The effect of fineness on NOx emission for pulverized coal combustion

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As an important operating parameter of P. C. boilers, coal fineness influences paralysis, char burning rate and flame temperature directly. It shows that the effect of fineness on NOx emission is relevant to coal properties and combustion conditions, according to the experiments carried out at a one-dimensional flame set of TPRI.

NOx emission

1. Conventional combustion

In conventional combustion, P.C. and total combustion air are fed into furnace together. When P.C. becomes finer, flame temperature rises, with the result that more thermal NOx is produced, therefor the total production goes up. This fact is much clear for the combustion of low volatile coal (LVC) based on the information of the experiments.

2. Air-staging combustion

In air-staging combustion, air is fed into furnace by stages. The combustion zone can be divided into two parts, an oxygen-deficient zone and an oxygen-rich zone. In the oxygen-deficient zone, a large amount of NOx is formed and most of it is reduced to N2 at the same time. We think the substance of the most importance responsible for the reduction is hot char particles, instead of CmHn, HCN, NHi, etc., which are thought to be the main factor in the reduction by some people, therefore, even in the oxygen-deficient zone, there is still adequate oxygen for the burning of volatile matters, so volatile matters, such as CmHn, HCN, NHi, etc., are burnt up immediately and have no chance to reduces NOx

Because of relatively small amount of pores in LVC, it is difficult for high temperature gas to spread into char particles core. So the reaction mainly occurs at the surface and easily affected by coal fineness. By contrast, there exists a large amount of pores in high volatile coal (HVC) and gas enters char particles core easily. For this reason, coal fineness has relatively less impact on the combustion of HVC than that of LVC. When P.C gets finer the temperature increase and more thermal NOx is produced. However, the ratio Ns/Nc (Ns-volatile Nitrogen, Nc-char Nitrogen) will rise and more fuel Nitrogen be released simultaneously on oxygen-deficient zone, what is more, the total surface of char particles will be enlarged, thus strengthens the reduction of NOx to N2 when fine P.C., especially that of LVC is burnt, so when P.C. gets finer in air-staging combustion, the trend of NOx emission finally depends on the competition between two opposing factors, that is, the increase in thermal NOx production due to flame temperature rise and the decrease in the production caused by the strengthened reducing ability of char particles. As the experiments indicates for HVC, finer the P.C., is a bit more NOx is produced in air-staging combustion, in the case of LVC, however, when P.C. gets finer, the NOx production decreases slightly or hardly increases.

Air-staging combustion arrangement
According to the results of experiments, for fine P.C. of LVC, the P.C. nozzle and staging air nozzles can be spaced relatively close with proper staging air ratio, yet for coarse P.C. of LVC there must be adequate distance to achieve low NOx emission. By contrast, the impact of coal fineness on the distance is little for HVC combustion.

Burn-out rate
In conventional combustion, there exists an optimal fineness to achieve maximum operation efficiency. While in air-staging combustion the coal fineness should be raised (R90/), otherwise unburned char in fly-ash will increase. Based on the information combustion than that in conventional combustion by raising fineness (R90/).

Engineering Application
For utility boilers burning LVC with air-staging arrangement, relatively high fineness may led to high burn-out rate and low NOx emission. What's more, the distance between P.C. nozzles and staging air nozzles can be shortened, thus reducing furnace height.

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