibit a single-peaked and symmetric distribution. For example, fluctuations in the blank voltage when using an infrared hydrogen analyzer to measure hydrogen content can introduce random errors. While random errors cannot be completely eliminated, they must be carefully considered during the coal testing process.

Systematic errors are errors that can be accurately identified through measurement, including the magnitude, positive values, and negative values of the errors. These errors are typically caused by fixed factors, resulting in a consistent difference between the true value and the test result. During repeated coal testing, systematic errors can occur, and these errors may not vary. For example, if the instrument temperature is too low during total sulfur determination, it can lead to incomplete combustion of the sample, resulting in lower test results. Reducing systematic errors is a primary focus for improving the accuracy of coal testing^[2].

Gross errors refer to errors caused by mistakes or oversights by testing personnel, and they involve a degree of uncertainty. For example, if the weighing bottle is not opened during the moisture determination process, it can lead to significant errors. To avoid such errors, it is important to establish clear operational protocols, increase supervision frequency, and utilize information technology solutions.

3 Improving coal testing accuracy based on work processes

Coal analysis comprises three main stages: sampling, sample preparation, and testing. Coal testing is a complex task with multiple influencing factors that can lead to errors and affect the accuracy of the results. These inaccuracies can, in turn, impact coal usage and other related aspects. To ensure the accuracy of coal testing results, it is essential to implement scientific control measures and strictly manage each stage of the testing process.

3.1 Enhancing Control in Sampling and Sample Preparation Processes

Before coal sampling begins, it is crucial to determine the type of coal testing samples needed, such as routine coal samples, particle size analysis samples, and total moisture samples, and to have a thorough understanding of the coal testing work. A well-defined sampling plan should be established, specifying the distribution of sampling points and the number of sub-samples to be collected at each point to prevent issues such as insufficient sub-sample quantity or lack of representativeness. For mechanized sampling, it is important to record the sampling ratio accurately, and in cases of material blockages or insufficient sample volume, arrange for manual sampling promptly. After sampling, samples should be stored in waterproof sampling bags according to relevant standards and sealed with identification tags to ensure the integrity of the coal samples.

The primary factor affecting sample preparation precision is the process of splitting, and the key factors influencing splitting precision are the uniformity of the coal sample before splitting and the retention of the coal sample after splitting. Therefore, it is important to prepare coal samples in a timely manner and control the processes of splitting and crushing according to relevant testing

standards to avoid contamination of the coal samples. Ensure that the characteristics of the coal sample preparation system, such as particle size and quality, comply with national standards, and that sample particle size, mixing frequency, and retention amount meet the prescribed requirements.

3.2 Optimizing Coal Testing Procedures

In coal testing, the analytical phase is a critical component affecting the accuracy of the results. Key points in the testing process for the five routine tests are as follows:

Total Moisture: The key to determining total moisture content is timeliness. To ensure that the moisture content of coal samples remains unchanged from sample preparation to testing, it is crucial to prevent any loss or gain of moisture. This requires storing the coal samples in sealed containers and keeping them in a cool, shaded area. Testing should be performed immediately after sample preparation to maintain accuracy.

Proximate Analysis: Proximate analysis includes the determination of moisture, ash content, and volatile matter, as well as the calculation of fixed carbon. The accuracy of moisture determination is closely related to the surrounding environment. Therefore, samples should be bottled only after reaching air-dry conditions, and the drying oven temperature should be adjusted according to calibration results, maintaining a temperature between 105 and 110 °C. Additionally, the weighing times for other components should be as close as possible to the moisture weighing time.

(1) **Ash Content:** The main sources of error in determining ash content are the oxidation degree of pyrite, the decomposition degree of carbonates (primarily calcite), and the amount of fixed sulfur in the ash. Using a slow ashing method is crucial for accurately measuring ash content.

(2) **Volatile Matter:** The key factors affecting volatile matter determination are heating temperature, heating time, and heating rate. It is essential to strictly control the testing temperature at $(900 \pm 10)^{\circ}\text{C}$, maintain a testing time of exactly 7 minutes, and ensure that the furnace temperature recovers to $(900 \pm 10)^{\circ}\text{C}$ within 3 minutes. These measures are critical for improving the accuracy of volatile matter determination. **Total Sulfur Determination:** The main factors affecting the accuracy of total sulfur determination in coal using the coulometric method are sample particle size and system airtightness. The sample must pass entirely through a 0.2 mm test sieve, and the instrument system must have good airtightness. **Hydrogen Determination:** The use of instrumental methods for determining hydrogen content in coal is becoming a major trend in future developments. The accuracy of these methods is primarily influenced by the precision of blank values and the calibration of standard curves. To enhance the accuracy of hydrogen determination, it is important to purge the system before the experiment and to use calibration standards with different values during the testing process.

Calorific Value Determination: The determination of coal's calorific value involves two main procedures: calibrating the heat capacity and measuring the calorific value with the bomb calorimeter. To ensure the accuracy of the measurements, it is crucial to maintain consistent environmental temperature and ignition heat across both procedures and each test. Eliminating or calibrating for thermal exchanges between the calorimeter system and the environment is essential. Keeping the water volume in the inner chamber consistent is a key factor in improving the accuracy of calorific value measurements.

