The Benefits of a Systematic Approach to Wax Quality Assurance

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EICF Technical Workshop
Bordeaux
September 2013

Agenda

- Quality Assurance and Systematic Approach
- Benefits of Process Based Testing
- The Role of New Technologies
- Systems Engineering
- Future Testing to Meet Tomorrow’s Challenges
- The Benefits of a Systematic Approach

Quality Assurance

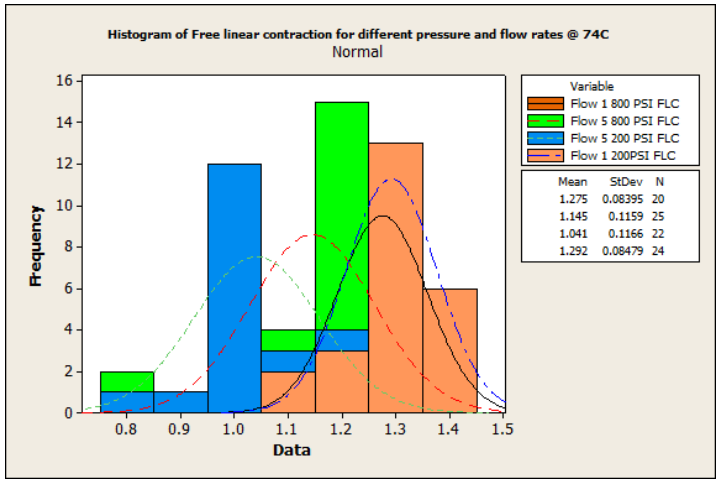
- Quality is often defined as “Fit for Purpose”
- With the assumption that if materials meet specification they will perform the same
- Modern manufacturing requires process materials to demonstrate less variation
- Suppliers are required to provide ever more detailed and meaningful test information
- This has led to the need for process based testing
  - Tests that simulate the foundry process
  - For a wax this means testing performance under injection conditions
- This process based testing provides useful data to aid production and reduce variability

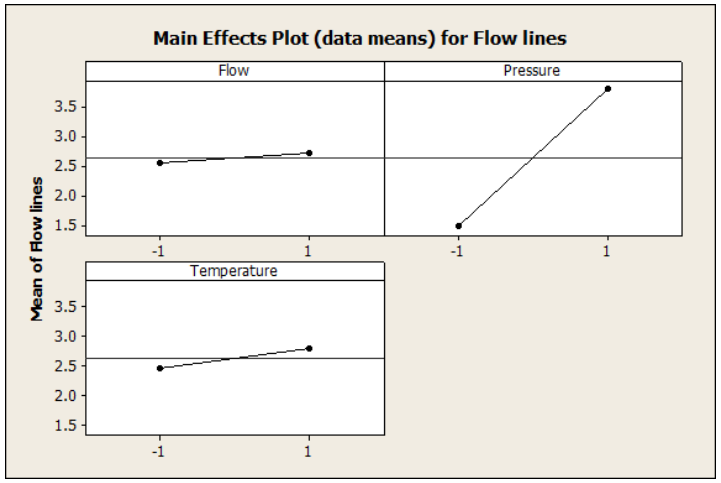
Systematic Approach

- Significant benefits can be gained by implementing a systematic approach to quality assurance
- By a systematic approach we mean a step by step improvement process
- The targets and end results include
  - Closer tolerances
  - Improved batch to batch repeatability
  - Ability to offer direct wax injection performance data to the foundry, helping to reduce process costs
- This systematic approach covers all areas of wax manufacture

