An Introduction to Self-Monitoring, Adaptive, Re-Calculating, Treatment Technology (SMARTT) in Degassing Aluminum

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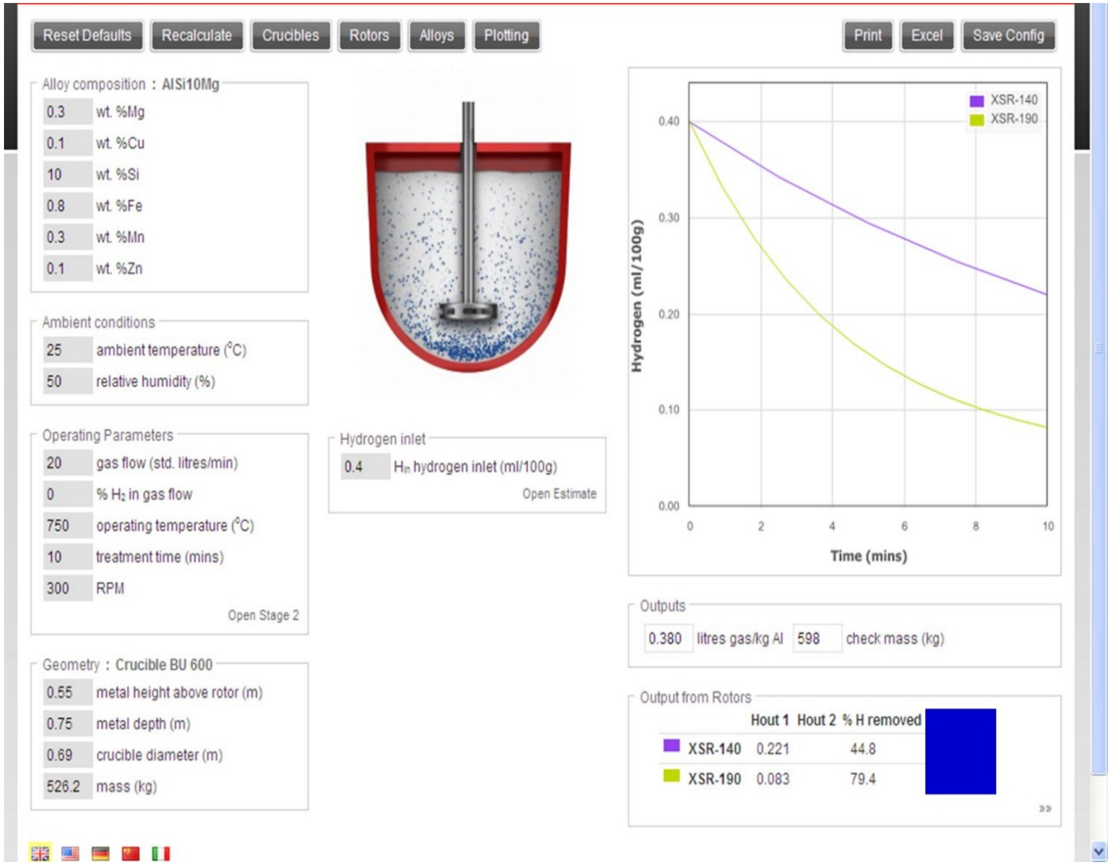
Outline

- Degassing model
  - Creation
  - Verification
- Degas modelling results for variations in:
  - ambient conditions
  - purge flow rates
  - rotor speeds
  - Alloys
  - Melt temperatures
- Introduction to SMARTT Degassing

Degas Modelling

- Web based program available on a license basis to colleagues
- Available in both metric and standard imperial
- Results can be output and saved
- Includes drop down of standard crucible/ladle sizes



Degas Modelling – Derivation & Verification

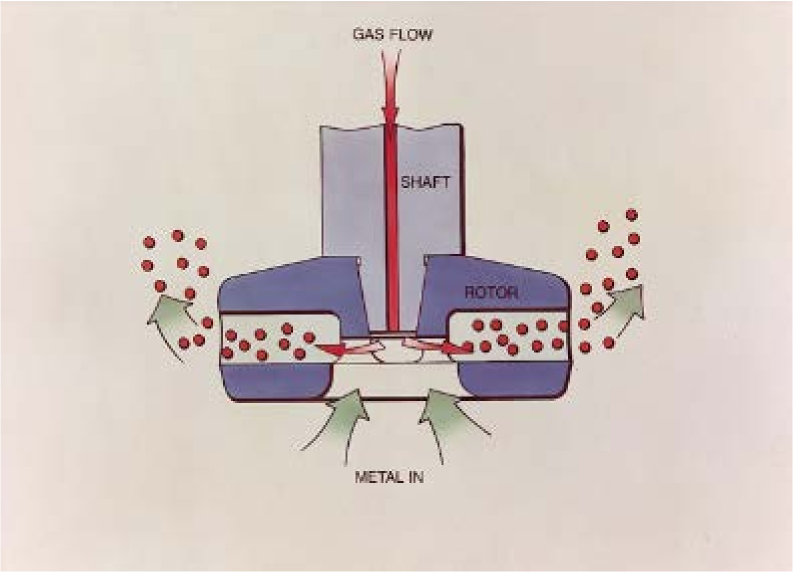
- Completed in 2011
- Tests run to identify 19 individual inputs
- Created by modelling oxygen in water using:
  - Henry's Law
  - Arrhenius relationship of O_2 diffusivity in water
- Adapted to aluminum using Sievert's Law
- Verified using a novel electrochemical, in situ, hydrogen sensor

Model Assumptions

- Assumes 100% of degassing treatments properly incorporate a baffle plate to break the vortex.
- Assumes there are no leaks in the purge gas line.
- Assumes graphite consumables are in operating condition.
- Assumes equipment is fully optimized.
  - Out of round is less than .007”
  - Tachometer, flow gage, etc. properly functioning.
- Assumes issues with “flooding” rotors are avoided.

