



Materials Processing Institute

Providing technical services for industrial problem solving, root cause analysis, process optimisation and process development.

Over 70 years of process and production experience, delivering innovative solutions to process industries





The unique combination of technical skills and facilities allow integrated teams of scientists and engineers to offer unparalleled capability to address clients process and production challenges.

The Materials Processing Institute offers:

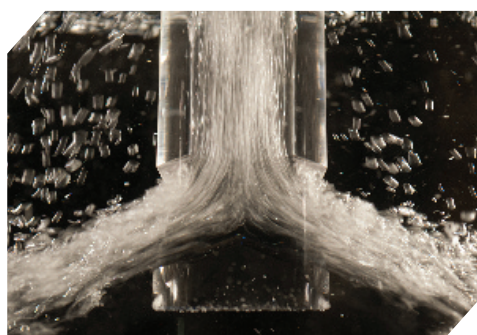
Process Optimisation – Enhancing operating efficiency and developing processes.

Through monitoring, measuring, modelling, and materials characterisation capabilities, the Institute is able to support clients in their pursuit of continual improvement. Enhanced production performance for existing assets and processes is realised, and rapid and effective implementation of new processes achieved.

Asset Integrity – Providing early warning of potential production interruptions, understanding of material limitations and root cause investigations into plant failures.

The Institute offers identification of failure mechanisms, advice on materials selection, and design and development of new materials; all fundamental to implementing robust and lasting improvements to plant and processes.

The Materials Processing Institute, which is independent, open access and not-for-profit, works with a wide range of process industries, delivering support that ranges from small scale, site based investigations, through to long term collaborations and research programmes; with support available to companies of all sizes from small start-ups to large multi-nationals.



PLANT AND PROCESS - METALLURGY AND ENGINEERING

A comprehensive range of metallurgical services and engineering capabilities are available. These include a state of the art scanning electron microscope (SEM), which plays a leading role in understanding the fundamental effect of composition on the behaviour of materials. It enables nanoscale chemical and physical imaging, which are used for:

- > **Failure Analysis**
- > **Corrosion / Erosion Studies**
- > **Analysis of Surface Effects such as Delamination and Peeling**

Additionally, **In-situ Engineering Measurements**, carried out at customer sites, including:

- > **Stress / Strain**
- > **Creep**
- > **Vibration and Movement**

and advice can be given on:

- > **Gas Cleaning Systems**
- > **Heat Exchangers**

Investigations into plant issues are backed up by provision of well researched practical and cost effective solutions, and advice is offered on stretching the capability of installed assets in terms of productivity and capability.

DESIGN, MANUFACTURE AND CHARACTERISATION OF METAL ALLOYS

Whether it is advice on selection and properties of existing materials, or design and development of a new material; through experience, knowledge and research, staff at the Institute are able to provide solutions in response to metallurgical challenges.

Optical Microscopy and **Etching** techniques are used to study crystal growth patterns, precipitates, microstructure, and structural and material defects of cast products, and SEM is employed for elemental mapping.

The Institute also has **Smelting Units**, which range in size from 20kg to 7000kg. These are used both in the manufacture of speciality alloys for the chemical, nuclear and engineering sectors, and also for materials research and development.



Root cause analysis to deliver lasting improvements in equipment and performance



SENSORS AND CONTROLS

Providing process control where human intervention is either not possible or undesirable. The Institute offers consultancy, design, installation and commissioning service for:

- > **Monitoring**
- > **Measurement**
- > **Control**
- > **Validation**
- > **Verification**

of both batch and continuous processes, including those in hostile environments. This may involve:

Equipment Monitoring

Application of measurements to understand equipment behaviour and performance, including the use of acoustic emission, accelerometers and strain gauges; to provide real time information on plant and equipment.

Product Measurement Systems

Development of measurement solutions to accurately configure processes and machines, then to monitor product dimensions / outputs with feedback to machine setup.

Measurement Systems for Harsh Environments

Design of systems that are able to operate in hostile environments such as high temperature, dust, steam, vibration.

