Composition, Control and Use of Investment Casting Wax

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Agenda

- Composition and Structure
- Properties
- Categories
- Recycling
- Selection
- Control and Testing of Wax
- Relationship between Wax and Injection Characteristics

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Investment Casting Wax

- Wax is the oldest thermoplastic material known to man
- Beeswax was utilized in the lost wax process by craftsmen in the ancient civilizations of China & Egypt
- Today the name ‘wax’ applies to any substance having wax-like properties
  - better described as industrial moulding compounds
- If the pattern is wrong, the casting will be wrong
- It follows that the choice of wax is critical

Composition of Investment Casting Wax

- Investment casting waxes are complex formulations containing many components :
  - Paraffin wax
  - Microcrystalline wax
  - Resins - strong, viscous, brittle
  - Polymers - ductile
  - Fillers - reduce contraction, improve mechanical strength
- The % addition and control of these additives is critical in determining the properties of the wax, they make each wax unique

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Structure of Investment Casting Wax

- Many variations are formulated to suit differing requirements
- Key properties such as melting point, hardness, viscosity, expansion and contraction, setting rate, etc are all influenced by the structure and composition of the wax compound
- Understanding the properties of the individual components and how they interact is essential in meeting foundries individual requirements
- The complex composition manifests itself in a physical behaviour different to that of other substances

Phase Changes of a Typical Wax

- Unlike other homogeneous chemical compounds, wax does not melt immediately on heating but passes through several intermediate states :

solid → plastic → semi-plastic → semi-liquid → liquid

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Expansion & Contraction of Wax

- The structure and components used in an investment casting wax will influence the expansion and contraction
- Like other materials wax expands on heating and contracts on cooling
- In comparison with a metal the expansion is relatively high
- Wax expansion and contraction rates are not uniform but vary with phase and structure changes during heating/cooling

Categories of Investment Casting Wax

- Pattern wax
  - straight (unfilled)
  - emulsified
  - filled
- Runner wax
- Water Soluble wax
- other Special wax
  - dipping/patching/adhesive
- Reclaim & Reconstituted wax

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Wax Recycling

- Customers used wax from autoclave returned to wax manufacturer for reprocessing
  - cleaned & filtered
  - additives to adjust properties to specification
- Reclaim wax for runner systems
- Reconstituted wax for pattern production
- Environmental and economic benefits

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Wax Selection

- Wax selection is determined by the particular application and the process criteria are :
- Injection
  - state/setting rate/rheology/geometry/equipment/surface finish
- Removal,handling,assembly
  - strength/hardness/setting rate/stability/ability to make joins
- Dimensional control
  - thermal expansion/contraction/cavitation/distortion
- Shelling/mould making
  - strength/wetability/resistance to binders and solvents
- Dewax and burnout
  - melting point/viscosity/thermal expansion/thermal diffusivity/ash content
- Other : cost/availability/recycling/toxicity/environmental

Process Control of Wax Products

Close control is achieved by :

- Automatic temperature control of the melting process
- Data monitoring of both temperature of the melt and process equipment
- Extensive testing
- Statistical Process Control of both raw materials and finished products

