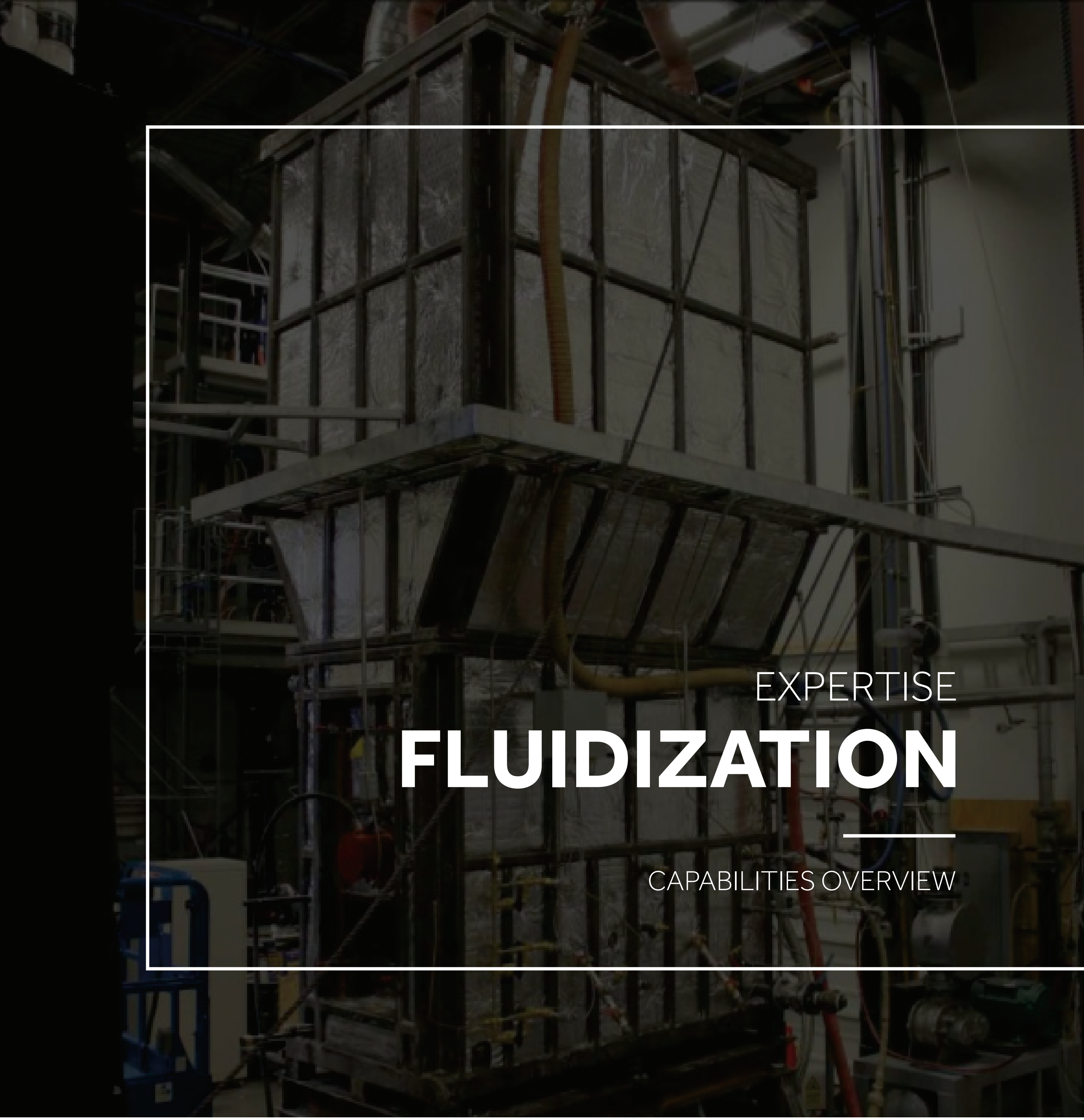


EXPERTISE

FLUIDIZATION

CAPABILITIES OVERVIEW

Coanda

A TETRA TECH COMPANY

www.coanda.ca

FLUIDIZATION CAPABILITIES

Our physical modelling laboratory is home to several fluidized beds, ranging from 4 inch diameter bubbling columns designed for rudimentary solids characterization, to 40 inch diameter by 32 foot tall circulating cold flow models that are geometrically similar scaled versions of commercial reactors.

PROJECT APPROACH

Our approach to fluidization projects typically begins with a literature review, followed by a dimensional analysis to determine the most effective approach to the development of a solution, including physical models, computational modelling, or analytical techniques.

When a physical model is selected as the best recourse, the model is engineered to ensure a good similitude between the model and the commercial vessel. Cold flow models are typically constructed from a combination of steel and acrylic materials, or glass if optical access is required at elevated pressure.

