Burden Distribution Model for Bell-less Top Blast Furnaces

The blast furnace, which is a counter current reactor, is controlled by several complicated interactions of gas flow, solid flow, heat and mass transfer. The cohesive zone at the lower part of the furnace is closely related to the productivity, stability and efficiency of the furnace. The shape of the cohesive zone is determined mainly by the radial distribution of the thickness of the ore layer and the burden permeability. The thinner the ore layer, the more rapidly the ore is heated and vice versa. Therefore, it is important to know the influence of burdening conditions on the radial distribution of ore layer thickness and burden permeability. Since coke is larger in size than ore and is about 10 times as permeable, the gas distribution control is attempted through control of the radial distribution of layer thickness of ore and coke.

The charging patterns and the resulting burden distribution affect the gas composition and temperature distribution in a major way. An increase in CO percentage of top gas and a decrease in fuel rate will occur with expansion of the CO$_2$ rich region to the center. For the purpose of high CO utilization, it is essential to have a uniform distribution of ore/coke over a major portion of the furnace radius, while retaining permeability in the narrow central region. This is achieved through sufficiently large burden particle size at the center resulting from size segregation, and low ore/coke ratio due to temporary fluidization at the center. The burden flow in the rotating chute and the formation of charge layers with their characteristic features of void distribution is attendant with the following aspects, which are not clearly understood even today.

- Friction characteristics of different charge materials
- Size segregation of material during flow along the chute
- Velocity spectrum at chute exit
- Widening of stream at the point of impact
- Percolation of finer material as it rolls over to the furnace center
- Layer compaction as the charge descends
- Scooping of coke as pellets fall on the coke layer

The material flow from the storage hoppers to the stock line in a bell-less top charging equipment till it forms a stable heap on the existing stock-line are analyzed under the following heads:

i) Discharge of material from the mouth of the storage hopper.
ii) Vertical fall through the discharge tube to the chute.
iii) Slide down of material in contact with the inner surface of the rotating chute till it exits from the chute.
iv) Free fall of material into the furnace till it hits the stock-line located anywhere in the stack.
v) Formation of a new profile on top of the existing stock-line, depending on the charge material behavior.

Mathematical models have been developed for calculating radial distribution of ore/coke layer-thickness-ratio, radial void distribution and mean particle diameter distribution as
functions of the charging sequence (tilt angle, rpm, quantity and order of charging) and physical characteristics of the charge material like particle size distribution, density etc. The software has extensive graphics for visualization of the layer formation at the upper stack of the blast furnace.