Drying your polymer

Why?

- Surface Moisture
- Hygroscopic:

Hygroscopic:

‘tending to absorb
moisture from the air’

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

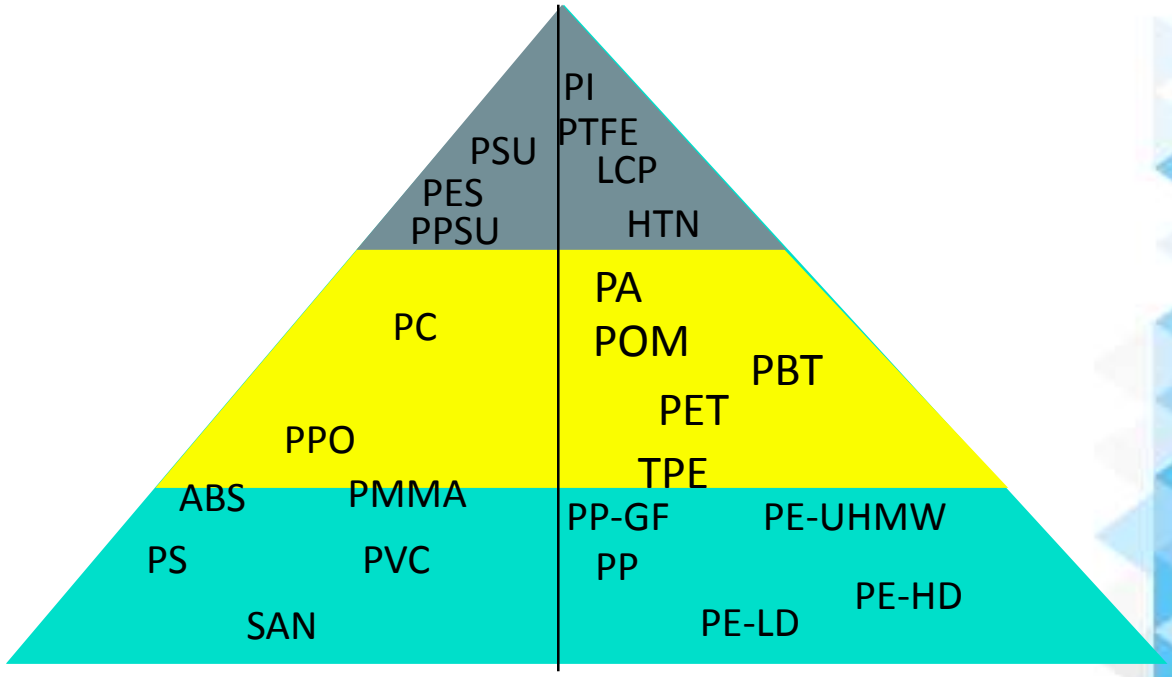
- HTN (High Temperature Nylon)
- PPS
- PES
- PSU
- LCP
- PTFE
- PI
- PEEK
- PEI