Process Monitoring Thermography

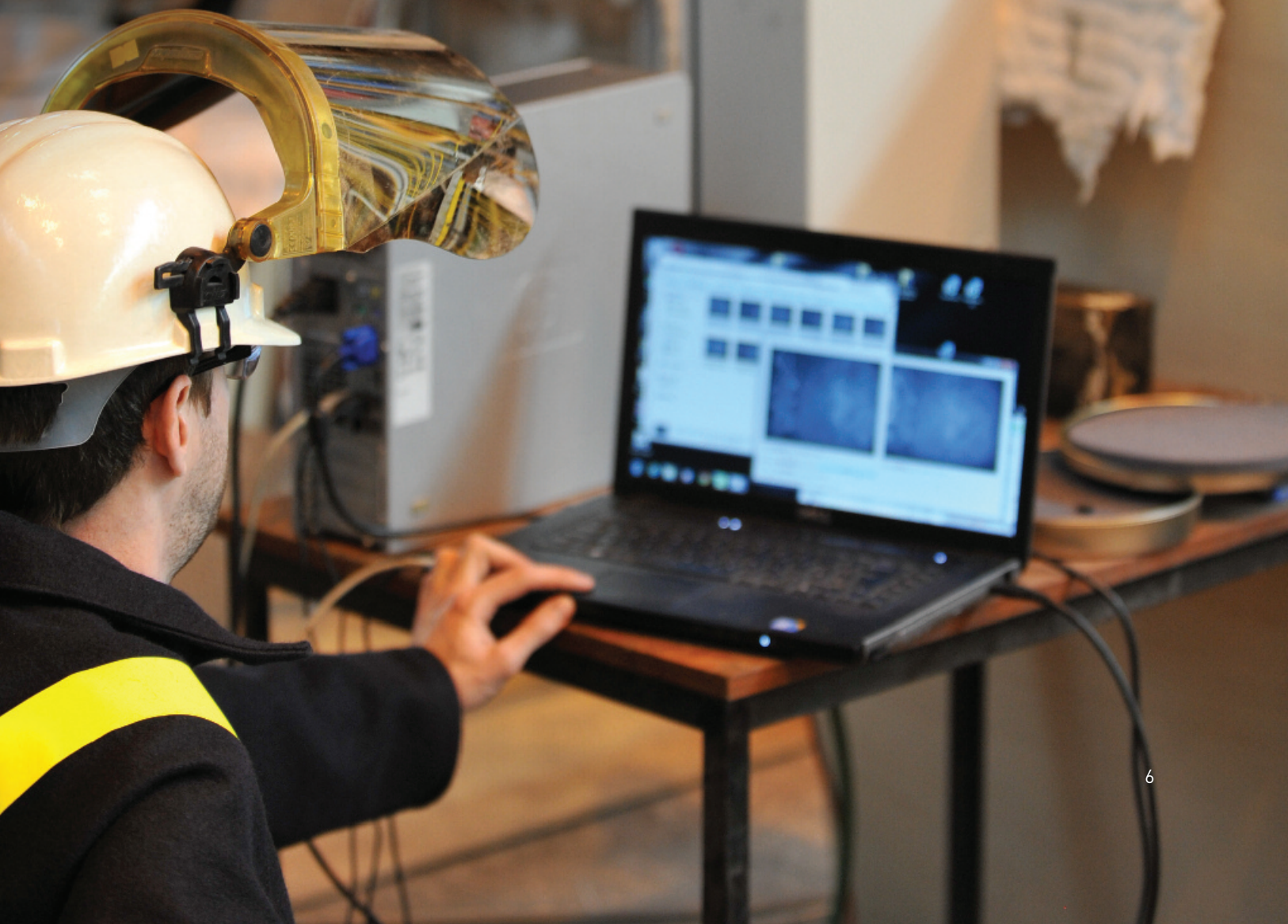
May be combined with engineering support and refractories technology to allow processes to be monitored to provide insight into operating parameters.

