CelSian lab experiments

We offer a range of measurements and experiments dedicated to help you understand glass melting. Typical measurements are listed below. However, one of our unique strengths is to build set ups and develop unique measuring methods that suit your needs. Our lab is equipped to simulate current and future sustainable melting processes, including alternative combustion and electrical melting.

Normally we supply measurement data, films and reports, but we can also supply you with glass samples.

Our typical experiments are:

1. Determination of Batch melting energy
2. High Temperature Melting Observation with unique in-situ Evolved Gas Analysis (EGA)
3. Batch pre-treatment trials
4. Carry over measurement
5. Decrepitation of dolomite and limestone
6. Glass melting from batch (range 10g-10kg)
7. Batch heat transfer measurements
8. Determination of dissolved gases
9. Refractory corrosion by flue gases
10. Refractory corrosion by molten glass
11. Batch free -time tests
12. Evaporation experiments
13. Surface tension measurements
14. Leaching tests
15. Measurement of pO_2 in a glass melt (Rapidox)
16. Characterization of glass defects
17. Other measurements

Short descriptions:

1. Batch melting Energy demand trials

The Heat Demand (HD) set up measures the energy required to melt a batch. It is based on drop calorimetry, but **adapted and calibrated for much larger batch samples**. The energy (J) to heat up batch from room temperature to glass melt temperature is derived from the experimental procedure. The setup is used to easily compare the energy requirement of different batch alternatives for melting a certain glass composition.

2. High Temperature Melting Observation (HTMOS) and Evolved Gas Analysis (-EGA)

With our HTMOS-EGA equipment we analyze gases produced by glass forming raw material batches during heating up (maximum temperature 1800°C) and simultaneously observe batch to glass conversion- viewing phenomena such as batch sintering, melting, foaming & bubble formation. Depending on the purpose of the investigation, the report includes information about:

- The amount, type and temperature range of gas forming reactions
- Observation of possible batch sintering
- Determination of the Melting onset temperature
- Observation of foam build-up and decay
- Observation of fining (fining onset temperature)
- Bubble size, their growth & ascent in melt
- Effect of furnace atmosphere on fining
- Effect of furnace atmosphere on redox of resulting glass
- Effect of furnace atmosphere on foaming

Depending on the objective of the study, we advise 2-5 trials during which the melting, foaming and fining behaviour of the batches and glasses will be observed and compared under different conditions.

Apart from a report describing the measured and observed phenomena, speeded up videos are produced from the images of the batch & glass.

3. Batch pretreatment

Batch pre-treatments techniques are used to improve the melting kinetics of batch materials or to improve the safe handling of (fine, fluffy) batches. The pre-treatment techniques which can be applied are:

- Pelletizing
- Briquetting
- Milling & Sieving
- Pressing

Samples of pre-treated batch can be sent to the customer. These samples can also be tested in our other equipment (for example the HTMOS set up).

4. Carry over measurement

Batch carry over tests is measured by placing a batch sample in a horizontal tube furnace. A flow of gas from a natural gas burner passes over the sample with a pre-set gas velocity. The carry-over is measured by collecting the released dust particles in a filter for a given time period. The amount of dust collected is measured together with the gas flow rate, giving the concentration. A chemical analysis of the dust can be performed to determine the source of the carry-over. An alternative batch component can be applied to decrease the amount of carry over in your furnace.

5. Decrepitation measurement of dolomite or limestone

Samples of dolomite or limestone are heated in platinum crucibles in an electric furnace. The weight loss due to decrepitation and the spread of the particles out of the crucible are measured and compared with a reference sample.

6. Glass melting tests 10g to 10kg

Batch/glass melting tests are carried out as part of studies to:

- Develop new glass types
- Investigate the effect of furnace atmosphere on the properties of a glass
- Produce glass samples e.g. glass bars, ingots
- Produce unique glasses (small scale production up to 10kg)

7. Batch heat transfer measurements

The equipment allows measurement of temperatures within a 5-10cm thick simulated batch blanket. Temperatures are measured at different levels from heated plate as function of time. This allows determination of the heat transfer within the batch. The data can be applied for more accurate CFD modelling studies.

8. Determination of dissolved gases in glass melts

- Dissolved gases are extracted using Helium flushing
- Determination of the amount and species of dissolved gases in production glasses. High CO_2, SO_2 or oxygen levels can be the cause of bad fining process.
- Measure solubility of gases (O_2, CO_2, CO, SO2) at different temperatures (can be used as input for detailed CFD modelling)

9. Refractory exposure tests: gaseous

For regenerator simulations with simulated glass furnace flue gases (temperature range 1200-500°C)

- Simulation of various flue gas mixtures (oxidized, reduced, Na +SO_2, Oxygen fired, or air fired)
- Different refractory qualities are tested on the corrosion resistance at different temperatures within 1 measurement.
- Chemical attack of these refractory materials is determined by visual examination and weight change over time.
- Optionally samples can be prepared and examined under SEM to determine the corrosion mechanism

10. Refractory exposure test in molten glass

Rotating refractory finger in melt (comparative tests) of various materials in a given glass at a certain temperature. We determine corrosion by the comparison of sample dimensions before and after testing.

11. Batch-Free-Time (BFT) tests for batches

- Determination of time for complete melting of batch under isothermal conditions by interrupted melting and determination of remaining crystalline species using XRD
- Typical temperatures used 1350˚C, 1400˚C, up to 1800˚C- depending on glass type
- Typically test of effect of batch composition, grain sizes on BFT, batch pretreatment (pelletizing, humidification), or melting flux additions on BFT

12. Evaporation experiments

A set up is available to determine the evaporation rates and detection of volatile species from a glass melt. These depend on:

- Batch and glass composition
- Impurities
- Furnace atmosphere
- Gas velocity above the melt
- Temperature and time

13. Surface tension by capillary bubbling

The surface tension of a molten glass is measured by blowing gas bubbles from a known diameter capillary through molten glass. We do this up to 1550 °C.

14. Leaching tests:

Measurement of the leaching of components out of various glass types

- Using glass powder
- Exposed to water / hot water / acid or alkaline solutions for a certain time
- Measurement of the concentration of leached components in the solution using ICP

15. Measurement of pO_2 (redox) in a glass melt (using Rapidox)

Measurements are carried out in molten glass in a Rapidox furnace to determine the pO_2 (redox state) of the glass as a function of temperature.

- Effect of type of cullet on pO_2
- Effect of fining agents
- Effect of oxidants or reducing agents on melt

16. Characterization of glass defects

Determination of type and probable source(s) of stones, knots and crystalline defects in glass using optical microscopy.

17. Other measurements

Below you can find a series of standard measurements of glass properties that we perform.
These include:

- Glass composition determined by XRF
- Iron redox derived from UV VIS spectral measurements and XRF measurements.
- Thermal heat conductivity is determined from spectral measurements
- IR spectral measurements to determine water content
- Measurement of specific heat
- Measurement of electrical resistance of molten glass
- Measurement of viscosity in molten and solid glass
- Measurement of density and coefficient of thermal expansion up to Tg
- Measurement of the gas composition of bubbles in glass
- Analysis of glass defects (stones, knots and cords) using scanning electron microscopy
- Determination of devitrification and crystal types (using XRD)
- Measurements of liquidus temperature
- ICP measurements