Relationship between polymers

ADVANCED POLYMERS

ENGINEERING POLYMERS

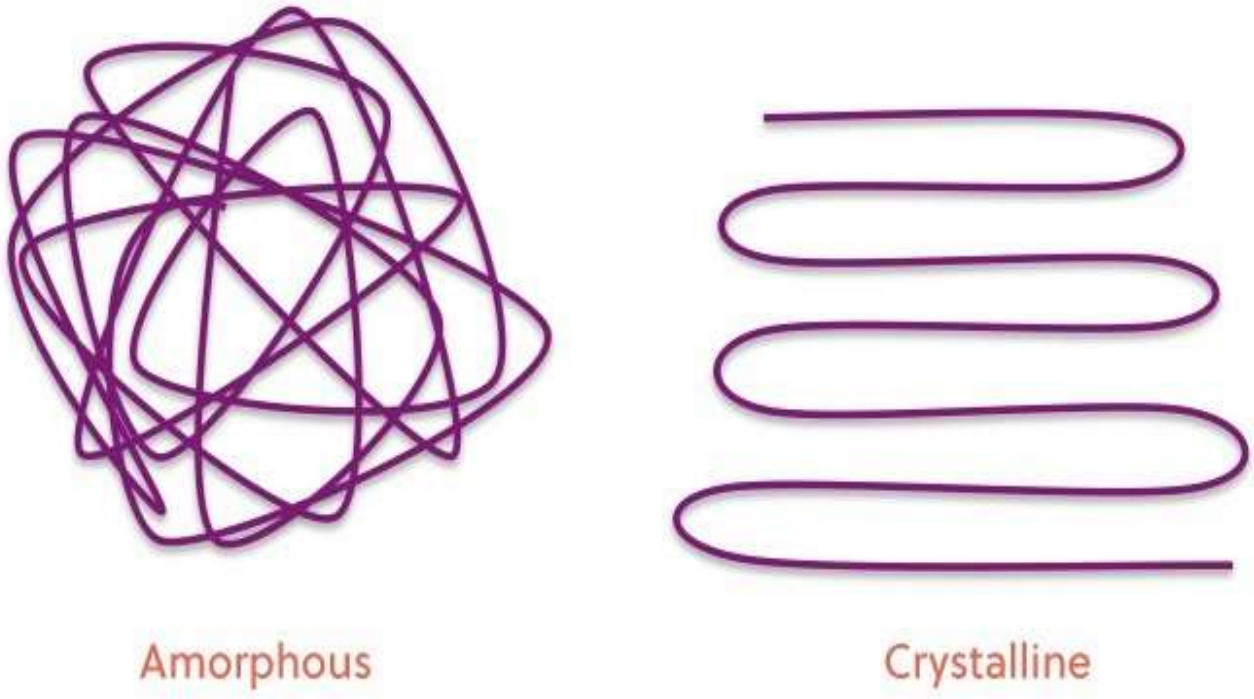
COMMODITY POLYMERS



Amorphous

Crystalline

THE STRUCTURE OF A POLYMER IS DEFINED IN TERMS OF CRYSTALLINITY



A well-ordered polymer is considered crystalline. The opposite is an amorphous polymer.

Upper moisture limits

Nylon 6	<0.2%
Nylon 6.6	<0.2%
PBTP	<0.04%
PETP	<0.02%
Acetal	<0.2%
TPE	<0.1%
LCP	<0.01%

Drying your polymer

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

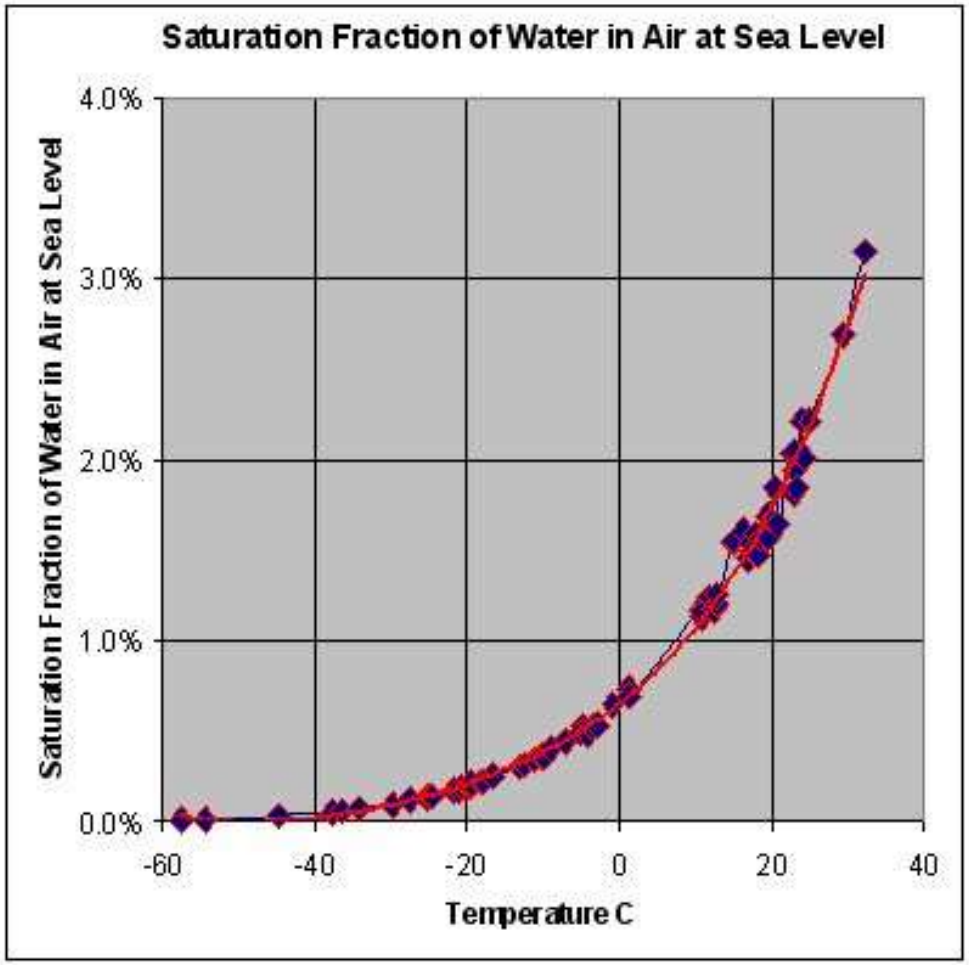
The dew point is used a lot by TV meteorologists and seen on most current weather conditions because it's a great indicator of the moisture content of the air, or humidity

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

…NOT THE DRYNESS OF THE PELLETS!.