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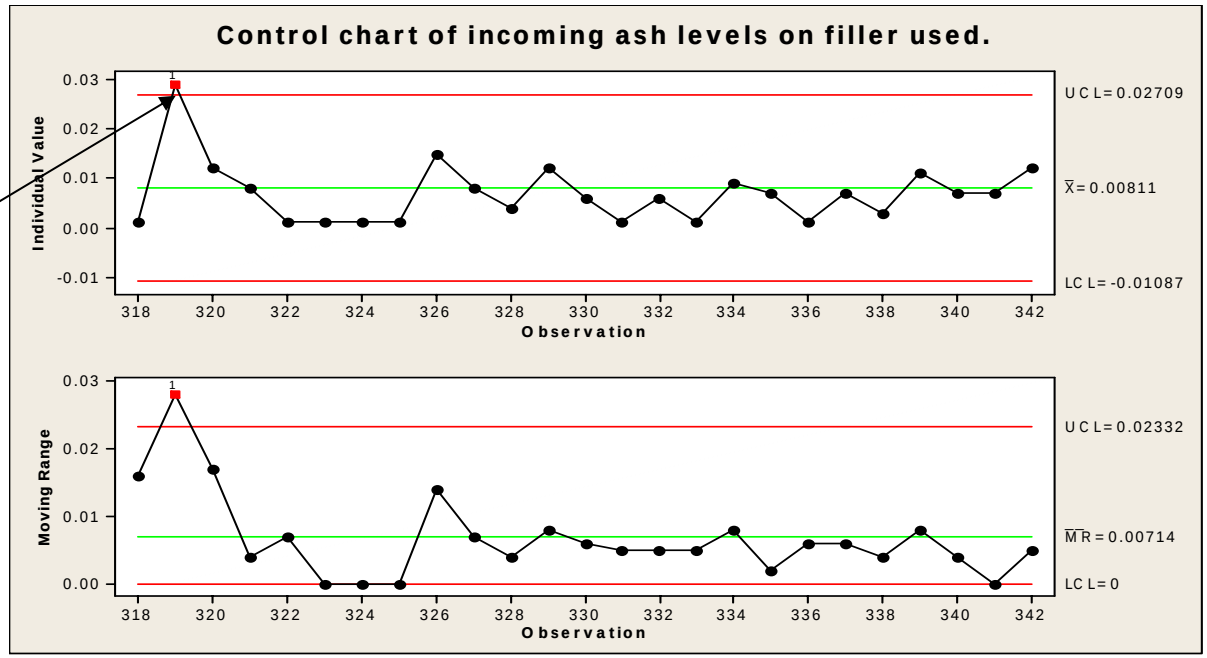
Statistical Process Control



Out of Control (Not used)

Both incoming test results and in-house test results on raw materials are fed into a control chart, and use based on the results determined.

The use of SPC also allows tracking of trends in suppliers processes, and allowing pre-emptive corrective action.

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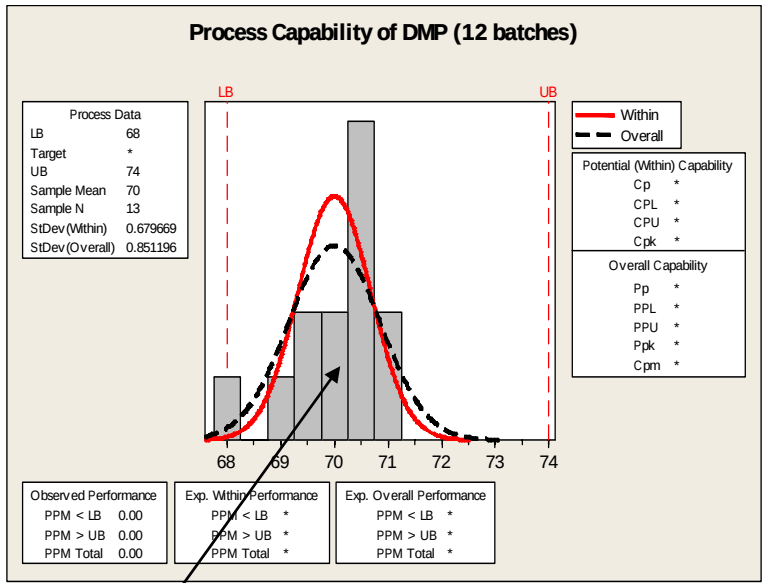
Wax Specification

- Products are tested to establish whether they meet specification
- The specification is determined during the development stage
  - it is a reflection of the capability of the process
- a provisional specification is introduced which is then reviewed after 12 batches
- The data is used to generate a process capability which is built into the formalised specification



SPECIFICATION WOULD NEED ADJUSTING IN LINE WITH RECORDED DATA.

