INEOS Polyolefins

What can happen to polymer granules from the supplier's silo to the extruder hopper?

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Session 2.3 paper 7695

TAPPI people resources solutions
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Part 1

Some basics on the way from the melt to the pellets

As the title could fill a small conference for its own,
the focus will be on the normal things,
what is guaranteed by the physics of polymers.

<u>So the topics will be the following:</u>

- **dust**
- **fibres**
- **angel hair**
- **streamers or snake skin**

- **and how to live and run a normal production with the physics of the polymers,**

as sometimes converters report on problems on melt quality and blockages in the conveying system

Behind the given words there are different definitions, here some pictures from the internet:

Dust

Dust : Fine powder with particles > 2µ and < 1000µ

Fibres

Fibers : Small particles with a length of approx. 10mm

Behind the given words there are different definitions, here some pictures from the internet:

Angel hair

Angel hair : Small threads of 1 to 10 cm

Streamers

Streamers : Broad (>2mm) ribbons of polymer with a length from approx. 20mm

The corresponding properties of polymers are:

- hardness
- softness
- melting point or better melting behaviour
- pellet geometry

How to describe them?

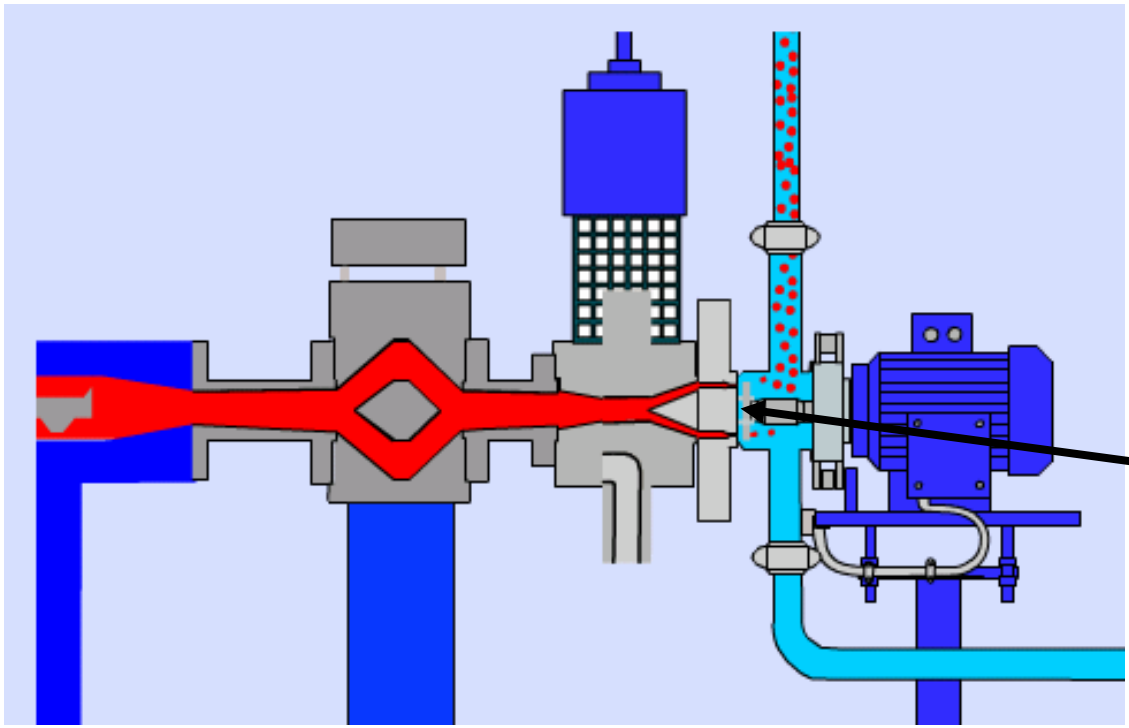
DSC melting point
Vicat Softening point
……
….

Wide range of polymers:

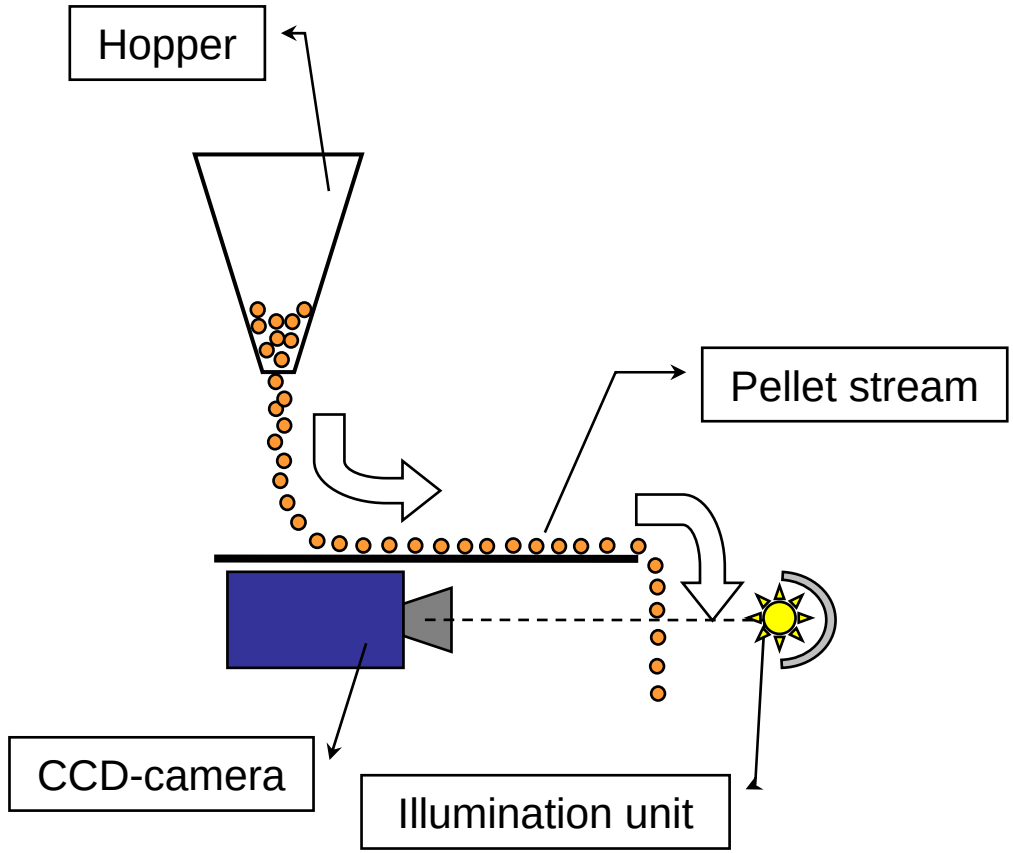
LDPE, LLDPE, HDPE
PP, Homo- and Copolymers
Acid Copolymers
EVA Copolymers

Let‘s start at the beginning, the birth of the pellet:

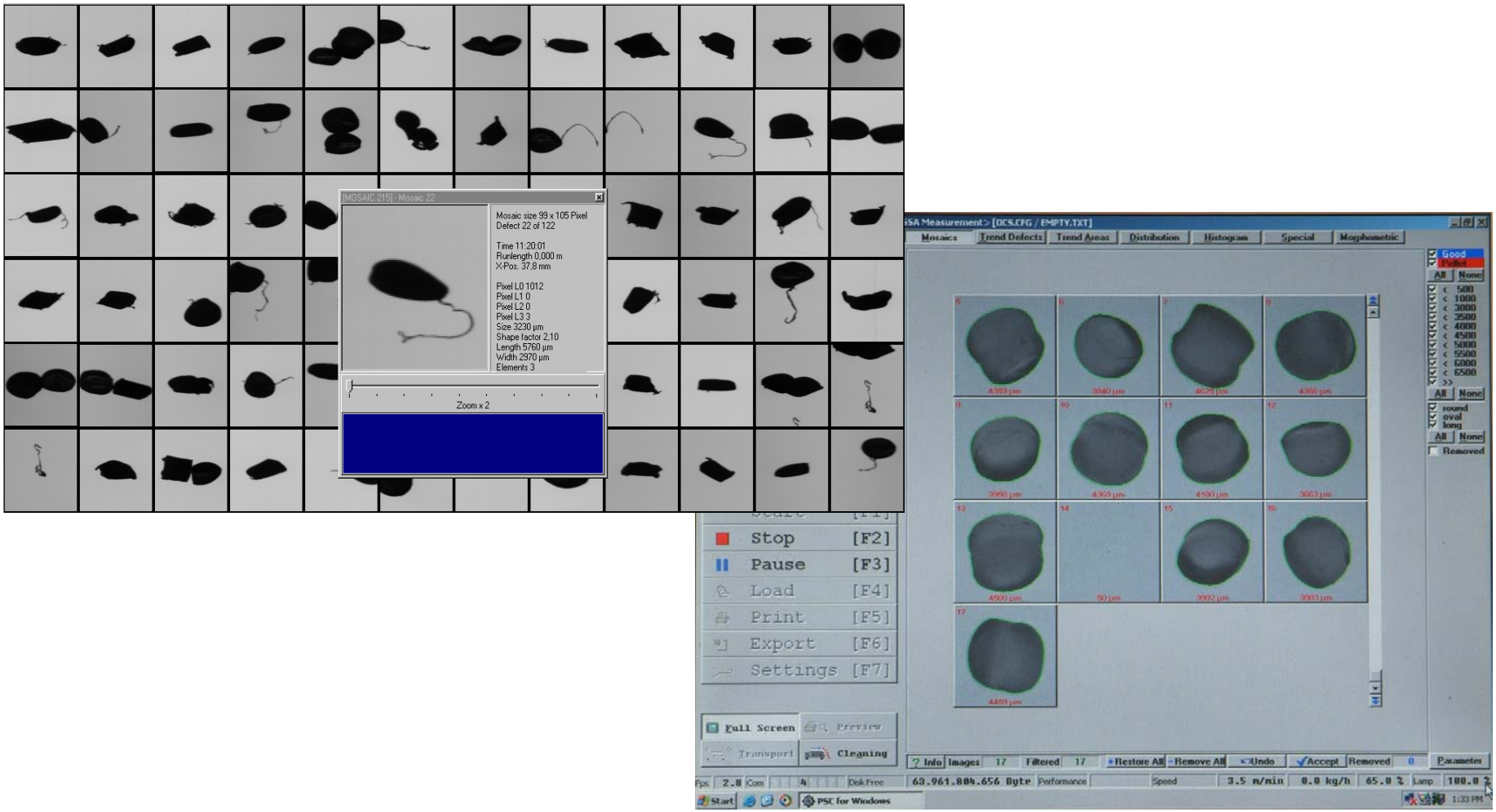
Mainly granulation under water is used, melt is pressed through the hole plate and cut under a water flow.
The water acts as coolant and transports the pellets.



