METHOD AND APPARATUS FOR PRE-HEATING RECIRCULATED FLUE GAS TO A DRY SCRUBBER DURING PERIODS OF LOW TEMPERATURE

CROSS-REFERENCE TO RELATED APPLICATION(S)

The present application derives priority from U.S. Provisional Patent Application No. 61/704,073 filed 21 Sep. 2012.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method and system for increasing the operational range and efficiency of an Air Quality Control Systems (AQCS) incorporating both a Circulating Fluid Bed Scrubber (CFB) with flue gas recirculation (FGR) system by automatically pre-heating flue gas recirculated to the input of the CFB dry scrubber during start-up, shut-down and other periods of low temperature operation. The invention is also effective for Spray Dry Absorbers (SDAs) and Transport Reactor (TR) type dry scrubbers.

2. Description of the Background

Power companies' efforts to reduce sulfur dioxide and other emissions have focused largely on the use of advanced emission control equipment and improving operating practices. A number of different Air Quality Control Systems (AQCS) have evolved for flue gas cleaning and desulfurization including Baghouses, Dry Scrubbers and selective catalytic reduction (SCR) devices. In most dry scrubbers, lime and water are sprayed into the gases. The lime and sulfur react to capture the sulfur, producing a waste byproduct. These scrubbers can reduce sulfur dioxide emissions by more than 95 percent. However, the flue gas coming from the upstream boiler is very hot. For proper operation of the dry scrubber, the gas must be cooled to near its adiabatic saturation temperature so that the gas holds as much water vapor as it can, without overcooling which can also cause adverse effects. Scrubbers control the flue gas temperature by varying their water injection rate. More water cools the flue gas more, and vice versa. This results in an operational balance or equilibrium that is maintained.

There are various types of dry scrubbers, including spray dryer absorber (SDA) systems in which flue gas is contacted with an aqueous lime slurry that is sprayed onto the flue gas. Contact with the aqueous slurry cools the flue gas to near the adiabatic saturation temperature and the SO_2 is removed from the flue gas. In contrast, circulating fluidized bed (CFB) systems use a dry powdered hydrated lime reagent, in addition to coal ash and other solids, to create a "fluidized bed" within the scrubber vessel. Water is direct-injected into the scrubber bed to cool and humidify it, but is not mixed with the lime in a slurry. Instead, the water wets the lime, and the water injection is controlled so that the lime dries completely in the scrubber vessel and downstream ductwork. In the case of a Transport Reactor the lime may be injected either dry or as a slurry. A Transport Reactor (TR) is differentiated from the SDA and CFB technologies mainly by the very high reactor vessel velocity and use of either a thin bed of lime, ash and byproduct or no bed of material in vessel. Additionally, some dry lime injection type TR designs differ from SDA and CFB technologies by injecting water directly into the recycled solids in a mill that is external to the flue gas stream. For the SDA, TR and CFB the by-products are dry.

For all three types of dry scrubber, whether SDA, TR or CFB, maintaining the proper operational balance or equilibrium is easier when the power plant is operating at normal capacity because the flue gas flow rate can support the operation of the pollution control equipment. For all three types of dry scrubber, whether SDA, TR or CFB, multiple parallel trains of scrubber vessel and associated particulate collector may be employed. However, flue gas flow rate can sometimes become a problem during start-up, shut-down and other low load conditions. Below certain minimum operational levels, poor acid gas removal efficiency is a direct result of low load operation, and low load operation is inevitable during unit startups and shutdowns, or during power plant cycling.

With the advent of new air pollution control regulations that do not permit any periods of non-compliance, even during boiler start-up and shutdown, taking the AQC System offline at low load is no longer an option. Any excursion of high acid gas emissions rates can result in the plant owner being in violation of laws punishable by fines and worse if the plant is a chronic offender. This has driven pollution control system manufacturers to add Flue Gas Recirculation FGR systems to their equipment in order to maintain the flow through the AQC System above the minimum operating velocity during all boiler load conditions. An FGR system recirculates a portion of the treated flue gas back into the inlet of the pollution control equipment, thereby increasing its volumetric throughput to a level at or above the minimum required to operate the equipment. The FGR system typically consists of a duct connecting the discharge side of the ID Fan with the inlet duct of the scrubber or other AQC Equipment, a control damper in that duct to regulate the amount of gas that is recirculated and flow measuring devices to allow the control system to determine the amount of gas being recirculated and the total amount of gas flowing through the AQC system. Although an FGR addresses flow rate, both a minimum flow rate and temperature are required in order to put a dry scrubber into service. If the flue gas temperature entering the SDA, TR or CFB is too low, insufficient water or lime slurry injection occurs, resulting in poor acid gas removal efficiency. Use of traditional FGR makes this issue worse as the cleaned flue gas used for gas recirculation is much cooler than the gases entering the scrubber system from the boiler or other source and, by itself, is much cooler than is allowable for proper scrubber operation.

Even with an FGR system it is possible to experience "excursion" issues, e.g., acid gas emissions leaving the scrubber system at values much higher than the allowable levels. For example, for any type of dry scrubber, SDA, TR or CFB, if one introduces flue gas into the reaction chamber prior to the time that they introduce the water and/or lime or other sorbent, there is nothing to clean the flue gas and SO2 and other acid gaseous emissions leave the scrubber system at values much higher than the allowable levels. Thus, for any traditional FGR system it is not possible for a dry scrubber of any type to receive flue gas from the boiler or other source and to scrub it as required without an excursion unless the scrubber has first been brought up to minimum flow and temperature, and lime and water have been added to the system.

It would be far more advantageous to devise a pre-heating system for dry scrubbers that employ FGR systems in order to maintain a minimum inlet temperature. This would satisfy the need for the inlet temperature to be above a certain level, thereby ensuring that the temperature is high enough so that when process water is added for promotion of the acid gas reactions with lime the scrubber exit temperature is maintained above the minimum required for proper system operation. Such a pre-heating system would ensure that no acid gas excursions occur even for applications where the flue gas temperature is insufficient for proper CFB, TR or SDA opera-