Drying your polymer

Dew Point



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

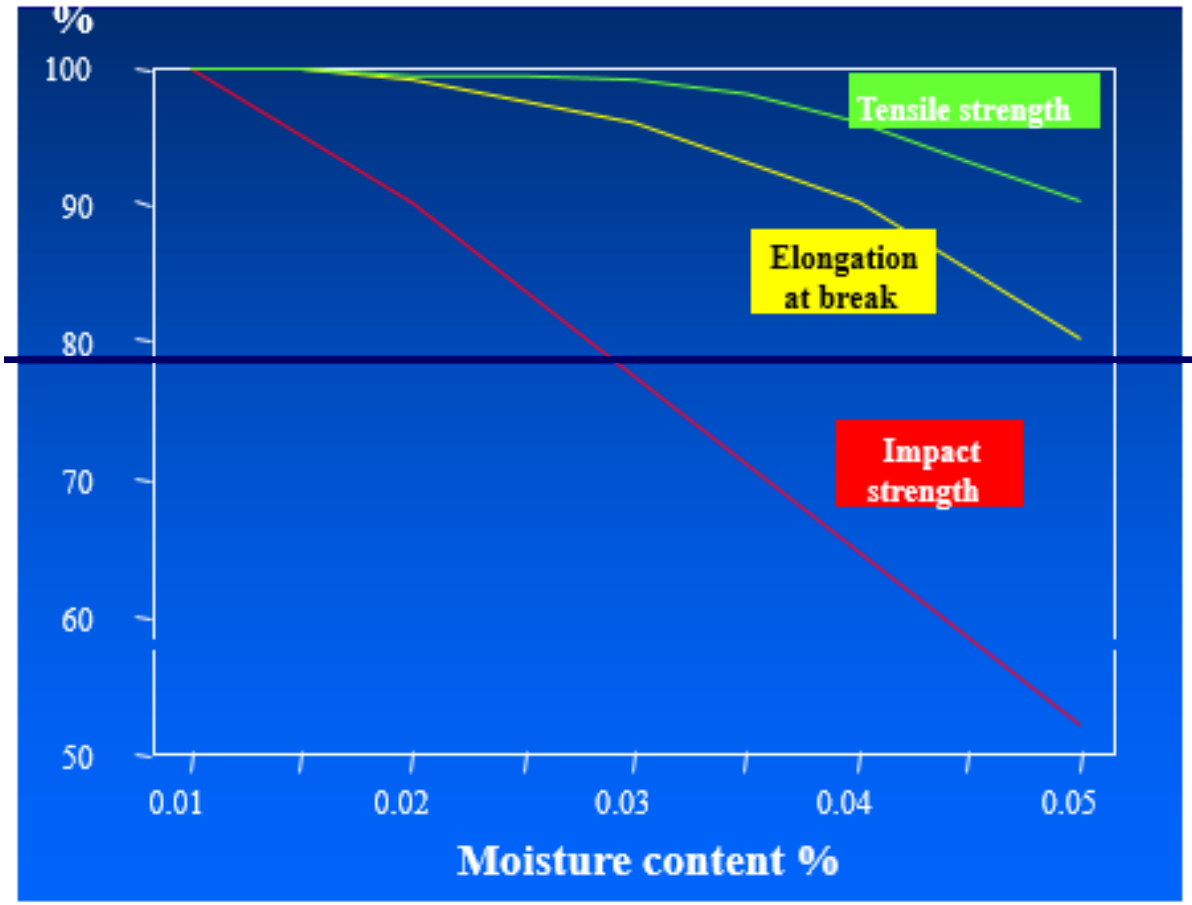
Moisture in the Granules

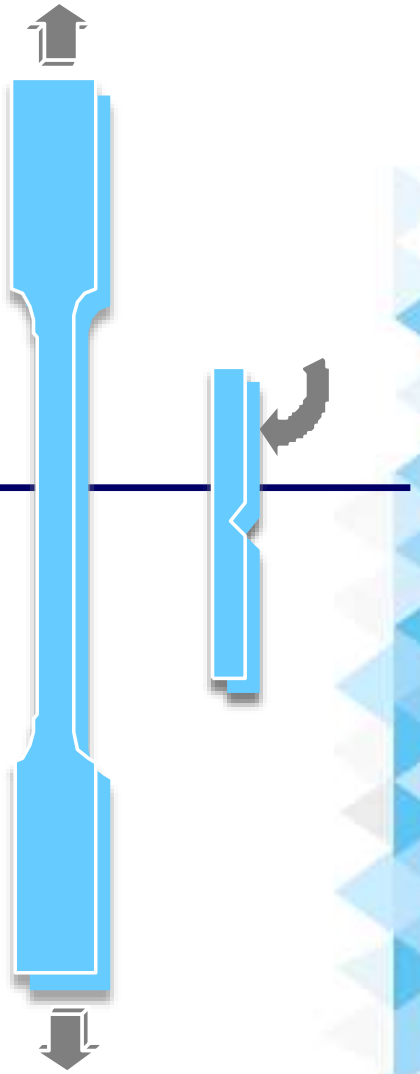
	Symptoms when moulding	Visible symptoms in moulded parts	Influence on mechanical properties
PA	• Drooling • Bubble information in purge	• Splaying in direction of flow • Increased formation of flash	• Lower impact and tensile strength
PET PBT	• No noticeable symptoms	• N.B.: Surface streaks (splaying)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

