MICRONIZED COAL WATER SLURRY

Advantages of CWF
As a liquid, CWF has inherent advantages over solid coal. It may be stored in tanks, transported by a variety of methods, including pipelines, and pumped, atomized, and burned much like a heavy fuel oil. Unlike pulverized coal, there is no dust explosion hazard, no space is required for coal storage piles or pulverizers, which are also expensive to purchase and operate. Since slurry manufacture involves fine milling of coal, it is compatible with beneficiation (treatment) processes, such as froth flotation, which reduce ash and pyritic sulphur content. Unlike pulverized coal, there is no need for expensive drying of the cleaned coal.

In some occasions NaOH has been added to slurries to capture sulfur oxides during the combustion process and reduce emissions. Due to the high moisture content of CWF, flame temperatures are considerably lower than in pulverized coal flames. This results in lower nitrogen oxide emissions.

Production Methods
CWF is being manufactured by many producers using proprietary processes. However, all share certain basic steps. The coal is crushed and mixed with water and wetting agents, then milled less than 50 microns (the mass median diameter or "mind" is typically 20 to 30 microns) and beneficiated to remove ash.

Cynergi's MCWS use micronized coal with median diameter typically around 1 micron. After being dewatered, flow and stability improvers are added to yield the final product. Additives (surfactants, dispersants, stabilizers) help to wet and separate individual coal particles and reduce the slurry viscosity, while stabilizers prevent the particles from settling into a hardpacked bed by suspending them in a weak "gel". Other additives include freezing point depressants, biocides, and caustics (to control the pH of the product).

Combustion Methods and Equipment
The methods of burning CWF in boilers resemble those used in both oil and pulverized coal firing. As with other liquid fuels, it is important that the fuel be as finely atomized as possible to maximize the surface area exposed to ignition heat sources and to minimize droplet volumes for rapid burnout.

As with heavy fuel oil atomization, pressure atomization is inadequate, so atomizers using either compressed air or high pressure steam are used.

Due to the erosive nature of the slurry, internal-mixing type atomizers, the most common being Y-jet and T-jet designs, are made with wear-resistant materials. In high-shear areas within the burners, inserts made of tungsten carbide or ceramic materials are used.

Manufacturers of external-mix atomizers have attempted to avoid the need for these costly inserts to prolong atomizer life by designing atomizers where the high-shear regions of fluid confluence are outside the atomizer. However, atomization quality is somewhat compromised in such designs.

Another goal of Cynergi is to design an atomizer (nozzle) that gives a very fine spray without consuming too much of the atomizing media, thus limiting the expense for that media.

Despite recent progress in atomizer design, an "ideal" design which divides a slurry stream into individual coal particles has not been achieved. The coal particles in a slurry droplet tend to agglomerate, and ultrafine grinding of coal and specific additives alleviate the problem.

One way to remedy this situation is to concentrate on the slurry rather than the atomizer. Secondary atomization techniques for disintegrating slurry droplets subsequent to or simultaneously with shear atomization appear to reduce the droplet size. Some of the methods are heating the slurry feed under pressure, dissolving pressurized Oxyhydrogen into the MCWF (Cynergi pat.), or adding labile compounds such as ammonium nitrate to the slurry to cause micro explosions when the slurry enters in combustion chamber.

Changing the burner is the most important aspect of retrofitting oil-fired boilers to fire CWF, but the greatest retrofit expense is related to the fact that...
coal combustion liberates much more ash than does oil firing. Modifications include making the furnace hopper bottom steeper to facilitate bottom ash removal; installing deslaggers for the furnace walls, soot blowers in the convection passes, ash handling equipment, mechanisms for removing fly ash from flue gases, such as electrostatic precipitators, bag filters, cyclones, etc.; replacing the economizer, if it is the finned-tube type with close spacings that could become plugged with fly ash, and possibly changing the tube spacing in the convection pass. Depending on the coal used and the country regulations governing the use of slurry, flue gas desulfurization may be required a potentially large expenditure.

Combustion Process

The basic combustion properties of CWF are more like those of pulverized coal than those of fuel oil. Due to the slowness of the heterogeneous char (solid carbon particle) combustion stage of coal combustion, the fuel burns much more slowly than oil. Since the char is a smaller "fraction" of oil than of coal, oil has a much shorter char combustion time. As with coal particles, slurry droplets need a long residence time, i.e., a large combustion volume and high excess air levels for complete combustion. Burner designs for the newer fuel borrow heavily from those used for PC firing. Once introduced into a furnace, CWF droplets must be dried and brought to the ignition temperature as quickly as possible to ensure burnout within the residence time available. The heat needed is supplied largely by hot combustion gases brought into contact with the fuel/air mixture as the result of strong internal and external recirculation patterns in front of the burner. These air patterns are created by air swirl vanes within the burner windbox. The vanes spin the air, thus imparting centrifugal force to it and forcing it at high velocity into the boiler. The centrifugal force results in a low air pressure zone immediately ahead of the burner nozzle for some distance. This low pressure zone draws combustion gases toward the burner, creating more turbulence and improving the combustion. Thus, internal and central recirculation of hot gases is set up, which aids in drying the slurry moisture, devolatilizing the coal, and heating the volatile matter evolved to ignition. External recirculation has a lesser but similar effect. Another source of heat to the unignited fuel spray is radiative heat transfer from the flame, and, to a smaller extent, infrared radiation from a portion of the combustion gases. An alternative to improve the combustion is to use CWOF with or HFO/Mazut in the emulsion, with flame booster effect. Once a slurry droplet has been dried and devolatilized and the volatile matter burned, the remaining char burns heterogeneously with oxygen diffusing into the particle to enable combustion. The combustion air swirl now violently mixes the char with the combustion air (the particle follows a helical path in the "tornado"), maintaining a high oxygen gradient and forcing many of the smaller particles into at least partial normal combustion reactions. The result is faster char burnout. With particles entrained in the vortex, the residence time available for combustion is lengthened as well.

Micronized Coal Water Slurry (MCWS) produces less slag than standard CWS, because MCWS has less tendency to deposit by inertial impaction. Deposition probes inserted into test furnaces clearly show fewer deposits for MCWS firing. Carbon burnout also is enhanced significantly. Cynergi’s researchers conducted atomization and combustion tests on conventional and micronized slurries (CWSF and MCWSF respectively). It was expected that if MCWSF produced smaller slurry droplets that burned out faster and yielded smaller fly ash, with a reduced potential for deposition and convection pass erosion, derating could be reduced when firing in an oil-designed boiler. The CWSF and MCWSF used in the study were all made from the same coal. The coal used in preparing the MCWSF had a mean diameter of 1 micron while that in the CWSF had diameter of 30 microns. Fly ash from the MC was the smallest. The next smallest ash was from MCWSF that was heated to 85°C before atomizing, which yielded a
very fine spray with only 2 percent of the droplets above 20 microns. Heating beyond 85 °C to 95 °C had little further effect on atomization of the MCWSF. Unheated CWSF, and dry PC had larger fly ash of similar size. Carbon utilization basically paralleled the trend described for fly ash. Evidently, grinding the coal to a fine consistency improve MCWSF atomization. Heating the MCWSF, which resulted in reduced viscosity, and perhaps also caused secondary atomization (flash evaporation of the water) to occur, produced smaller droplets, smaller fly ash, better burnout, and a reduced tendency to form deposits. Reduced viscosity also means less atomizing fluid consumed (a lower A/F) compared to the CWSF. Heating the slurry is beneficial only if the additives are stable and reduce viscosity.

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