Understanding how the Properties and Use of Wax can Affect Foundry Performance

Bilbao May 2006

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Overview Of Paper

Foundries often have defects which unfairly or otherwise are blamed on the wax.

Blayson has undertaken a large amount of technical work to understand how the use and properties of the wax can affect foundry performance, in particular;

- **Wax Properties, Injection Parameters and their effect on linear contraction and surface finish**

- **The make up and possible effect of wax “Ash”**

- **Filler separation and its effect on wax contraction**

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Section One

Factors affecting the Free Linear Contraction of Wax

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Nature of the Experiments.

- Three sets of experiments were conducted looking at this characteristic.
- A designed experiment involving wax temperature as measured in the holding tank, the injection pressure and dwell time
- A measurement of the Free linear contraction on a very cold die, and also a very hot die
- A measurement of the contraction with different filler loadings in the wax

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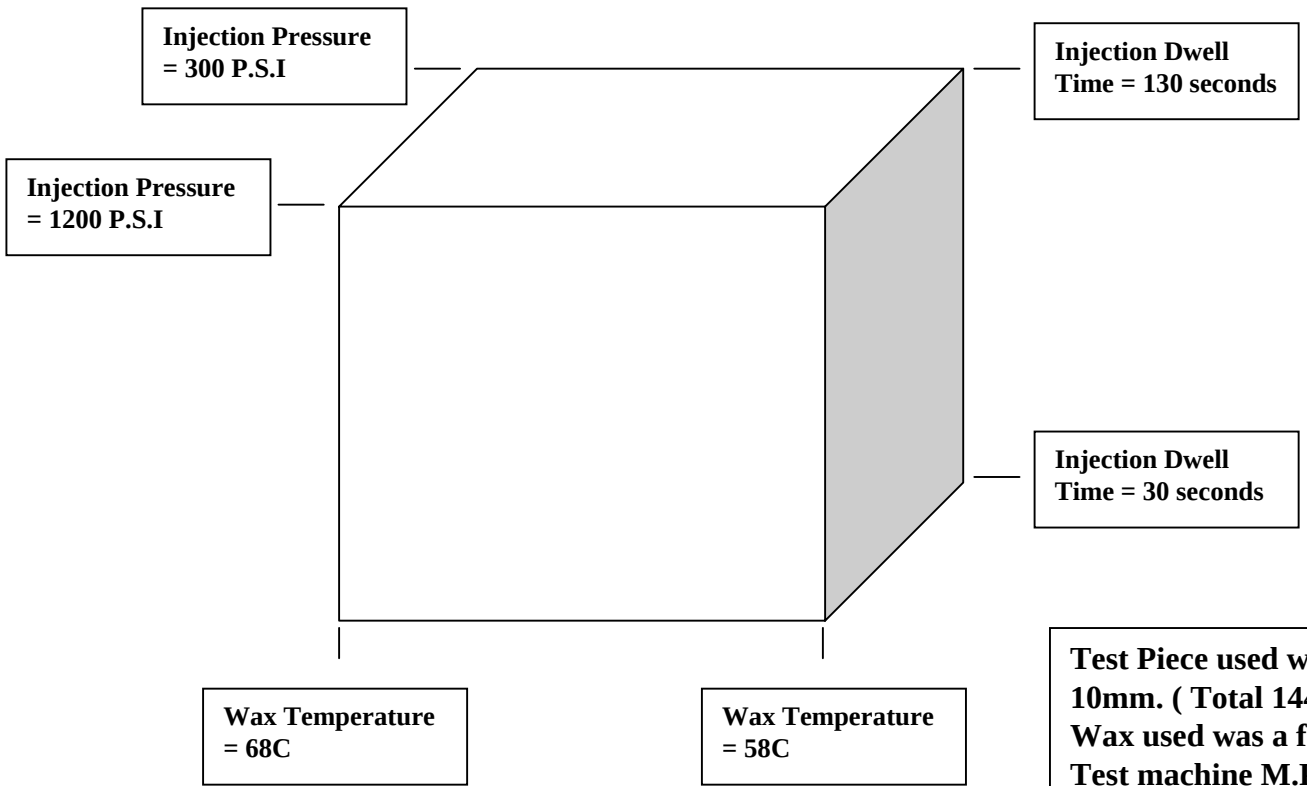
Breakdown of the Designed Experiment.

Designed experiment constructed to consider interaction between : Wax temperature, Injection pressure and Dwell time.



Test Piece used was ; 150 * 16 * 10mm. (Total 144 pieces)
Wax used was a filled, Virgin wax.
Test machine M.P.I.
Temperature conditioned for 24 hours.

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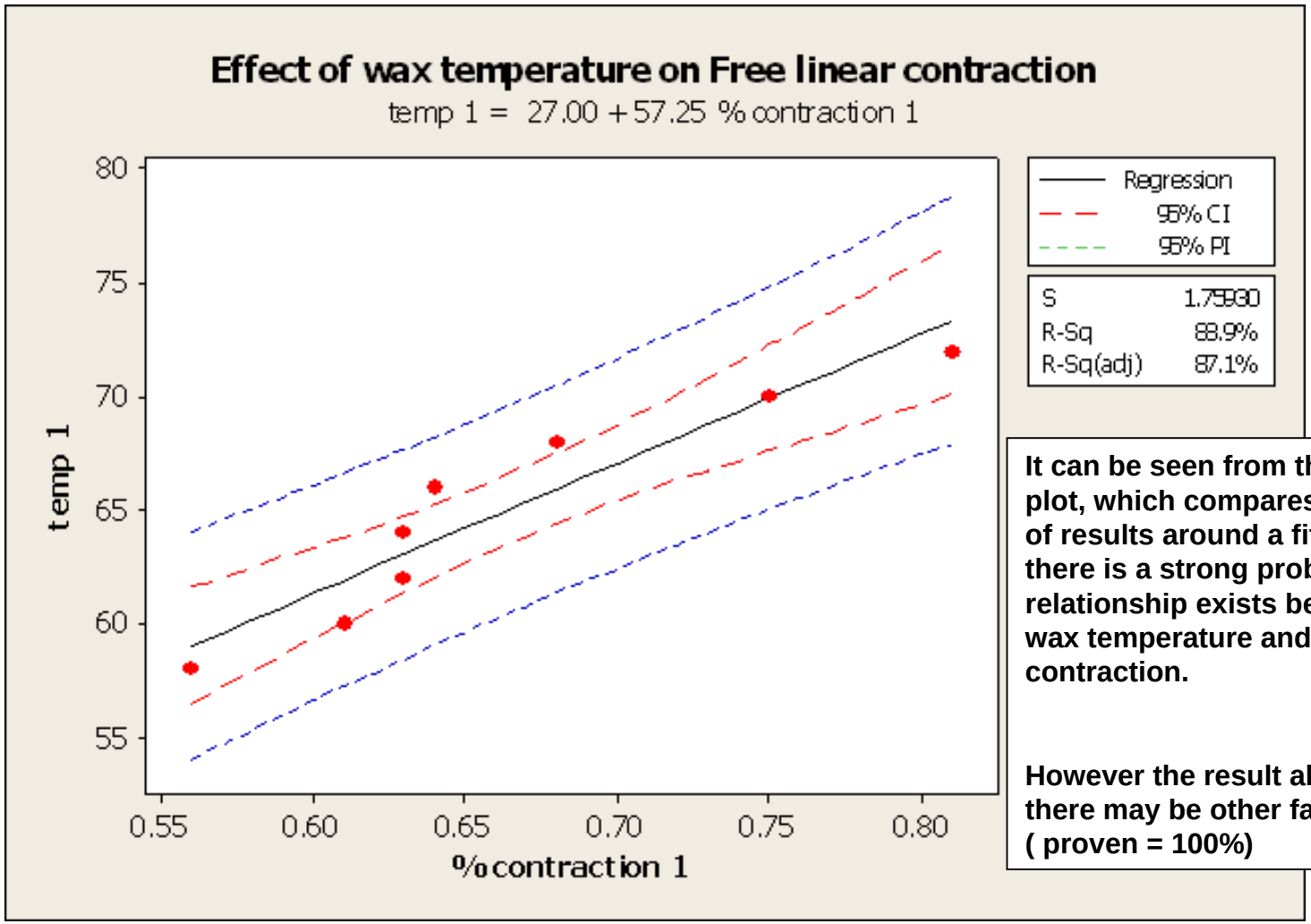
Effect of Wax Temperature on Free Linear Contraction.