How to recognise excess moisture content

Moisture content v Mechanical properties

Rynite® PETP





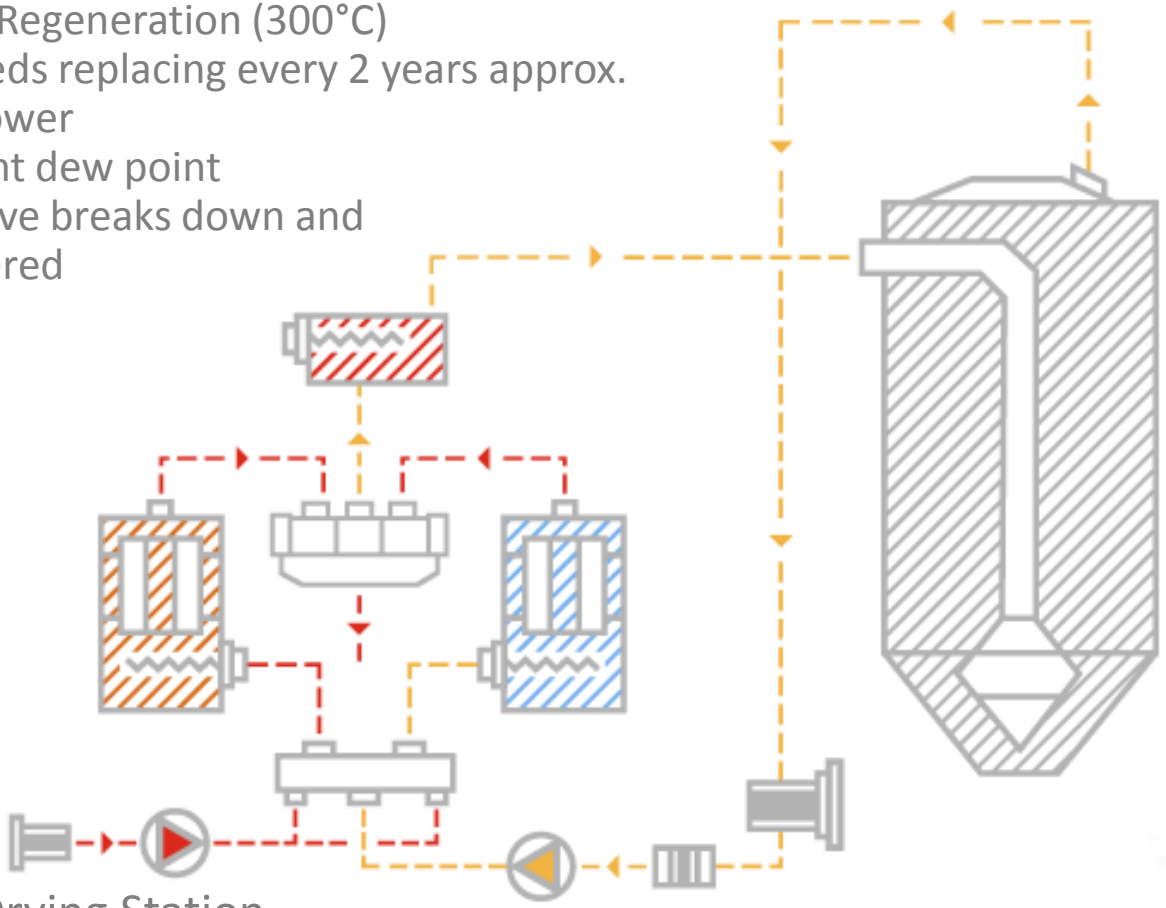
Drying Technology

