Drying your polymer

Why?

Hygroscopic:
‘tending to absorb moisture from the air’

- Surface Moisture
- Hygroscopic:

WITH DRYING TECHNOLOGIES
Drying your polymer

And

Because all material manufacturers recommend an upper moisture limit for the optimum processing of their materials!

Where do they get these figures from?

They mould test bars
Drying your polymer

Commodity Polymers

- Polyethylene
- Polypropylene
- Polystyrene
- Acrylic
- PVC
- ABS
- SAN

Engineering Polymers

- Polyesters (PBTP & PETP)
- Modified PPO
- Nylons (= Polyamides)
- Acetal (= POM)
- Polycarbonate
Drying your polymer

Advanced Polymers

- HTN (High Temperature Nylon)
- PPS
- PES
- PSU
- LCP
- PTFE
- PI
- PEEK
- PEI
Relationship between polymers

ADVANCED POLYMERS
- POM
- PA
- PI
- PTFE
- LCP
- HTN

ENGINEERING POLYMERS
- PC
- POM
- PET
- PBT
- TPE
- PP-GF
- PP
- PE-UHMW

COMMODITY POLYMERS
- ABS
- PMMA
- PVC
- SAN
- PS
- PP
- PE-LD
- PE-HD

Amorphous
Crystalline
A well-ordered polymer is considered crystalline. The opposite is an amorphous polymer.
## Upper moisture limits

<table>
<thead>
<tr>
<th>Material</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nylon 6</td>
<td>&lt;0.2%</td>
</tr>
<tr>
<td>Nylon 6.6</td>
<td>&lt;0.2%</td>
</tr>
<tr>
<td>PBTP</td>
<td>&lt;0.04%</td>
</tr>
<tr>
<td>PETP</td>
<td>&lt;0.02%</td>
</tr>
<tr>
<td>Acetal</td>
<td>&lt;0.2%</td>
</tr>
<tr>
<td>TPE</td>
<td>&lt;0.1%</td>
</tr>
<tr>
<td>LCP</td>
<td>&lt;0.01%</td>
</tr>
</tbody>
</table>
Early Dryers for Hygroscopic Resins

Late 1950’s - Carl Whitlock developed desiccant bed dryer
Early models utilised silica gel as desiccant but could not attain -40° dew point.
Molecular-sieve desiccant was developed by Linde Div. of Union Carbide

-40 Dew Point Dryers Became the Industry Standard
Drying your polymer

Good Drying

- Temperature
- Dew Point (dehumidifier)
- Air Flow
- Time
- Maintenance
- Moisture analysis
Drying your polymer

Dew Point

The dew point is used a lot by TV meteorologists and seen on most current weather conditions because it's a great indicator of the moisture content of the air, or humidity.

DEW POINT MEASURES THE DRYNESS OF THE AIR THAT SURrounds THE PELLETS –

...NOT THE DRYNESS OF THE PELLETS!.
Drying your polymer

Dew Point

Graph: Saturation Fraction of Water in Air at Sea Level

- X-axis: Temperature (°C)
- Y-axis: Saturation Fraction of Water in Air at Sea Level
Drying your polymer

Wet material - Hydrolysis

- Surface finish
- Lower mechanical properties
- Impact strength and elongation to break
- Electrical properties
- Short shots
- Splay marks (v wet)
- Lower Viscosity & flash
- Discolouration
- Excess torque on machine
- Greater power consumption
- Melt....disaster
# Moisture in the Granules

<table>
<thead>
<tr>
<th></th>
<th>Symptoms when moulding</th>
<th>Visible symptoms in moulded parts</th>
<th>Influence on mechanical properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA</td>
<td>• Drooling</td>
<td>• Splaying in direction of flow</td>
<td>• Lower impact and tensile strength</td>
</tr>
<tr>
<td></td>
<td>• Bubble information in purge</td>
<td>• Increased formation of flash</td>
<td></td>
</tr>
<tr>
<td>PET PBT</td>
<td>• No noticeable symptoms</td>
<td>• N.B.: Surface streaks (splaying) are not visible</td>
<td>• Much lower impact and tensile strength</td>
</tr>
<tr>
<td>POM</td>
<td>• Bubbles may be formed in the purge</td>
<td>• There may be splaying</td>
<td>• None</td>
</tr>
<tr>
<td></td>
<td>• Some mould deposit may be formed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEEE</td>
<td>• No noticeable symptoms</td>
<td>• Slight increased tendency to form flash</td>
<td>• Lower impact and tensile strength</td>
</tr>
</tbody>
</table>