It can be seen from the fitted line plot, which compares the spread of results around a fitted line, that there is a strong probability that a relationship exists between the wax temperature and the wax contraction.

However the result also suggests there may be other factors (proven = 100%)

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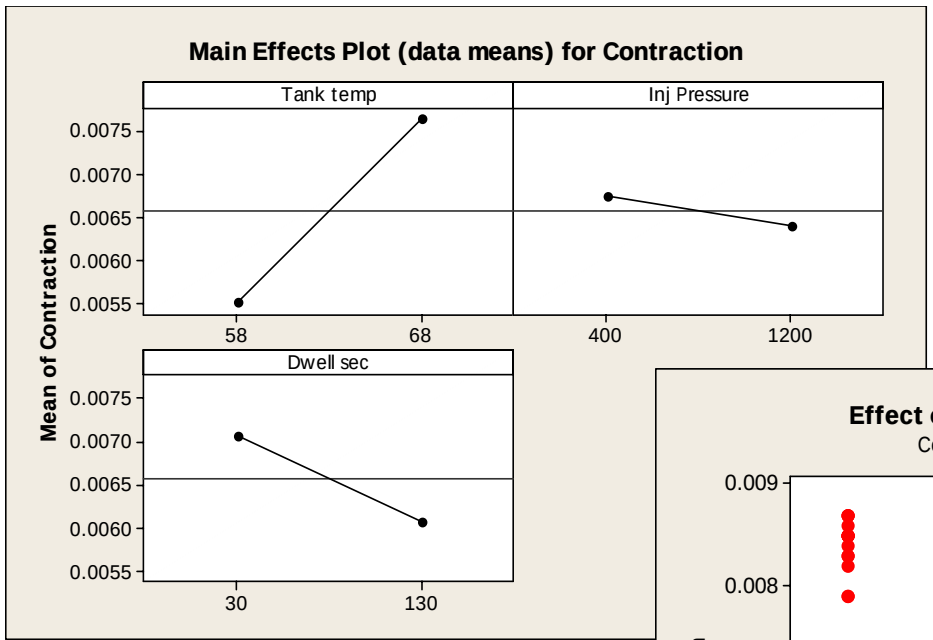
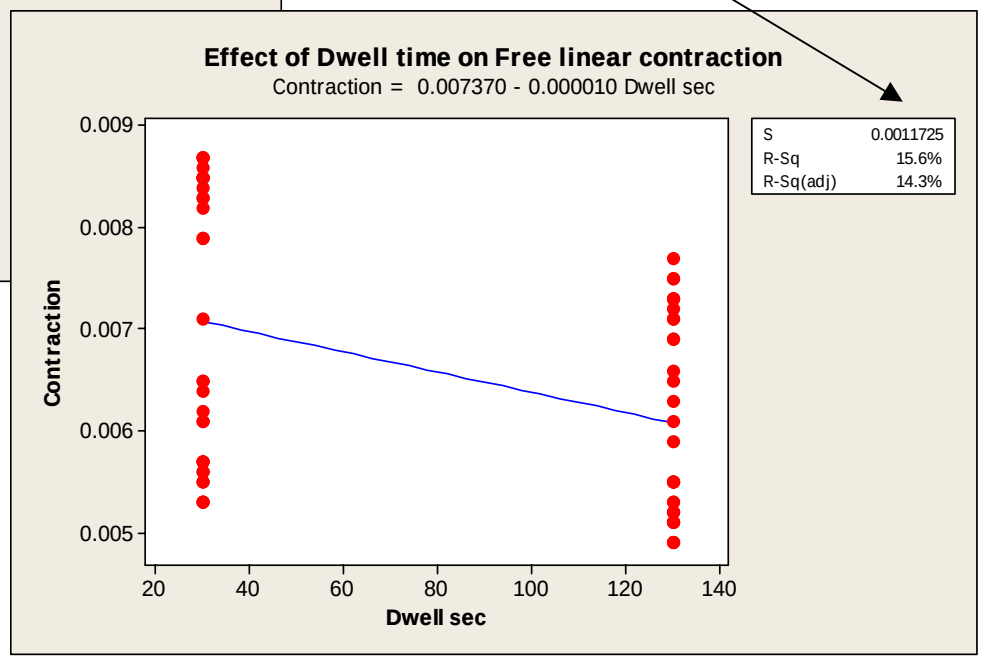
Effect of Dwell Time and Injection Pressure on Free Linear Contraction.



Effects plot suggests that there may be a relationship between dwell time and wax contraction, however the fitted line plot dismisses this.

Only 15% correlation.



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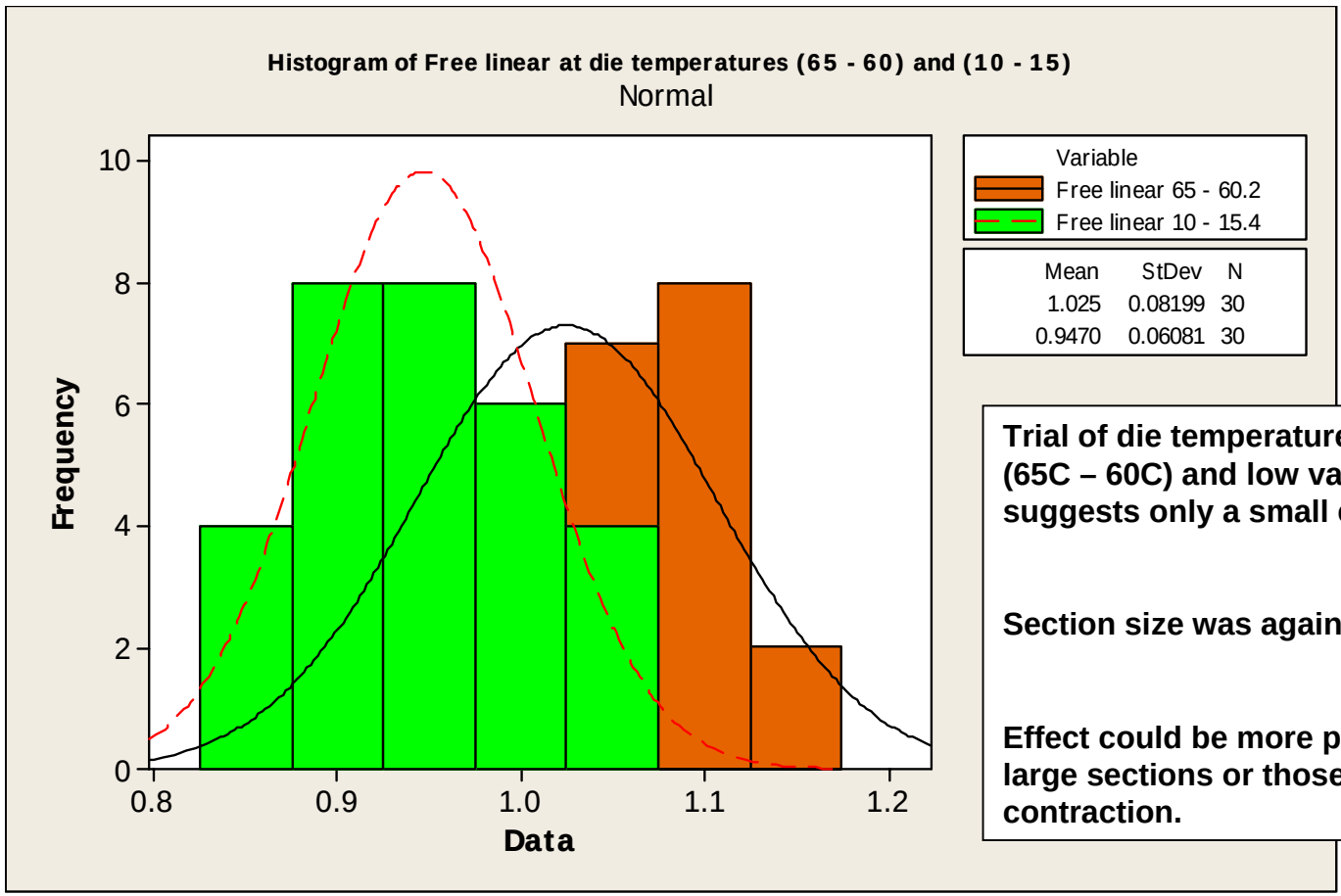
Effect of Die Temperature on Free Linear Contraction



Trial of die temperatures at high value; (65C – 60C) and low values (15C – 10C), suggests only a small effect exists, if any.

