New Developments in Pattern WaxTechnology

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Agenda

- Wax recycling – environmental considerations
- New wax developments
  - Emulsified
  - Liquid Filled
  - On-site recyclable filled wax
  - Non filled wax
- Filler reclamation
- Innovative wax test and manufacturing procedures

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Wax Recycling – Environmental Considerations

- Traditional view relates to the effects of manufacturing on the environment
- Modern thinking means the opposite approach must be taken
- Environmental demands and legislation are forcing changes on manufacturing processes
  - Global warming
  - Landfill costs (+33% in UK from April ’08)
  - REACH

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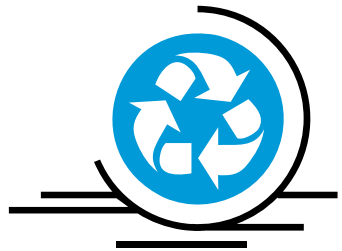
Traditional Wax Recycling

- Has some impact on the environment
- Filler disposal
  - Typically 30% recycled wax sent to landfill
- Used wax not seen as an important commodity by foundries
  - “Waste wax”
  - Often incorporates extraneous materials
- Increased restrictions on landfill
- Need to reduce environmental effects
  - Whilst maintaining/improving wax performance



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Resulting Needs

- New products allowing more efficient recycling.
- Innovative wax test and manufacturing procedures
- Minimise/eliminate disposal of traditional fillers
- Advanced recycling techniques

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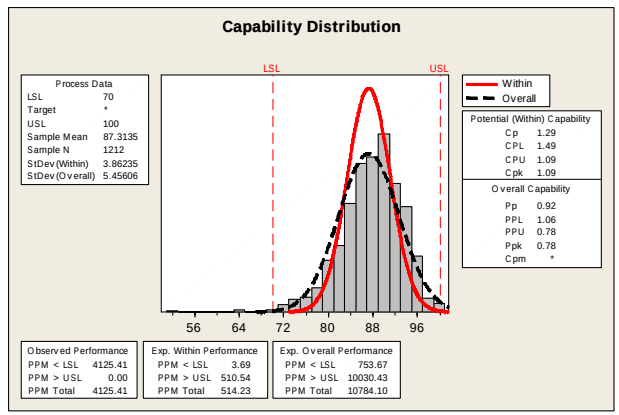
Emulsified Wax

- Waste disposal benefits – water filled
- Fresh thinking offers new potential
  - '2nd Generation' emulsified wax
- New emulsifying agents available
  - More fluid/less viscous
  - Less cavitation.
- Enhanced recycling properties
- Improved dimensional capabilities
- Greater design flexibility for
  - Wax
  - Products



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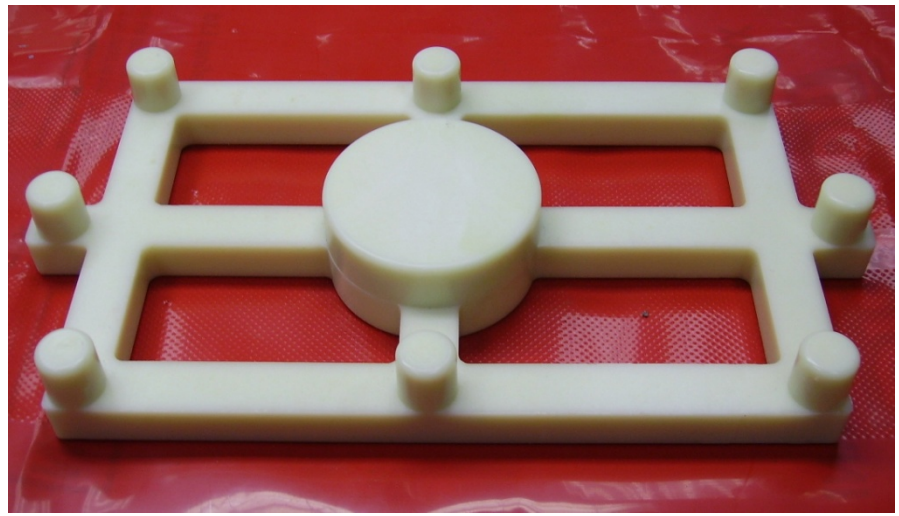
Liquid Filled Wax

- New approach to wax products based on emulsified wax concept
  - but with liquid fillers
  - with boiling points significantly above 100°Celcius
- Liquid fillers are more stable at higher temperatures
  - Can be held at elevated temperatures for long periods
- All of the benefits of emulsified wax
  - plus improved performance