4 Improving coal testing accuracy based on influencing factors

Factors affecting testing accuracy are numerous and include: personnel, facilities and environmental conditions, testing methods, equipment, measurement traceability, Sampling,

Sample Handling, and so on.

4.1 Personnel

Ensuring the quality of testing fundamentally depends on the qualifications and abilities of personnel. Based on the needs of inspection and testing work, it is necessary to employ a sufficient number of relevant professionals and managers. Provide continuous education and training for testing staff and implement effective supervision to continuously improve quality awareness, technical skills, and professional competence. Perform qualification verification for personnel engaged in specific tasks to ensure that all operators of specialized equipment, those conducting testing activities, and those evaluating and signing test reports have the required skills and credentials.

4.2 Facilities and Environmental Conditions

Laboratories should be equipped with adequate facilities and space to carry out testing or calibration activities^[3]. Ensure that all areas and facilities meet the environmental requirements of the testing methods and equipment. If necessary, implement measures to check that sampling and testing equipment performance is not affected, and record the environmental conditions and any measures taken.

4.3 Testing Methods

National standards for coal testing are crucial for ensuring the accuracy of test results. Typically, coal testing is conducted using either national standards or industry standards. Unless specified by the client, national standards should generally be prioritized. Methods should be validated before use, and if non-standard methods are employed, they should be confirmed. Develop appropriate technical specifications or operating procedures to ensure proper adherence to standards. The technical manager should review and update standards at least quarterly to ensure that the standards used are current and valid.

4.4 Instruments and Equipment

Laboratories should establish procedures for managing instruments and equipment. Develop and implement comprehensive maintenance and upkeep protocols, including an annual maintenance plan to ensure that instruments are regularly maintained and kept in optimal working condition. Create an annual calibration and verification schedule to periodically calibrate instruments, ensuring they do not exceed their service intervals. For equipment that cannot be calibrated or verified, perform functional checks. For frequently used and precision instruments, conduct interim checks—such as using standard reference materials—to verify accuracy at least once between calibration periods. Equipment that fails interim checks or calibration should be taken out of service as required to prevent misuse or operation beyond its range. Emphasize the importance of tasks such as curve calibration and heat capacity calibration to ensure there are no systematic deviations.

4.5 Reference Materials and Reagents

Reference materials should be selected to cover the full testing range, ensuring their validity and purity. They must be accompanied by a corresponding certificate of standardization and should be

traceable. Both reference materials and reagent solutions should be stored according to specified requirements to prevent degradation. Before use, a check of appearance and storage conditions should be conducted. For perishable reference materials, an interim check should be performed once half of the material has been used. If any doubts arise during acceptance or interim checks, or if the material is deemed non-compliant, its use should be discontinued. Additionally, when the remaining quantity of reference materials or reagents drops below 10% of the original amount, they should be discarded to avoid compromising the accuracy of coal testing.

4.6 Quality Control of Results

To ensure the validity of results, laboratories should implement appropriate quality control measures. Effective quality control is essential for guaranteeing result accuracy. Quality control generally includes both internal and external methods^[4].

Internal quality control measures may involve increasing the frequency of spiked samples, using control charts, comparing results across different instruments, re-testing retained samples, comparing methods, and conducting intra-laboratory comparisons.

External quality control measures may include participating in proficiency testing programs and engaging in inter-laboratory comparisons beyond proficiency testing.

4.6.1 Control Charts and Sampling Comparison Charts for Mechanical Equipment

In the coal testing process, using reference materials is an effective quality control method. For parameters such as total sulfur, hydrogen, and calorific value, the results of reference material testing should be used to generate control charts, which can effectively alert to the occurrence of systematic errors.

For each sampling system, after every sampling event, calculate the sampling ratio and establish the corresponding sampling ratio control chart. If the sampling ratio exceeds the control limits (either upper or lower) for the system, it may indicate a potential systematic error in the sampling system. The cause should be investigated and addressed accordingly.

4.6.2 Instrument Comparison

To detect differences in results when testing the same sample with different instruments, laboratories should regularly conduct instrument comparisons. These comparisons should be performed by highly skilled technicians. Additionally, testing the same sample with the same instrument within a short time frame helps minimize other experimental errors.

4.6.3 Retesting of Retained Samples

Retesting of Retained Samples involves reanalyzing samples that have been stored under unchanged testing conditions after a period of time, using the same or different methods. The results from the initial and subsequent tests are compared and assessed. Typically, the repeatability limits specified by national standards are used as the basis for evaluating the precision of the test data.

4.6.4 Proficiency Testing

Proficiency Testing is used to assess whether a laboratory has the capability to perform specific testing activities and produce valid and accurate test reports. Proficiency testing not only aims to

achieve satisfactory results but also helps evaluate the effectiveness of the internal quality management system, the adequacy of process control points, and whether personnel and equipment meet the required standards. It is a process that enhances accuracy.

5 Conclusion

Analysis indicates that improving the accuracy of coal testing is a complex issue. In addition to continual technological optimization and method improvement, it is essential to establish robust standards and a management system tailored to the specific laboratory. Enhancing the overall competence of testing personnel, accurately and completely following national standards, properly using reference materials and reagents, and ensuring the accuracy and stability of instruments and equipment are all critical for continuously improving coal testing accuracy. In summary, enhancing the accuracy of coal testing is a primary concern in laboratory operations and requires significant attention and resources for ongoing resolution.

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