Benefits of Process Based Testing

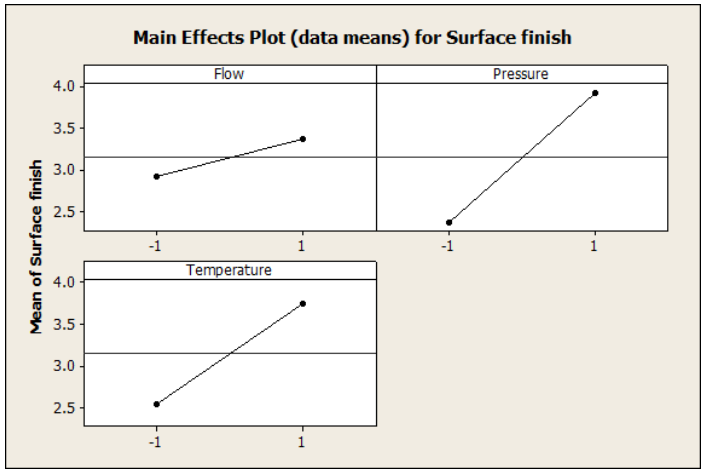
Process Based Testing

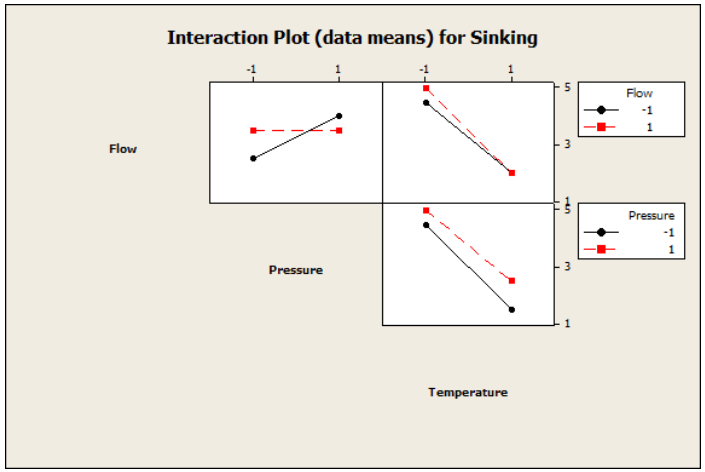




- Process based testing has been implemented for
  - Free linear contraction
  - Fluidity
- The next stage is to measure and control additional aspects of the wax
- Research programmes have taken place into how wax properties affect injection performance
- Tests using both hydraulic and screw wax injection machines

Process Based Testing - Initial Results





- Research demonstrates that the following factors have the greatest effect on injection performance
  - Temperature
  - Pressure
  - Flow
  - Time of injection
- This suggests a need to characterise these criteria using
  - Design of experiment techniques
  - Data collection and evaluation

Benefits of Process Based Testing to Quality Assurance

- Greater understanding of the implications of wax properties
- Advance warning of possible process variations
- Allows closer cooperation between supplier and customer