SUPPORTING INFRASTRUCTURE

Coanda's supporting infrastructure includes a variety of pumps and blowers: two 150 horsepower blowers, a 270 horsepower compressor, and various pumps ranging from 3 – 50 horsepower.

Our laboratories, one in Burnaby, BC, the other in Edmonton, AB, offer a total of over 50,000ft^2 of customizable research and development space.

Coanda's Burnaby laboratory is home to several fluidized beds of varying shapes and sizes (3 shown)

CUSTOM RESEARCH EQUIPMENT

FROM REAL WORLD TO LABORATORY

Engineers and scientists at Coanda work from client drawings of existing equipment or blank page process specifications to design custom laboratory models. Scale models are designed to allow maximal access for data collection, flexibility in adjustment, and re-configuration for testing design alternatives. Laboratory models often allow the ability to more safely and easily explore wider performance bands, operating scenarios, and sensitivities than full-scale operating process equipment.

"We have specialized in turning real-world challenges into manageable laboratory based apparatus for over two decades."

Dr. Darwin Kiel P.Eng., President

Recirculating "Doughnut" Fluidized Bed model with UV Particle Tracing Measurement

HANDS-ON EXPERIENCE

We have decades of experience designing, procuring, constructing, and operating experimental equipment in our laboratory. Our range of apparatus includes water channels, fluidized beds, gravity separators, mixing vessels, and hydrocyclones.

Typically, our cold flow physical models operate using appropriately scaled fluid analogues to maintain similitude to the commercial application. In certain instances (where chemical reactions cannot be neglected for example), real process materials are used, and the physical model is then generally operated at elevated pressure and temperature.

- 25+ years in business
- dozens of fluidization projects
- 80+ scientists, engineers & technologists
- bespoke fluidization capabilities

PIONEERING MEASUREMENT TECHNIQUES & INSTRUMENTS

Phosphorescent solids tracer energizer and injector

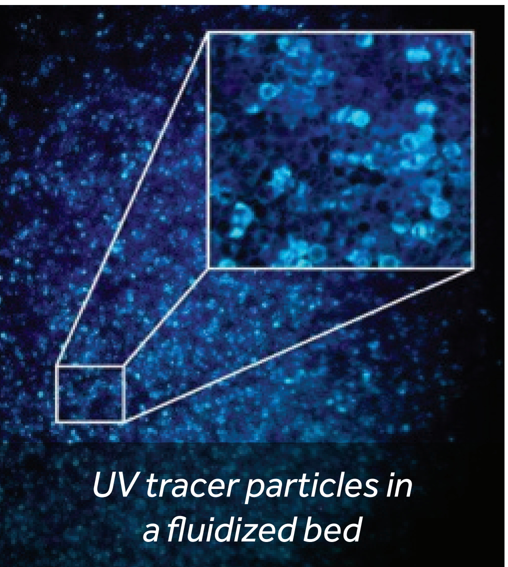
Conventional instruments or measurement techniques often cannot meet the needs of research projects. Coanda develops new instrumentation and measurement techniques as needed to support experimental requirements.

UNDERSTANDING FLOW ISSUES

Residence time distribution (RTD) measurements provide an effective technique to diagnose flow behaviour within a wide range of systems. By analyzing a controlled tracer addition to a system, we can reveal flow distribution issues such as short-circuiting, recirculating regions, and dead zones.

Liquid Tracing

Liquid tracers are typically used in systems containing only liquid, or liquid-solid (slurry) flows, however they can also be used in gas-solid fluidization applications. Chemiluminescent tracers are often used in opaque systems, where they are detected with the same optical probes that we use to detect phosphorescent solids. With sufficient optical access, laser-induced fluorescence (LIF) techniques enable qualitative flow visualization and quantitative concentration measurements of fluorescent dye illuminated by a targeted laser system. Conductivity probes are useful for saline tracer solutions in obscured or opaque systems not suitable for optical techniques.



UV tracer particles in a fluidized bed

Gas Tracing

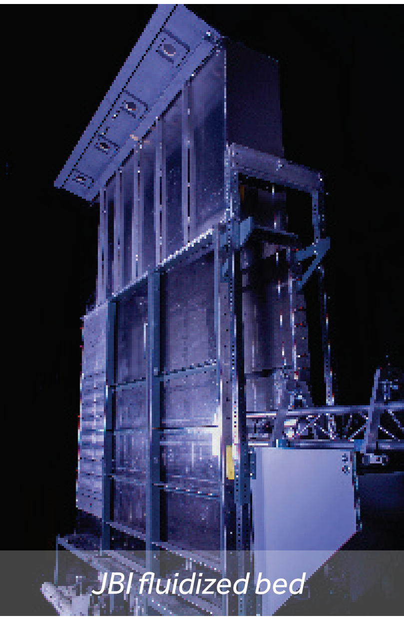
Gas tracers are used on a wide range of systems including gas-only, multiphase gas-liquid, and gas-solid systems. We offer gas detection systems such as a photo-ionization detector, infra-red, and thermal conductivity.

