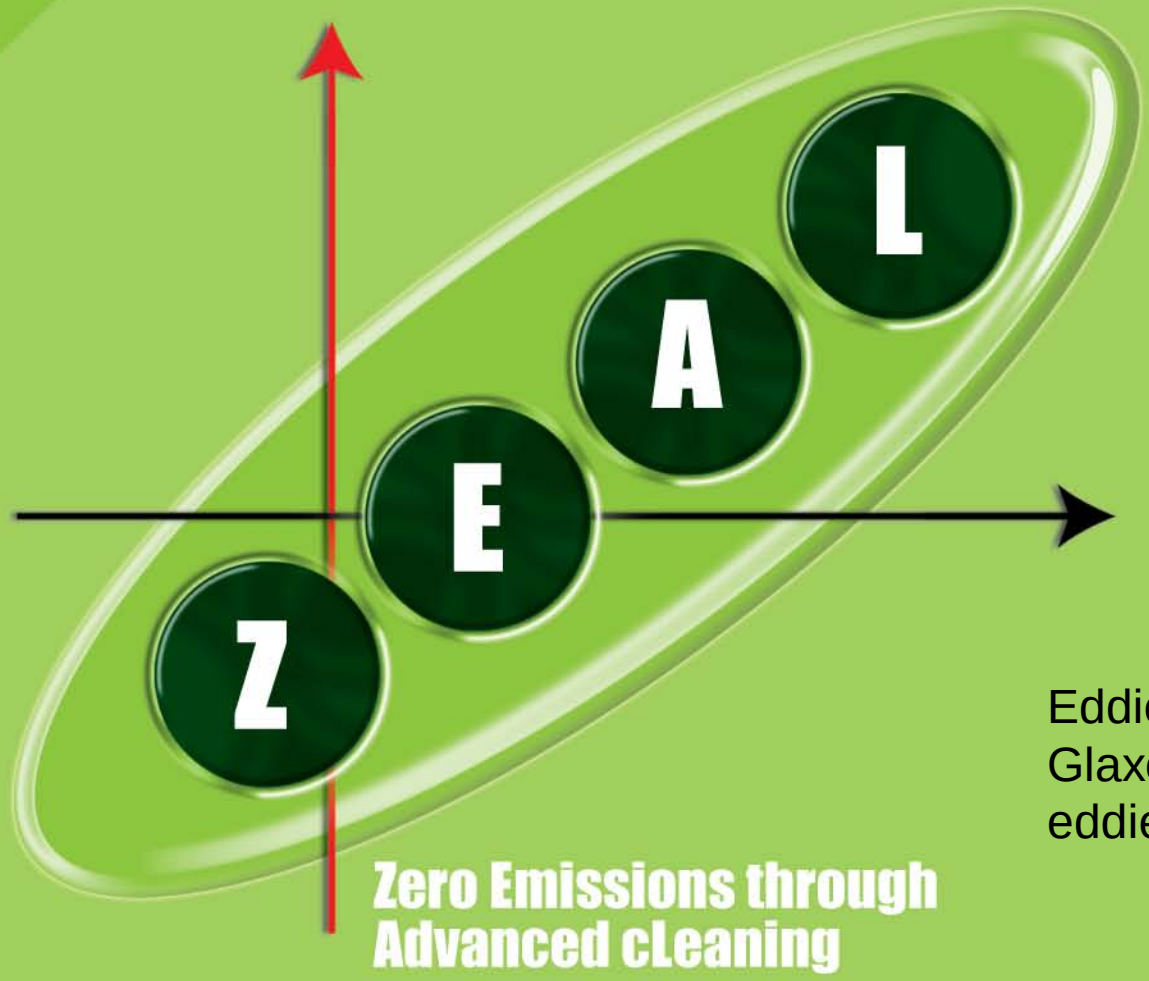
Project Zeal, Reduction or Elimination of Waste from Production



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Presentation Outline

- About Project Zeal
- Overview of Cleaning
- Cleaning of Toothpaste
  - Measuring Cleaning Cost
  - Experimental Set-Up
  - End Point Detection
  - Mechanism of Cleaning
  - Scalability
  - CFD Modelling
- Zeal Outputs

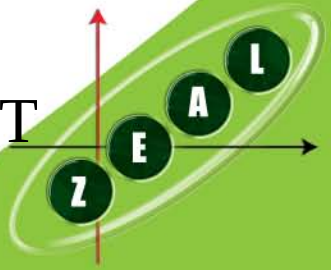
Project Zeal

- A consortium of 11 partners
  - 3 Universities
  - 4 End Users (Manufacturers)
  - 4 Suppliers
  - Co-funded by the Technology Strategy Board
  - EngD's funded by the EPSRC
  - 4 Year Project
- Aims: To investigate cleaning of process plant
  - Measuring
  - Modelling
  - Controlling

Zeal Deliverables

Academic cleaning process understanding at industrial flow-rates

- Zeal deliverables
  - Benchmarking Tool
  - Custom Made Pilot Plant
  - Challenge Minimum velocity & Temperature for cleaning
  - Cleaning by product type
  - Scale-up Cleaning
    - Coupon rig
    - Length Scales
    - Diameters
  - CFD and simplified practical models
  - Measurements in-line & off-line
  - End-point Determination
  - Multiple measurements combinations for use in PAT



Cleaning-
A “Non Value Added” Operation

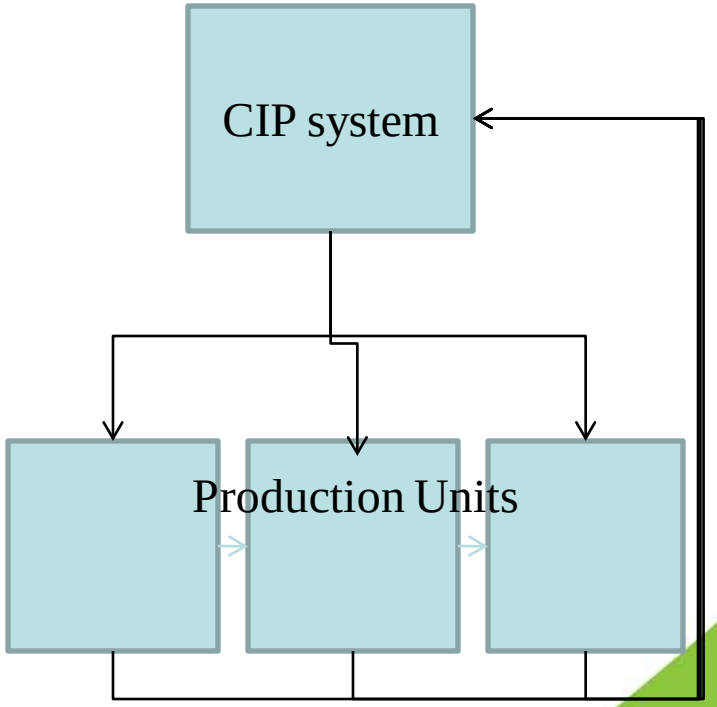
- Product Safety
- Product Change-Over
- Product Quality
- Process Efficiency
- Safe Working Environment

