

Overview

The Research Institute for Industry (RIFI) delivers applied research and engineering solutions to industry. RIFI is an industrial arm of the School of Engineering Sciences at the University of Southampton drawing on the knowledge and themes within many of the School's research groups.

RIFI has access to a wide range of facilities for analysis, mechanical testing, metallurgical examination, erosion, corrosion testing and electrochemical corrosion and protection. Erosion rig facilities currently include air-sand erosion rig, free-jet impingement, slurry pot, high temperature gas blast, high-velocity slurry jet impingement (high kinetic energy), micro-wall jet, rotating disc and cylinder electrodes, pin-on-disc test rig, taper-roller bearing rig, ball cratering and nano-indentation test rig.

We have carried out research and consultancy on corrosion, erosion and erosion-corrosion on a wide range of industry problems, including: desalination plants, oil and gas valves, pipe systems loss of contaminant, pump impellers, coatings and modelling of erosion-corrosion. Test materials include: diamond-like coatings, polymeric coatings, high velocity oxy fuel (HVOF) and plasma electrolytic oxidation (PEO) coatings, stainless steels, nickel-aluminium bronze and tungsten-carbide based hardmetals.

Air-Sand

Air-sand erosion test rig

- Designed to impinge solid particles on test specimens at near sonic velocities under controlled erosive conditions.
- Consists of a compressor supplying air continuously to two desiccant columns for drying to a dew point of -70°C .
- The air is then regulated before being accelerated through a venturi type nozzle where the sand is injected at a fixed rate.
- Downstream, the flow of air and sand enters a 1 m length particle acceleration tube of 0.016 m diameter and a throat velocity of Mach 1.9 is achieved.
- The erosion chamber, is designed to allow variation of the jet impingement angles from 90° to 20° and the standoff distance (sample to acceleration tube) from 10 to 100 mm.
- In-situ observations and high-speed photography of the samples during the test are made possible through two optical window ports located on the chamber.
- Solid particles are accelerated up to 400 m s^{-1} (size dependant).

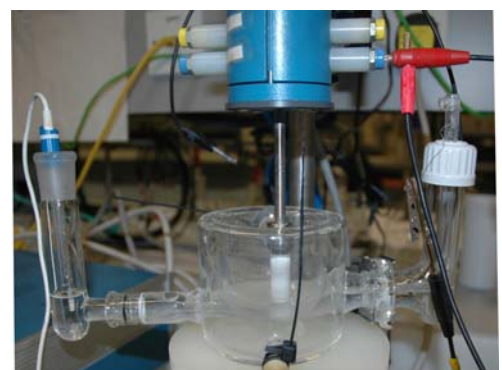


Single-phase (aqueous)

Rotating electrode cells

Laminar, turbulent and transitional flow can be obtained using a variety of electrode geometries.

- Rotating disc electrode (RDE). Electrodes 2 – 10 mm diameter. Rotation rate $< 6000\text{ rpm}$.
- Rotating cylinder electrode (RCE). Electrodes 7 – 100 mm diameter. Rotation rate $< 5000\text{ rpm}$.
- Rotating cylinder Hull (RCH) cell for controlled, non-uniform current distribution. Electrodes 5 – 12 mm diameter. Rotation rate $< 2000\text{ rpm}$.

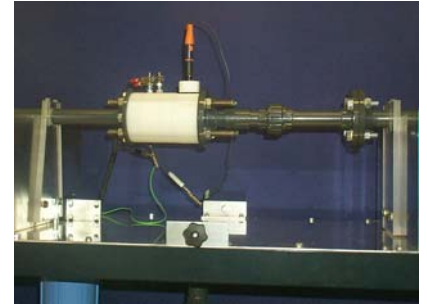


Corrosion and erosion testing at Southampton

Pipe flow loop

Pipe flow loop incorporating a test cell configuration enabling electrochemical investigations under fully-developed fluid flow fields, from laminar, transient to turbulent flow regimes.

- Test section inside pipe diameter of 0.028 m and a total solution reservoir of 210 L.
- Flow velocity range of at 0.04 to 2.7 m s⁻¹ through a 0.028 m diameter test section.
- Equivalent to Reynolds numbers of 1000 to 75000.
- Standard electrochemical corrosion techniques: DC voltammetry, Tafel extrapolation, linear polarisation, zero resistance ammetry and electrochemical noise measurements.



Multi-phase (aqueous + abrasive particles)

Micro-wall jet

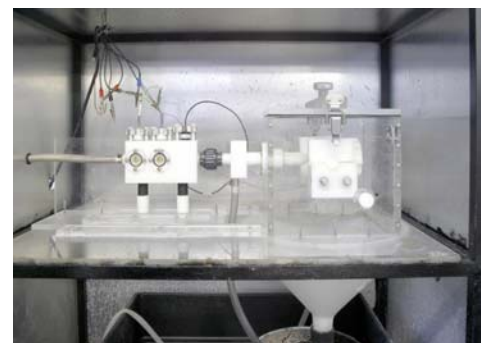
Flow cell incorporating the 'micro-wall jet' configuration enabling electrochemical investigations under well-characterised fluid flow fields.