**How to recognise excess moisture content**
Moisture content vs Mechanical properties

Rynite® PETP
Drying Technology

- Hot air......
- Twin tower central desiccant driers
- Rotor Wheel dryer
- Vacuum Drying
- Compressed Air Driers
- Silo Dehumidification Units
Drying Technology

Twin Desiccant

- Traditional Technology using two molecular sieves
- Process then Regeneration (300°C)
- Desiccant needs replacing every 2 years approx.
- Uses more power
- Less consistent dew point
- Molecular sieve breaks down and has to be filtered
Advanced Drying

- Dew Point control
- Material Management – Link to machine output
- Temperature ΔT - anti stress
- Load cells on hopper – linked to throughput+
- Load cells on desiccant beds
- Inverter on blowers
- Weekly Timer
- Link to real-time moisture meter (Dryscan)
100% Pure Crystalline desiccant is embedded in a woven substrate

The result is 100% pure molecular sieve desiccant that is permanently bonded onto the substrate, delivering a uniform -40 °C

The desiccant impregnated substrate is then formed into a tightly wound wheel that contains more pure desiccant than a twin tower of 3 times its size.
Desiccant Wheel Drying
## Twin v Rotor wheel

<table>
<thead>
<tr>
<th>Rotor Wheel</th>
<th>Traditional Desiccant</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔ Dust free</td>
<td>✗ Dusty and material contamination</td>
</tr>
<tr>
<td>✔ Low maintenance</td>
<td>✗ Higher Maintenance</td>
</tr>
<tr>
<td>✔ High efficiency</td>
<td>✗ Only 70% desiccant, 30% clay binder</td>
</tr>
<tr>
<td>✔ <strong>Constant and uniform dew point</strong></td>
<td>✗ Inconsistent dew point</td>
</tr>
<tr>
<td>✔ Longer desiccant life (&gt;5 year)</td>
<td>✗ Low desiccant life (&lt;2 year)</td>
</tr>
<tr>
<td>✔ Regeneration at 130 °C maximum</td>
<td>✗ Regeneration over 320 °C</td>
</tr>
<tr>
<td>✔ Smaller and compact footprint</td>
<td>✗ Larger footprint</td>
</tr>
</tbody>
</table>
Drying Technology

Dew Point Control Profile

Dew-point meter/time
Dew-point limit: -20°C

Towers only exchanging when reach saturated value
Dew Point setting

What should my Dew point be?

• The truth is: -20°C to -30°C is fine mostly, higher levels are suggested due to covering inefficient dryers.

BUT:

• To run your dryer at -50°C takes dramatically more power than to run at -30°C

• Therefore to run at -30 compared to -50 is DOUBLE the power!
Note! Most of the work is done Dew Point -10 to -30!
Drying Considerations: For both virgin and rework, hopper dryers sized to afford the following conditions are strongly recommended:

- Moisture content must be below 0.2 wt%.
- Dry fresh bags for 2 to 4 hours at 80 °C.
- Dryer dew point must remain below –18 °C
- Air flow rate about 3.7 m³/h per kg/h of resin being processed (1 cfm/lb/hr).
- Note: Moisture content above 0.2% will result in loss of strength and toughness.
All polycarbonate resins are hygroscopic and must be thoroughly dried prior to processing. A desiccant dehumidifying hopper dryer is recommended. To achieve a moisture content of less than 0.02%, hopper inlet air temperature should be 120°C and inlet air dew point should be -29°C or lower. The hopper capacity should be sufficient to provide a minimum residence time of 4 hours.
ABS Dew Point -29°C

INEOS LUSTRAN ABS 488 RESIN IS A GENERAL-PURPOSE INJECTION MOULDING GRADE OF ABS (ACRYLONITRILE BUTADIENE STYRENE).

Drying prior to processing is recommended in a desiccant dehumidifying hopper dryer. **An inlet air dew point of -29°C** or below is recommended to achieve a moisture content ≤ 0.1%. Typical drying conditions are 2 hours at 82°C–88°C. Drying for 4 hours at 71°C–77°C is also adequate.
MULTIPLE HOPPER SYSTEMS

One Dryer multiple hoppers

Different not much advantage over single units.