The Role of New Technologies

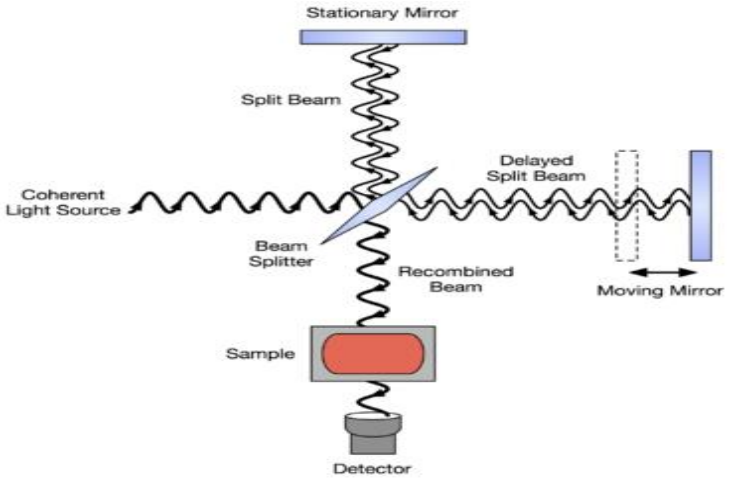
Traditional Tests and Reasons to Change

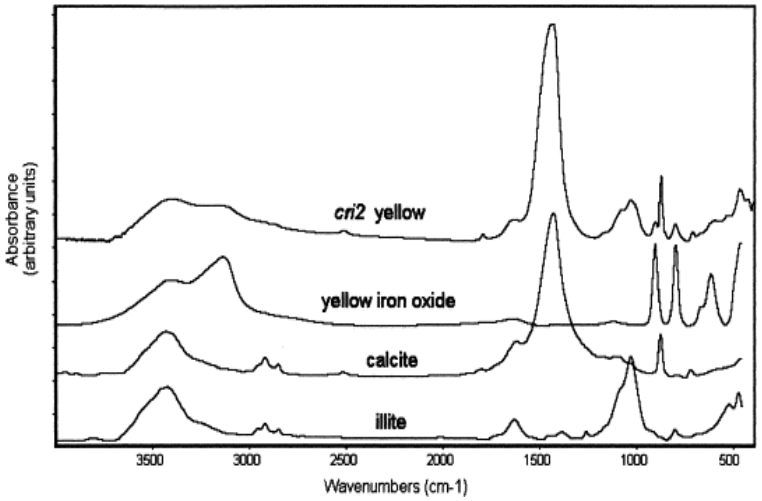
- Wax testing has been based around the Petrochemical industry
  - Congealing Point / Melting Point
  - Viscosity
  - Penetration
  - Percentage Ash
- Complex casting geometries require a change in thinking
  - How does a material flow?
  - How does melting and solidification impact on wax performance?
  - How and why does a wax distort?

New Technologies

- Technology allows a change in thinking and extends wax testing boundaries
- Infrared analysis (FTIR)
  - Fingerprint of raw materials
- Differential scanning calorimetry (DSC)
  - How phases impact on performance
- Rheometry
  - An understanding of wax flow
- Non-contact measurement
  - The modelling of distortion

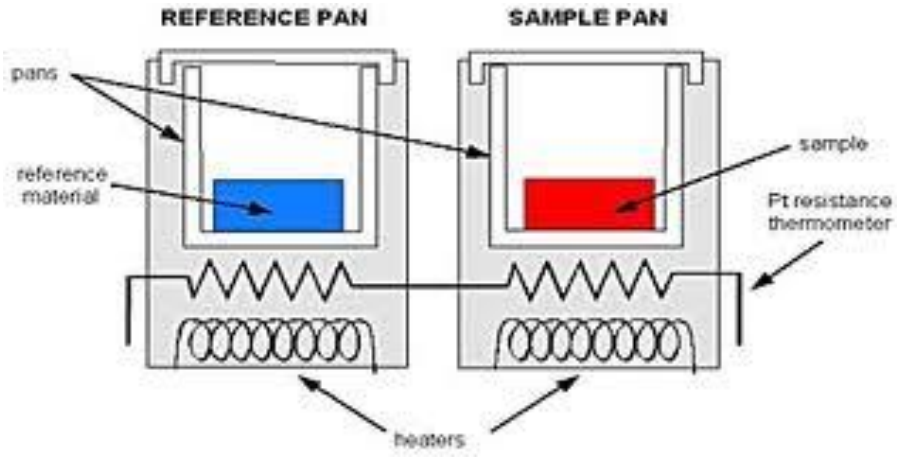
Infrared Analysis (FTIR)

