Technical Overview of Recent and Ongoing Developments

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Excessive unburned carbon (UBC) loss in boiler operations is largely the result of the mandating of low-NOx burner retrofits so as to lower primary NOx emissions. But industry deregulation will bring unrelenting competitive pressure for lower busbar costs and will lead increasingly to corrective actions so as to be achieved with cost-effective monetary and manpower outlay! This challenge is spawning numerous and diverse new developments in application of hardware, the "bricks and mortar" of the power generation business …. and in use of advanced process control methodologies. Moreover, the press for controlling UBC is resulting in a “raising of the bar” in effective management of boiler operations and maintenance activities. An example is the narrowing of tolerable ranges for inter and intra-burner coal and air and fuel flow balancing and in mechanical tolerancing of the equipment components that play a part in this difficult to maintain flow balance. The uniqueness of each operational aspect must be understood, and this includes the hardware of the combustion system as well as feasible control opportunities – and the human factors – in devising and implementing the best mix of abatement measures for each unit.

Increased understanding of the complex organic constituency of coal from diverse sources, including the relevant characteristics of the many, individual, maceral species and sub-species, will be critical in combustion optimization. Site-specific knowledge of the key petrographic properties of relevant coal sources, particularly of maceral components within the important inertinite group, can be essential to an understanding of optimal coal particle size and air/fuel ratio levels.

Combustion system hardware developments range from advanced burner designs and upgrading of pulverizers that will allow lower burner-zone stoichiometry …. to improved technologies for measurement and balancing of burner-to-burner coal and air flow along with increased emphasis on mechanical tolerancing. It is noteworthy, per introductory commentary of conference chairman Sarkus at last year's meeting, that when, at an early date in the late 1980s, utility boiler suppliers (OEMs) could foresee major 1990s activity in supply of low-NOx burner retrofits, they urged, without gaining industry agreement or attention, that "new pulverizers" be retrofitted at the same time. Retrofit upgrading of pulverized coal production/supply thus continues to present major opportunity for cost-effective improvement in reducing UBC and in primary deNOx.

Particularly in the case of pulverized-fuel/dry bottom type boilers built prior to the 1980s, such combustion systems have inherent, correctable, design engineering deficiencies that were of no great concern or import to the owner and supplier at time of purchase. These contribute to normal/expected, but unnecessarily high, gross NOx emission levels. Thus, the recent broad acceptance and retrofit use of low-NOx burners (as a common cornerstone, nationwide, for primary deNOx programs) can be seen to be a type of Faustian bargain. An eyes-closed, ready-to-serve, O.E.M.- means for suppressing combustion-zone NOx levels, it brings about reduced combustion efficiency accompanying an otherwise avoidable, large increase in generation of carbon monoxide in flue gas and of unburned carbon in ash. Thus, unattended to, generic shortcomings in design/operation of existing boilers and their auxiliaries are a root cause of unnecessary and avoidable NOx emission that deters maximum abatement via primary deNOx means while incurring hard-to-accept UBC levels. Broad gains can be achieved by corrections, so far as possible, that optimize the air/fuel ratio at each individual burner. Such a retrofit program is carried out to improve the degree and uniformity of coal pulverization, at the same time more accurately balancing/equalizing coal-fuel and air flows among all burners.

In the new era of industry deregulation a broadened use of non-OEM furnace tune-up measures can be expected, in part, to mitigate UBC:

- Improve sizing of fired coal including pulverizer internals reworking to reduce primary-air/fuel mass-flow ratio to a near-optimum level, at the same time reducing pulverized-coal particle size and minimizing the proportion of coal of excessive particle size supplied to burners. This includes better monitoring of coal size generation; adjustment of classifier elements for more favorable size distribution; alteration of the throat dimension and other mill elements for improved air flow control (leading to improved fuel flow control); and, when justified, alteration/retrofit upgrading of classifier hardware for improved particle separation.

- Horizontally balance within 5%, burner to burner fuel feed from individual pulverizers to equalize duty on burners, applying ISO 9931 standard for improved pulverized coal flow measurement
- Horizontally equalize primary-air/fuel flow ratios among burners, incorporating means for determination of variation in primary air/fuel ratio, burner to burner
- Horizontally equalize secondary air flow at either the inter or intra-burner level
- Improve burner conditions so far as alignment, vane and impeller conditions, and attention to adjustment and wear.

Application of low-NOx combustion, particularly without furnace tune-up, as above, is seen to hinder high-value fly ash utilization in two ways:

- Much publicized increase in UBC content of fly ash that prevents commercial use as cement component
- Little mentioned, or understood, impairment of ash pozzolanic properties, caused by the greatly reduced fuel firing temperature, a significant byproduct management concern in western Europe where throwaway disposal of fly ash is not feasible.

Control of UBC loss is nonetheless seen to represent not only improved combustion efficiency but also an opportunity to reduce disposal costs by fostering major ash byproduct uses that are not compatible with carbon contamination. New, on-line, monitoring systems for ash carbon can be a process feedback element – or a monitoring checkpoint for byproduct quality, with means for diverting substandard ash to suitable ultimate disposal.

Combustion system control developments include application of new technologies for accurate measurement of burner coal and primary air flows not heretofore possible. Similarly, process signals are now being derived from burner sensor arrays, such as advanced waveform analysis by flame detection devices. These “upstream” process parameters are inputs for advanced computer software application that harnesses the capacity of today’s powerful microprocessors …. to analyze and continually advise operators …. or optimize results from multi-variable control regimes in a closed loop.

To justify and effectively utilize investments in these technologies via an ability to “deliver the goods” the human element cannot be ignored. Management must grasp that operators and maintenance technicians who are to successfully carry the ball, hour-to-hour, will require an increased awareness of the inter-related processes of combustion and NOx formation and the control/abatement options that are available along with fullest understanding of their own roles. Operators must be trained to this higher level of understanding, at least to the extent of fulfilling their purpose …. as opposed to those of the magical " black boxes" …. in ensuring stable, optimized and safe boiler operations. Equally important from a management perspective is the need to clearly identify the key requirements of each part of the control chain - from the mechanical tolerancing of replacement parts along with their installation and condition over time – to the verification of the accuracy of the process monitoring devices. These responsibilities must be invested in field personnel that have the tools and training …. and, last but not least, authority …. to act when corrective steps are required.