- Nozzle diameter: 300 µm
- Stand off distance: 350 µm
- Velocity range: 0.5 – 30 m s⁻¹
- Electrode materials (WE): Platinum and copper based alloys.
- Counter electrode: Platinum wire
- Reference electrode: Silver / silver chloride
- Electrode size: 3 mm
- Electrochemical corrosion techniques: DC voltammetry, AC impedance, Tafel extrapolation, linear polarisation and zero resistance ammetry.



Slurry jet impingement erosion-corrosion rigs

- Technique utilises a high pressure water jet containing abrasive particles.
- Jet impingement angle and velocity can be easily controlled.
- Velocity range: 3 – 15 m s⁻¹
- Sample size: 50 x 50 x 5mm



Corrosion and erosion testing at Southampton

Water-sand slurry erosion jet impingement (high kinetic energy)

- Consists of a 10 L reservoir in a loop of 0.019 m diameter piping around which the slurry is circulated by a variable speed mono-pump controlled by a frequency inverter.
- Sample is located in front of the returning slurry stream.
- Slurry flow rates can be varied between 0.3 and 1 kg s⁻¹ and are measured by a non-intrusive type electromagnetic flow meter connected to a chart recorder.
- A slurry jet is produced by accelerating the flow through a nozzle at velocities of 2 to 32 m s⁻¹.
- Jet velocities can be varied at constant flow rates and by selecting suitable jet nozzle diameter range particle dropout is avoided.
- The slurry jet impingement angle can be varied.



Slurry pot erosion-corrosion test rig (low kinetic energy)

- Constructed from uPVC and any parts in contact with the solution are either plastic or coated.
- Baffles stop the establishment of a forced vortex and ensure specimen passing through a stationary fluid.
- The rotating part of the rig is a Nylon-coated steel shaft driven through a belt by the motor.
- At the end of the shaft, two parallel Nylon-coated steel arms are used to securely clamp the specimens.
- Specimens are cylindrical rods (Ø 5 mm x 50 mm), in between plastic (Delrin™) cups.
- Velocity range between 0 to 12 m s⁻¹.



Examples of eroded surfaces



Abraded slurry pump



Cavitation erosion damage to the pump impeller



Eroded choke valve

Corrosion and erosion testing at Southampton

Specifications for some of the test rig facilities at the University of Southampton

Parameter	Air-sand erosion rig	Slurry jet impingement	Slurry pot	High temp gas blast	Micro-wall jet
Particle type	Sand, SiC grit, alumina grit, glass beads, diamond grit	Sand, SiC grit, alumina grit, glass beads, diamond grit	Sand, SiC grit, alumina grit, glass beads, diamond grit	Sand, SiC grit, alumina grit, glass beads, diamond grit	Electrode materials: Platinum and Cu based alloys
Angle of impingement	20-90°	20-90°	N/A	90°	90°
Velocity range	Throat velocity of Mach 1.9	3 – 15 m s ⁻¹	0 – 12 m s ⁻¹	~	0.5 – 30 m s ⁻¹
Particle speed (m s⁻¹)	10 – 400 (particle size dependent)	(3 – 15), (15 – 100)	5 – 12	10	N/A
Particle flux / Concentration	0.05 – 8.0 kg m ⁻² s ⁻¹	~2% w/w	~2-5% w/w	0.05 kg m ⁻² s ⁻¹	ppm
Maximum dose	84 L or 225 kg (sand)	N/A	N/A	N/A	N/A
Specimen size	50 – 200 mm diameter or square	50x50x5mm or Ø50mm	40xØ5 (cylindrical rod)	50x50x5mm	Electrode size 3 mm
Acceleration tube bore, pipe diameter	5 – 15 mm thick < 200 g in weight, 16 or 20 mm	19 mm	N/A	10 mm	Nozzle diameter 300 µm
Acceleration tube length	1 m	6.2, 8.0, 10.0 and 14.5 mm	N/A	200 mm	Stand of distance 350 µm
Aspect ratio	63 or 50	N/A	N/A	20	N/A
Test temp.	10 – 20°C	0 – 90°C	0 – 90°C	200°C	N/A
Noise level	< 70dBA	N/A	N/A	N/A	N/A
Specimen mass measurement	balance precision (±0.01mg)	balance (±0.01mg)	balance (±0.01mg)	balance (±0.01mg)	balance (±0.01mg)