PREDICTION OF THE RADIAL SOLIDS CONCENTRATION DISTRIBUTION IN CIRCULATING FLUIDIZED BED RISERS

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The presented work deals with the development of a model for the prediction of the radial solids concentration distribution in circulating fluidized bed risers. In order to provide a substantial basis for the model development, non-invasive investigations on the solids distribution over the cross-section of a pilot plant scale circulating fluidized bed riser are carried out using X-ray computed tomography. The examined operating range covers cross-section averaged solids concentrations between 2.7 vol.% and 38.1 vol.% while superficial gas velocities were adjusted in the range from 0.4 m s-1 up to 6.0 m s-1. Especially in the case of dense gas-solid flow conditions detrimental beam hardening effects gain influence, distorting the results of the X-ray measurements (1). Thus, a novel calibration method is presented to facilitate the derivation of volumetric solids concentrations from the measured tomographic attenuation data. In this, an emphasized feature consists in the elimination of low energetic radiation from the incident X-ray spectrum to avoid beam hardening effects, which are caused by the pipe material and the fluidized solids. Evaluation of the presented technique by comparison of the derived cross-section averaged solids concentrations with those obtained from differential pressure measurements confirms its high accuracy. Subsequently, the technique is applied for quantitative analysis of the radial solids concentration distribution in a gas-solid circulating fluidized bed riser in dependence of the overall solids holdup and the superficial gas velocity. The high spatial resolution and the non-invasive character of the applied technique allow for detailed examination of the solids concentration prevailing in close proximity of the inner riser wall as well as in the center of the cross-section. The tomographic X-ray scans of the cross-section of the riser, operated under dilute and highly dense conditions, provide a comprehensive set of measurement data, based on which a model is developed that allows for the prediction of the radial solids concentration distribution in vertical gas-solid upflow. The proposed model is found to reliably predict the radial solids concentration distribution under dilute as well as under dense flow conditions.

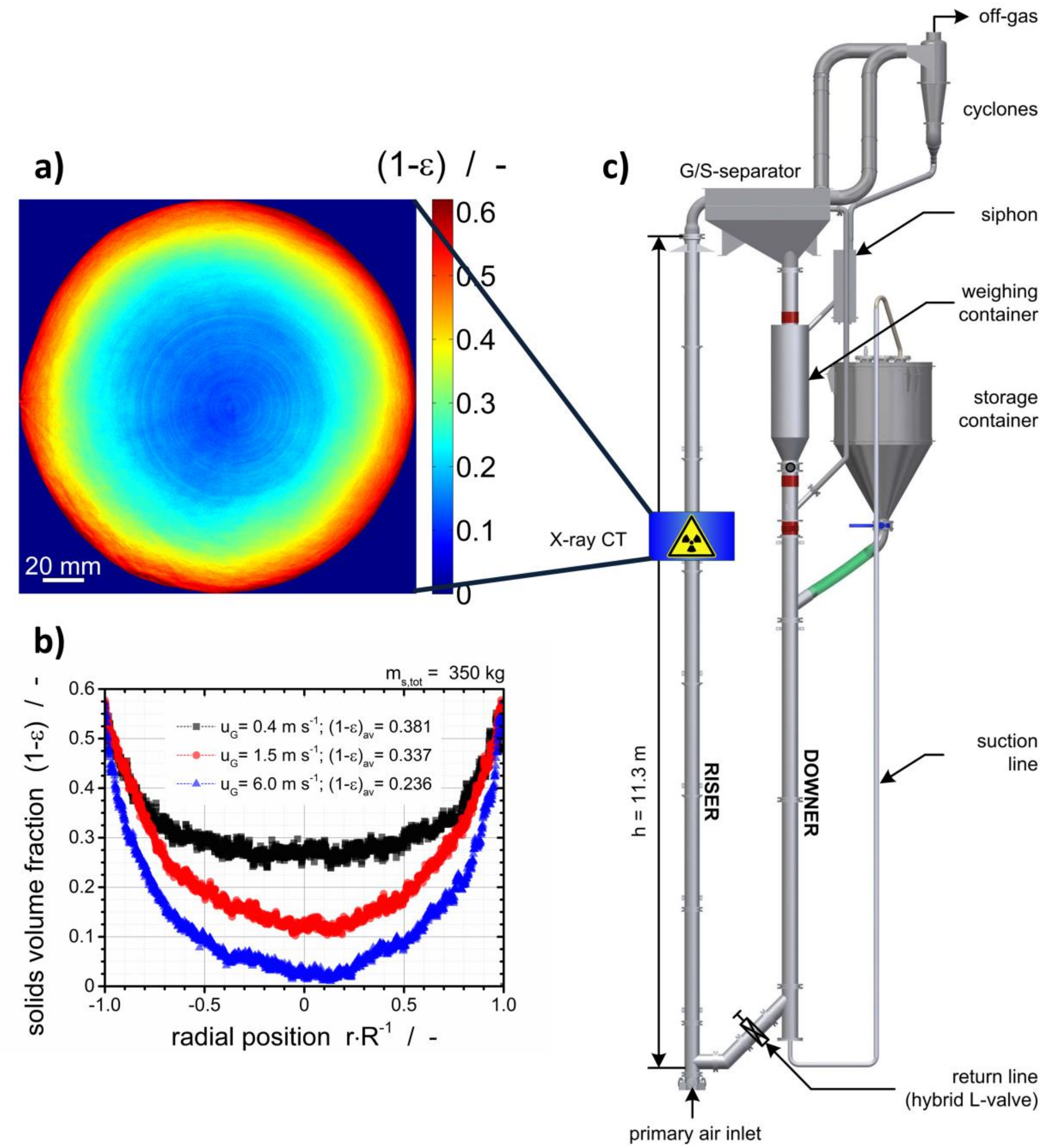

Figure 1: Investigation of the solids distribution over the cross-section of a pilot plant scale circulating fluidized bed riser; a) X-ray tomographic scan of the riser cross-section at an averaged solids holdup of $(1\text{-}\varepsilon)_{av} = 0.337$; b) radial solids concentration distribution under various operating conditions; c) Experimental setup of the circulating fluidized bed

REFERENCES

1. F. Meng, N. Zhang and W. Wang. Virtual experimentation of beam hardening effect in X-ray CT measurement of multiphase flow. Powder Technol., 194: 153-157, 2009.