Section size was again 150 * 16 * 10mm

Effect could be more pronounced on large sections or those with restricted contraction.

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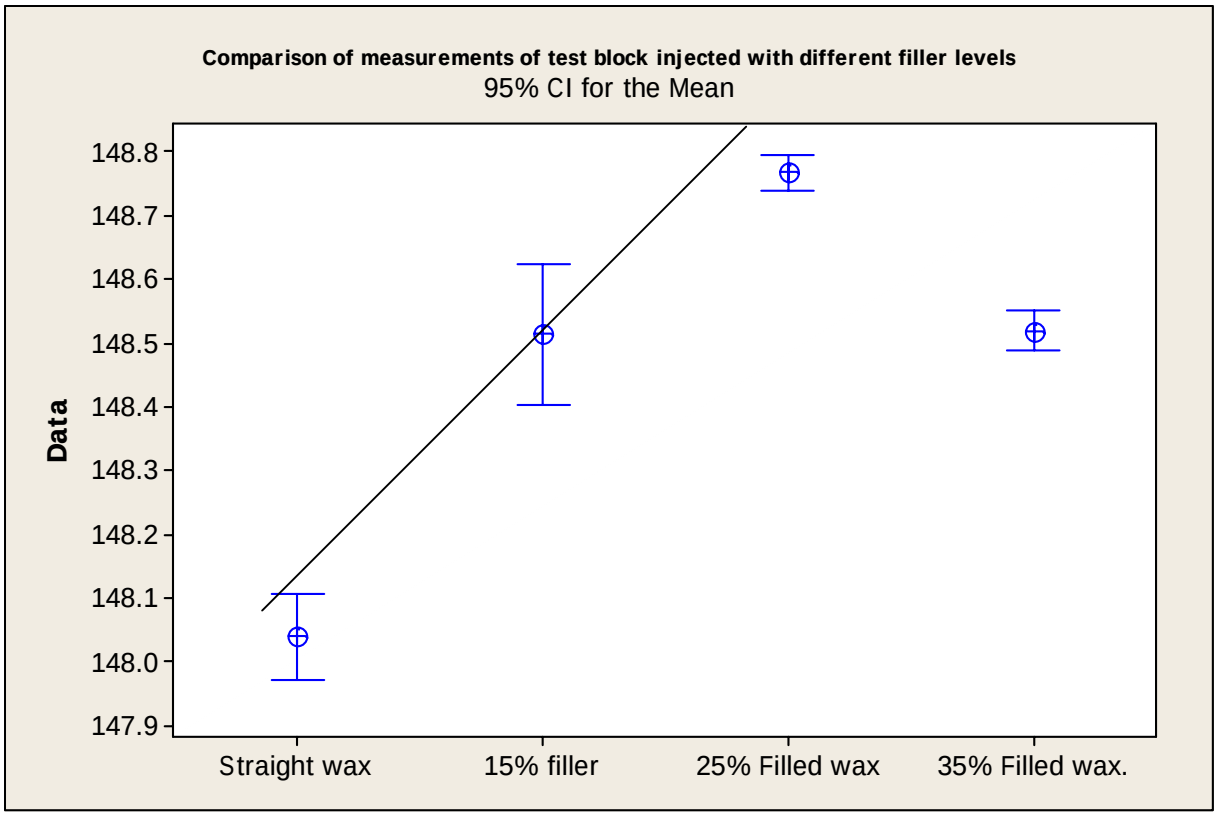
Effect of Filler Loading on Wax Contraction



Analysis of data gathered injected test blocks at different filler levels, demonstrates the following;

1. **That filler level does have an effect on the contraction of the wax. (Important if wax is unstirred or left over periods of time)**
2. **That other factors affect the contraction (25% result is greater than 35% result.)**

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Conclusions from Section 1

- The contraction of the wax is very much dependant upon Temperature.
- Dwell time and Injection Pressure do not appear to have a significant effect.
- Die Temperature also appears to have little effect on Free Linear Contraction.
- Filler Loading does have a significant effect on wax contraction.
- These results apply to Free Linear Contraction only, we do not have the data to comment on restricted contraction, although there is no reason to believe that the conclusions should be different.

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Contraction.. Recommendations

- Ensure that the wax temperature is carefully controlled, wax thermal conductivity is very poor, so the time required to stabilise temperature will be measured in hours not minutes. Effective control of wax temperature can be aided by use of a fast melter coupled with a level controller.
- Do not rely on machine gauges, these are situated around the edge of the tank, and do not give an indication of the core temperature.
- Ensure that the wax is stirred at all times, and that in areas where stirring does not take place, ie the injection unit, that it is “purged” if not in use.

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Section 2

Wax Properties, Control and their affect on Surface Defects.

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Nature of the Experiment

- The results shown in this section are based on an experiment conducted using supplied tooling (a blade die)
- The aim of this experiment was to reduce surface defects, in particular; flow lines, surface pitting or “orange peel” and surface cavitation or “sinking”
- Again this experiment took the form of a designed experiment, with the variables being Temperature (72& 76C), Pressure (200 & 600 PSI), Flow (1& 5)
- The scoring was a visual analysis, from 1 to 5

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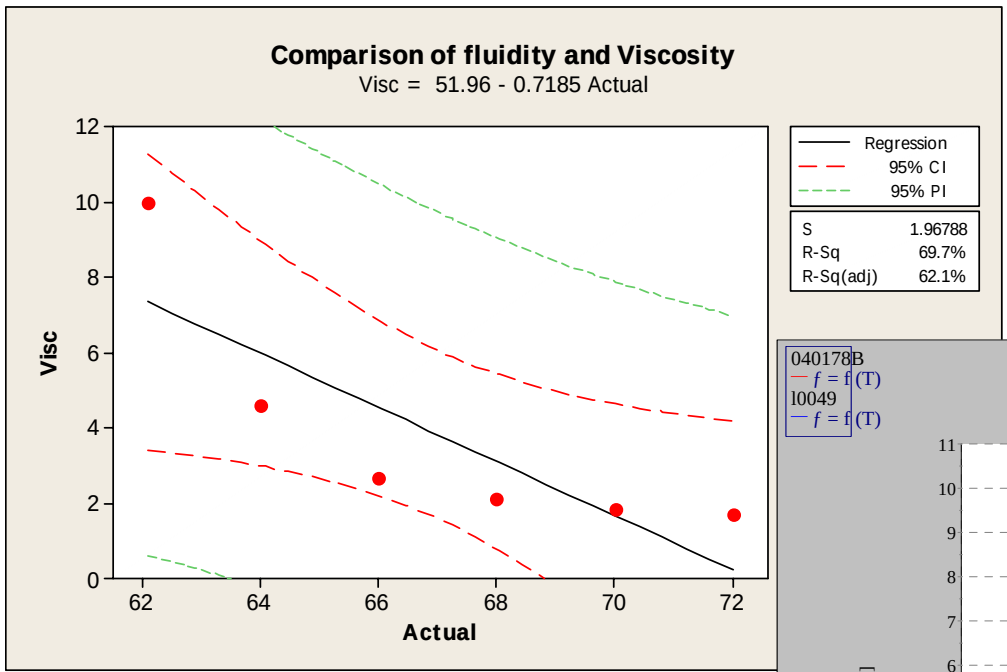
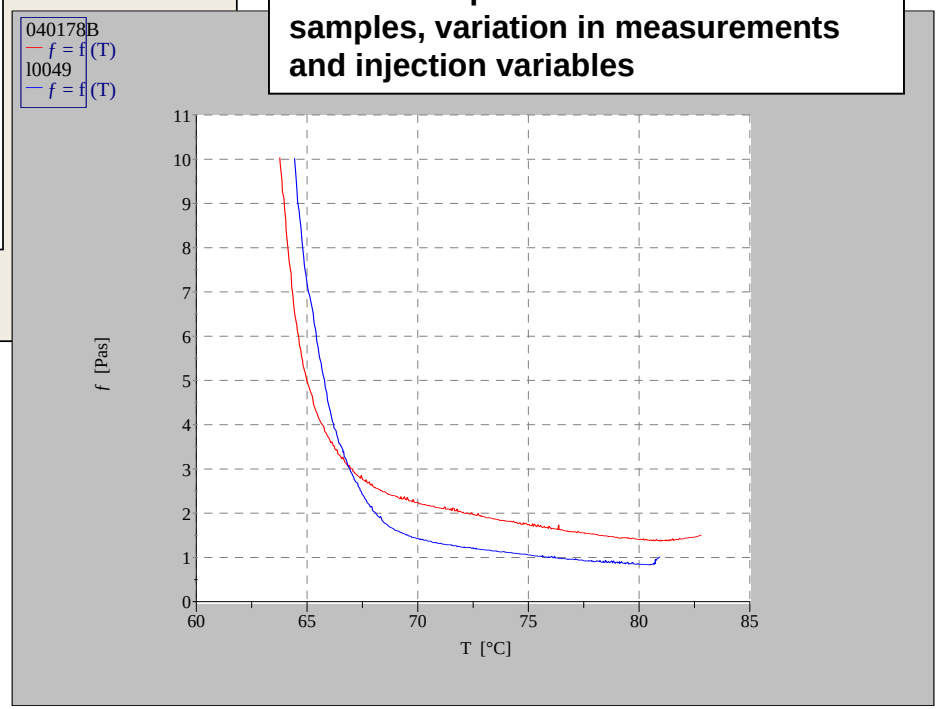
Relationship between Fluidity and Viscosity