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Test Methods

Industry recognised physical tests are :

- Congealing Point
- Drop Melt Point
- Viscosity
- Penetration
- Ash
- Filler content
- Mechanical strength

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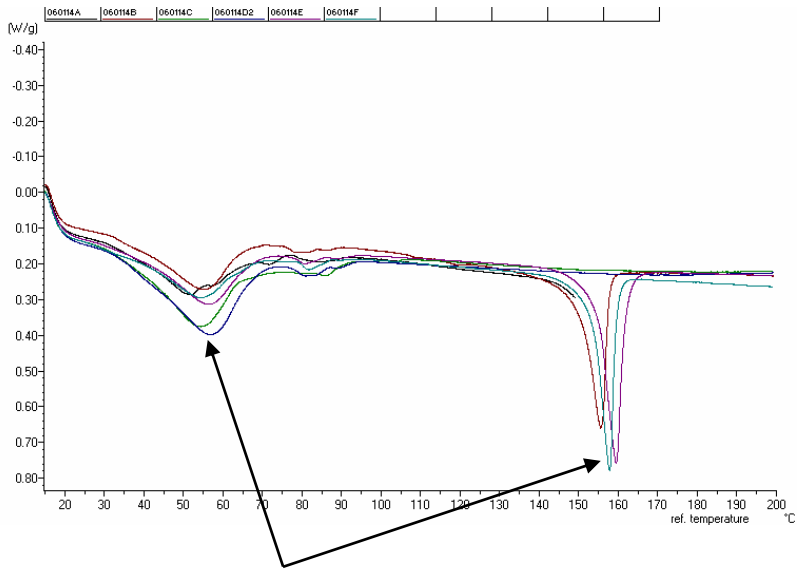
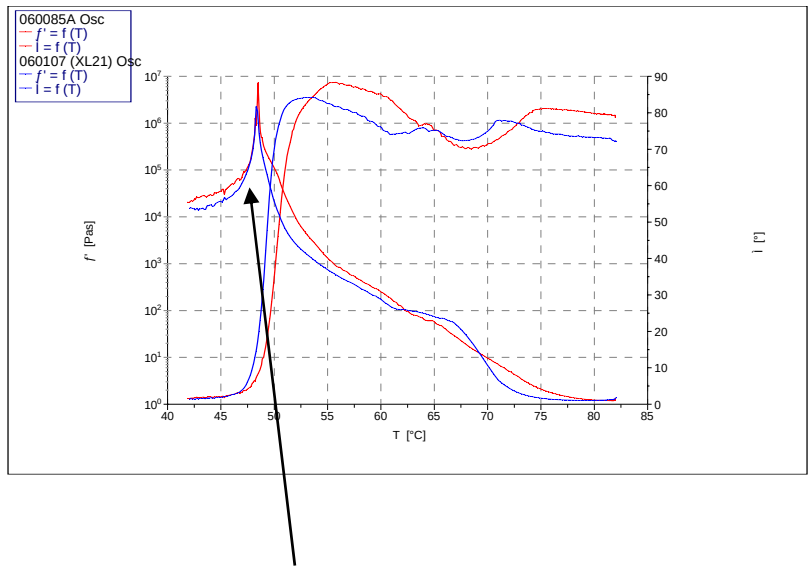
DSC, Oscillation



<u>DSC</u> analysis gives an indication of the melting phases of different compounds.



<u>Oscillation curves</u> give an indication of the shear properties of wax at different temperatures. Gives a good indication of the setting properties of a wax.

