Issue No. # EE05

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a) Where would you measure the stack gas temperature and why do you recommend this location, in the system

- ***The ideal location to measure the stack gas temperature is at the exit of the final heat exchanger coils of the boiler*** (ie. Immediately after low temperature heat exchanging coil or Economizer (if present) or Air Pre-Heater (if present)).
- The objective of measuring stack temperature is to know the stack losses from the boiler. If it is measured from other locations (say at Induced Draft fan outlet/exit from chimney) the loss in the flue gas duct would have reduced the flue gas temperature. This leads to a wrong conclusion of low stack loss.
- If the temperature is measured at a location prior to the final heat exchanger coils, the flue gas temperature would be higher and leads to a wrong conclusion of high stack loss.
- Hence, the stack gas temperature measured at the exit of the final heat exchanger coils of the boiler will reflect the actual stack loss.

b) Which is the best solution, to measure either O_2 or CO_2 in the stack gas and why is it the best solution

In any combustion process, if the excess air is increased, CO_2 reduces and O_2 increases. The CO_2 achievable at optimum combustion is 12-13 % for liquid fuels; 15-16 % for coal and 9.5 to 10 % for natural gas. It may be noted that higher CO_2 is attained even at lower air to fuel ratio. Under this circumstance, combustion is incomplete and associated with heavy black smoke. ***Hence, CO_2 is not the sole criterion for judging the combustion efficiency***.

The measurement of oxygen is the best solution because

- ***Oxygen measurement is useful to know whether the air to fuel ratio (ratio between the quantity of air supplied to the quantity of fuel fired) is at optimum level or abnormal***.
- Further measurement of Oxygen indicates whether combustion is complete or incomplete.
- If oxygen is less than 3.5% to 4.0%, then combustion is incomplete and indicates that unburnt fuel is present in the flue gas. If oxygen is more, it indicates **excess air** is more. Hence, the results of the O_2 measurement at stack can be directly co-related to control the air supplied through the Forced Draft (FD) fan to the boiler for combustion.
- The 4 to 20 mA output from O_2 sensor can be fed to AC variable speed drive of FD fan to regulate the air flow or to maintain the optimum air to fuel ratio at the burner.
- Continuous monitoring of O_2 gives the benefit of lowering the emission of oxides of nitrogen (No_x) to the environment.
- The accuracy of O_2 sensor is far better than CO_2. The typical accuracy of O_2 sensor is ± 1 % and that of CO_2 sensor is ± 5 %.
- ***Zirconia based O_2 Sensors*** which are available in the market has higher life and accuracy than the CO_2 sensors.

c) Where would you place the O_2 sensor and why do you select this location

- The ideal location to measure the O_2 in any furnace is at the zone where the combustion is complete. At these zones, there will be practical difficulties to place the sensor due to high temperature constraints and safety. However, in practical condition the measuring provision to place the O_2 sensor is provided only at just before Air Pre-Heater. ***Hence, the suitable location to place the O_2 sensor is just before the air pre-heater***.
- If the O_2 sensor is placed after Air Pre-Heater (APH), the **air ingress** (which will not participate in combustion) from APH will result in increased oxygen level. Further, this will lead to wrong conclusions that, the excess air level is high at the flue gas. ***Hence placing the O_2 sensor after the air pre-heater is not recommended.***
- In the combustion area, combustion will be in progress and the oxygen measurement at this location will be of no use as the combustion is incomplete.
- The combustion process is complete, by the time, the flue gas reach APH. Hence measurement is recommended at this point.

Note: If continuous monitoring of the APH performance is also needed an additional O_2 sensor can be placed after APH too. The difference in O_2 before and after APH will indicate the air ingress occurring at the APH.