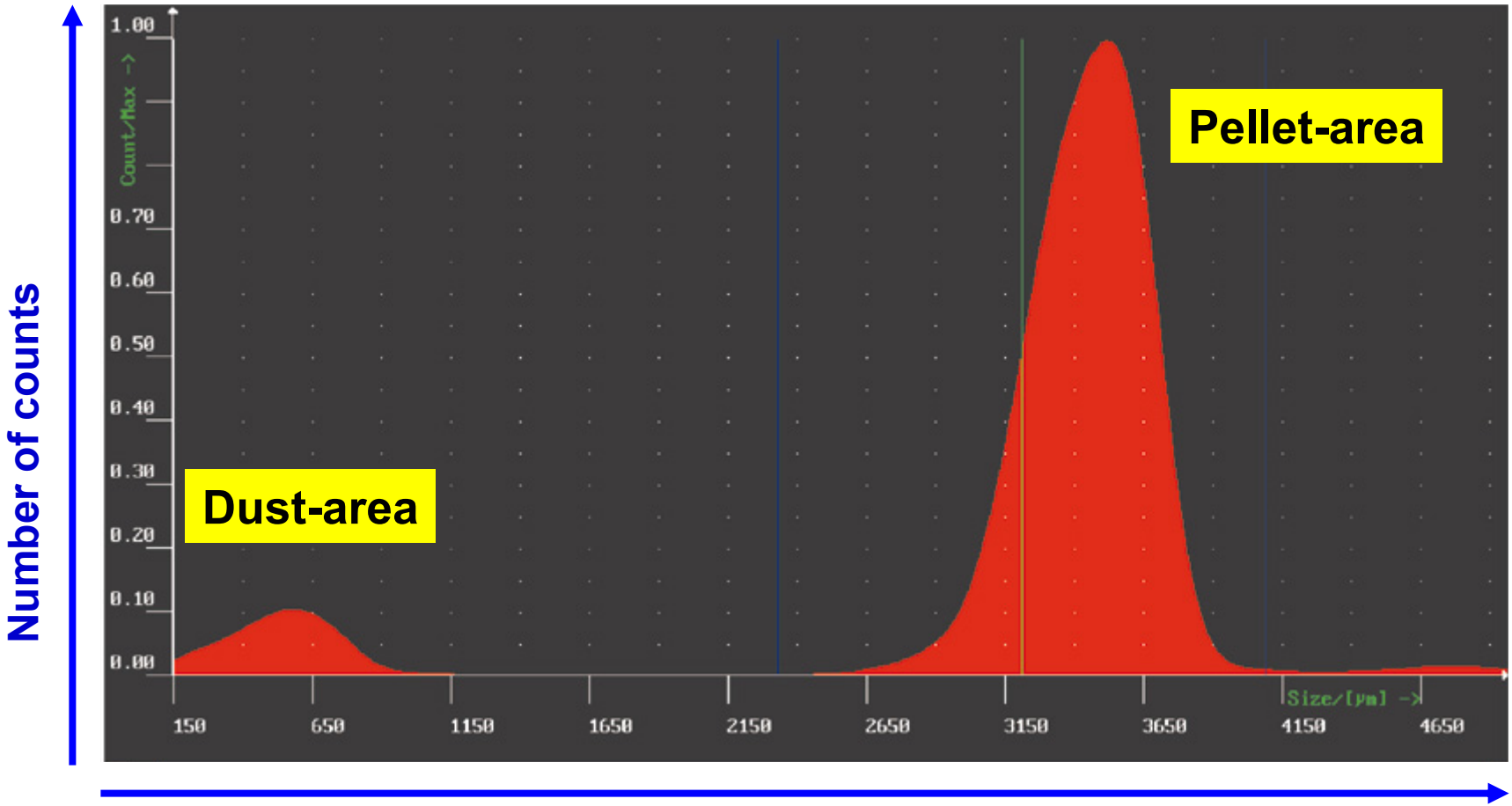
With CCD cameras the pellets can be monitored:
Their size and size distribution can be documented