Process Monitoring Audiometry

Systems developed using the noise emitted from a process as a measurement and control tool.



Knowledge and control of
conditions and events in
inaccessible areas



PHYSICAL MODELLING

The capability to carry out experiments designed to mirror plant processes, with appropriate geometric and dynamic scaling rules applied. Used as either the precursor to, or to simply validate a mathematical model, in addition to being used to gain insight and understanding of production plant issues.

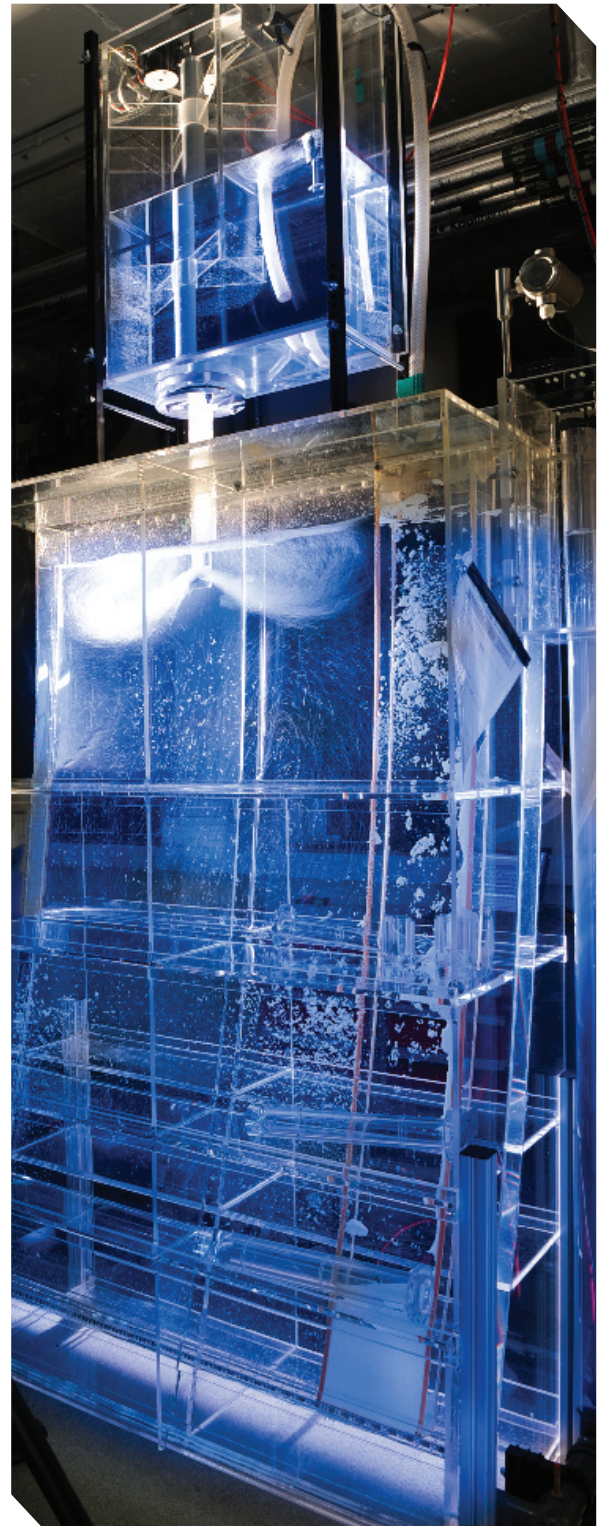
Fluid and Particle Flow Modelling with Laser Imaging

In-house simulation and design expertise allows the Institute to supply clients with understanding, solutions, and new ideas on control of processes. New process designs are investigated and optimisation carried out for existing processes. This provides both a tool in itself and also allows for validation of the Computational Fluid Dynamics model.

For processes involving **any fluid matter, from molten metal or glasses, to solvents and particles**, physical process modelling is available for investigations at bench scale through to pilot scale. A purpose built experimental fluid dynamics facility at the Institute uses media such as water, air and smoke, for non-isothermal modelling, with a wide variety of measurement techniques available, including laser based Particle Image Velocimetry (PIV).