Parameters to be Modelled

ATL 1000 with 850 kg melt		XSR 220 rotor
AlSi7Mg		420 rpm
750 °C melt temperature		20 l/min inert gas
50 % relative humidity		0.30 ml H2 / 100 g Al starting level
25 °C outside temperature		



Hydrogen Equilibrium

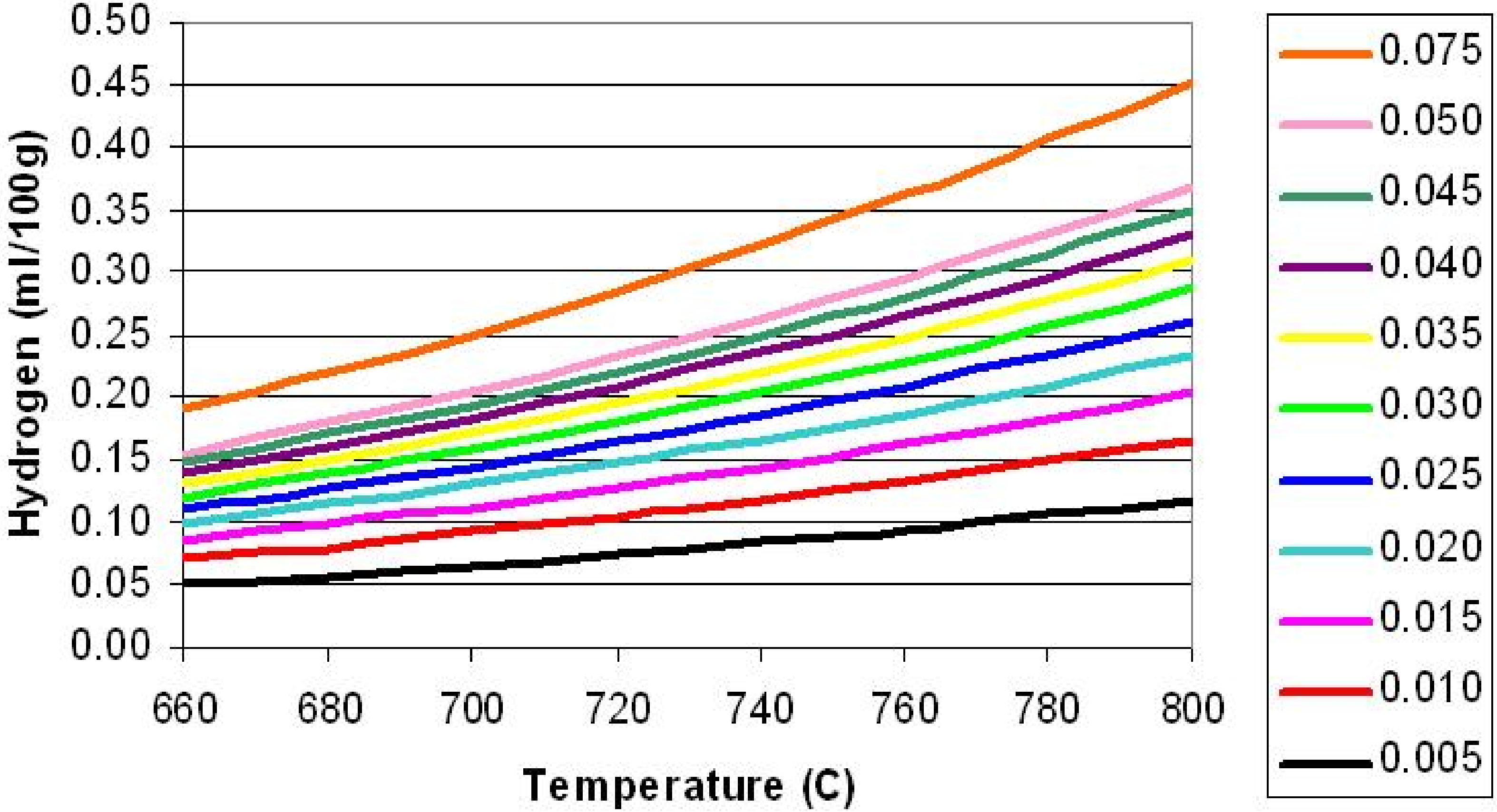
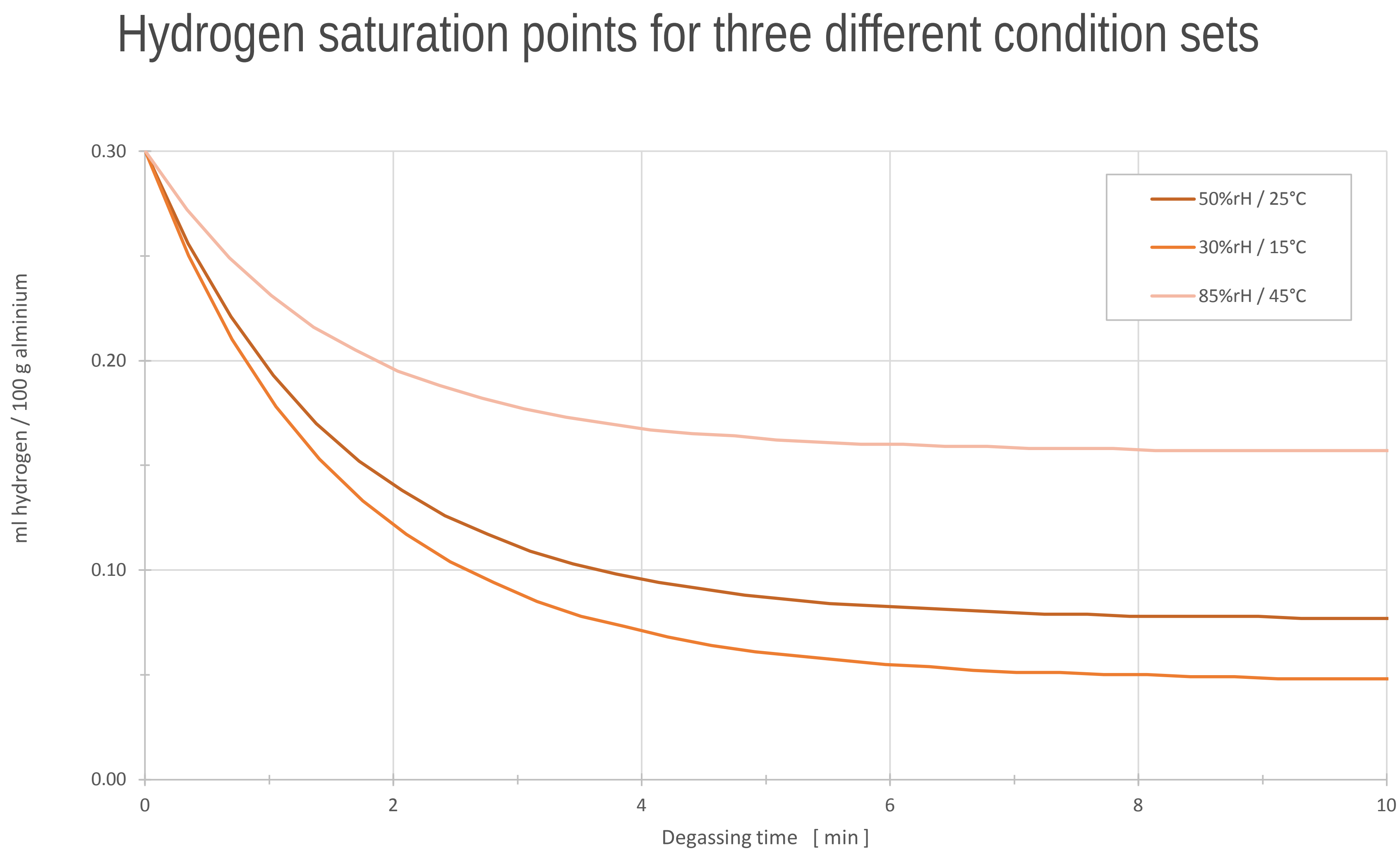