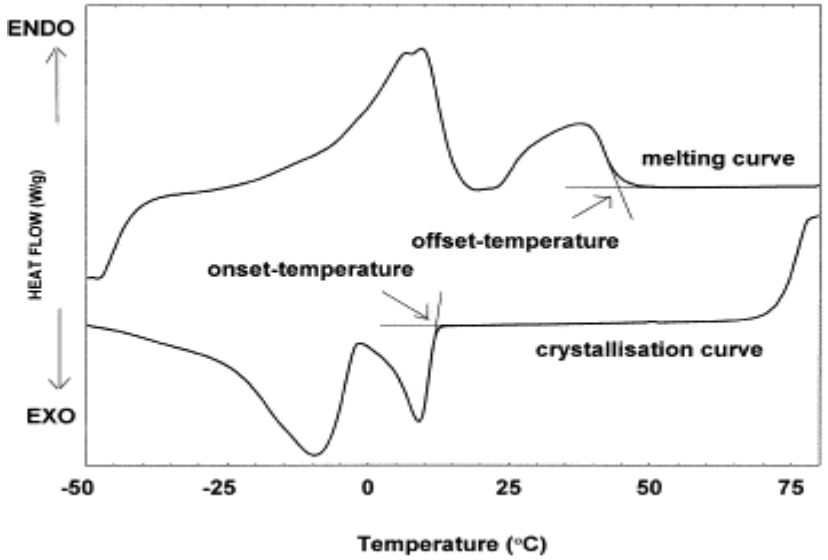




- FTIR operates by comparing two beams of infrared radiation
- The beam splitter divides the radiation
  - Material and control
- The two signals are compared
- The differences in absorption are shown as the material influence
- This fingerprint can be compared with data libraries

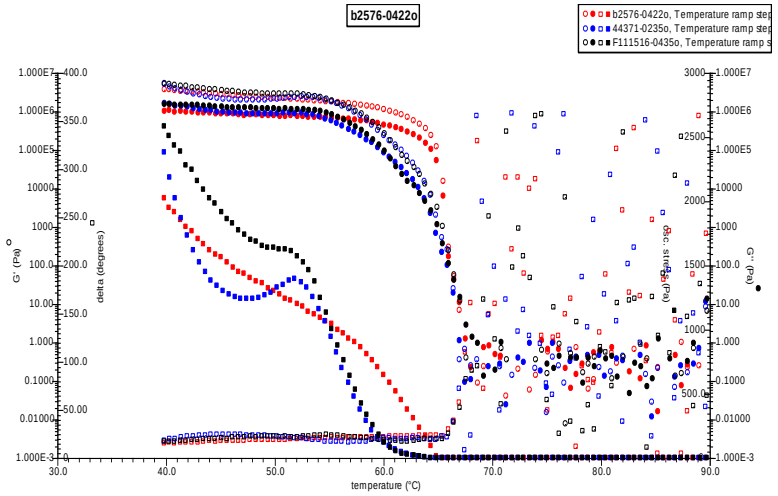
Differential Scanning Calorimetry (DSC)

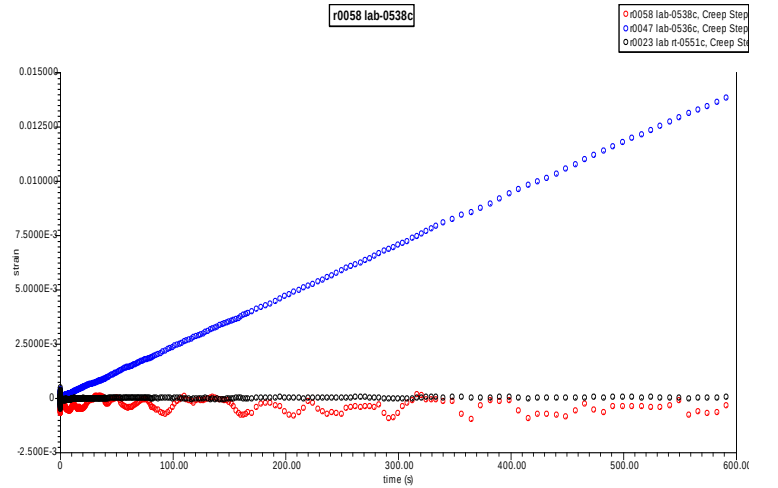




- DSC is a comparative technique
  - very effective in detecting material changes and differences
- The results are shown as phases, endothermic and exothermic
- Used on both incoming raw materials and finished products