Industrial CIP

- Cleaning of production equipment is usually performed by CIP or Cleaning- In-Place

A CIP system

- Pre-rinse – gross product removal
- Detergent step (Alkali and/or Acid)
- Post detergent rinse
- Sterilisation
- Post sterilant rinse



Industrial CIP

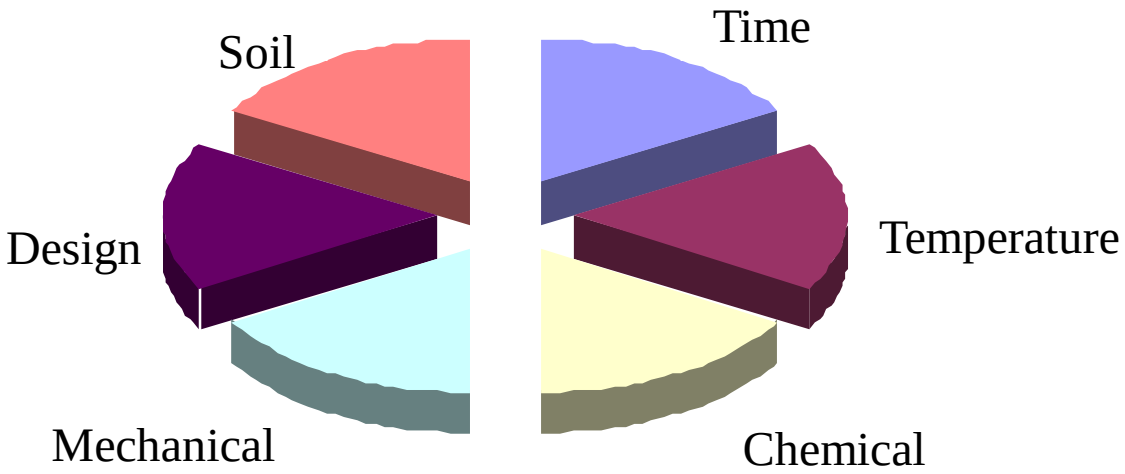
- Needs to be
  - Repeatable
  - Reliable
  - Require minimal intervention

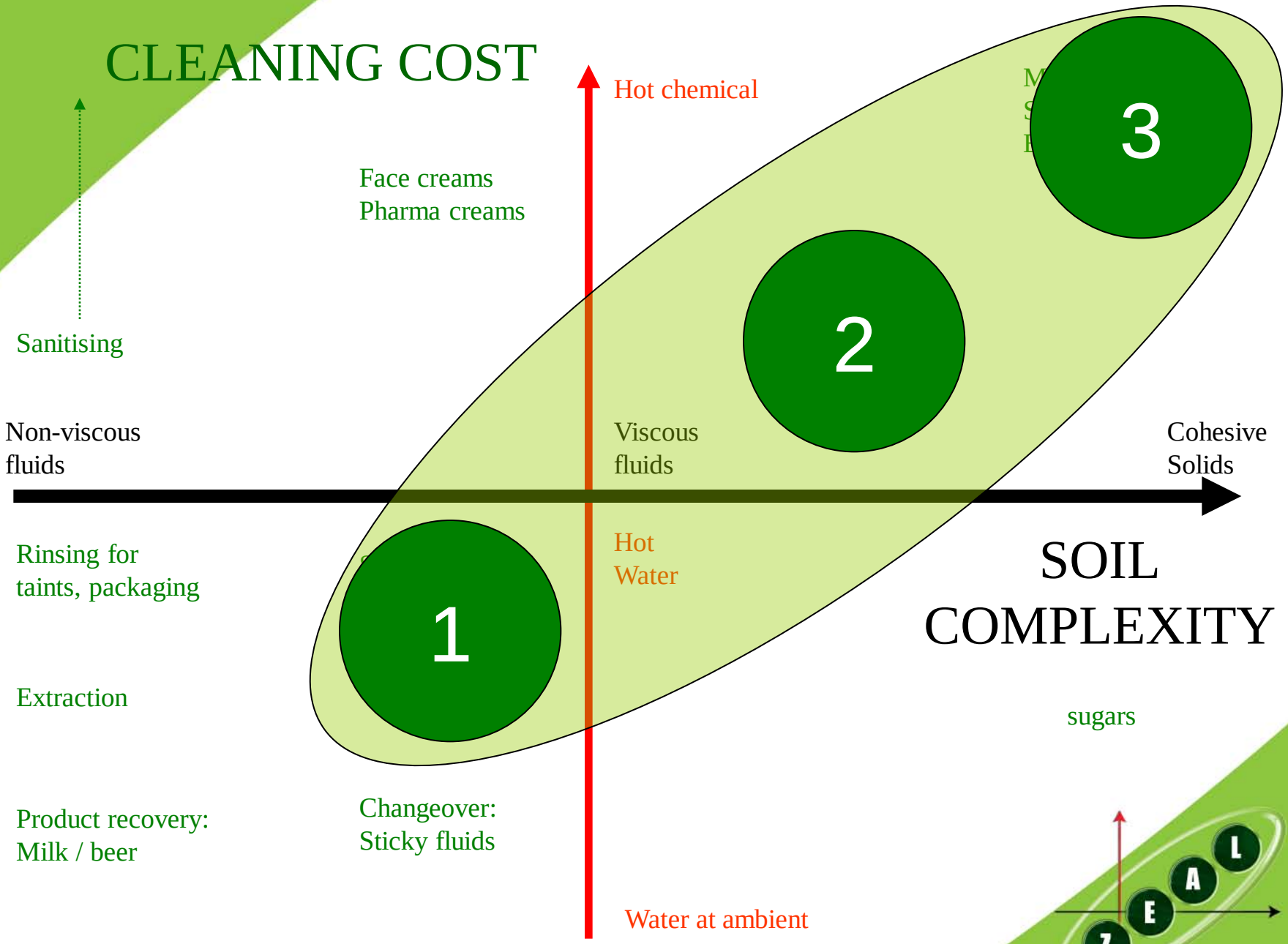
- Efficient cleaning process
  - Minimal time
  - Minimal water usage
  - Minimal energy input
  - Minimal chemical usage
  - Hence, a smaller environmental footprint