Physical modelling is particularly beneficial where the process physics are too complex for computational or engineering models and has applications in:

- > Fluid Separation Optimisation
- > Fume Hood Performance Checks
- > Burner Design
- > Reactor Problems
- > Heat Exchanger Optimisation
- > Mixer Properties



OFFLINE SIMULATION TECHNIQUES

Finite Element Analysis (FEA)

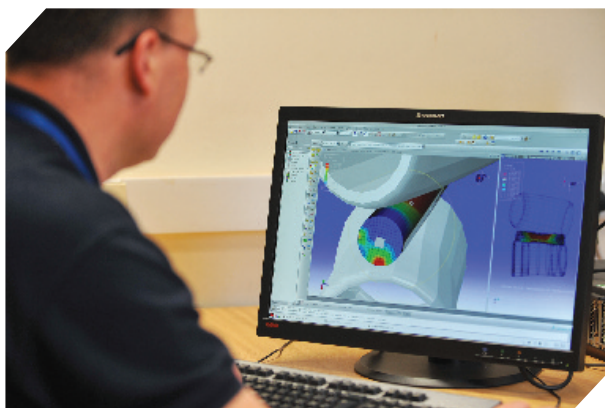
FEA can be used to show whether a component or assembly might be expected to fail prematurely, or alternatively to assess if it is likely to work in the way it was originally designed. It involves a computerised method for predicting how a product or material item of plant, reacts to forces, vibration, heat, fluid flow, and other physical effects.

Computational Fluid Dynamics (CFD)

CFD enables fluid flow to be simulated without the requirement to build a physical model. It provides a qualitative prediction of fluid flows by means of mathematical modelling and numerical methods, enabling scientists and engineers to perform numerical experiments in a 'virtual flow laboratory'.

Discrete Event Simulation (DES)

Particularly valuable where machine and materials interactions are involved; for example, simulating product movement around a plant or storage facility, or process flows in a manufacturing process; as design or system changes can be made offline, without any financial or production impact. This powerful tool depicts the behaviour of a complex system as a series of well-defined and ordered events. Once a system has been 'modelled' in this way it is possible to quickly analyse the system's behaviour over time and find answers to "why" or "what if" questions.



THERMODYNAMICS

The Thermodynamics Laboratory has a range of furnaces primarily for the empirical determination of thermodynamic and kinetic constants and for the study of high temperature reactions.

Equipment includes the capability for controlled atmosphere and rapid quenching of reaction products and a levitation furnace for the study of chemical interactions, without interference from support materials, such as refractories.

The equipment allows both data to be generated to extend and validate commercially available thermodynamic modelling tools, and the study of more complex systems than would be possible by numerical simulation alone.

Thermodynamic modelling may be utilised for:

- > **Calcining and Dehumidifying**
- > **Pyrometer Testing**
- > **Metal, Alloy, Slag Preparation**
- > **Droplet Studies**
- > **Heat Treatments**
- > **Melting Studies**

RAW MATERIALS, BY-PRODUCTS AND PRODUCTS

A wide range of experimental instrumentation with highly skilled personnel

MATERIALS AND MINERALS

For the characterisation of materials and minerals, the Institute has a number of materials testing laboratories with extensive analytical instrumentation, complemented by a range of preparatory equipment. Process and production experience permits not only determination of chemical and physical properties, but also advice on suitability or possible better alternatives, in relation to particular applications. Failure analysis and compliance to specification / quality assurance checks can also be performed.

With extensive knowledge in **Glass, Ceramics, Refractories and Carbonaceous Materials**, the Institute has the capability to test and develop ore composites and agglomerates at pilot scale and to determine product characteristics such as strength, degradation, reducibility, porosity and morphology.