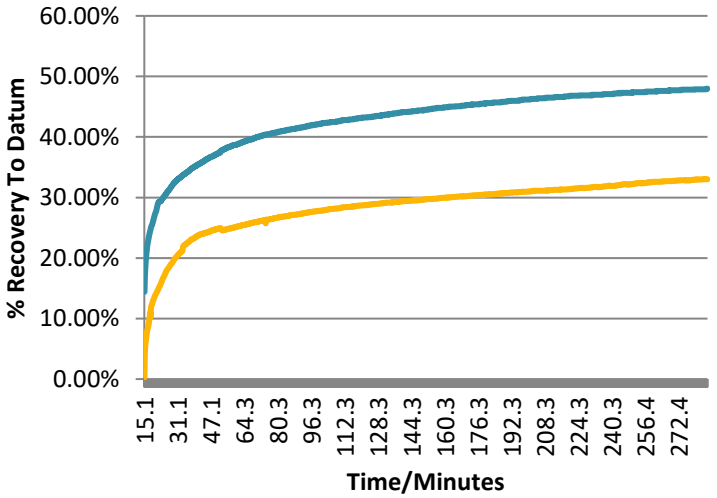
Rheometry





- Rheometry provides a unique fingerprint for a material across variables such as
  - Flow
  - Solidification
  - Viscoelastic strength
  - Resistance to deformation
- It is most powerful when modelling paste or gel like materials
- The molecular structure is not sheared
- In the example shown all three materials are microcrystalline wax

Non-Contact Measurement



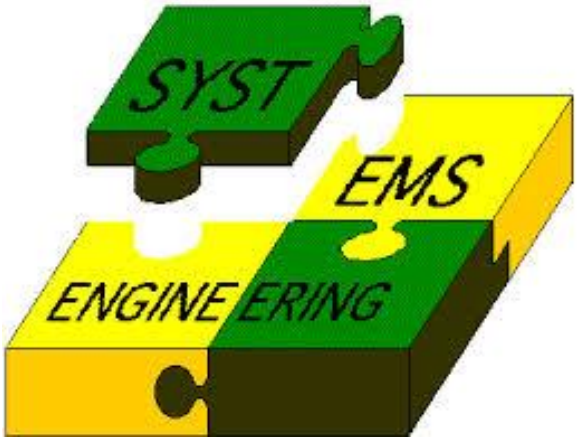
- Contact probes can restrict true wax distortion
- The use of laser measurement overcomes this problem
- Allows a valuable insight into the parameters affecting this property
- How best to design and control wax materials to overcome or minimise hysteresis effects
- Research into this vital area of interest continues and the conclusions will be reported at a later date

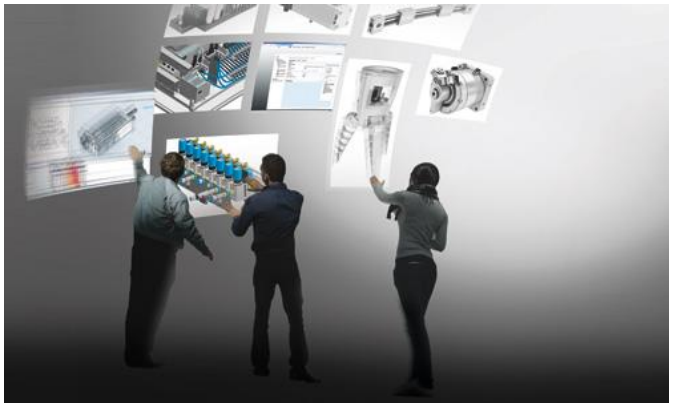
Benefits of New Technologies to Quality Assurance

- Allows both raw materials and finished products to be analysed in much greater detail
- Acceptance criteria can be used as quality control tools
- Invaluable in research and development programmes