Understanding the Process of Cleaning

- Soil / Foulant / Deposit
- Surface
- Cleaning Fluid

Removal Mechanisms

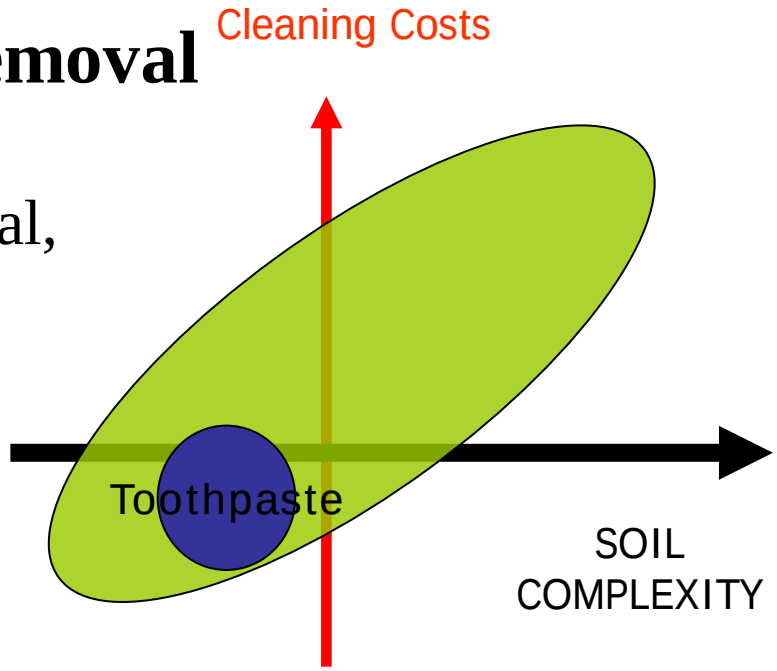



CLEANING COST
Hot chemical
Face creams
Pharma creams
3
2
Sanitising
Non-viscous
fluids
Viscous
fluids
Cohesive
Solids
Rinsing for
taints, packaging
Hot
Water
1
SOIL
COMPLEXITY
Extraction
sugars
Product recovery:
Milk / beer
Changeover:
Sticky fluids
Water at ambient

9

Toothpaste Cleaning Problem – Bulk Product Removal

- Toothpaste is a viscoelastic material, typical of many FMCG products
- Complex rheological fluid
  - Viscoelastic
  - shear thinning
  - cohesive; particulates
- Density of approximately 1.3gcm^{-3}
- It fully fills the pipeline system in a factory
- Bulk material requiring fluid mechanical removal
- Example of Type 1 soil as classified in the cleaning map



ZEAL - HOME NAVIGATION PAGE

Introduction

Assessment Information

Utilities & Effluent Costs

Product Types

Cleaning Scenario

Clean Times & Consumptions

Data Entry navigation & data cross-link matrix

Plant Data

Site Information

Cleaning Data (Generic)