Solids Tracing

We have developed a novel method of solids tracer addition and sampling for performing solid-phase RTD studies in fluidized bed reactors. Phosphorescent tracer particles are charged under UV light prior to injection into the system, where they continue to phosphoresce and are detected by an optical probe. Other available techniques for solids tracing include heat tracing, and visible dye tracing.

NOZZLE JET-BED INTERACTION

Measurement Technique Development Example



JBI fluidized bed

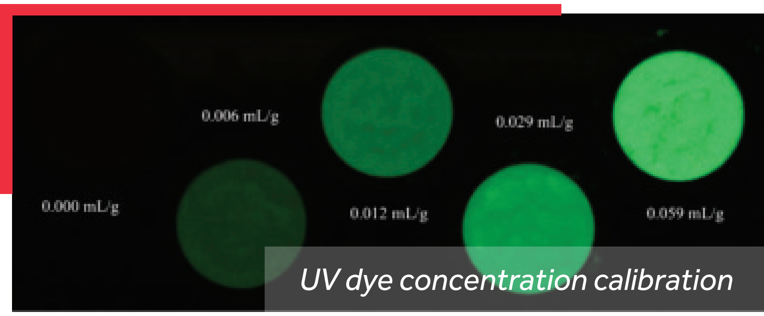
VISUALIZING INSIDE THE BED

We have developed a nozzle jet-bed interaction (JBI) measurement technique which quantifies the performance of spray nozzles operating inside fluidized beds. JBI is a batch mode experiment whereby the nozzle under study, whether a hydraulic or gas-atomized design, sprays dyed liquid into the fluidized bed for a short duration.

After the preset spray duration (typically 5-10 seconds), the fluidized bed is slumped and the nozzle is turned off simultaneously. The slumped bed is then excavated in (typically) 1 inch increments using a 2-axis (horizontal and vertical) traversing vacuum nozzle. After each layer is excavated, the newly exposed surface is then photographed under UV illumination.

Any liquid present at the surface of that layer will fluoresce with an intensity proportional to the liquid-on-solids concentration. The photographs are then stitched together and calibrated to produce a complete 3D map of liquid distribution inside the bed.

***JBI**: a technique to quantify the performance of spray nozzles inside fluidized beds*



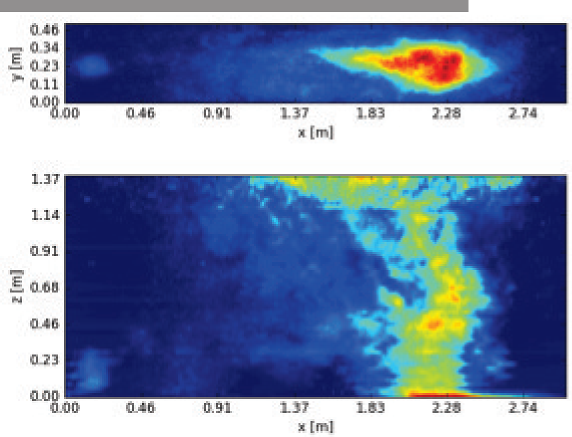
UV dye concentration calibration

QUANTITATIVE RESULTS

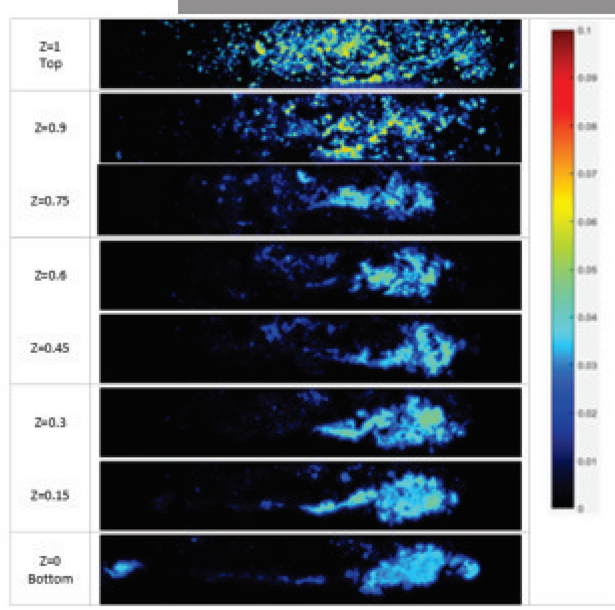
JBI is a quantitative measurement that typically returns liquid mass balances (experimentally measured : injected) on the order of +/- 20%. Data set analysis can produce liquid concentration histograms, liquid-on-solids film thicknesses, as well as spatial liquid distribution calculation metrics like Earth Mover's Distance (EMD). EMD quantifies the amount of work required to transform the measured liquid distribution into a perfectly mixed state throughout the entire bed.