Expert knowledge can be provided to clients on the determination of:

- > Requirement for pre-treatment of raw materials to improve physical or chemical properties
- > Possibilities regarding use of specified materials
- > Processing of residual materials
- > Optimisation of material blends

Characterisation of **organic liquid samples** such as bio-oils, petroleum and polyaromatic hydrocarbons is carried out, as well as impurity analysis.

Specifically for **carbonaceous material**, proximate and ultimate analysis, automated reflectance, coke characterisation and petrography are performed.

The Institute also utilises its extensive materials and engineering knowledge to provide design, commissioning and consultancy services, for **materials handling equipment**, for:

- > Chemical / mineral / waste feed systems
- > Recycling separation facilities
- > Raw materials sorting / transporting



Materials characterisation for process planning and control

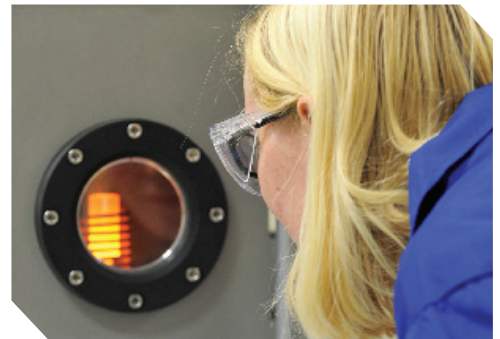


THERMAL TECHNOLOGY SERVICES

Supporting Energy, Waste and Production sectors, the Materials Processing Institute offers expertise in **Gasification**, **Pyrolysis** and **Torrefaction**, with facilities for investigating the effect of material composition and morphology on physical properties and process parameters.

Facilities and capabilities include:

- > **A fully instrumented 350kg capacity moving wall batch pyrolysis unit, which permits monitoring of:**
 - The development of charge temperature during heating
 - Internal gas pressure
 - Wall pressure generation and charge shrinkage
 - Off-gas analysis
- > **High Temperature Materials Laboratories equipped for the characterisation of materials properties from ambient temperature to 1700°C with:**
 - High temperature viscometer
 - Simultaneous Thermal Analysis of phase transformation, reaction and enthalpy data
 - Wettability
 - Hot stage microscopy with controlled atmosphere for softening, surface tension and melting point studies
- > **Expertise in design of slag chemistries to optimise conditions relative to:**
 - Slag viscosity and basicity
 - Interaction with refractory lining
 - Chemistry of feedstock
 - Generation of particulates
- > **Materials Testing Laboratories which are ideal for investigations into new and alternative raw materials, as well as supporting development of techniques for material beneficiation and consumable items, such as refractories:**
 - With a range of high temperature furnaces and materials handling equipment, for both routine quality control checks and development of new tests and techniques
 - Testing agglomeration and sintering



Profiling material behaviour at
high temperature for setting
production parameters



SERVICED PILOT PLANT AREAS

Allow off-site scale up and practical training opportunities

UPSCALING

Customers and collaborators are able to explore, develop and optimise, materials and processes, realising lasting improvements in energy efficiency and process reliability; and work on reducing any adverse environmental impact.

Acceleration towards commercial realisation can be achieved offline and away from production, whilst allowing clients to reduce the risks associated with new processes and product development.

With facilities ranging from laboratory scale experiments through to the construction and operation of a demonstration scale pilot plant, the Institute offers clients support at any stage from the fundamental idea or invention, through to commercial technology delivery.

The Materials Processing Institute's **fully serviced pilot space** is supported by:

- > Experienced process scientists and engineers to design, build and operate pilot equipment
- > A range of on-site analytical services for product qualification
- > Design of relevant experiments for plant / process validation and verification
- > Assistance with COSHH and Risk Assessments
- > HSE support, and guidance on permits to operate

Such facilities may equally be used for **Testing or Training** purposes, as may the Institute's laboratory areas.

TRAINING COURSES

The Institute offers practical and theoretical training courses, and these can be tailor-made to meet client's requirements. Training can be carried out either at the Institute, which has modern, well equipped **conference and training facilities**, or at the client's own site.



Design, commissioning and
consultancy services, to support
improved performance





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