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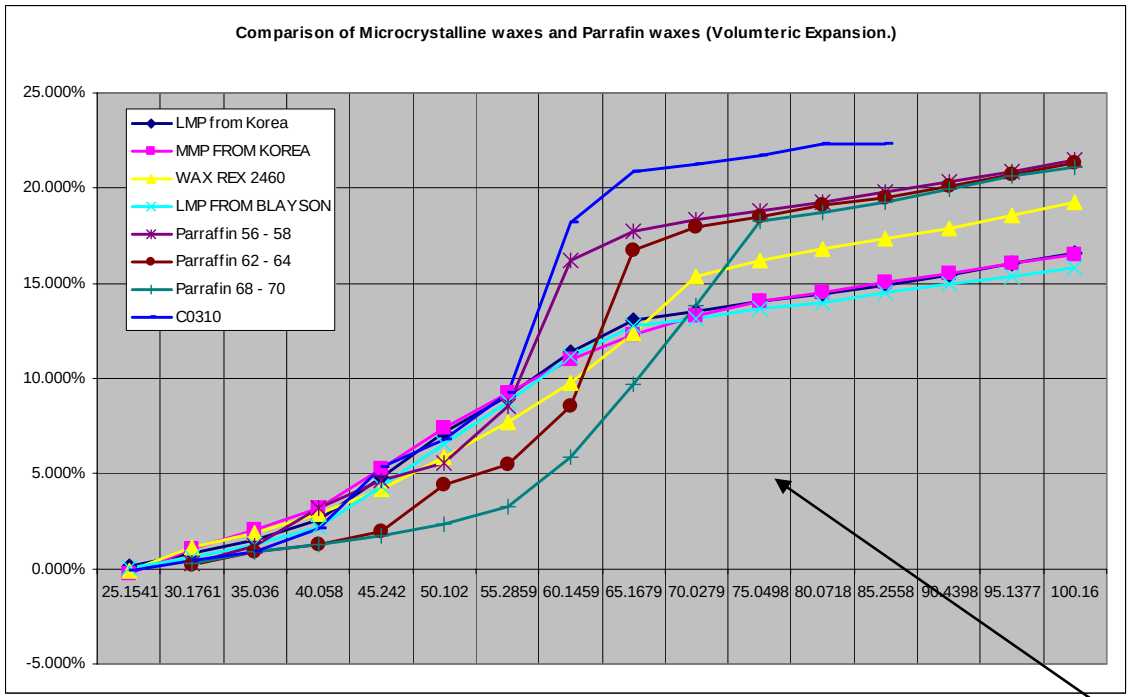
Volumetric Expansion



Blayson Japan has developed a <u>volumetric</u> expansion test to dewax temperatures.

A unique feature is that data capture is automatic and not dependent on operator measurements.

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Relationship between Wax and Injection Characteristics

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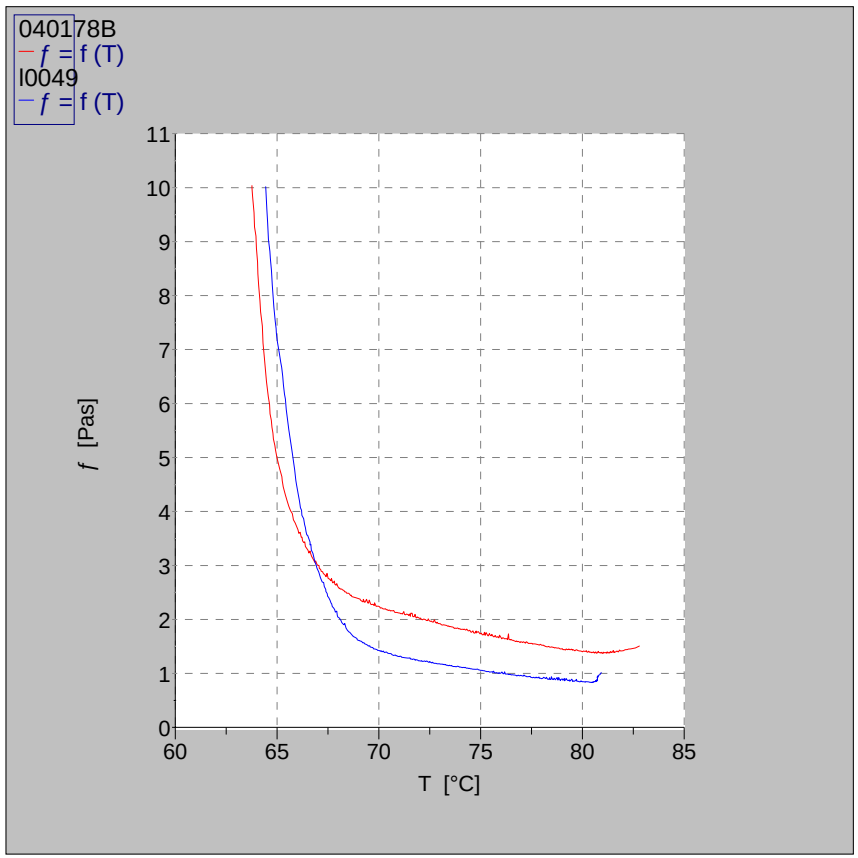
Wax Fluidity