Heaters on all hoppers then balancing airflow is complex

Good for space saving
The History of Vacuum Drying

1960’s:
First commercial application of vacuum drying of DuPont Nylon®

DuPont Polymerizer

1974: Dr. Dan Fox
(inventor of Lexan® Polycarbonate)

“Vacuum is without question the best process for drying hygroscopic polymers”
Drying Technology

Why Vacuum?

Vacuum Significantly Reduces the Boiling Point of Water.

At Vacuum of 90% Water Boils at 50°C
Drying Technology

Vacuum Drying Today

1. Heat

2. Vacuum

3. Retention of Material
Current Vacuum Dryer Design

**STEP 1**: Heating Hopper: Insulated stainless steel hopper for drying temperatures up to 350°F (175°C).

**STEP 2**: Insulated Vacuum Vessel.

**STEP 3**: Insulated Retention Hopper for dried material.

**LOAD CELLS**: Control material level and document material consumption.

**Dry Air Membrane**: Provides dry air purge for vacuum vessel and dry air blanket of the

**VBD-150**
Vacuum Drying Technology

Heat the pellets to the required temperature...20-25 minutes.

Vacuum is applied. Water vapor trapped inside the pellet instantly boils

Pellets are ready for the processing machine in about 35 minutes
Drying Technology

Rapid Dryer: Vacuum Batch Dryer VBD

<table>
<thead>
<tr>
<th>Material</th>
<th>Desiccant dryer (mins)</th>
<th>VBD (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS</td>
<td>180</td>
<td>20</td>
</tr>
<tr>
<td>PC</td>
<td>200</td>
<td>25</td>
</tr>
<tr>
<td>PA</td>
<td>240</td>
<td>40</td>
</tr>
<tr>
<td>PET</td>
<td>360</td>
<td>60</td>
</tr>
</tbody>
</table>
Drying Technology

Vacuum Benefits

- **ENERGY CONSUMPTION**
  - 50-70% less energy

- **STRESS**
  - 6 times less heat history

- **ZERO MAINTENANCE**
  - Minimal moving parts

- **SPEED**
  - 6 Times Faster
Drying Technology

Compressed Air Drying System

- Drying system extremely compact and can be installed directly on the machine throat
- High dew-point level reached due to the combination of compressed air technology and twin desiccant beds
- Automatic parameter setup selecting material from a pre-recorded list
- Automatic air flow control with automatic ratio valve installed on the compressed air circuit
- Low energy consumption, no need for regeneration via heating
Drying Technology

Compressed Air

- Small throughputs 1 – 7 kg/hr
- Ideal for on machine mounting
- Booster on-machine central drying plant
Which Dryer

- **No 1!** Material management – process machine stop – dryer ramp down.
- Power kW/kg processed?
- Insulation hopper
- Insulation pipe work
- Line cleaning closed loop?
- Inverters on pumps
- Choose a dryer to suit your production requirements, i.e. Jobbing or long-production runs
- Gravimetric
Drying – Top Tips

• **Pre-drying**
  
  • Dry storage environment will reduce the granule moisture content before drying.

• **Climate**
  
  • Less drying required in summer months and cycle times can be adjusted to reduce energy use.

• **Post drying**
  
  • Keep material in a sealed container or convey through a sealed system

• **Drying is often a hidden cost**
  
  • study the amount of time taken, the temperature required and the kWh used.
The Holy Grail

- We measure the moisture level of material coming in – why?
- We measure the throughput – Halo
- We feedback to dryer & calculate the real capacity of the dryer
- We then adjust the Air-flow and the temperature
- We have alarms for under capacity
- Finally, we have a double check on the machine to guarantee the dryer is performing plus the material has not been standing – i.e. – the material is within moisture limits.
Bry-Scan in-line moisture meter
In-Line Moisture Analyser

How it works

Moisture measurement technique is based upon the relatively high dielectric constant of water in comparison to the dielectric properties of other materials also includes the measurement of diamagnetic properties. The variation of water content within the product, would result in a large variation in the combined dielectric constant which would then be measured by monitoring the change in the dielectric signal.

Examples of dielectric constant of materials

- Water (80 – 36)
- Polymers (2 - 5)
- Cereals (3 - 6)
- Cement (2 - 4)
Summary

• Drying is essential for many materials – often even non-hygroscopic materials perform better having been through a dryer e.g. PS and PP

• Choose a dryer to suit your production requirements, i.e. Jobbing or long-production runs

• Consider performance, cost of running and maintenance
Thank you