Management View

Process & Cleaning Diagrams

CIP & Effluent Monitoring

Overall Cost Summary

KPI's

COST GROUP **CLEAN** DETAILS

Tanker Bays

COST GROUP **COST** DETAILS

Process

Assessment Results

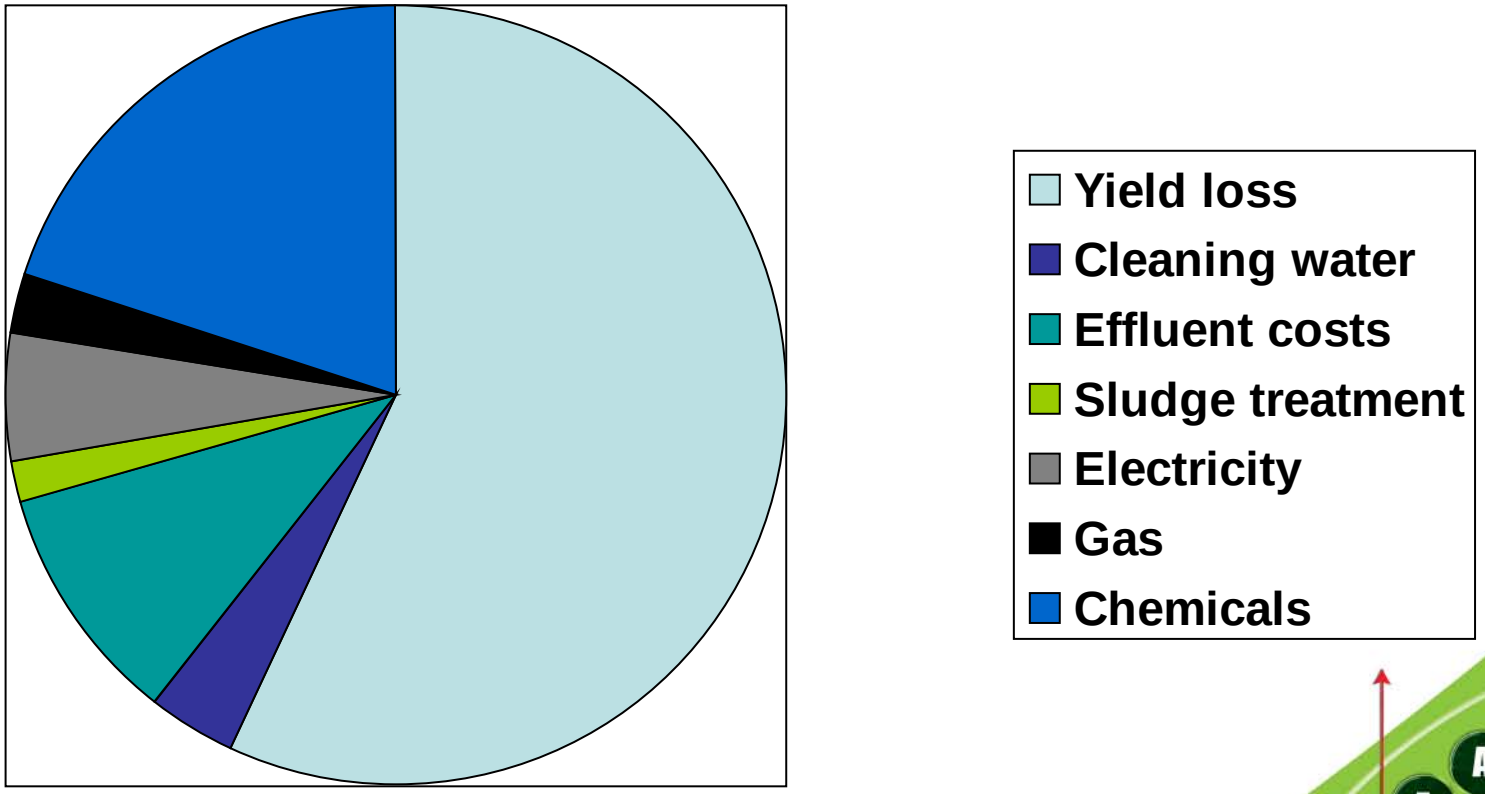
TEXT COLOUR CODE KEY

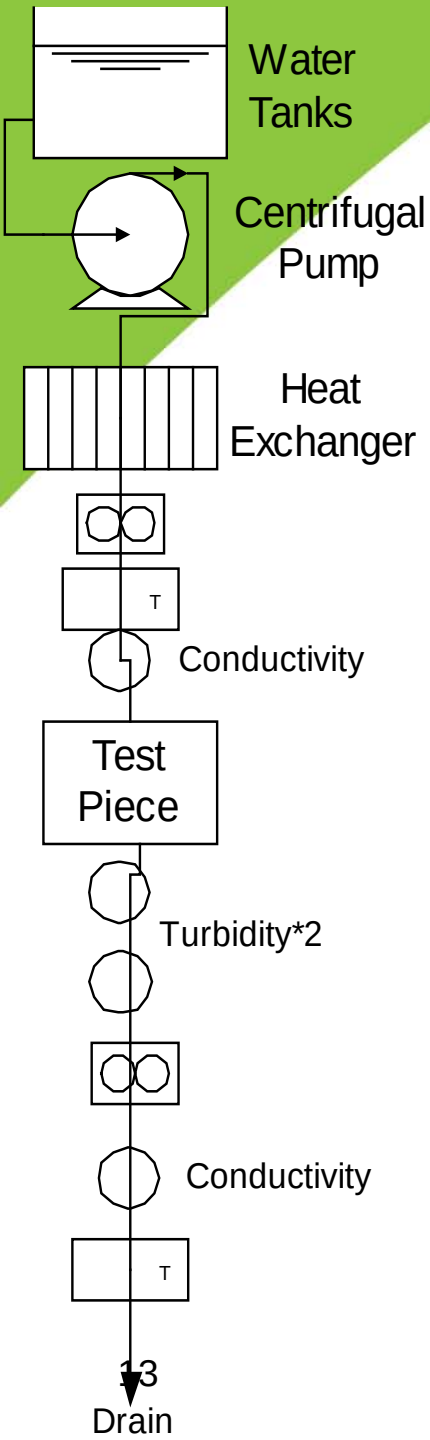
RED = REQUIRED DATA ENTRY FOR COSTS/BENCHMARK

GREEN = OPTIONAL DATA ENTRY

BLUE = REPORTS COSTS & BENCHMARK SCORES

"Cleaning costs £741,257 per year adds about 1% to the costs of manufacture based on mixer cleans 2007"



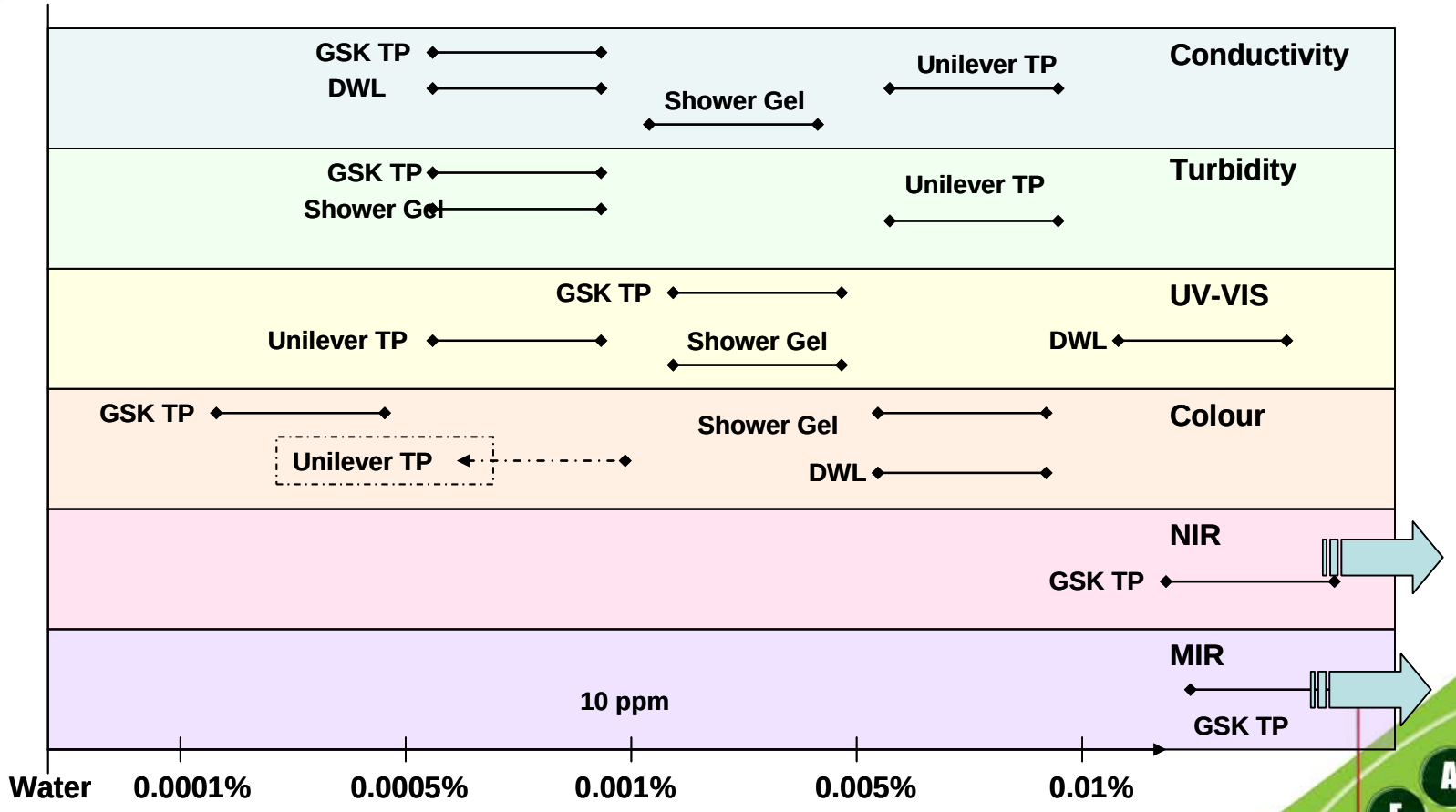


Birmingham University Pilot Plant

Measurements:

- Conductivity (Inductive) – Inlet & Outlet
- Temperature – Inlet + thermocouples at strategic points around the plant
- Turbidity (FTU) & Turbidity (PPM)– after test section
- NIR
- MIR
- Ion Chromatography swabs on cleaned surface

End Point Detection : Sensitivity Limits



Cleaning Mechanism: 2”; 0.5m; 1ms^{-1}; 50^{o}C

Fully Filled

1. Core Removal

2. Thin Film Removal

3. Patch Removal

Start

After 1s

After 15s

After 3min 30

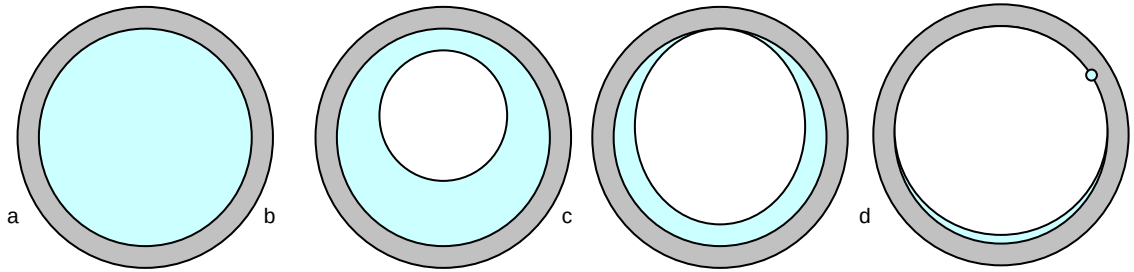
Total cleaning time: 5min40

<u>End of Cleaning Criteria <</u> 4ppm

- Limit of measurement reading (<95% clean)
- Turbidity probe provides a calibrated numerical output in concentration units – this output is the most sensitive at cleaning end point

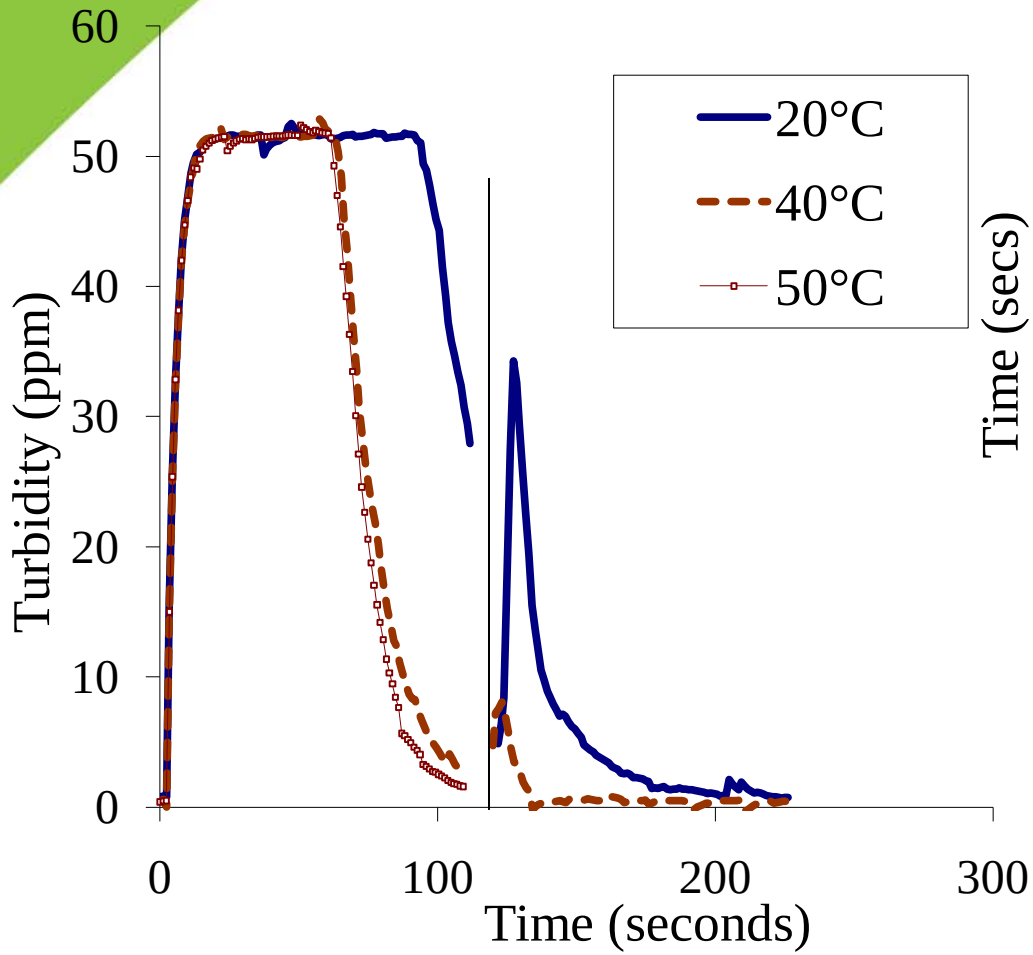
Experimental Results

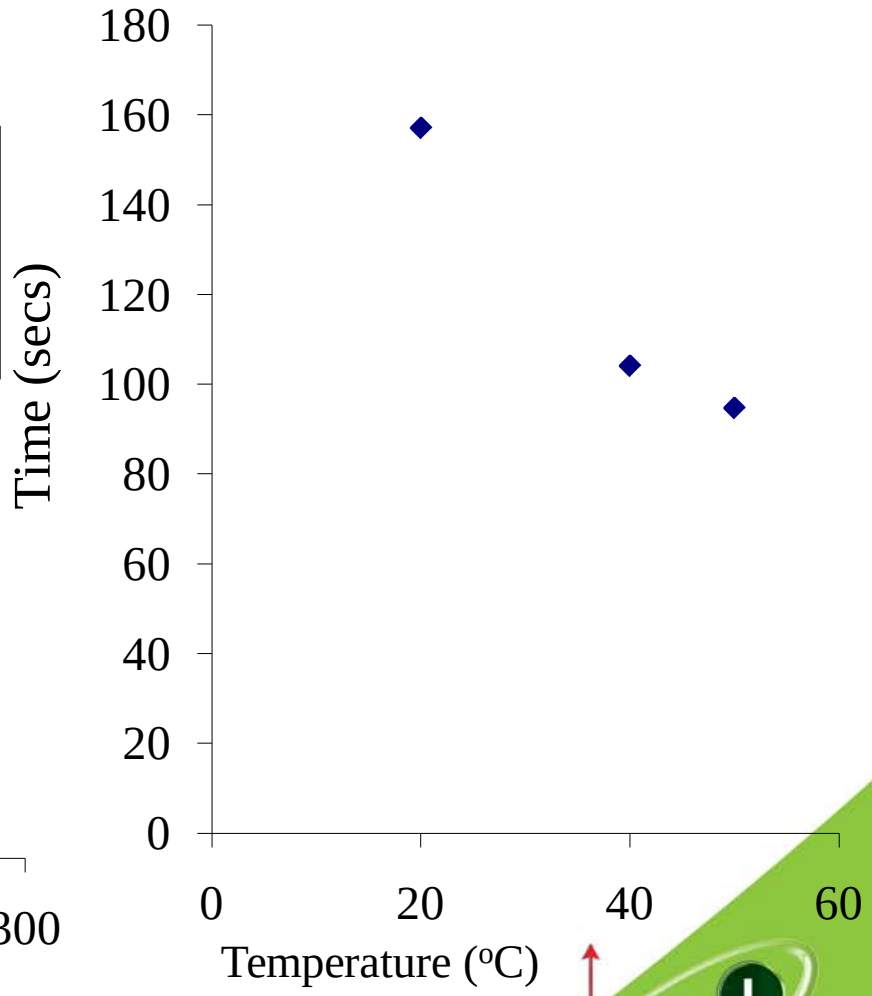
- **Cleaning Mechanism identified:**
  - **Core clean**
  - **Film Cleaning**