Clearly a relationship exists between wax fluidity and Viscosity. The more Viscous a wax, the less it will flow, given the same temperature, pressure and flow conditions are maintained.

Would suggest that the reason or lack of absolute proof is due to number of samples, variation in measurements and injection variables



Minor variations that take place within specification, in particular parameters such as Congealing point need to be taken into account when injecting.

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Results of Trials

- To understand Fluidity relationship, a “Fluidity spiral” was injected at the same time as the patterns
- Results were analysed using tools such as;
- “ Comparative Analysis.”
- “ Time plots”
- Histograms

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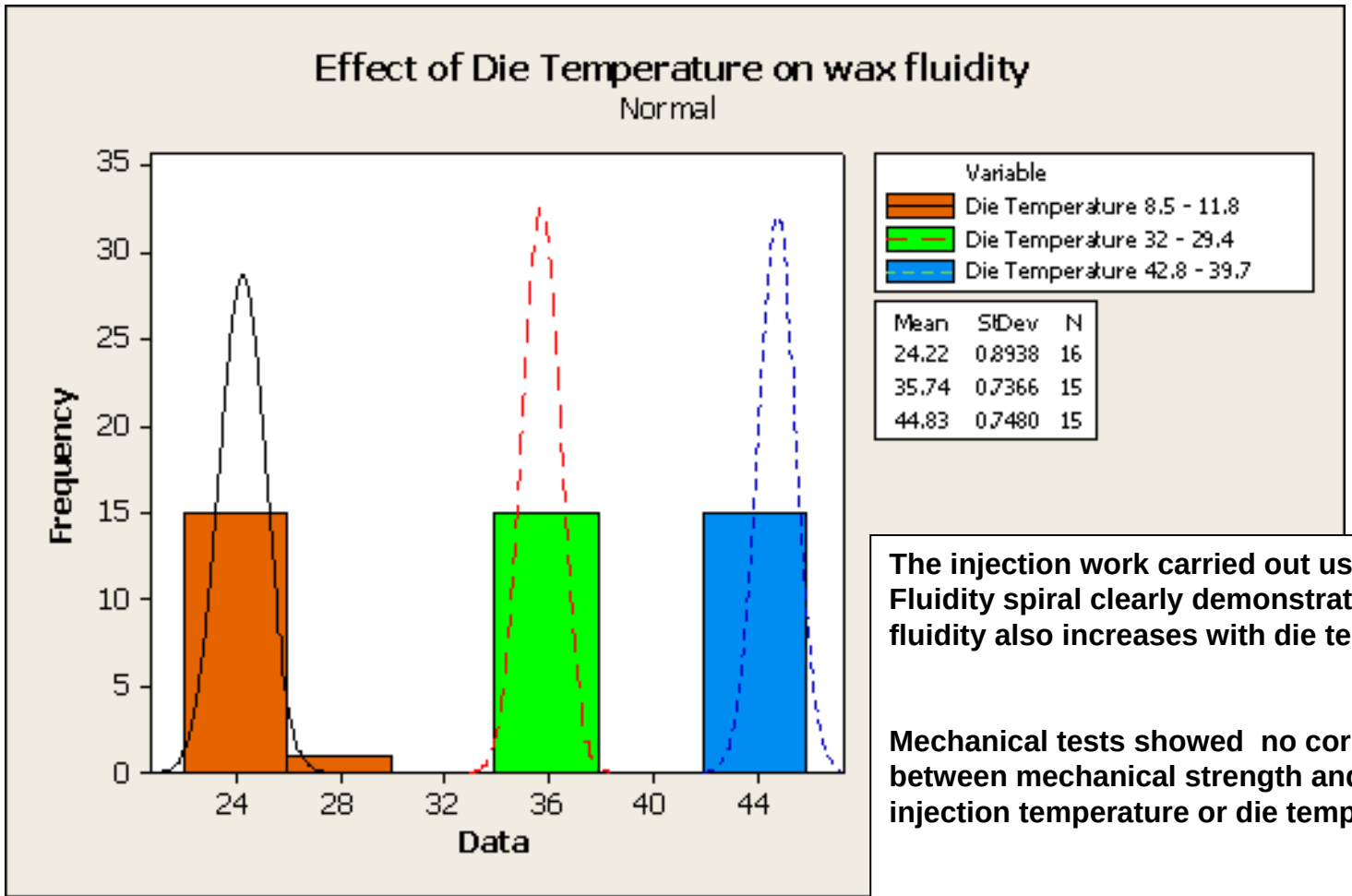
Effect of Die Temperature on Fluidity.



The injection work carried out using the Fluidity spiral clearly demonstrates that wax fluidity also increases with die temperature.

Mechanical tests showed no correlation between mechanical strength and either injection temperature or die temperature.

All work took place with a filled wax.

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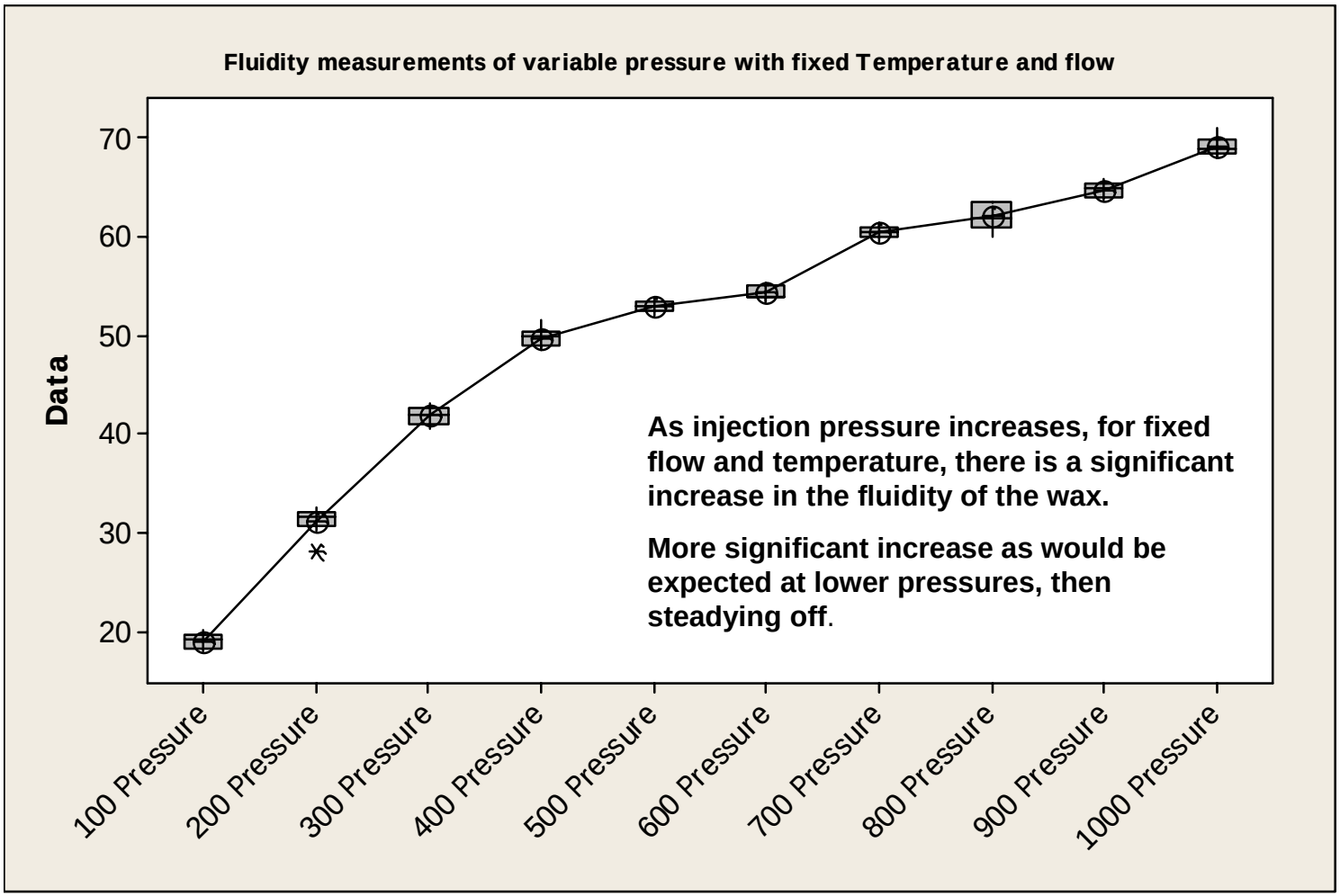
Relationship between Fluidity and Injection Pressure.