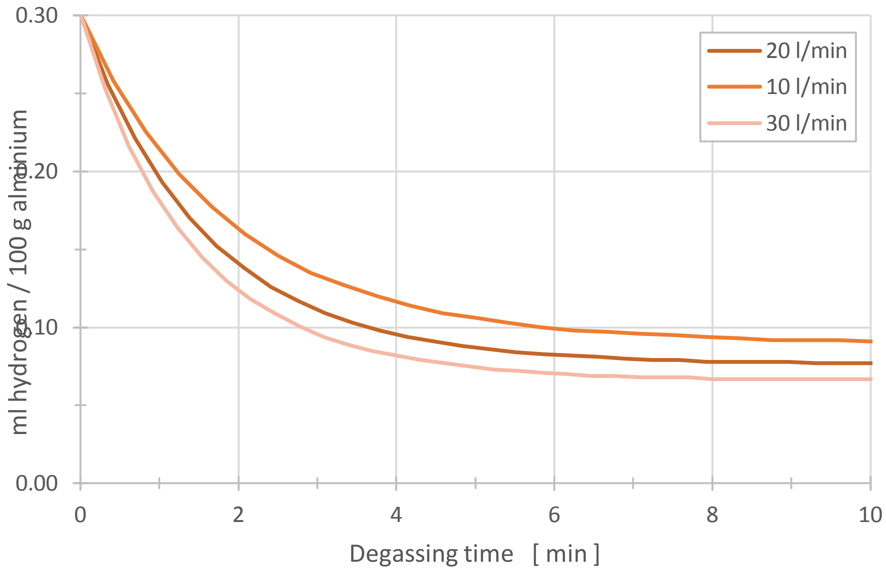
Figure 2: Influence of ambient conditions on hydrogen equilibrium (.005 atm.=5ºC/50 % rH; 0.05 atm.=35ºC/90 % rH)