- 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



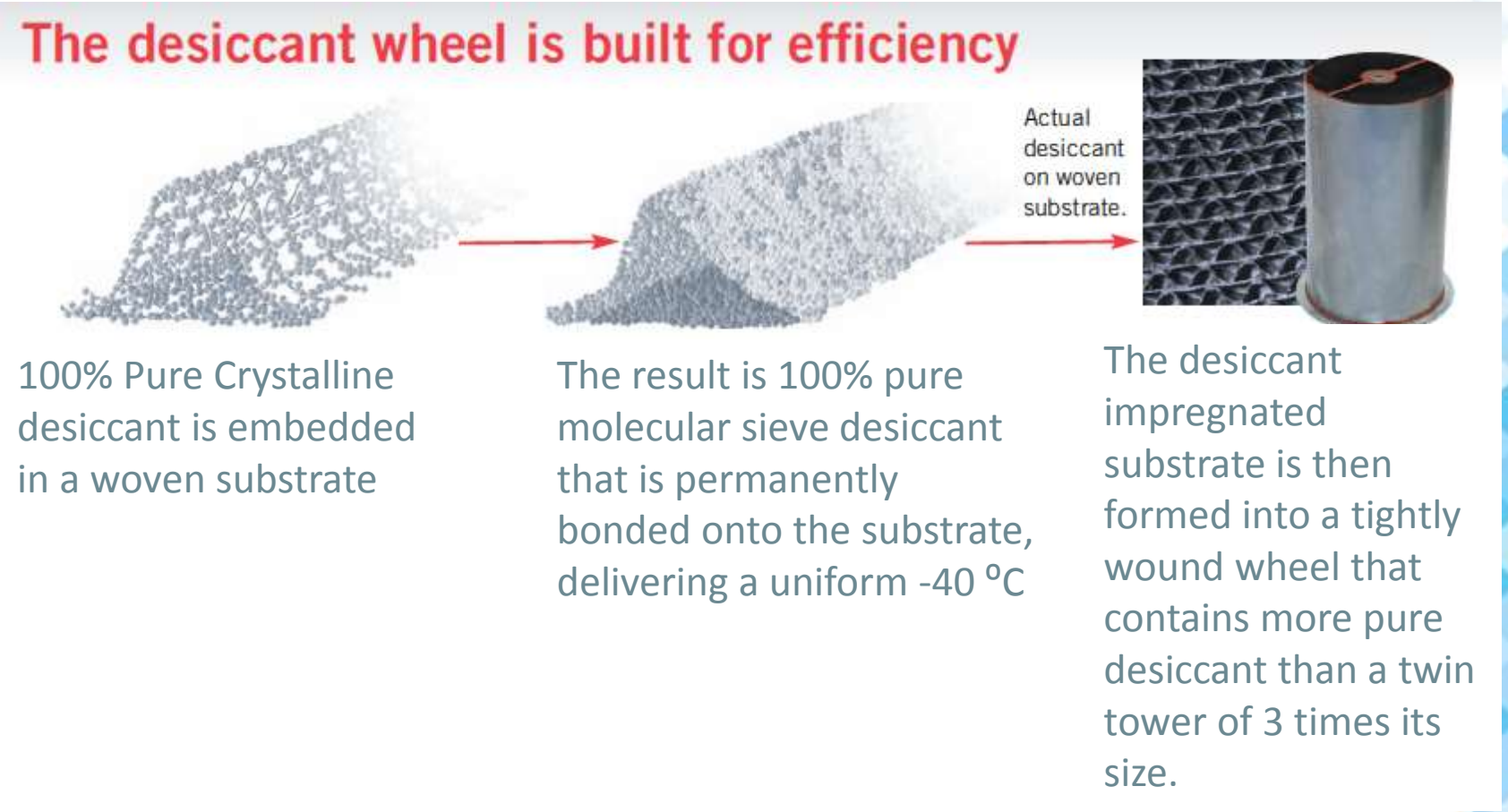
Twin Desiccant Drying Station

Drying Technology

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)