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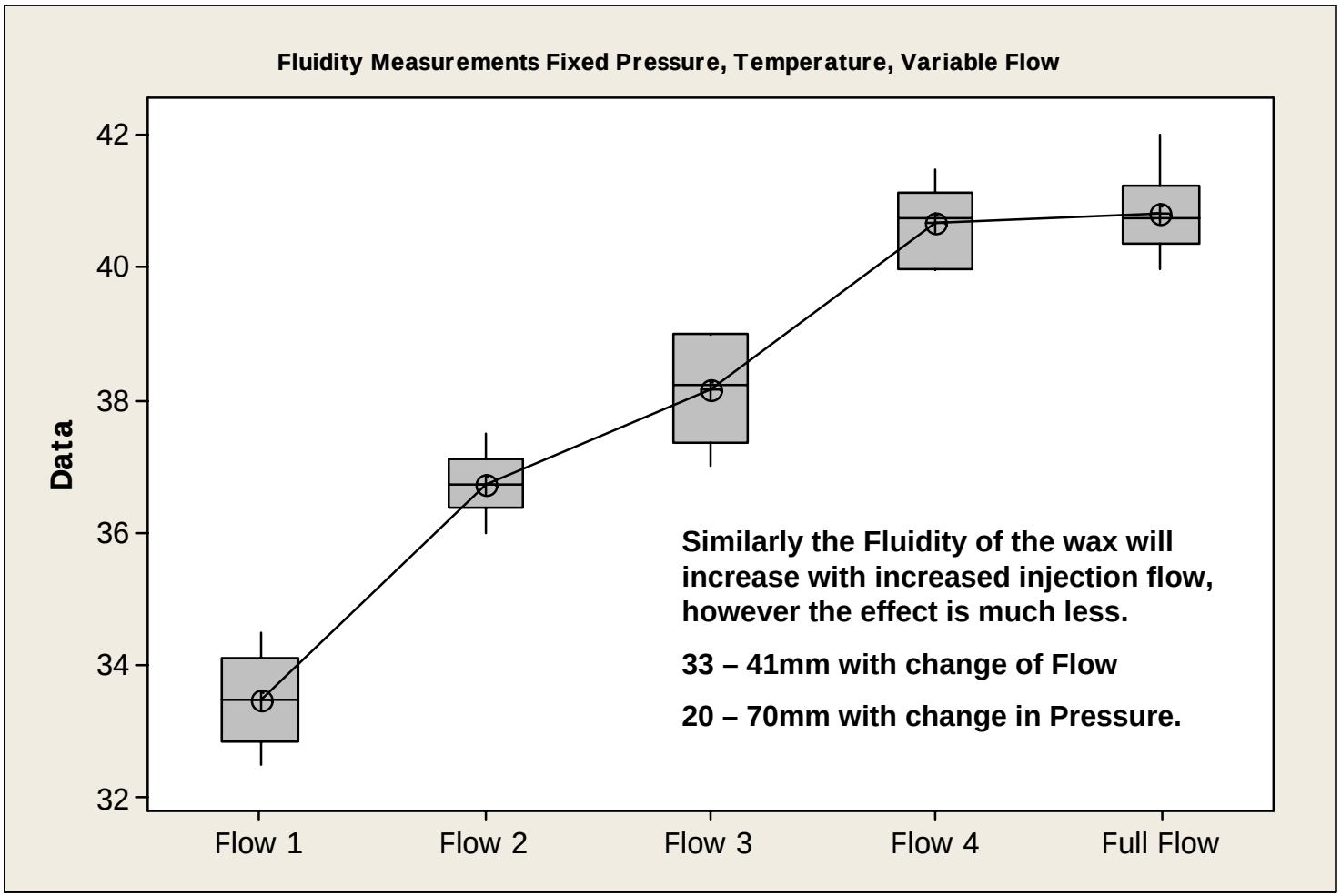
Relationship between Fluidity and Flow



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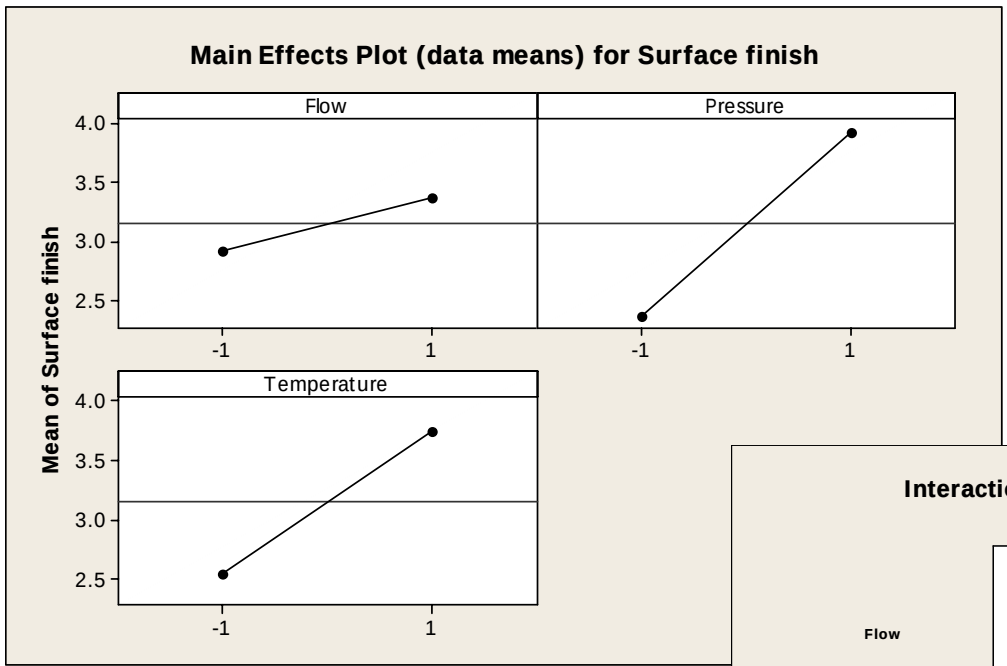
“Orange peel”