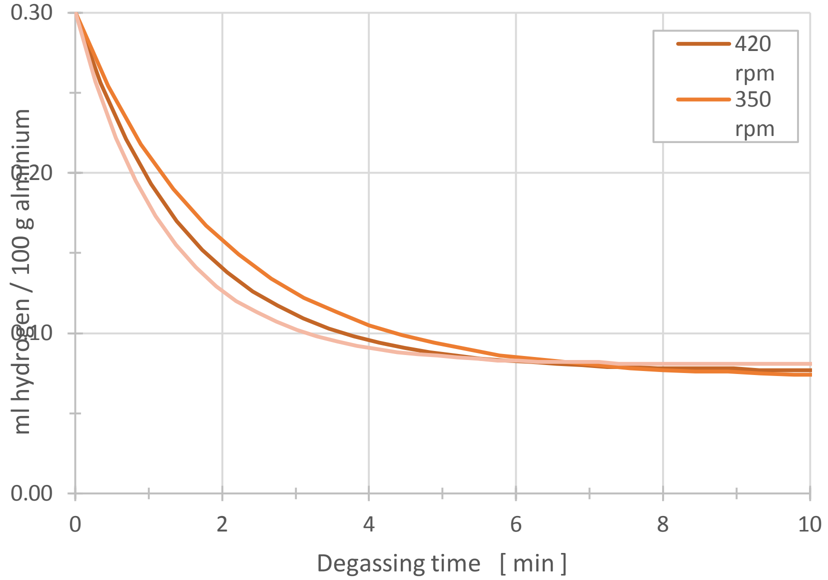
Modelling Results



Modelling Results

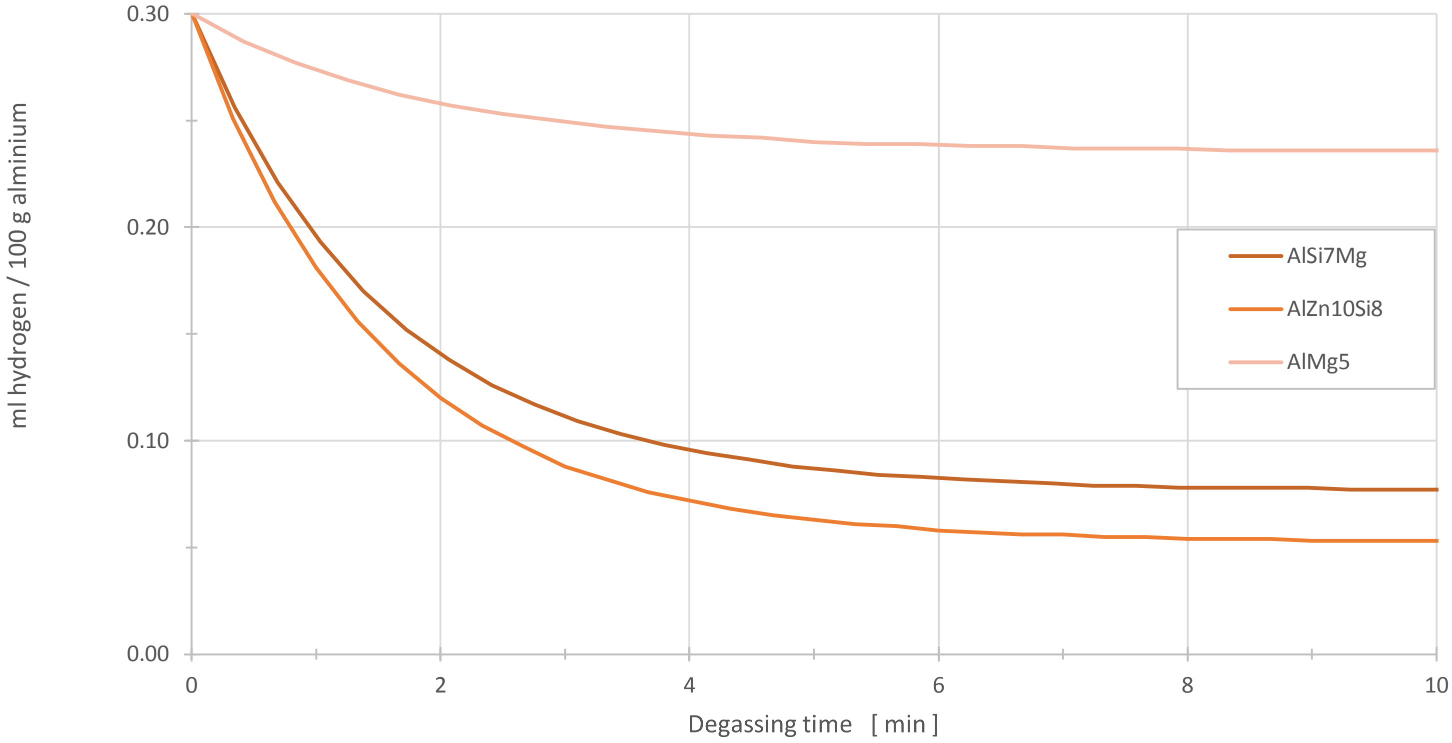
- Models for inert flow variations (bottom left) and rotor speed variations (bottom right).