Systems Engineering

Putting Systems in Place

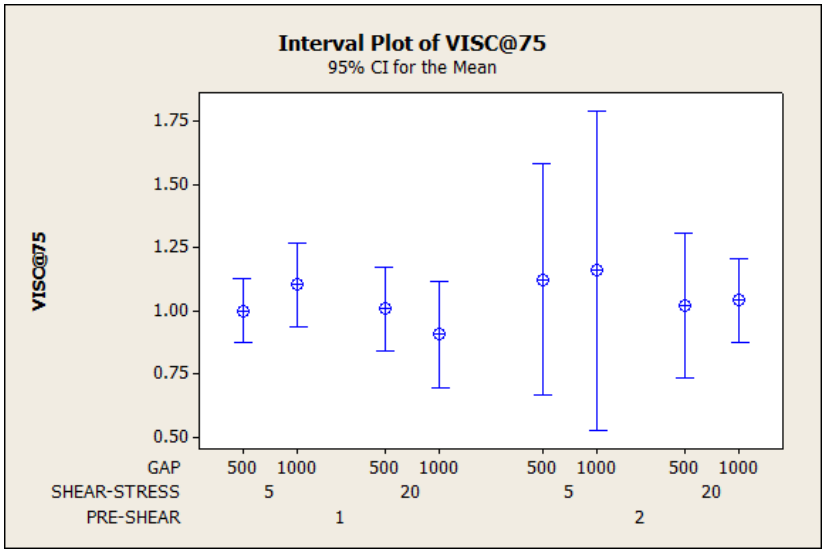


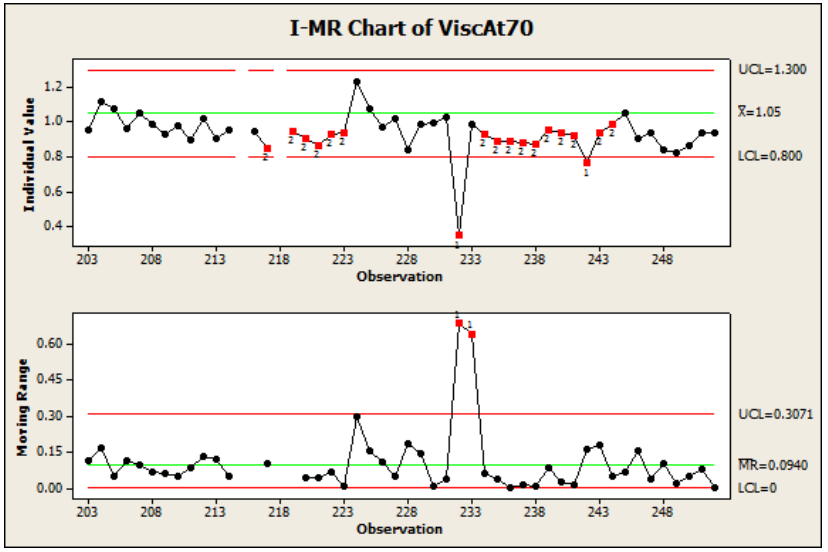


- To support process based testing and the introduction of new technologies it is necessary to put systems in place that will
  - Monitor data and respond to changes
  - Quickly identify trends in a material which can then be evaluated
- Data is analysed by
  - Capability analysis
  - Moving range control charts
- Techniques can be evaluated by procedures such as Gage R&R

Process Development

- Before any process can be developed it is essential that baseline data is determined
- Design experiments to understand how variables are affected by process conditions
- Monitor the variables
- React to trends
- Repeat the process





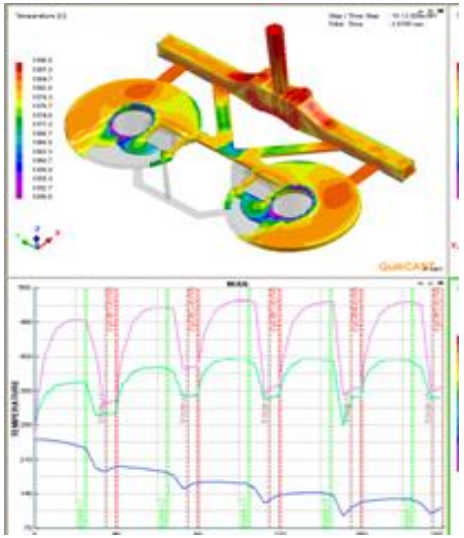
Benefits of Systems Engineering to Quality Assurance