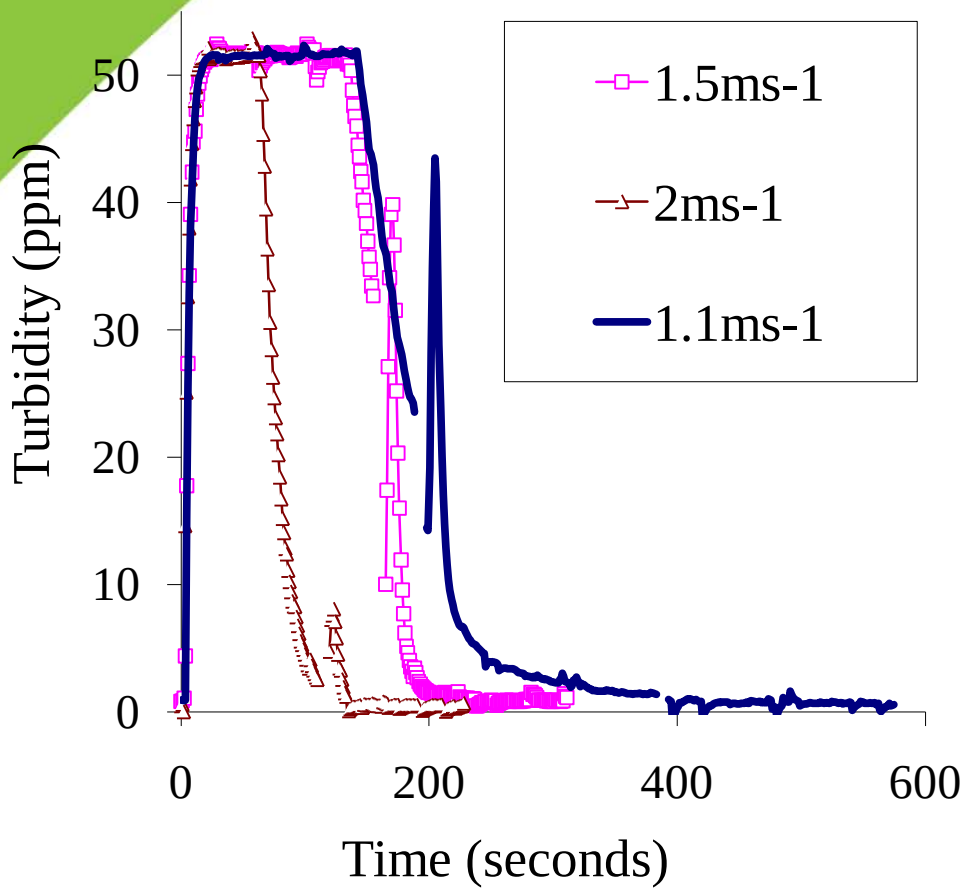
- Minimum Velocity before product movement
- Faster flow rates produce quicker cleaning times
- Hotter temperatures produce faster cleaning times
- Plastic cleans quicker than stainless steel
- On short runs; length does not significantly alter the cleaning time
- Larger Diameters take longer to clean
- Conductivity tracks cleaning reasonably

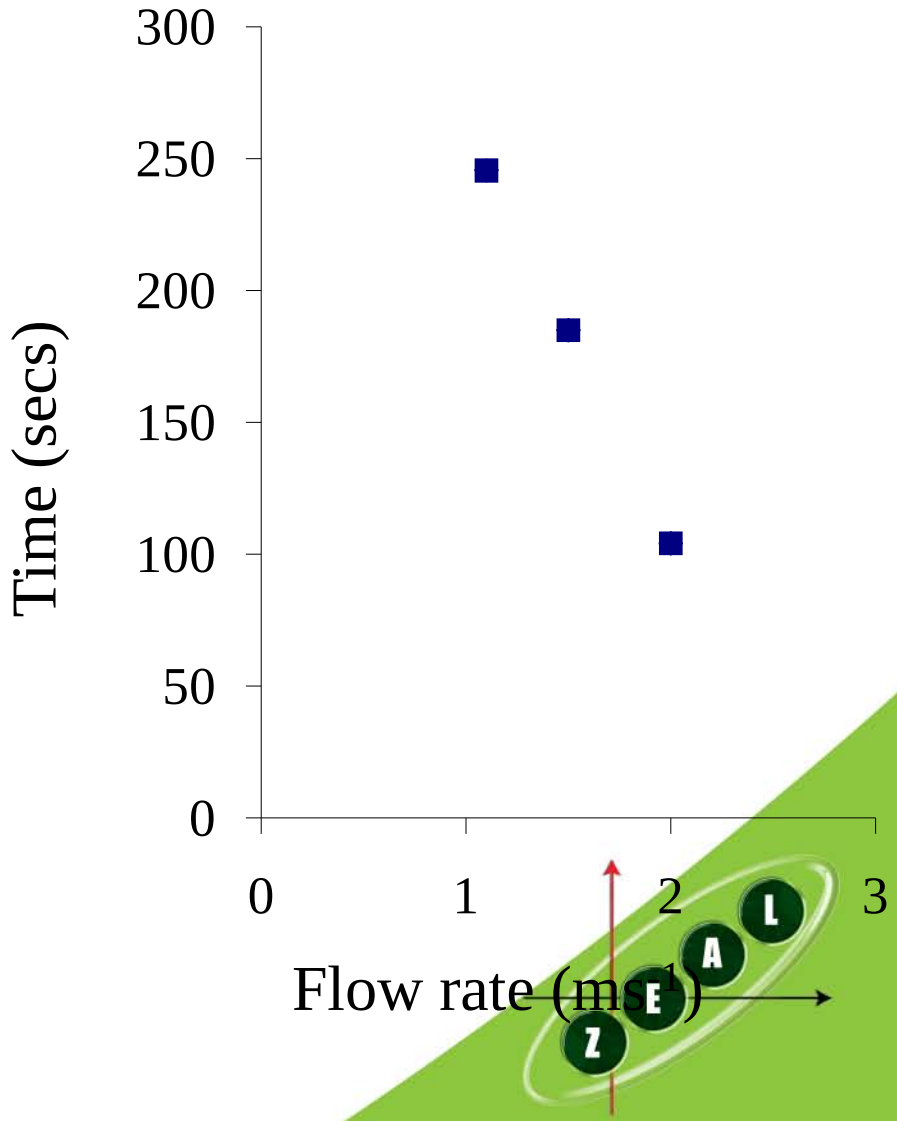
The Effect of Temperature, 2”, 1m, 2ms^{-1}