- Wax fluidity is key to control of many problems
  - flow lines
  - surface finish
  - non fill and air entrapment
- A relationship exists between wax temperature and fluidity. Important when operating near the congealing point
- Effect of die temperature should not be underestimated

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Fluidity Measurement

- Wax Fluidity can be measured using the ‘Fluidity Spiral’
- Injected at :
  - fixed wax temperature
  - fixed die temperature
  - fixed injection pressure
  - fixed flow rate
- Can be used with each new batch to estimate its flow characteristics and allow adjustments to be made prior to start of production

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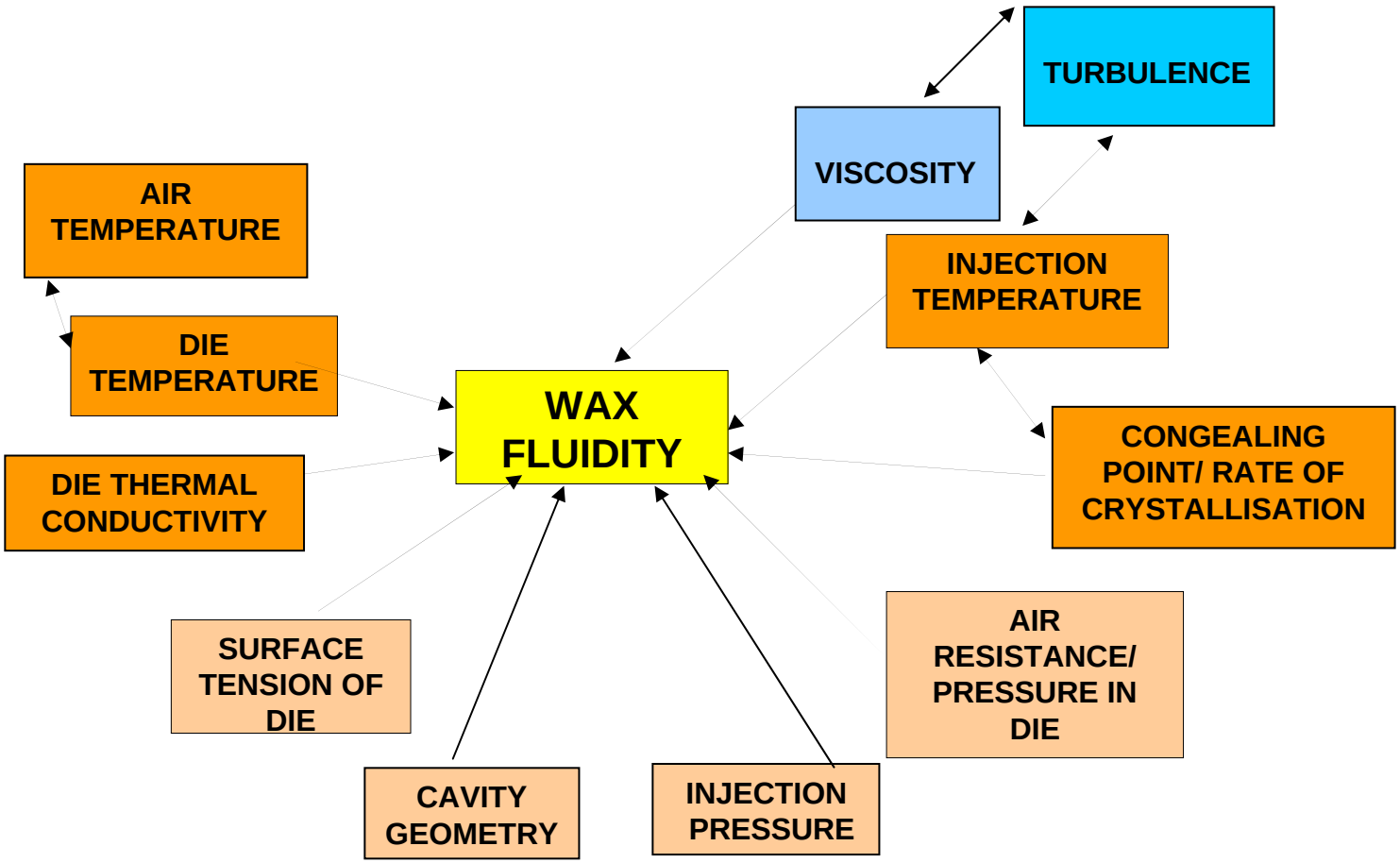
Factors Affecting Fluidity



