To improve fluidization quality and mass transfer rate of biomass fluidized beds with pulsed gas flow, an existing fluidized bed with rectangular cross-section area was modified with the insertion of a tapered bottom section such that dead zones observed in the original design could be eliminated. Batch drying tests were performed as an indirect indicator of gas-solid contact efficiency and mass transfer performance. Compared to the original design, biomass particles could be fluidized at a wider range of gas pulsation frequencies with significantly reduced channeling and gas bypassing in the new tapered design. Faster drying and thus improved mass transfer were also observed in the tapered bed, as reflected by both the instantaneous drying rate and final moisture content of the sample. A simple particle drying model was applied to fit measured drying curve, and the results showed that under the same operating condition fluidized bed with a tapered bottom had a higher effective vapor diffusion coefficient compared to the original design.