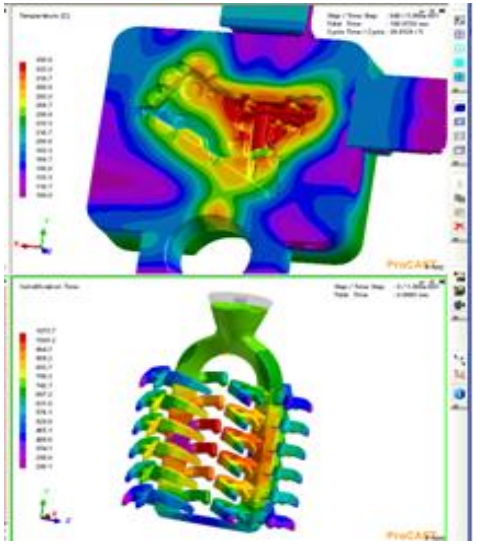
- Implementing a systems based approach to quality assurance using process based testing and new technologies gives
  - Enhanced control of materials
  - Greater consistency over time

Future Testing to Meet Tomorrow's Challenges

Modelling

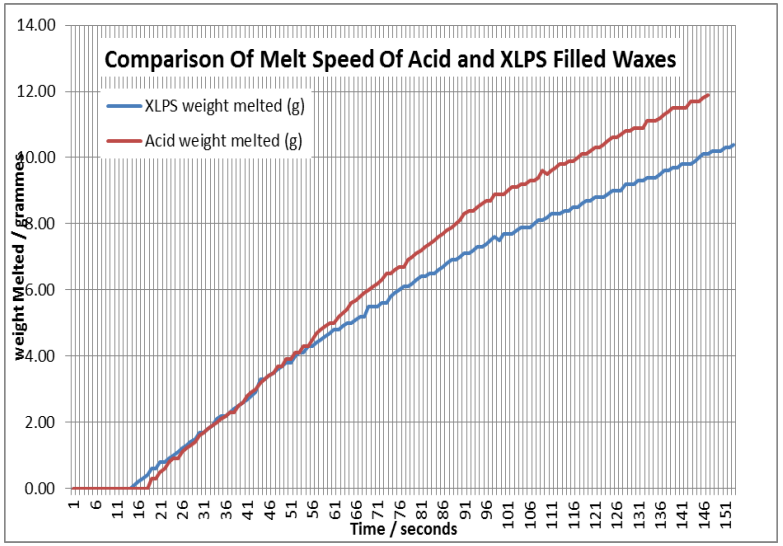
- Likely to focus on performance based modelling
- Techniques for dimensional characterisation and flow modelling under development
- Future evaluation will be
  - Effect of process conditions on final shape
  - Relating test results to flow conditions





Blue Sky

- To gain a deeper understanding of wax and how best to control and use wax requires a different approach and different thinking
- Fully understand the individual needs of the customer
- May involve designing tests to
  - Fit a particular situation
  - Gain information about a specific parameter



Benefits of Future Testing to Quality Assurance

- By modelling the performance of wax under foundry conditions crucial information for the end user may be possible
- The use of modelling techniques may help to reduce both time of wax testing and approval costs

The Benefits of a Systematic Approach

- Wax manufacture has needed to adapt its processes and products to suit ever more demanding requirements
  - Particularly in the Aerospace and Industrial Gas Turbine sectors
  - Castings are becoming increasingly more intricate
- The use of new technologies and methods has led to a deeper understanding of the mechanics of wax compounds
- A drive to improve and focus on the quality ethos has led to
  - New skills and knowledge
  - Looking at wax design and manufacture from different perspectives
- Adopting a systematic approach to methods, systems and controls has achieved
  - **A more repeatable product**
  - **Delivering process improvements and cost savings to the foundry**

Thank You