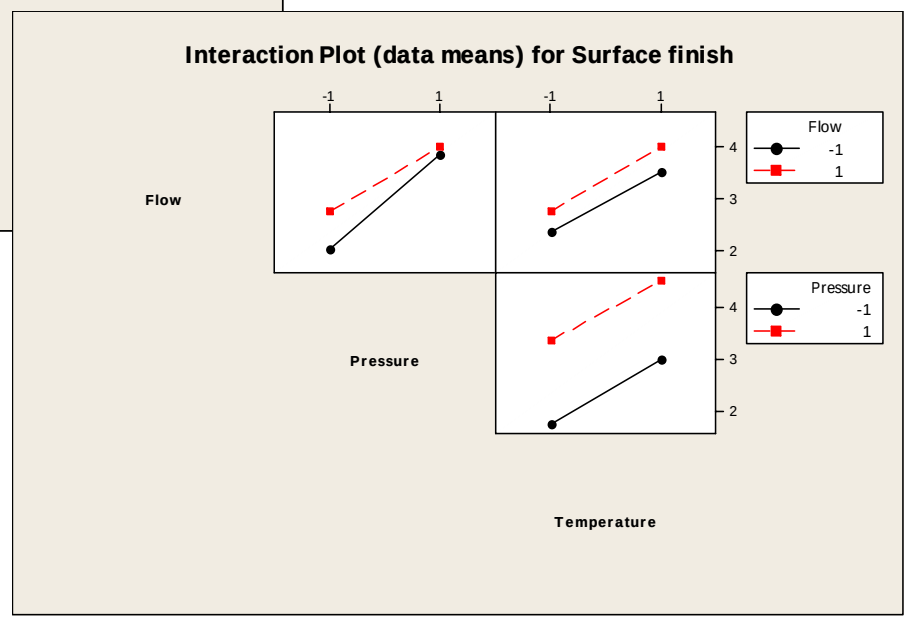


Clear from the experiments looking at Surface finish, that there is a relationship between surface finish, “ orange peel effect”, and fluidity. (changes in Pressure and Temperature affected this defect)

Regression results.. Single effect 8.09

Dual effect.. 0.19

three way effects.. 1.28



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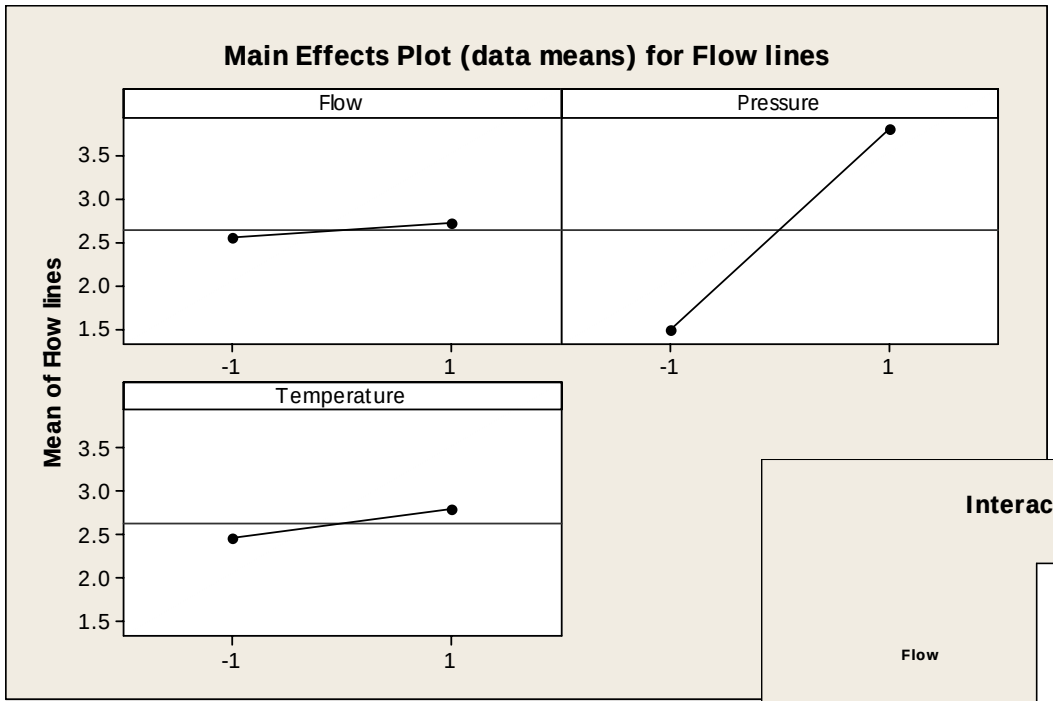
Flow Lines



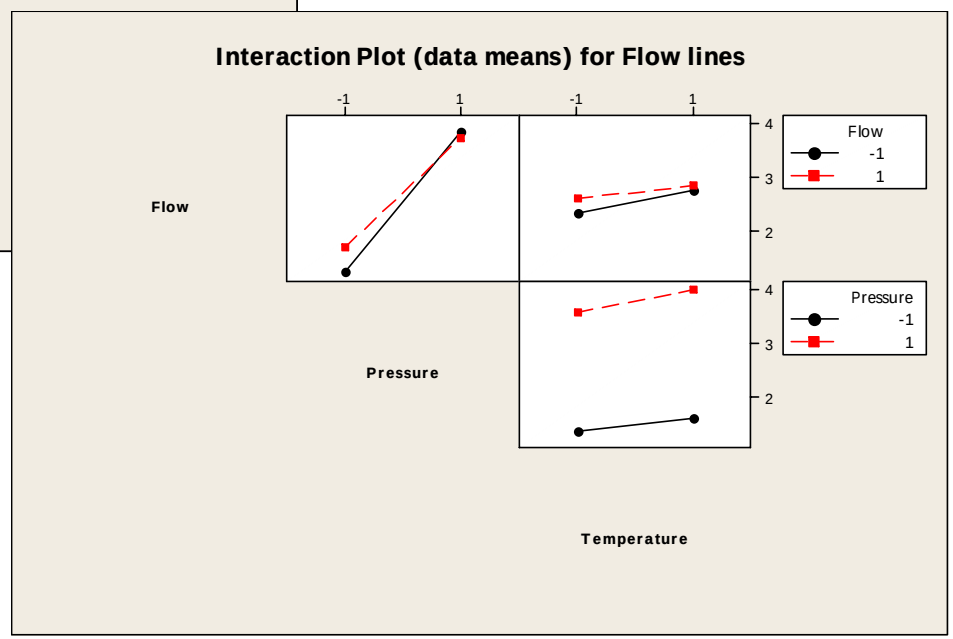
Flow lines however seem to be a function of Injection pressure.

Regression results.

Single effect.. 11.08

Dual Effect.. 0.17

Three way.. 0.06



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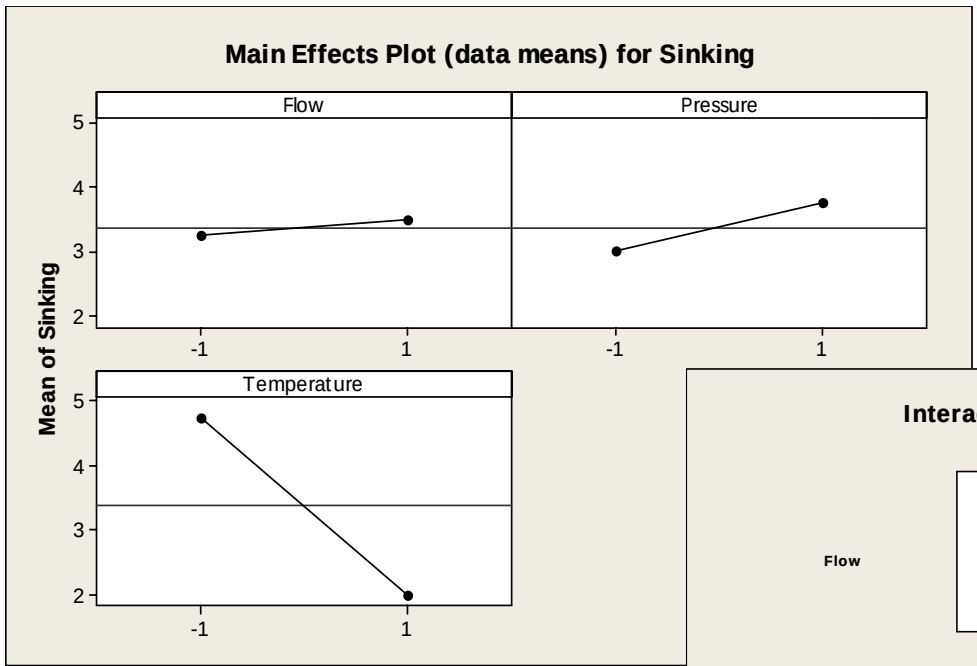
Surface Cavitation (“Sinking”)



