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Deciphering high-frequency pressure signals in a gas-solid vortex reactor via machine learning

Aim

This study aims to extract the hydrodynamic information of a gas-solid vortex bed through analyzing high-frequency pressure signals via machine learning models.

Justification

The gas-solid vortex reactor (GSVR) is a promising reactor technology for process intensification due to its enhanced heat and mass transfer characteristics. Several processes, e.g. pyrolysis, drying, fluid catalytic cracking and coating have been tested in GSVRs. Gas-solid fluidization in the GSVR is even more complex compared to conventional fluidized beds because of the centrifugal force. To unravel the transport properties in the GSVR, various visualization techniques have been adopted, such as high-speed imaging and particle image velocimetry (PIV). However, transparency of the equipment and constraints on operating conditions can hinder the application of these visualization techniques.

In this work, machine learning (ML) based high-frequency pressure (HFP) signals analysis is introduced. HFP data are easily obtainable as HFP sensors are robust and relatively cheap. Given the massive chaotic pressure data recorded by HFP sensors, machine learning is one of the most powerful tools to deal with. Important gas-solid hydrodynamic properties, e.g., velocity distribution of solids, bubble size and bed voidage can be derived from analyzing pressure signals. Moreover, early detecting the changes in gas-solid hydrodynamics becomes possible when real-time pressure is recorded and analyzed simultaneously.

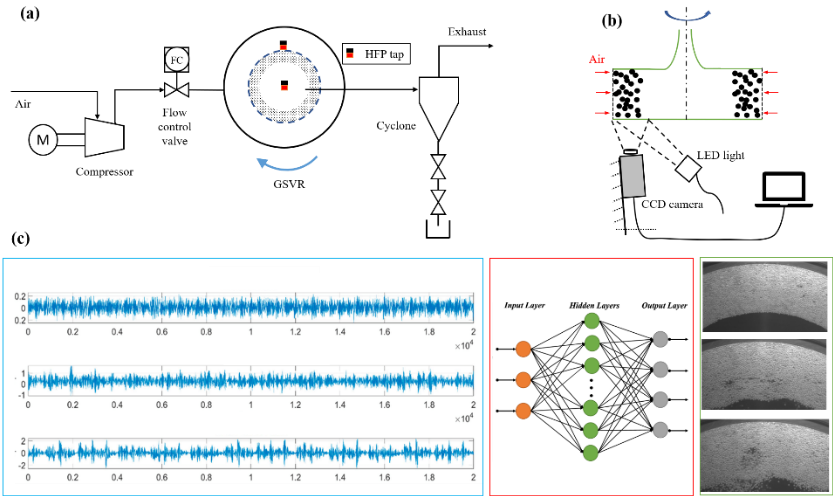

Figure 1. (a) process flow diagram of the setup, (b) side view of the STARVOC reactor along with the imaging equipment, (c) diagram of ML model: input - HFP, output – labeled hydrodynamic information of the gas-solid bed.

Program

1. Literature survey on the characterization of gas-solid hydrodynamics.
2. Perform gas-solid fluidization experiments: PIV measurements and HFP measurements.
3. Image analysis to understand fluidization phenomena in a GSVR, important hydrodynamic properties will be obtained, e.g. velocity of solids, fluidization regimes, bubble size, etc.
4. Train deep learning neural network to link HFP signals to gas-solid hydrodynamic information.

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