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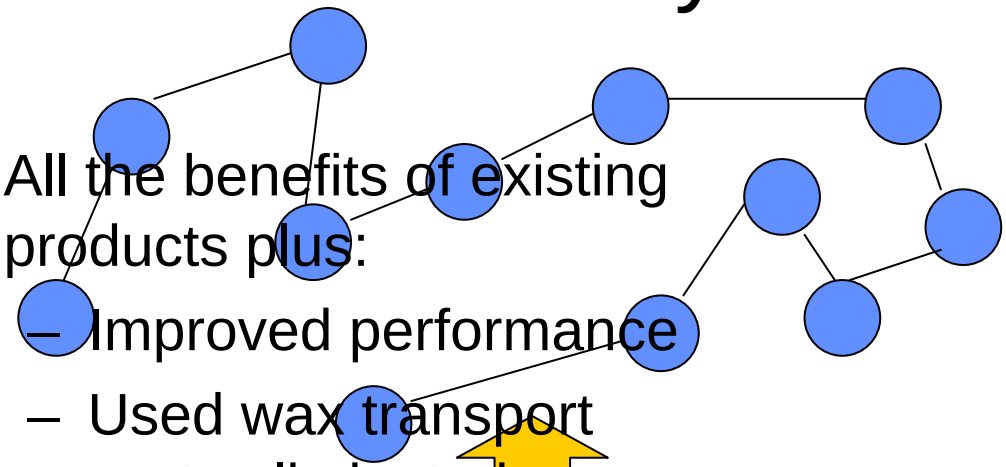
On-Site Recyclable Filled wax



- All the benefits of existing products plus:
  - Improved performance
  - Used wax transport costs eliminated
  - No need to change process
- On-site reclamation not new
- Existing products perform well
  - but more advanced products now available
- New wax developed and tested

TEMPERATURE
> 95°C

IN SUSPENSION

AFTER SETTLEMENT

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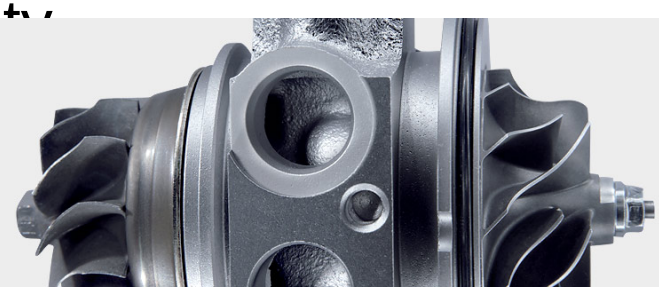
Non-Filled Wax

- Non filled wax is very low ash and very fluid
- Tra ssibilities in use
  - C er
  - I
- Nev r development
  - E wax
  - S
  - I
  - Low ash
  - High fluidity
- Will allow injection of more detailed pieces and lower injection temperatures
- Potential use for Aerofoil/IGT/Turbowheels



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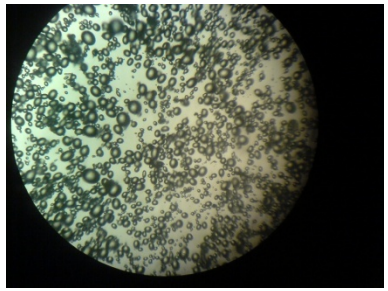

Filler Reclamation

- One third of most recycled wax goes to landfill
- Two possibilities are being explored

1. Reclamation of filler for re-use in wax
   - Pilot plant built and tested at Blayson Japan
   - Feasibility study to be undertaken
2. Used filler as ‘fuel’ for power generation

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Process Related Testing

- Existing wax tests do not necessarily reflect injection process needs
- In particular
  - Viscosity
  - Flow characteristics
  - Setting properties

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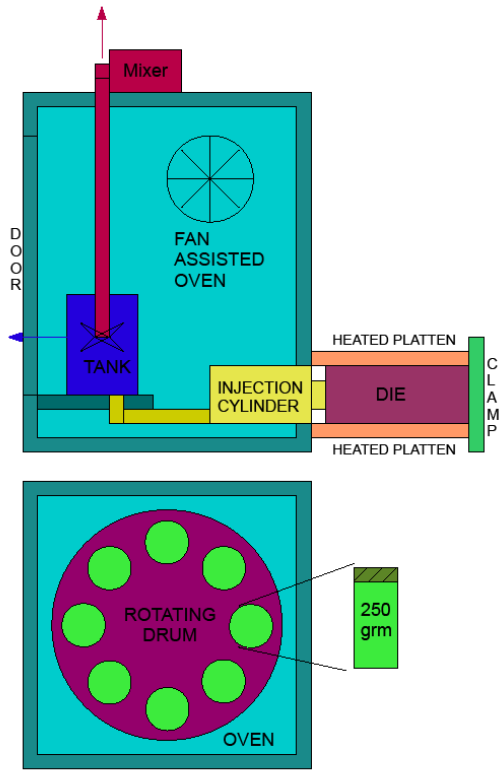
Injection Performance Testing

- Laboratory machine has been developed that measures Fluidity rather than Viscosity
- Based on current injection processes
  - Mimics foundry conditions
- Capability to indicate injection criteria on batch to batch basis
- Effective on both virgin and recycled products