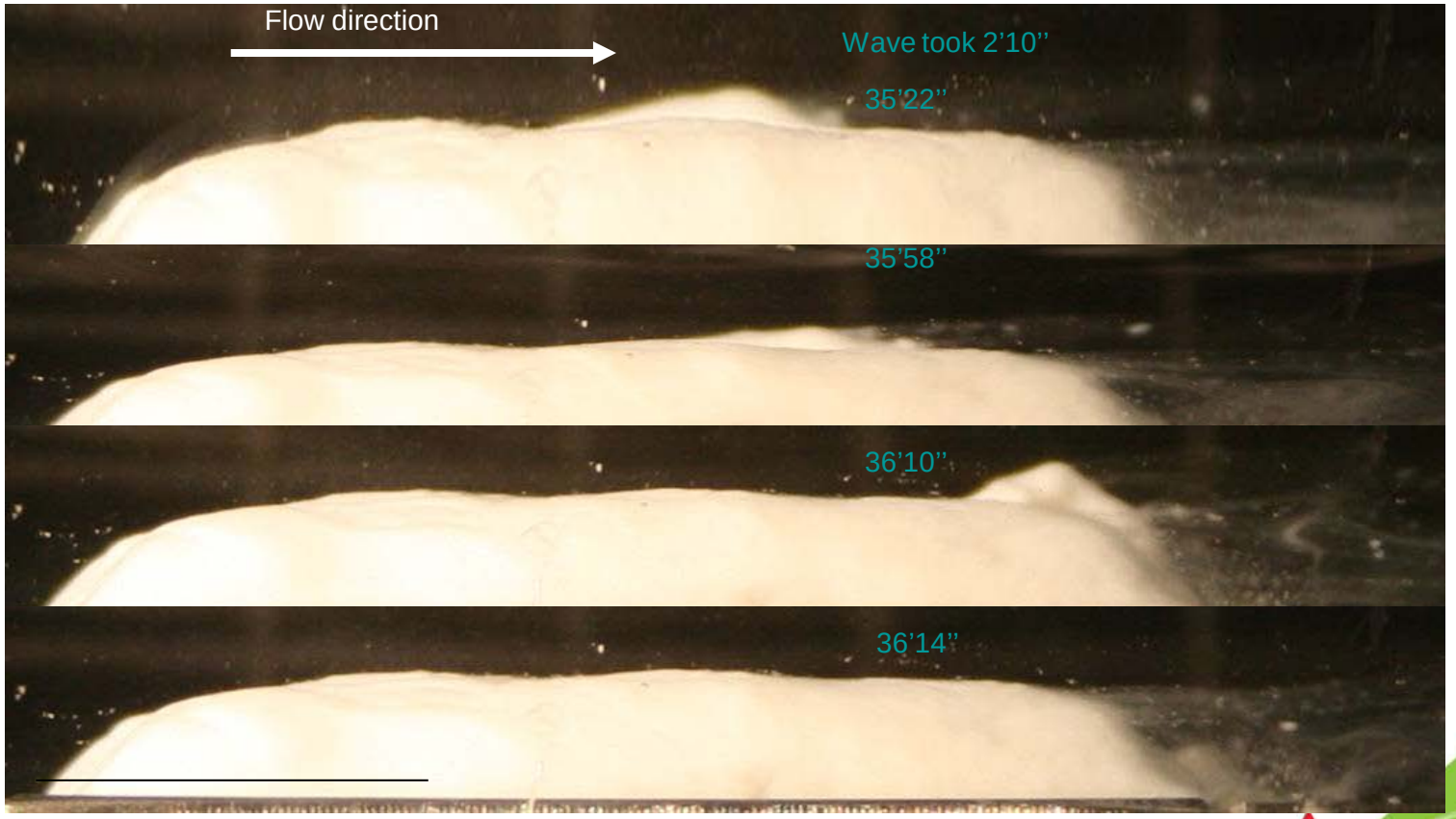
The Effect of Flow rate; 2”; 1m, 40ºC



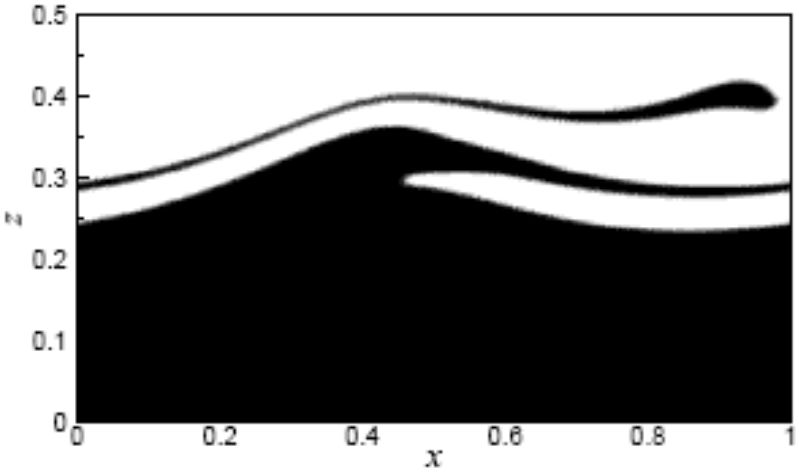


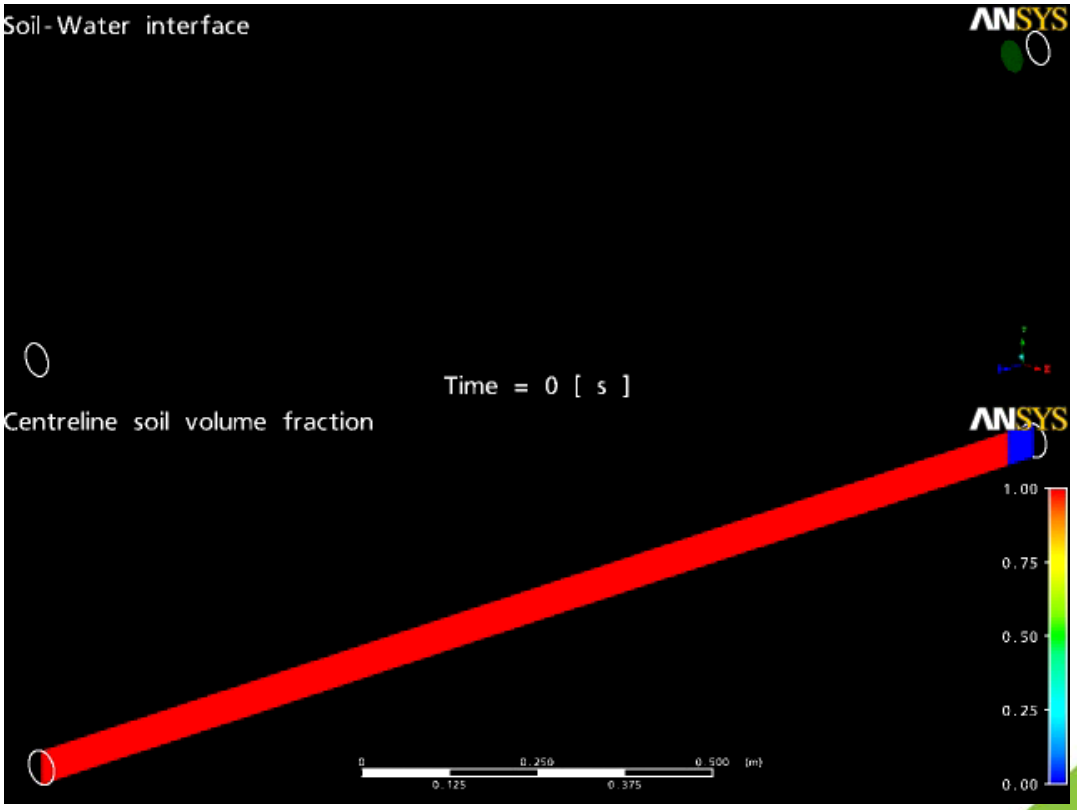
Cleaning Mechanism Coupon Rig - Waves

Square Deposit, Cleaning Time 5 hrs
5 hrs



Imperial CFD models



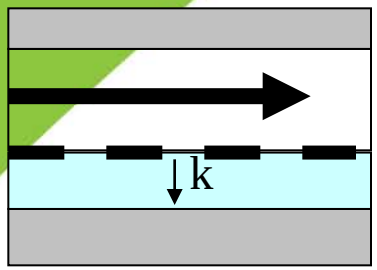


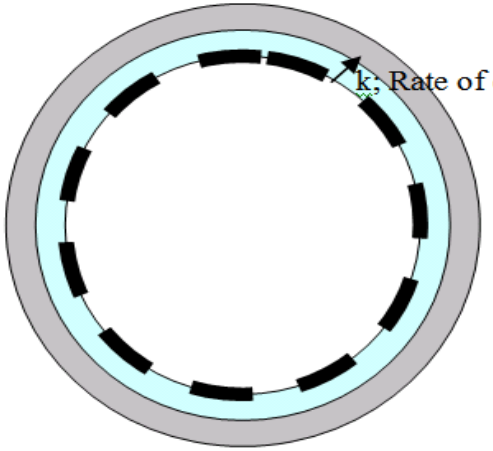
•New cleaning models for 2D showed development of waves: *Novel techniques (diffuse interface method) used to develop models*

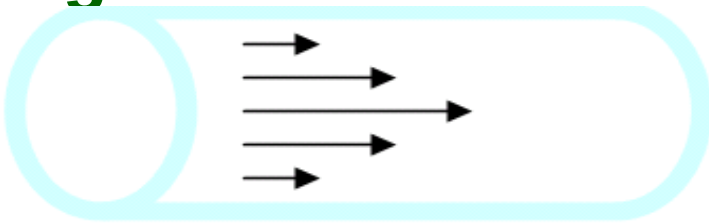
- *3D CFD: Turbulence via Large Eddy Simulation Approach*
- Simplified CFD ‘ practical models’

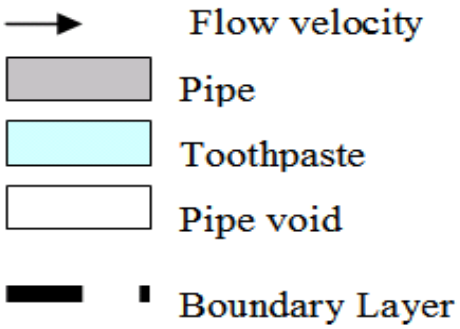
- **Prashant Valluri**
- Lectureship in Chemical Engineering at University of Edinburgh; Institute of Materials and Processes, School of Engineering

Cleaning Process Understanding









Coupon

•Known thickness and known reduction in thickness

• Known mechanism for removal when fluid flow passes over a thin film

Pipe Rigs

• Thin Film Removal

• Unknown thickness (as function of core removal)

• Process Data – can calculate core removal time (Wey)

• On-line/ Off line Measurement – can see reduction in turbidity; Conductivity; Visual verified by IC

Zeal Outputs

- Benchmarking Tool to standardise the approach to accurately calculating the cost of cleaning
- Pilot Plant based experimental apparatus capable of mimicking typical industry flow rates and temperatures of cleaning fluids
- A laboratory based apparatus showing scalability to pilot plant scale
- A ‘Product Map’ of several different FMCG products and their cleaning requirements
- Assessment of end point detection equipment for several FMCG product types
- Cleaning Process Understanding / Mechanism
- CFD Modelling for 2 fluid phase interactions during cleaning
- On-going work includes
  - Numerical modelling to provide feedback data for PAT
  - Scalability work from coupon rig to pilot plant
  - Evaluation of different diameters and lengths of test sections
  - CFD and practical evaluation of different geometries, T pieces, bends, valve housings

Acknowledgements

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ALFA LAVAL

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