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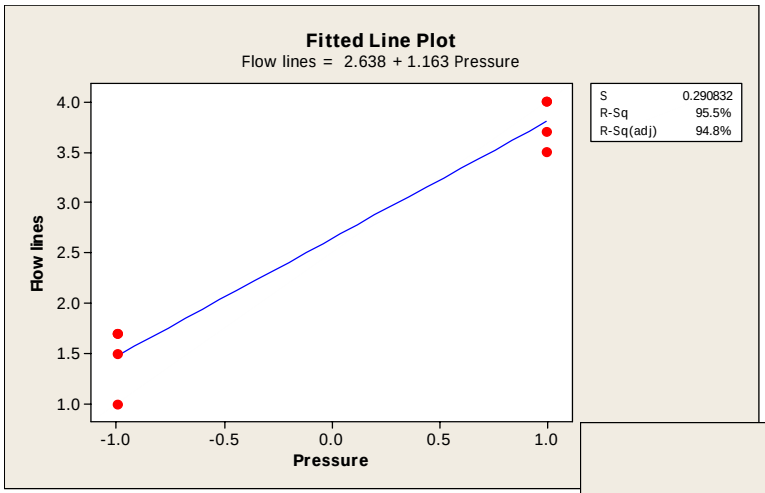
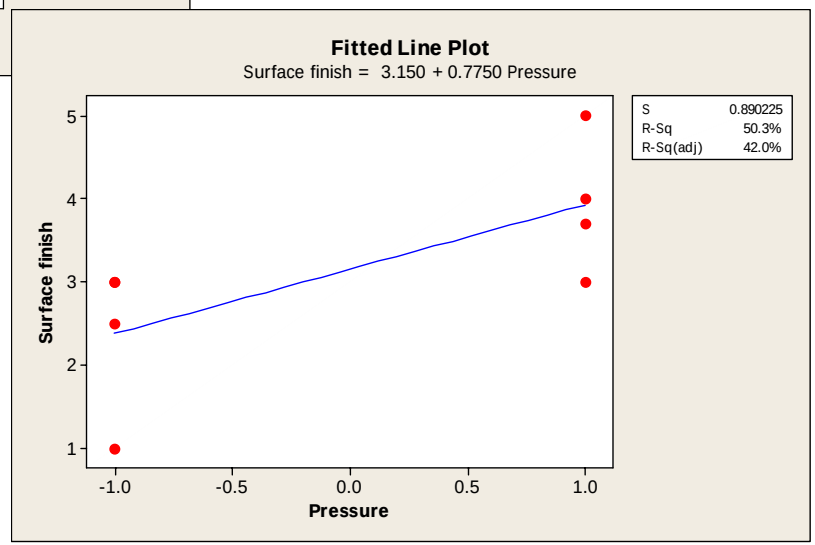
Relationships with Injection Pressure





Recent trials suggest a relationship between flow lines and pressure, higher pressures minimise flow lines.

Evidence exists for a similar relationship between pressure and surface finish (orange peel).

Obviously care must be taken when using cored parts (core breakage)