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Wax Injection Properties

- Current information is laboratory based rather than process based
- New equipment designed, developed, tested to show setting characteristics of wax under injection conditions
  - Can be used on production machines
  - Gives real time measurement
  - Capability to assess injection performance
  - Optimisation of pattern production

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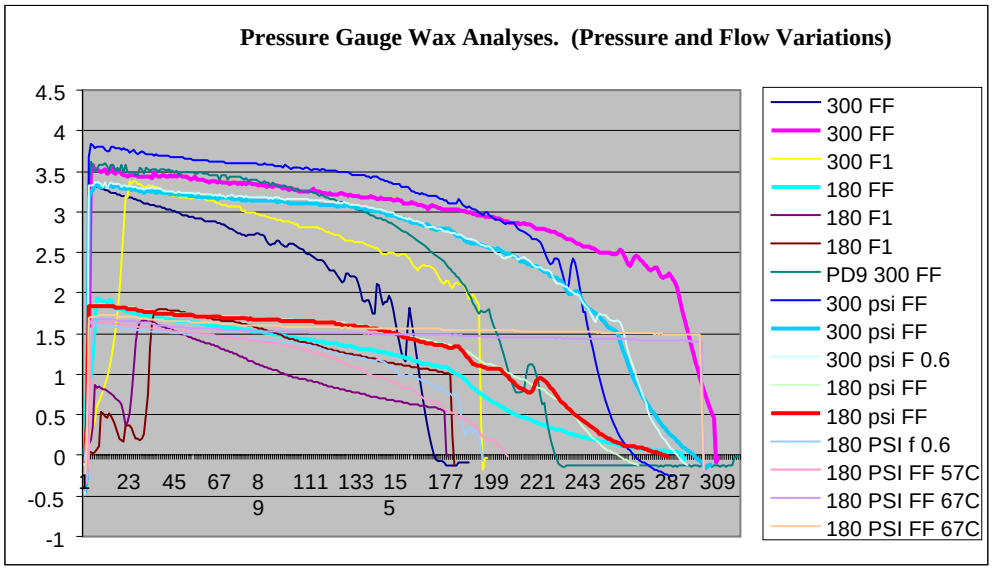
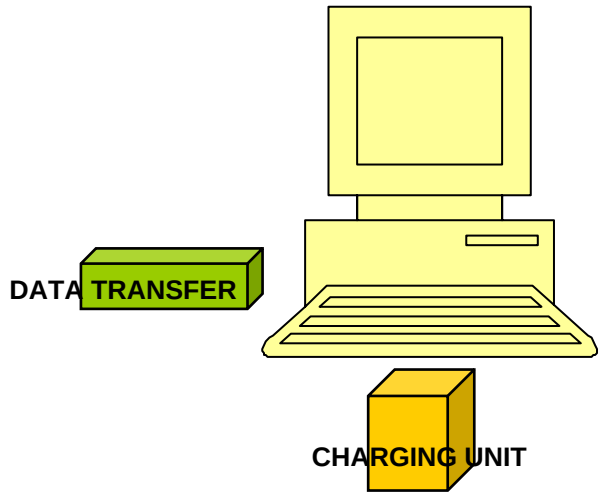
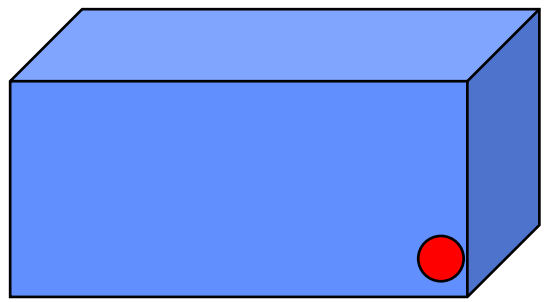
Injection Equipment Schematic







DIE INCORPORATING PIEZO ELECTRIC PRESSURE GAUGE.

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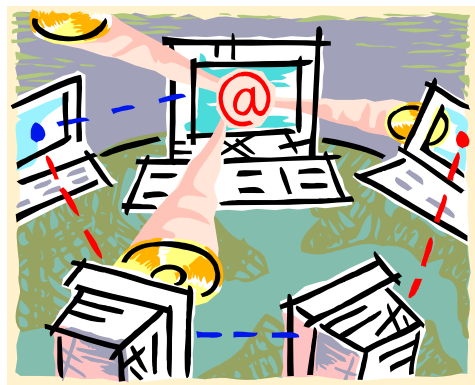
Predictive Production Control

- Batch manufacturing system being redesigned
  - to incorporate raw material capability
- Greater product consistency
- Improved speed of manufacture
  - for virgin and recycled wax



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Summary

- In order to meet the changing needs of industry new and improved materials and processes are required
- Extensive R&D is resulting in innovative wax materials
- Designed to benefit the investment casting process and the environment

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