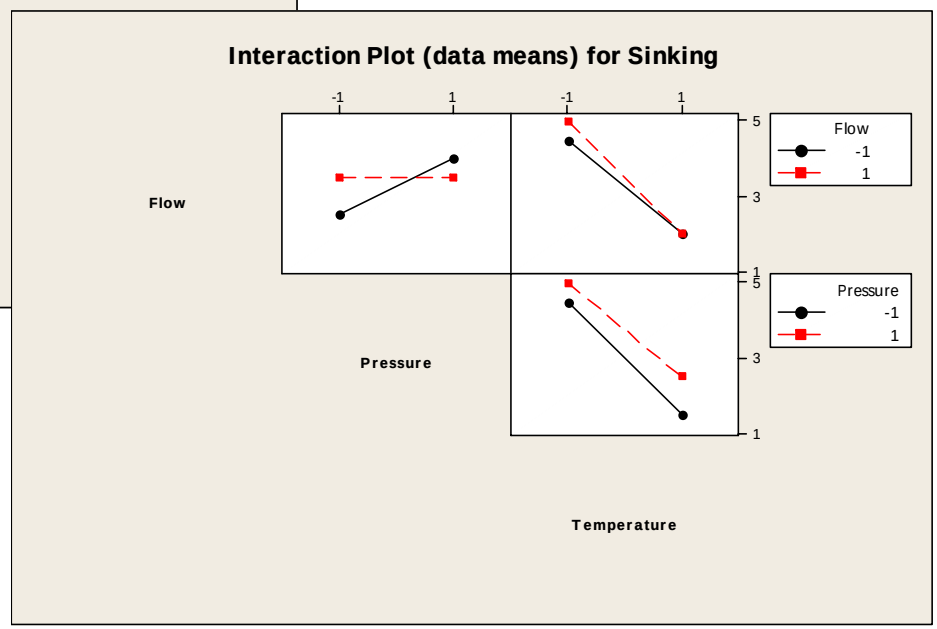
Sinking is very much Temperature dependant;

Regression analysis;

Main effects..16.37

Two way.. 1.37

(suggests lack of feed material, same principle as poor sprue design.)



Conclusions of Section 2

- Viscosity indicates the Fluidity of a wax, and may vary within specification
- The Fluidity of a wax increases with wax temperature and die temperature
- The Fluidity of the wax can be improved with increased flow and in particular increased injection pressure (beware of core breakage)
- The “orange peel” effect is related to wax Fluidity and can be improved by changing Injection Pressure, Flow and Temperature

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Section 3..
The Composition of ‘Ash’

The make up of the Ash contained within Virgin and Reclaimed wax and its possible affect on Foundry Inclusion Matter

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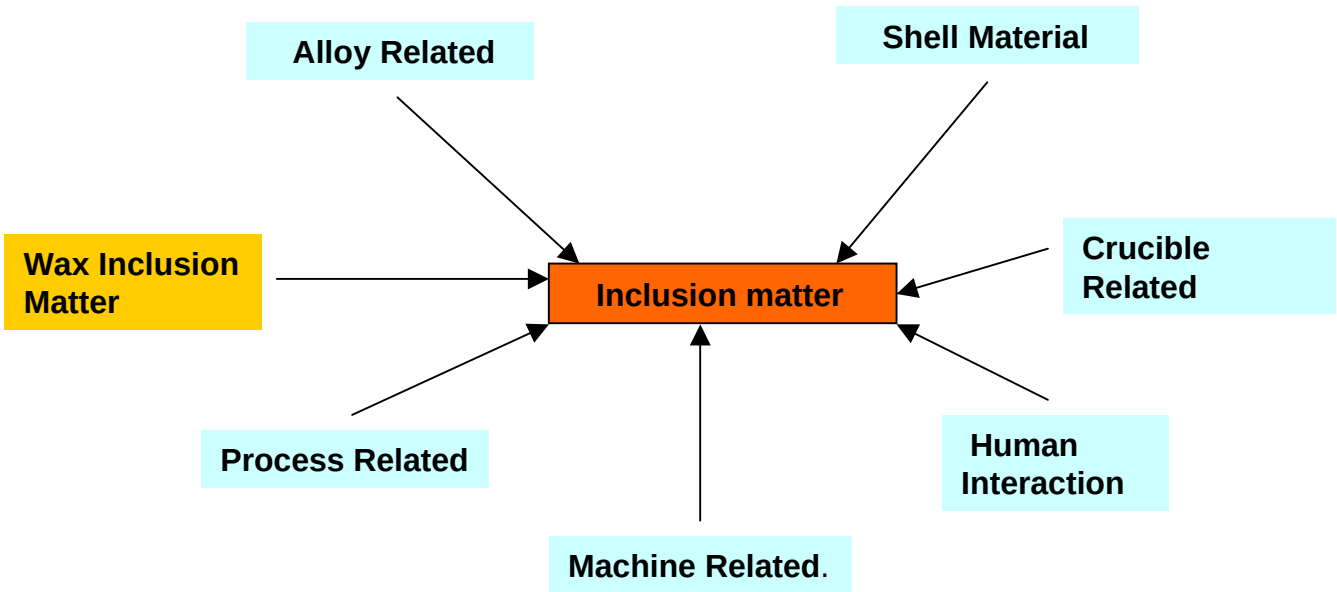
General causes of Foundry Inclusion matter



Inclusion matter found in castings can be a results of many possible causes.

The above is just a summary of some of the main ones.

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Understanding the make-up of wax related ‘Ash’

- The affect of Ash on a foundry process should be neither underestimated or overestimated, it is very much dependant on; types of alloy, mould orientation and N.D.T criteria.
- To understand the make up of the Ash, tests included;
  - Elemental analysis of the material removed from the reclamation process
  - Analysis of the effects of liquid additions to the wax

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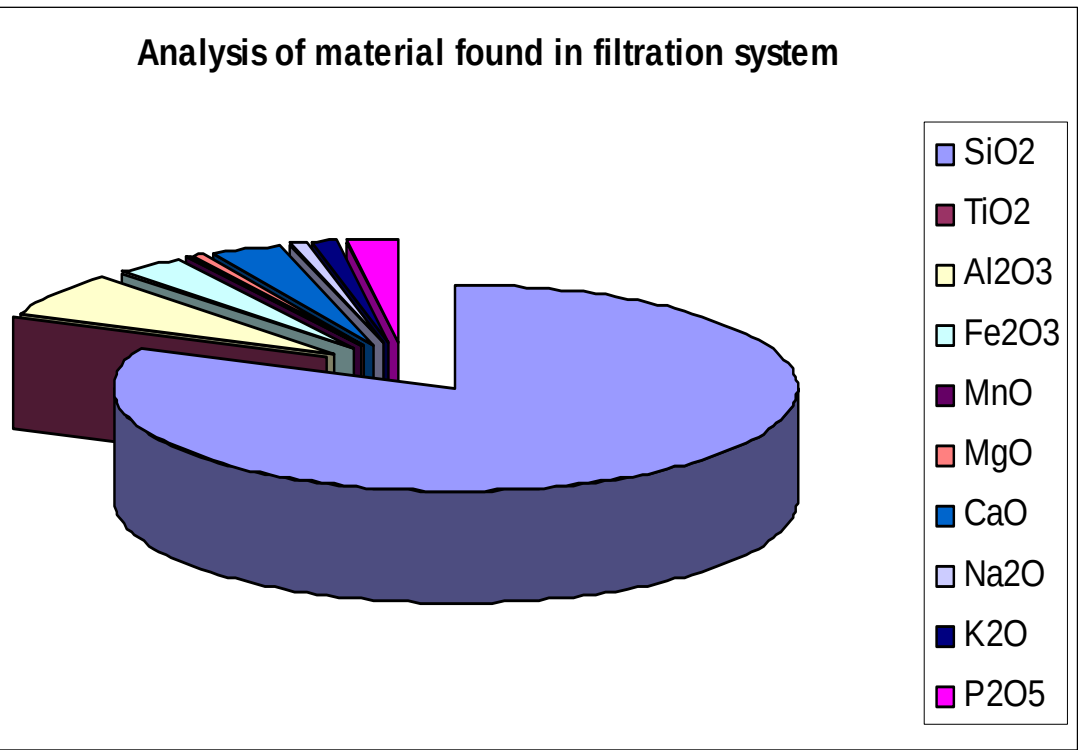
Elemental Analysis

Analysis of material found in our filtration process showed high levels of silica in particular, followed by Alumina. Zirconia was not part of the test.

Suggests that the vast majority of the solids in the waste material are from the shelling process

The filtration system removes the vast majority of them, other processes may not be as effective.