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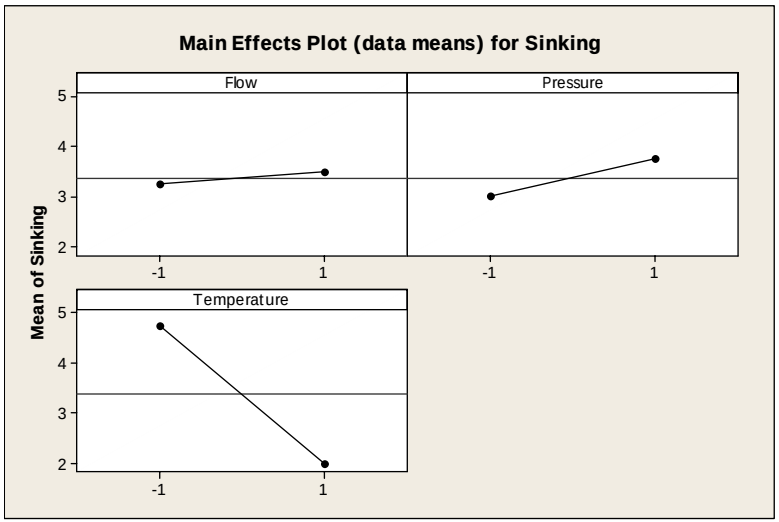
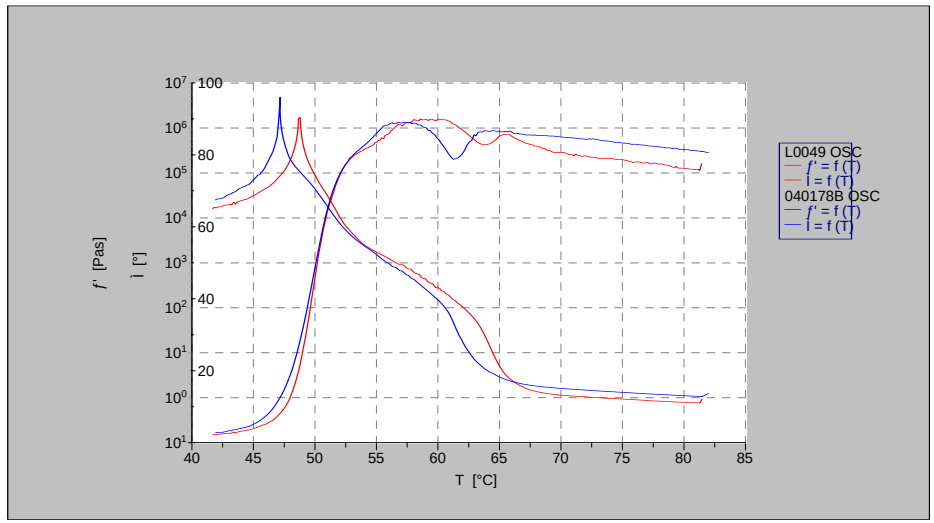
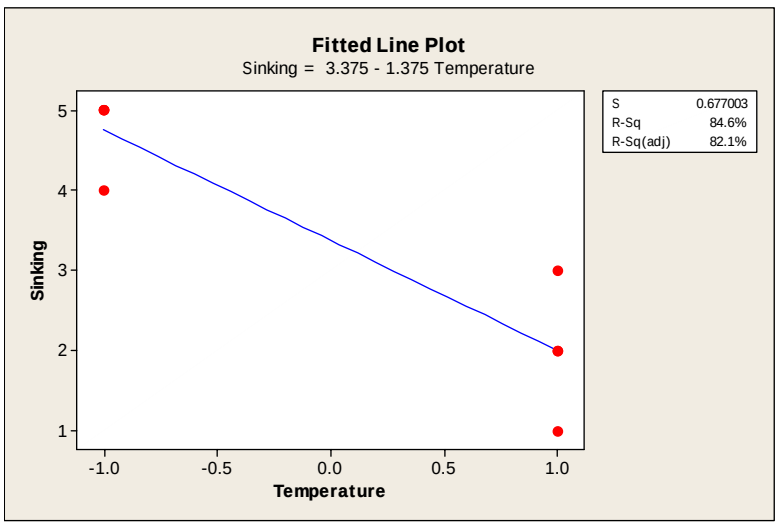
Temperature and Cavitation







Injection trials suggest a strong link between wax temperature and cavitation.

Indications are that the cause is the time that the wax is liquid/semi liquid, increasing the temperature increases the time.

This explains why sprue size and location affects sinking, and also that sinking is probably related to the setting rate of the wax.

Filler reduces liquid by around a third and reduces contraction.

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Summary

- Investment casting wax compounds are complex
  - consist of many different components
  - consequently exhibit a range of properties
- Wax properties influence pattern behaviour in the foundry and ultimately the quality of castings produced
- Correct product choice allied with strict process & quality control procedures is essential
- More information available at www.investmentcasting.com

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