

# 流動床燃焼内における砂粒子の流動化速度の研究

## Characterization and Development of Fluidizing Velocity Profile of Sand Particles in Fluidized Bed Combustor (FBC)

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### Abstract

When gas is passed through an inert bed of solid particles such as sand, supported on a perforated plate, the gas, initially, will seek a path of least resistance and pass upward through the sand. With further increased in the gas velocity, the gas starts bubbling through the bed and the particles attain the state of high turbulence. Under such conditions, the bed assumes the appearance of a fluid and exhibits the properties associated with a fluid and hence it is called 'Fluidized Bed'. If the velocity is too low, fluidization will not occur, and if the gas velocity becomes too high, the particles will be entrained in the gas stream and lost. Hence, to sustain stable operation of the bed, it must be ensured that gas velocity is maintained between minimum fluidization velocity and particle entrainment velocity. Different sizes of sand particles exhibit different fluidization behavior. The fluidization quality is closely related to the intrinsic properties of fluidizing medium. Properties such as particle density, particle size and surface characteristics definitely affect the outcome of the fluidization. Sand was chosen as a fluidizing medium due to its characteristics that can withstand high operating temperature of more than 1000 °C. Apart from that, its cheap cost and availability make it preferred choice for the operation. The proposed work will study through experiments to deduce a new classification of local sand in a fluidized bed based on the minimum fluidization velocity of inert particles according Geldart's classification operated at both room temperature and higher temperature conditions.

### 1. Introduction

Fluidized bed has been used widely in thermo chemical processes such as pyrolysis, gasification, liquefaction and combustion. The unique operational advantages such as fuel flexibility, intense solid mixing, and efficient heat transfer mechanism between solid fuel and inert particles, have nominated the fluidized bed combustor the most efficient reactor for the above processes (Fotovat, Chaouki, & Bergthorson, 2014). Many industrial processes utilizing the advantage of gas-solid mixing in fluidized bed that may operate in the following regimes: fixed bed, particulate fluidization, bubbling fluidization, slug flow regime, turbulent fluidization, fast fluidization, and pneumatic transport (A. Shukrie, 2012; Basu Paudel, 2011).

It was the pioneered work of Professor Derek Geldart (Geldart, 1972), who first categorized the behavior of particle fluidized by gases falls into four clearly recognizable groups A, B, C, D, characterized by density

difference ( $\rho_s - \rho_f$ ) and mean particle size. The most easily recognizable features of the groups are: Group A particles, demonstrate dense phase expansion after minimum fluidization and prior to the commencement of bubbling; and those in Group B bubble at the minimum fluidization velocity. Group C was the smallest and most cohesive whilst Group D particle was the largest and demonstrated spoutable behavior. Particle mixing, reported by Geldart, was found to be much poorer in group C and D rather than the fluidized bed operated with powders of groups A or B. Thus, many commercial units operated by using particles classification of Group A or B (Formisani, Girimonte, Vivacqua, & Rende, 2013; Oliveira, Souza, Lim, & Grace, 2008).

Combustion of biomass particles in fluidized bed combustor is a cumbersome process due to their irregular size, density and shape (Paudel & Feng, 2013). Generally, an inert material, which was used for startup of a bed, like