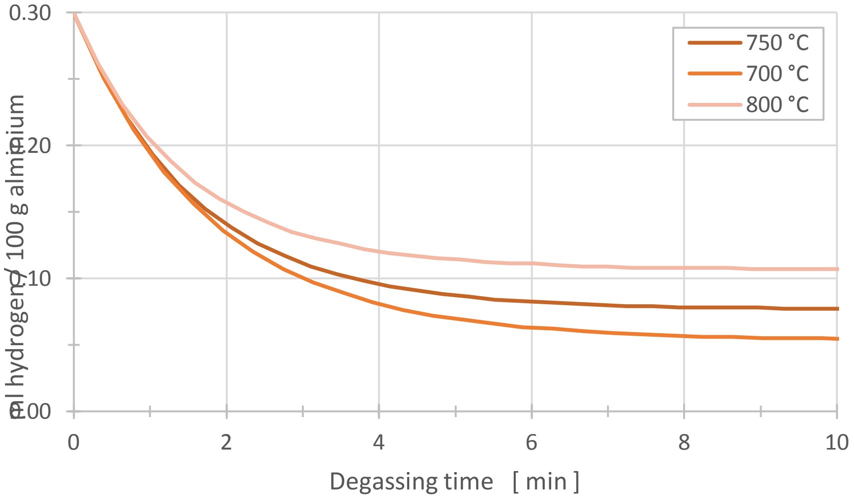
Modelling Results

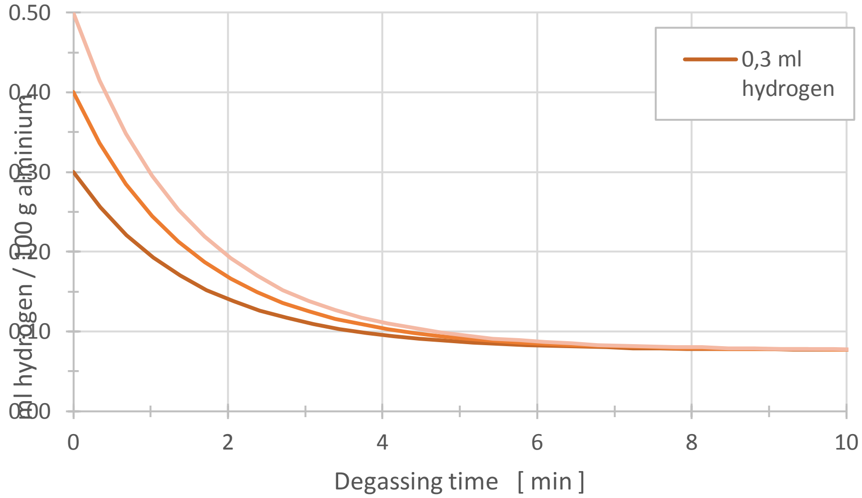
- Degassing curves for different alloys under the modelled conditions



Modelling Results

- Models for different treatment starting temperatures (bottom left) and different initial hydrogen levels (bottom right).





SMARTT Degassing

- **S**elf-**M**onitoring **A**daptive **R**ecalculating **T**reatment **T**echnology.

- Model integrated with a rotary degassing unit with automated flux additions.

- Several validation trials have been completed.

- Unit will tell you when a desired cycle is not possible (e.g. too low a hydrogen level for the melt temperature).

Trial Unit Specifications

- Unit combines rotary degassing with automated treatment additions.

- The trial unit can perform multiples of the following treatments:
  - Remove hydrogen (degas)
  - Treat oxides (cleaning flux)
  - Grain refine
  - Modify eutectic with sodium
  - Remove alkalis
  - Add hydrogen (upgas)
  - Model degassing

- The subject unit uses a removable baffle, hoppers with auger feeders and PLC controls to perform and sync all of the treatments.

Four Optimization Schemes

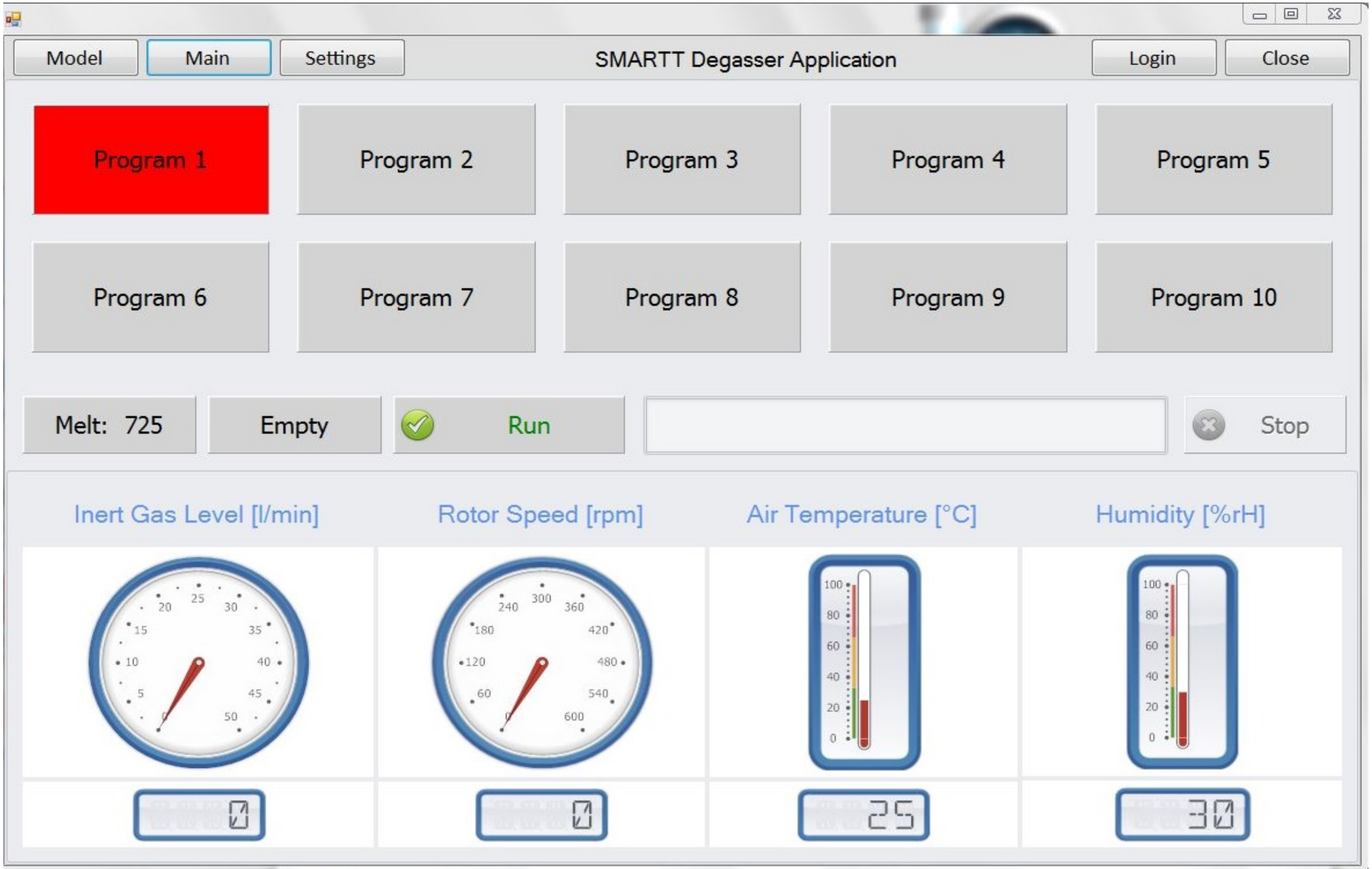
- **High-speed degassing** – shortest possible treatment time at highest possible rotor speed and inert gas flow rate. A minimum treatment time is observed to allow homogenization and oxide removal.