Rotor Wheel Drying Technology

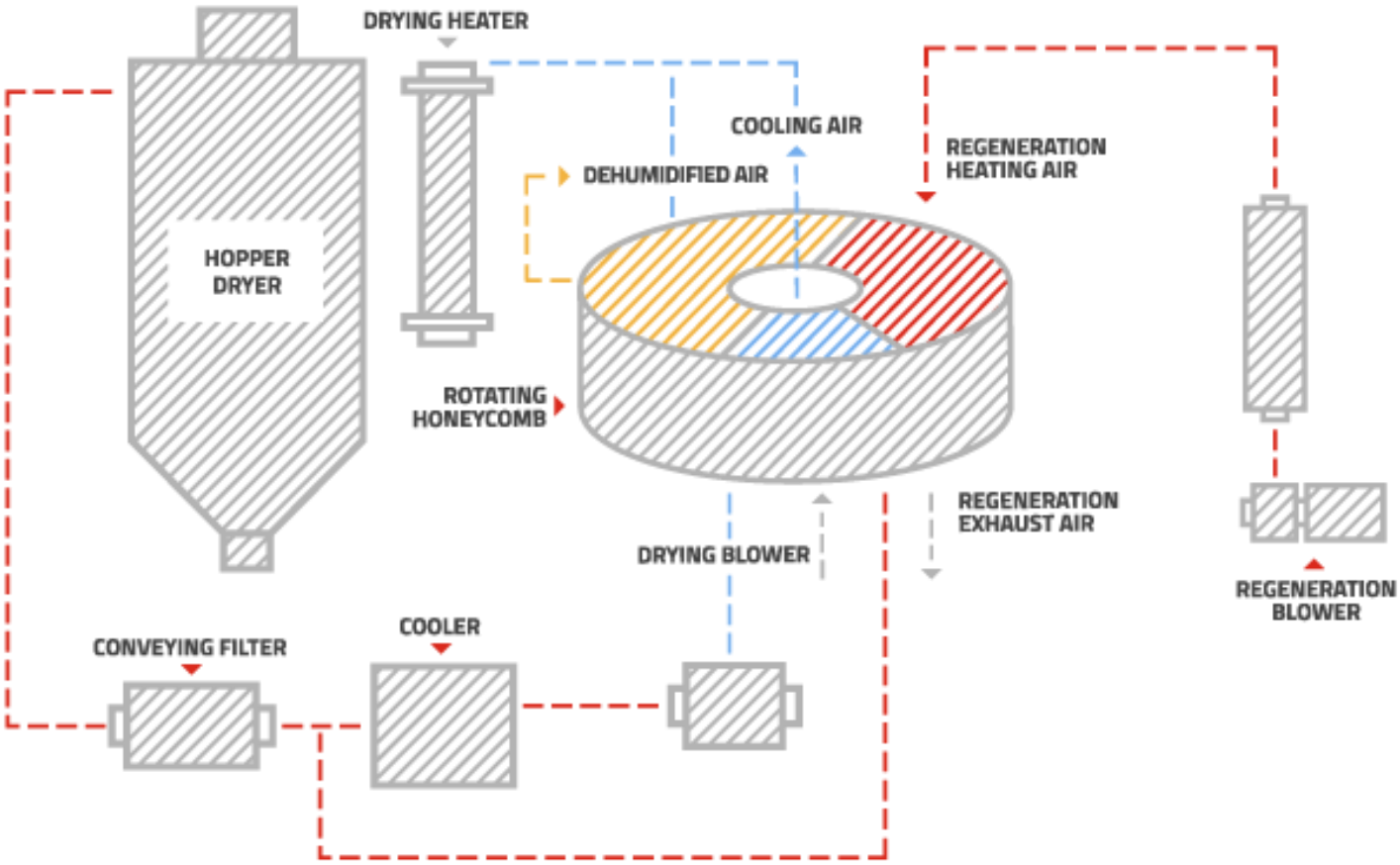


100% Pure Crystalline desiccant is embedded in a woven substrate

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

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

Rotor Wheel

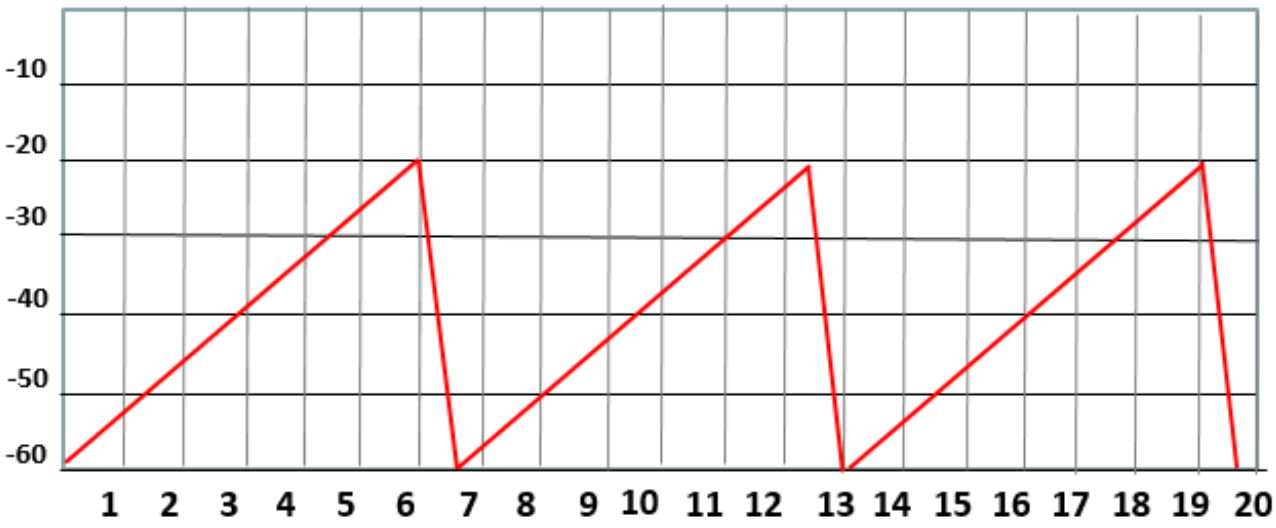
- ✓ Dust free
- ✓ Low maintenance
- ✓ High efficiency
- ✓ **Constant and uniform dew point**
- ✓ Longer desiccant life (>5 year)