Important to discuss the needs of your process with your wax supplier



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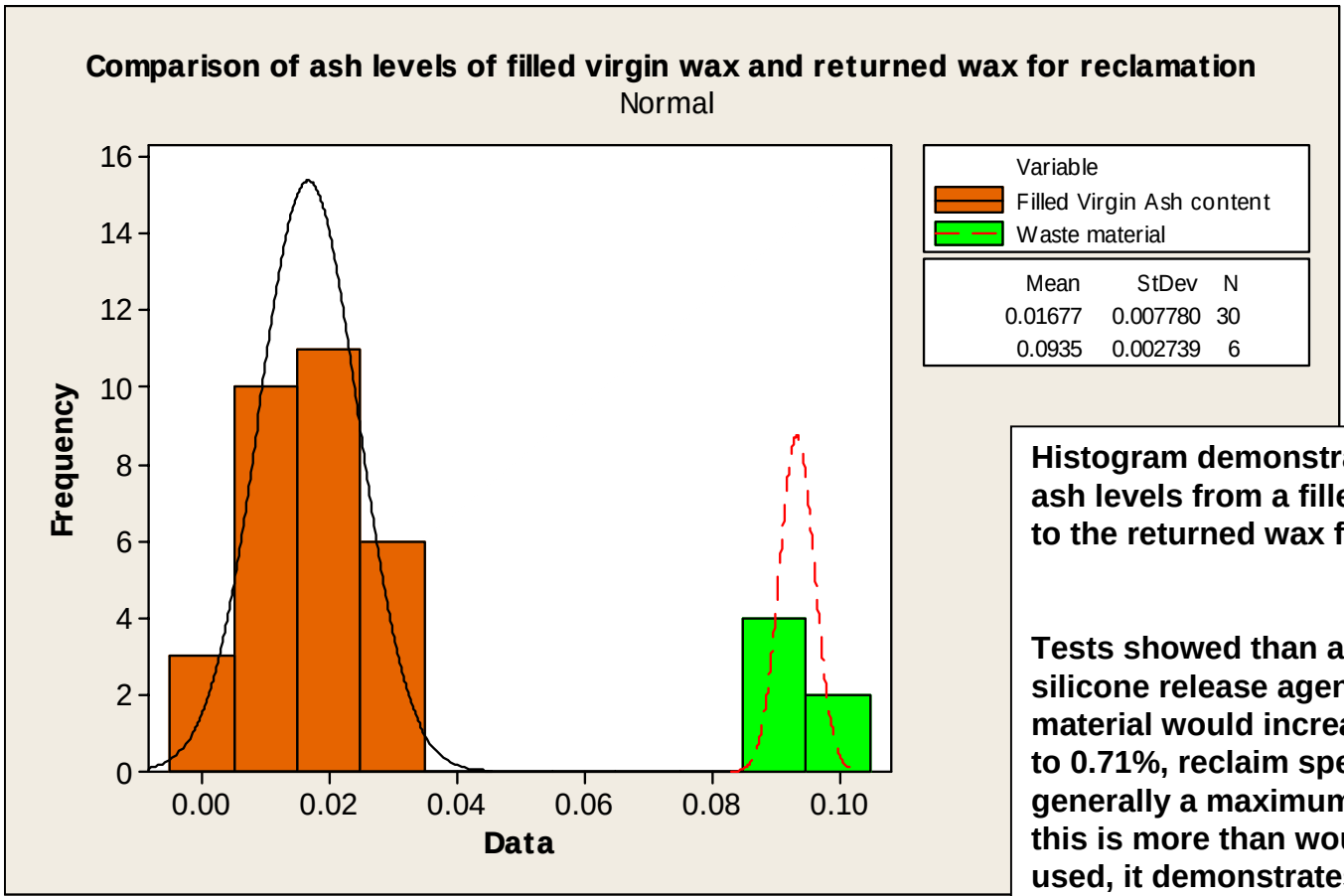
Silicone Additions



Histogram demonstrates the increase in ash levels from a filled virgin wax (0.17) to the returned wax for reclamation (0.94)

Tests showed than addition of 4% silicone release agent to the filled virgin material would increase this ash content to 0.71%, reclaim specification is generally a maximum of 0.15%. Although this is more than would generally be used, it demonstrates the effect of silicone in the process.

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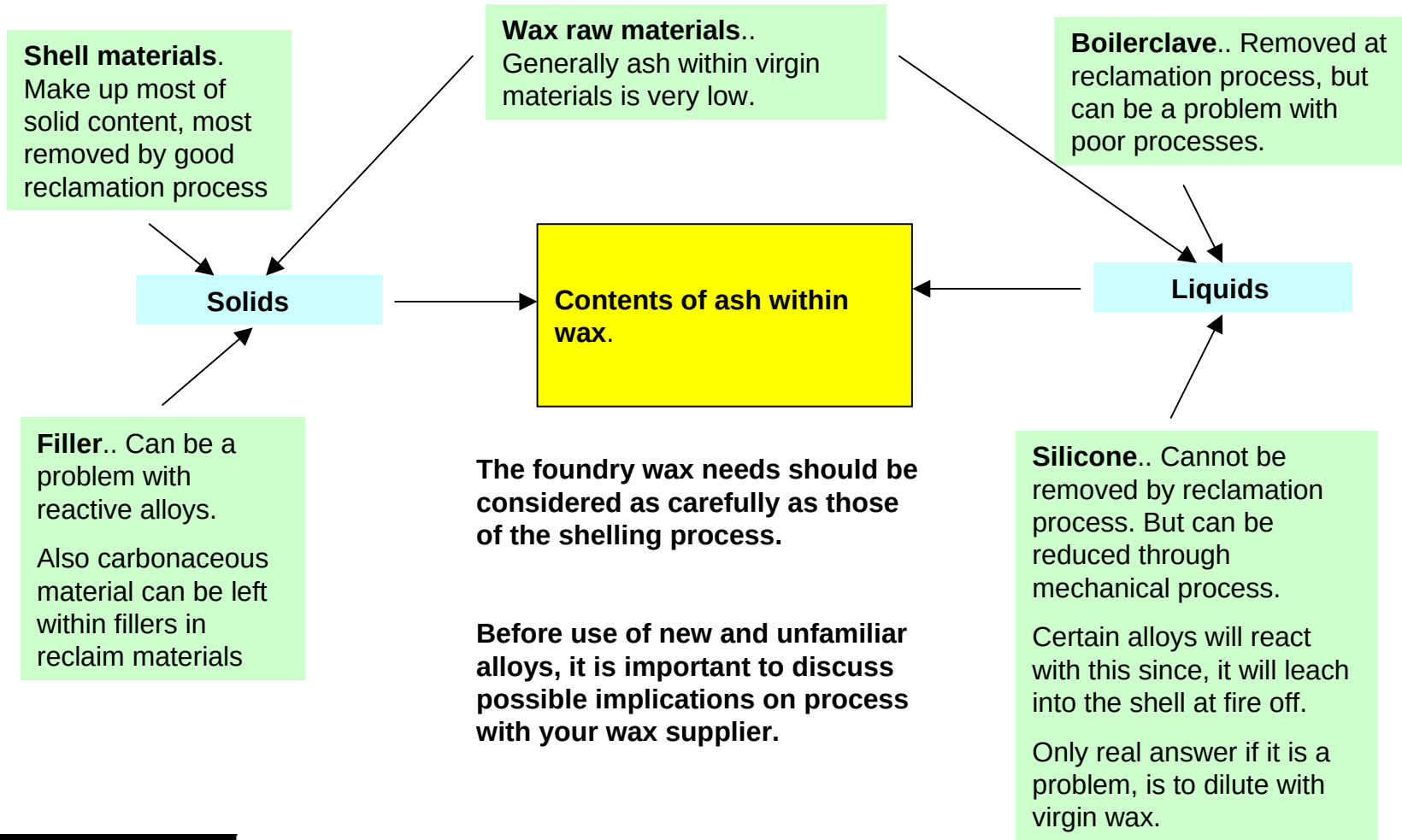
Possible Sources of Ash



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Section 3 - Conclusions

- Ash is but one of many possible sources of inclusion matter, and its effect is process dependant
- Analysis of materials found in the filtration unit suggest that the solid material is mainly shell debris
- The use of silicone release agents within a process can significantly contribute to the Ash levels

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Summary of Causes of Examined Defects

- Changes in wax contraction are generally temperature related, but can also be affected by filler separation.
- Flow lines can be improved by increasing injection pressure.
- Surface pitting is related to wax fluidity.
- Sinking is related to wax temperature.
- Ash contained within a wax may be made up of shell materials and silicone additions amongst other things.

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