In-situ Tests and Analysis for Droplet Size Distribution on the Clean Flue of Coal-fired Power Plant

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Abstract. The clean flue gas after FGD of coal-fired power plant is taken as the analysis object, and the particle size analysis for droplets under complex conditions is studied. Selected 600MW unit is typical enough, the particle size range is mainly between 3 and 20 μm. The test will provide the first-hand data for the removal of fine droplets.

1. Introduction

Strengthening the emission control of air pollutants from thermal power plants is of great significance to promoting the technological progress and sustainable development of thermal power industry, improving environmental quality and safeguarding human health. Ultra-low emissions have become mandatory in a growing number of places [1]. Especially, particulate matter concentration has been gradually considered as an impact evaluation object. Related technologies have been developed rapidly, such as wet electro-static precipitator (WESP), tube-bundle type demister and vane liquid–gas separators[2-4]. Particulate matter is mainly divided into two categories: one is dust, undissolved sulfate, sulfite and unreactive absorbent and other filterable particles, and the other is soluble solid in droplets[5]. For the former, there have been already viable means to be removed effectively when the particle diameters is larger than 2μm. In the meanwhile, more and more measurements for particulate matter are also applied, such as weight method, laser light forward scatting, AC micro-charge, and β-ray method. Although there are still many problems for every single method, these online SEMS or offline testing methods still provides reliable data support for ultra-low emission processes [5,6]. However, there is still no effective analyzing method for the second type of particulate matter.

In fact, in the low concentration range, removal efficiency of fine droplets has increasingly become a key factor affecting overall environmental performance. Measurement of fine droplets concentration has gradually been included in the test items. Most test facilities are trying to adapt the equipment to the total concentration of fog drops on site. However, in many cases, the equipment can only be purchased from a single source, and its accuracy is not easy to guarantee, and the comparative experiment is also difficult to obtain. Moreover, the removal efficiency varies greatly with the size of fog droplets. Up to now, for fog droplets in clean flue, we have only a vague understanding of the concentration and true size distribution. Therefore, it is an Innovative attempt to obtain the first-hand data on site. It is of great significance to research and development of new ultra-low emission technologies. It also promotes deeper understanding the behavior of fine droplets removal technique.
It is a great technical challenge to measure the particle size of fog droplets in extremely complex field. This will provide first-hand data on the droplet’s removal in coal-fired power plants. Furthermore, a useful reference will be offered for pollution control in other industries such as steel, chemicals and pharmaceuticals.

2. Test condition and method
Test location: Clean flue after desulfurization tower of in coal-fired power plant 600MW, that of the outlet of desulfurization tower demister. Droplets size distribution of clean flue gas can be obtained.

Test instrument: laser particle diameter analyzer (OMEC DP-2). The receiving end and transmitting end of the particle size analyzer are respectively placed on the platform set on both sides of the flue, and the test holes on both sides of the flue are opened and then covered with glass to obtain the measurable area. The receiving end and transmitting end should be precisely positioned to meet the highly focus requirements.

3. Results and discussion

3.1. Test Method Analysis
The laser particle size analyzer is composed of the transmitting end and the receiving end of the laser. A laser is fired from a measuring hole on one side of the clean flue, which is received by a receiving end on the other side of the clean flue. The fine droplets in the flue scatter the laser, and the particle size distribution of the droplets in the flue can be measured by analyzing the scattering of the laser.

As can be seen from figure 1, the particle size distribution appears to be a bimodal structure, located between 0-30μm and 50-100μm, respectively. However, according to our experience, the presence of larger than 50μm is unreasonable. Droplets larger than 50μm can be removed with great efficiency by the demister located at the top of the desulfurization tower, even a normal demister. On the one hand, the appearance of large fog droplets may be due to the agglomeration of droplets, which will be almost impossible to enter the chimney and have little impact on the subsequent processing equipment. Therefore, the factors in this part can be ignored.

![Figure 1. Original Test data for the droplets size distribution](image-url)
Similar results are appeared in subsequent measurements, as shown in figure 2. In addition to the effect of fog droplet agglomeration, the peak in the large size area is probably caused by the vibration of the equipment.

Due to the limitation of the field conditions, vibration of the platform for placing the equipment is inevitable. The vibration will lead to the detector signal drift during the measurement time. Normally, the Fourier lens of the particle size analyzer will accurately focus the laser light source on the 0 point position of the detector, resulting in a deviation in the angle of scattered light. Therefore, the laser focus shift will produce more stray light, which will lead to a decrease in the instrument's resolution. The larger the particle, the more it is affected by the vibration.

Take 70μm diameter droplets as an example, its main scattering angle is about less than 1 degree. Therefore, the scattering angle above this particle size is greatly affected by vibration, thus generating some false signals. After considering the vibration intensity, we find that the higher the vibration amplitude is, the more obvious the false signal is. The impact of the vibration on the data was so great that the false peak signal caused by the vibration was eliminated in the subsequent experimental results. However, for the test results less than 50μm, the vibration will lead to an expansion of the acquisition angle range of scattered light and a slight expansion of the particle size distribution range to some extent, but it can still achieve the experimental purpose of obtaining particle size, and the experimental results have an effective reference value.

3.2. Size Distribution Analysis

In order to reduce the experimental error, subsequently, 4 tests were completed at different times of the day, with 3 reports for each test, as shown in figure 3.
The average curve of multiple test results was obtained by the statistical analysis method, as shown in figure 4. The droplet size range is mainly in 3~20μm. The particle size peaks are 8.3μm and 13.2μm, respectively and D50 is about 8~13μm. A clear range of particle size was obtained. This shows that this
The test method is feasible and the experimental accuracy is rather ideal. Considering the extremely complicated experimental conditions, we are satisfied that the experimental results can achieve such a high consistency.

3.3. Experimental meaning

These data have a strong guiding significance for the development of fine droplets removal technology, for example, the laboratory can prepare droplets with similar diameter, or obtain appropriate conversion coefficient from a wider distribution of droplets. When evaluating the separation efficiency in the CFD process, the particle size of fog droplets can be set as 5, 10, 15 and 20 µm. More importantly, it is helpful to improve our understanding of the properties of fog droplets in the clean flue.

4. Conclusion

This paper provides first-hand data for the continuous progress of the fine droplets removal technology of thermal power plants. However, due to the extremely complex site situation and the difficulty of the work, the experimental results may need further discussion. We will take more reliable means to carry out further research in the following work and continue to work for a better environment.

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