These quantities are used to assess, compare, and optimize liquid-on-solids coverage performance of various nozzle designs, bed fluidization regimes, and solids properties.

composite 3D map of slumped bed



slumped bed layers



ADVANCED MEASUREMENTS

Our measurement approach leverages advanced instruments to overcome the challenges associated with systems involving non-Newtonian fluids as well as more conventional single phase and multi-phase flows (gas-liquid, gas-solid, liquid-solid and gas-liquid-solid).

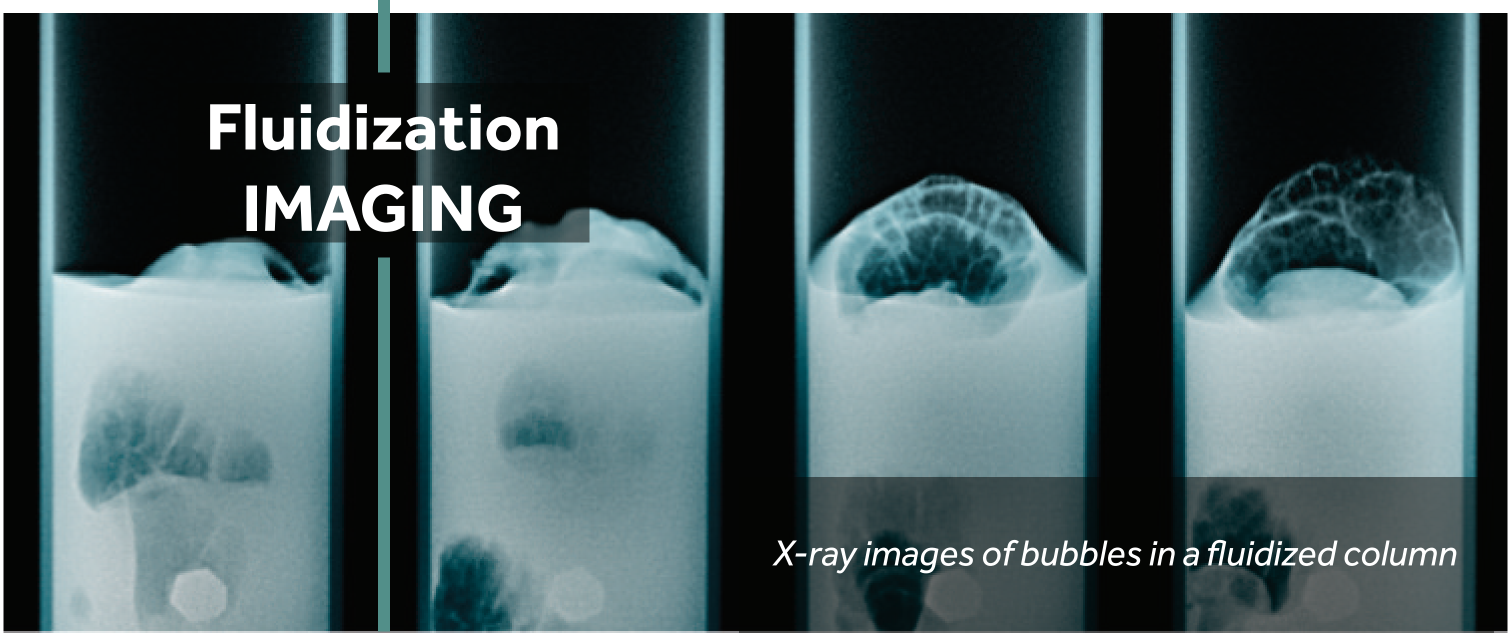
Our other instrumentation and measurement capabilities include fast response helium gas tracer detectors, a number of nuclear (gamma) densitometers, and bed voidage probes that detect changes in capacitance.

Coanda is constantly acquiring, optimizing, adapting, and developing new measurement techniques

X-RAY IMAGING

We offer a number of X-ray imaging systems, covering a wide range of imaging needs, as well as experience constructing custom shielding enclosures around our process models in order to capture images during regular operation. X-rays allow imaging through opaque materials such as inside high pressure steel vessels.

One of our systems includes extensive collimation (limiting secondary scattering) and is mounted on highly accurate traverses in order to create an image by slowly scanning a 1D detector and “fan” of radiation.



X-ray images of bubbles in a fluidized column

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