- **Low gas degassing** – runs the treatment for a given time at lowest gas consumption and correlative rotor speed to achieve the target.

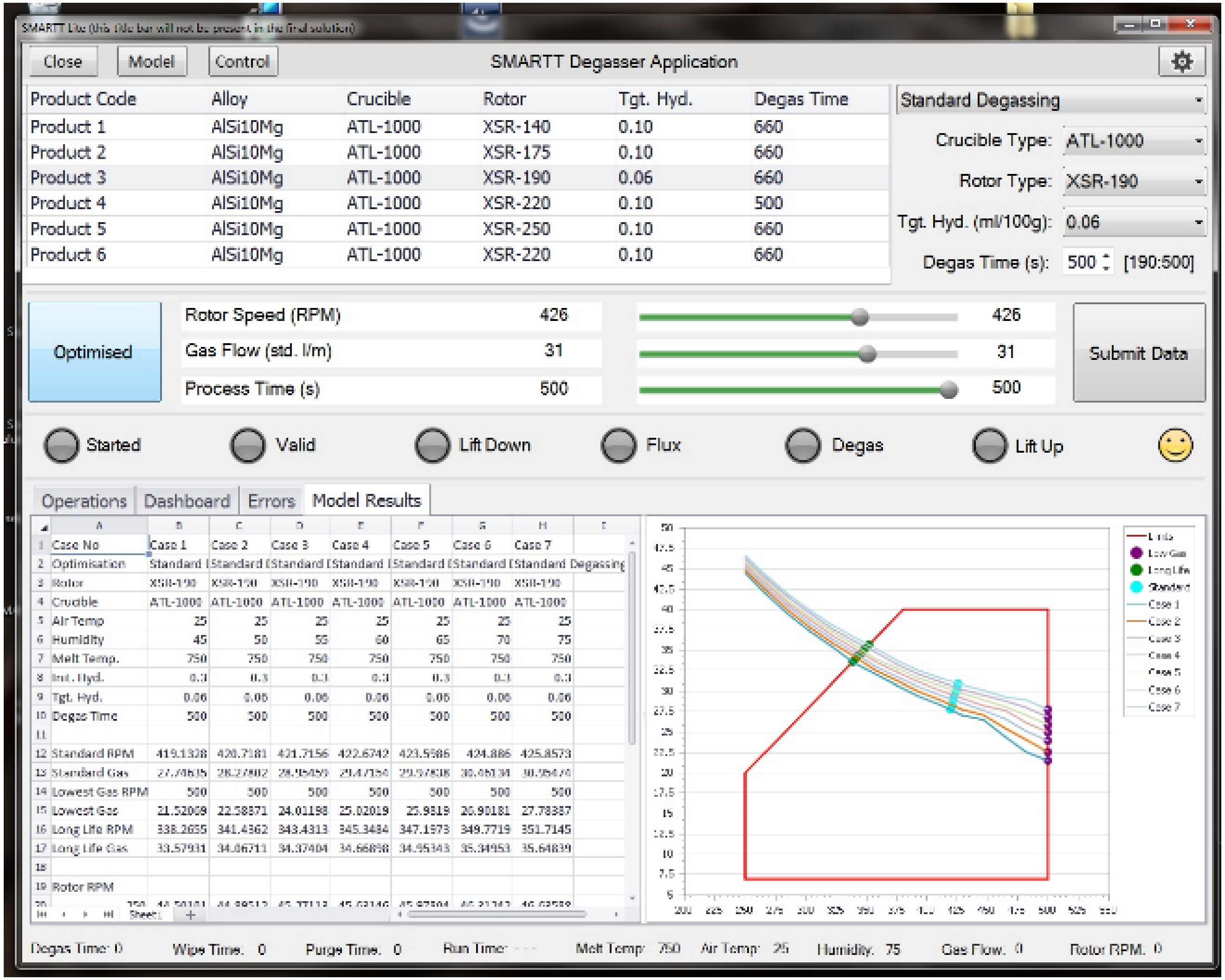
- **Long life degassing** – runs at lowest possible rotation speed to reduce the shaft and rotor abrasion. The corresponding inert gas flow depends on the total treatment time.

