UNIVERSITI TEKNOLOGI MARA

BINARY FLUIDIZATION OF OIL PALM RESIDUES WITH SILICA SAND IN A GAS SOLID FLUIDIZED BED SYSTEM

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Thesis submitted in fulfilment of the requirements for the degree of
Master of Science

Faculty of Chemical Engineering

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Candidate's Declaration

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ABSTRACT

Fluidization of palm kernel shell and palm pressed fibre were carried out in a binary particle system using silica sand as the second material. The main objective is to find fluidization hydrodynamics and behaviour as preliminary study for fluidized bed gasification of oil palm residues. Physical and chemical properties of the materials' that have been investigated include determination of particle's density, mean diameter, compressibility, classification and material's analysis of ultimate, proximate and gross calorific value respectively. Fluidization was accomplished in a 0.15 m diameter by 1.0 m height cylindrical column gas-solid fluidized bed system. Air was supplied by a 1.5hp blower and the superficial air velocity applied to the bed is in the range of 0 to 47.2 cm/s. Fluidization of pure oil palm residues show that biomass particles could not fluidized well. Therefore, silica sand was added to enhance fluidization. The mixtures were prepared by adding 70 weight %, 75 weight %, 80 weight %, 85 weight %, 90 weight % and 95 weight % of silica sand with palm kernel shell and/or palm pressed fibre respectively. Bed was kept constant at 3 kg for the whole experiments. Two distinct types of bed arrangement i.e. layer and random mixture methods were applied. In layer mixture method, silica sand was placed at the bottom of the fluidization column and oil palm residue was poured unto it. Meanwhile, oil palm residues were pre-mix with silica sand using Z-blade mixer for 10 minutes prior feeding in random mixture method. It was found that random mixture method is the preferred bed arrangement. Fluidization for mixture of palm kernel shell and silica sand is achieved up to 30 weight % of the total bed weight. Meanwhile, for mixture of palm pressed fibre, fluidization is limited to 20 weight % of the total bed weight. Quality of fluidization dropped with increasing percentage of oil palm residues in the mixture indicated by segregation, the formation of square-nosed slugs, channelling and vertical rat holes. Critical parameters such as minimum fluidization velocity, U_{mf} and complete fluidization velocity, U_{cf} show increment pattern with increasing weight percentage of oil palm residues in the bed for both types of bed arrangement. The appropriate design value of the superficial gas velocity to be used in the operation of biomass gasifier is to take U_{cf} twice the U_{mf} for mixture of palm kernel shell with silica sand and thrice the U_{mf} for mixture of palm pressed fibre with silica sand. Relationship between variables such as U_{mf}, U_{cf}, bed expansion ratio throughout the process, (H_t/H_s), bed expansion ratio at minimum fluidization, $(H_t/H_s)_{mf}$, bed porosity and fluidization index, FI were obtained which are very much dependent on the types of materials tested, bed arrangement methods and bed compositions. Modification of correlation by Bilbao et al. (1987) has been proposed to predict U_{mf} for binary mixture of palm kernel shell with silica sand which found to be $U_{vf} = U_{mf}^{P} - \left(U_{mf}^{P} - U_{mf}^{F}\right)\left(0.0022X^{F} + 0.83\right)$.

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