- ✓ Regeneration at 130 °C maximum
- ✓ Smaller and compact footprint

Traditional Desiccant

- ✗ Dusty and material contamination
- ✗ Higher Maintenance
- ✗ Only 70% dessicant,30% clay binder
- ✗ **Inconsistent dew point**
- ✗ Low desiccant life (<2 year)
- ✗ Regeneration over 320 °C
- ✗ Larger footprint

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

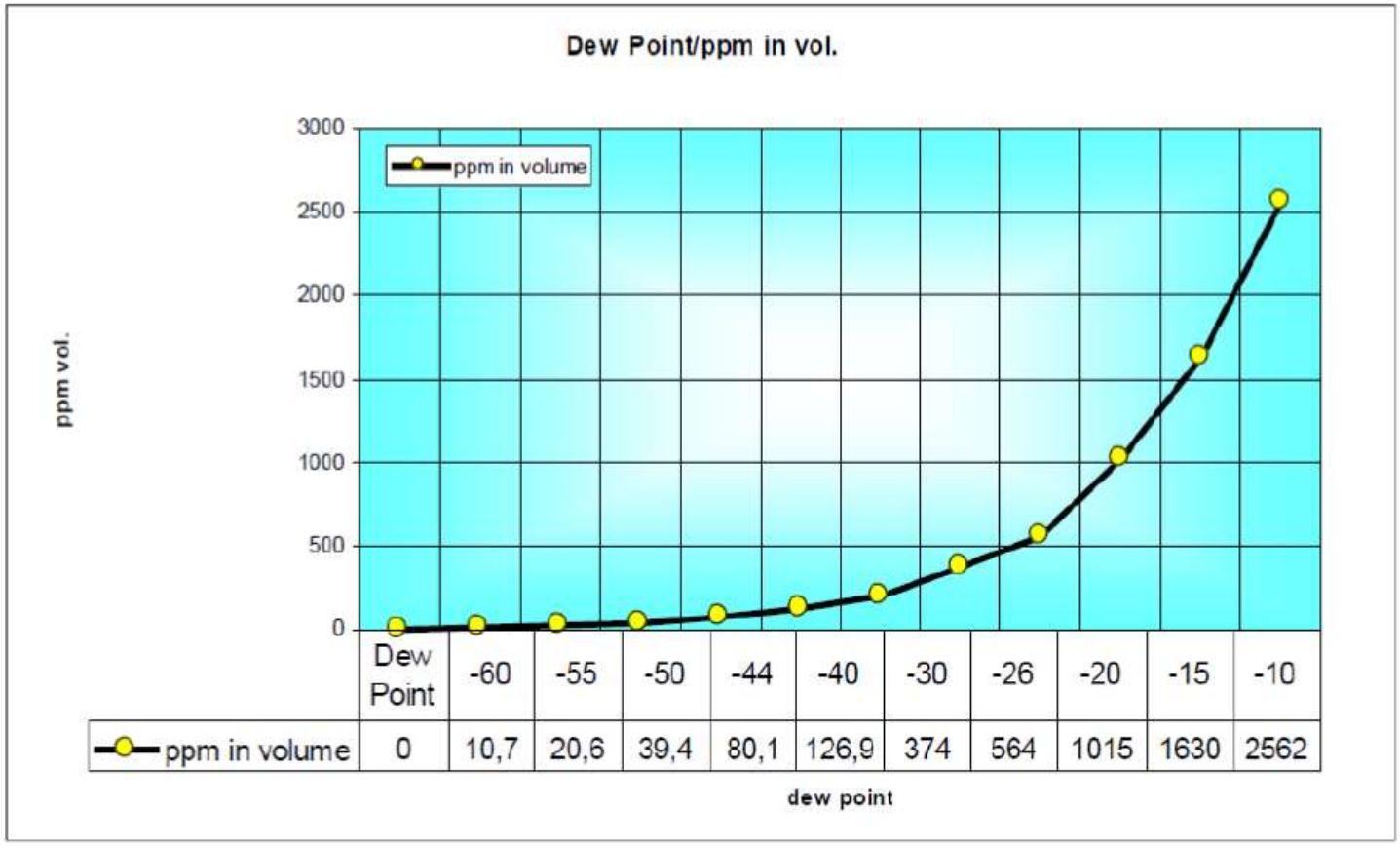
What should my Dew point be?