- **Standard degassing** – the average of low gas and low speed provides a balance between the two extreme schemes.

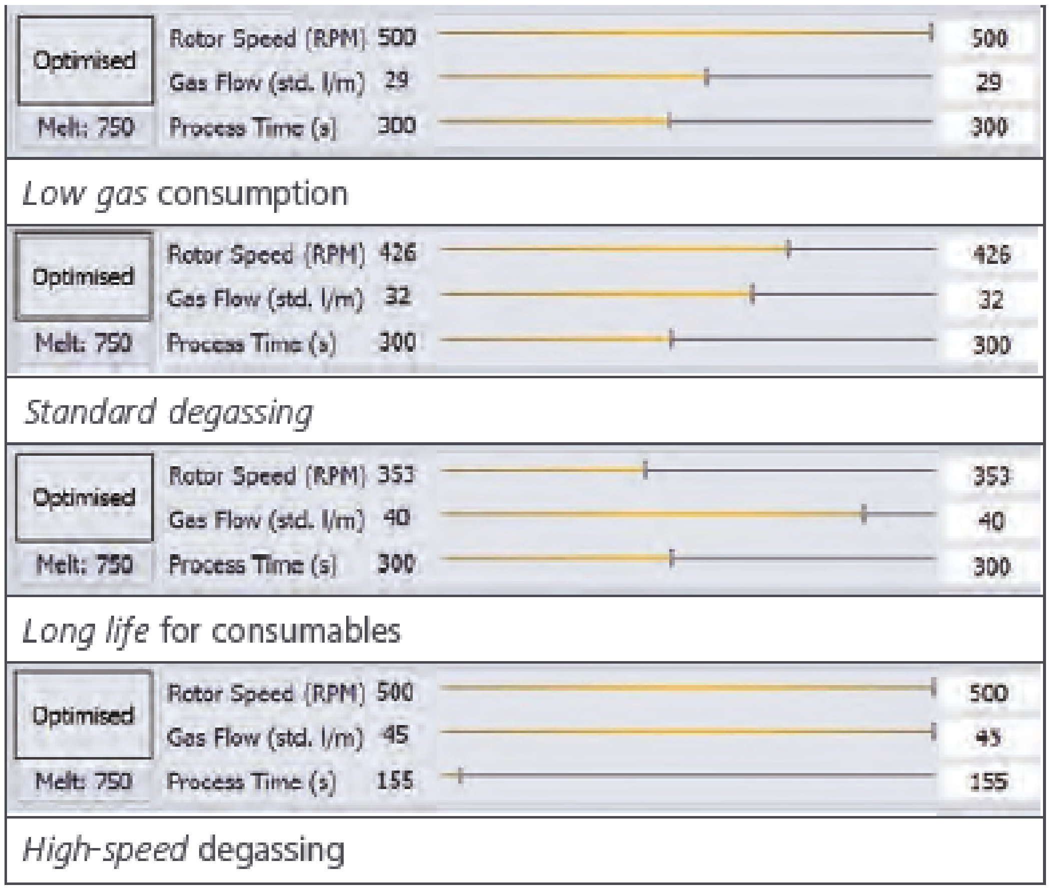
Degassing Interface - Operator



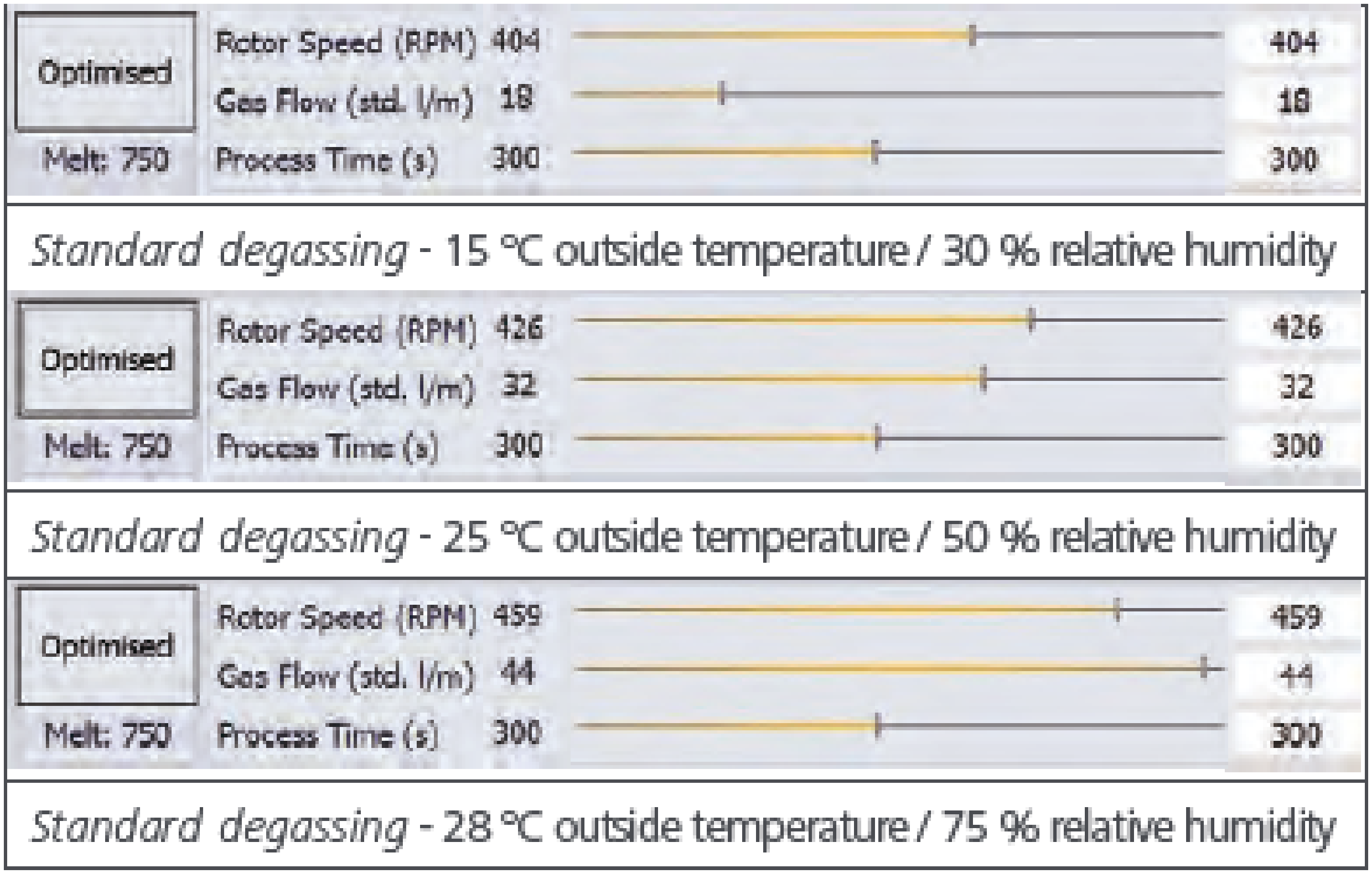
Degassing Interface - Engineering



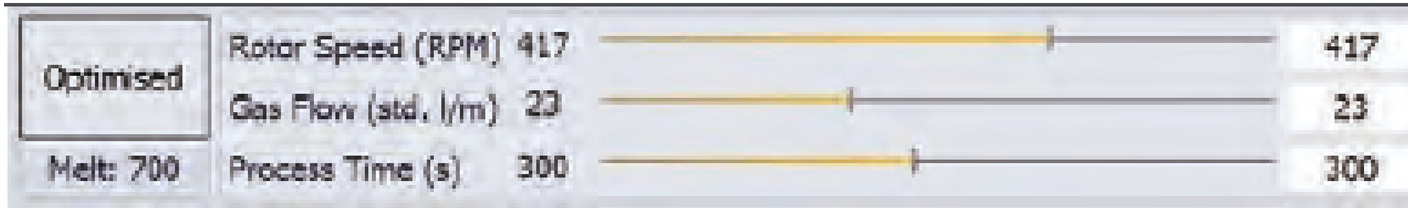
Results Parameters for 4 Optimization Schemes



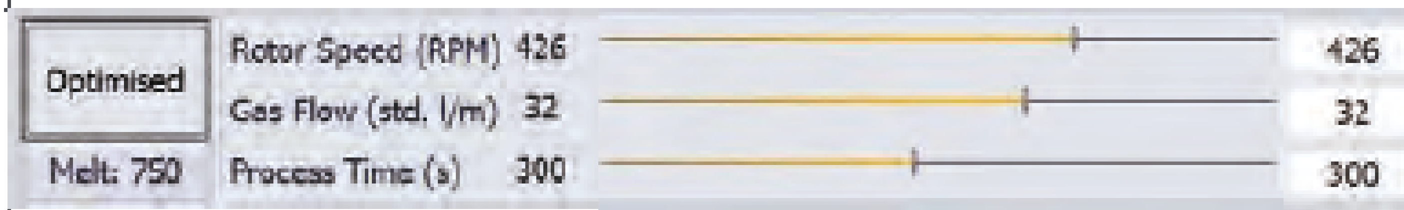
Effects of Ambient Temperature & Humidity



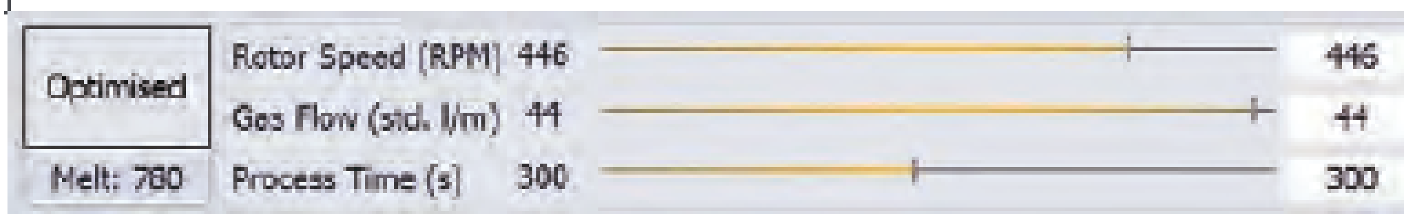
Effects of Metal Temperature



Standard degassing – 700 °C melt temperature



Standard degassing – 750 °C melt temperature



Standard degassing – 780 °C melt temperature

Summary/conclusions

- A model was developed and verified for predicting rotary degassing effectiveness within molten aluminum alloys.

- The model can be used to identify opportunities to reduce cycle time and/or reduce purge/consumable spend.

- The model was successfully adapted to a commercial metal treatment station and several units are in use.

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