- 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!



	Dew Point	-60	-55	-50	-44	-40	-30	-26	-20	-15	-10
ppm in volume	0	10,7	20,6	39,4	80,1	126,9	374	564	1015	1630	2562

Du PONT - Why 50˚C Dew point?

Nylon Dew Point 18˚C

Du Pont Nylon

PROCESSING GUIDELINE SUMMARY Zytel® PA thermoplastic polyamide

- 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.

BAYER - Why 50˚C Dew point?

Polycarbonate Dew Point

Polycarbonate Resins Bayer MAKROLON® 2405, 2407 and 2456

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.

INEOS - Why 50˚C Dew point?

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

DuPont Polymerizer

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

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

Drying Technology

Current Vacuum Dryer Design

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

VBD-150

LOAD CELLS: Control material level and document material consumption.

STEP 2: Insulated Vacuum Vessel.

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

STEP 3: Insulated Retention Hopper for dried material.

Vacuum Drying Technology

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

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

<u>Pellets are ready for the processing machine in about 35 minutes</u>

Drying Technology

SUMMIT SYSTEMS
PLASTICS AUTOMATION

Rapid Dryer: Vacuum Batch Dryer VBD

Drying Times (mins)		
Material	Desiccant dryer	VBD
ABS	180	20
PC	200	25
PA	240	40
PET	360	60

Drying Technology

Vacuum Benefits

ENERGY CONSUMPTION
- 50-70% less energy

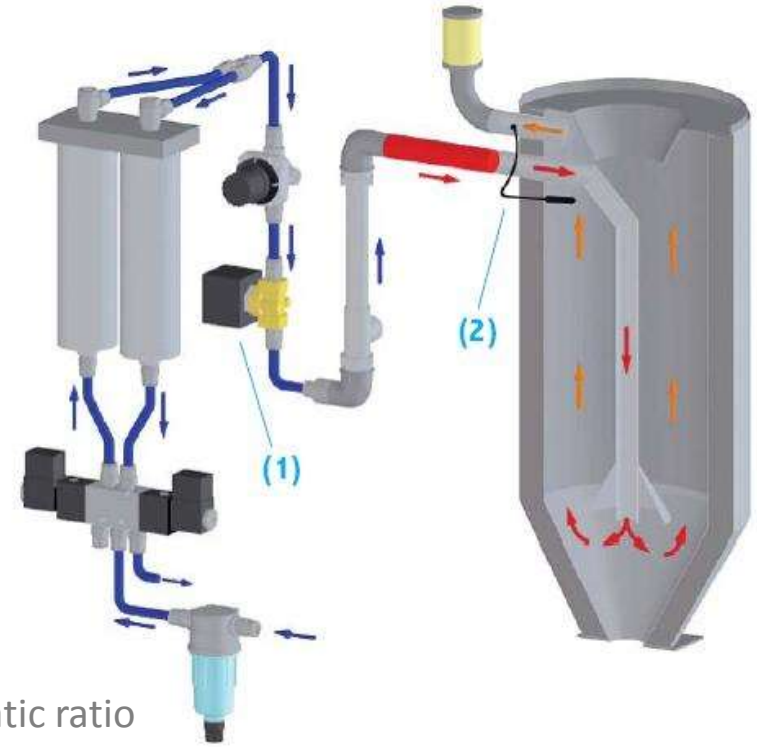
STRESS
6 times less heat history

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

SUMMIT SYSTEMS
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Thank you