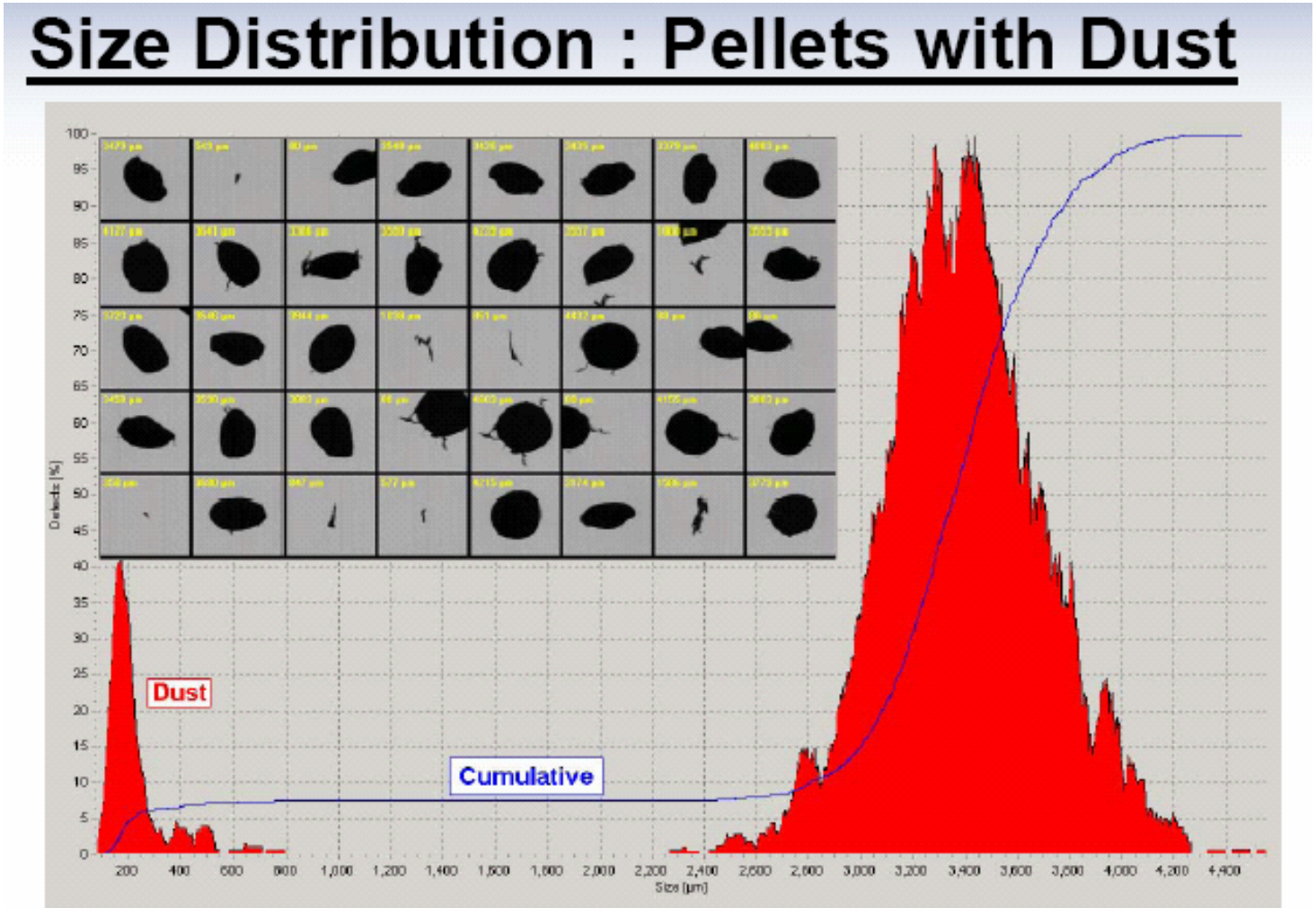
With CCD cameras the pellets can be monitored:
The individual pellets are classified



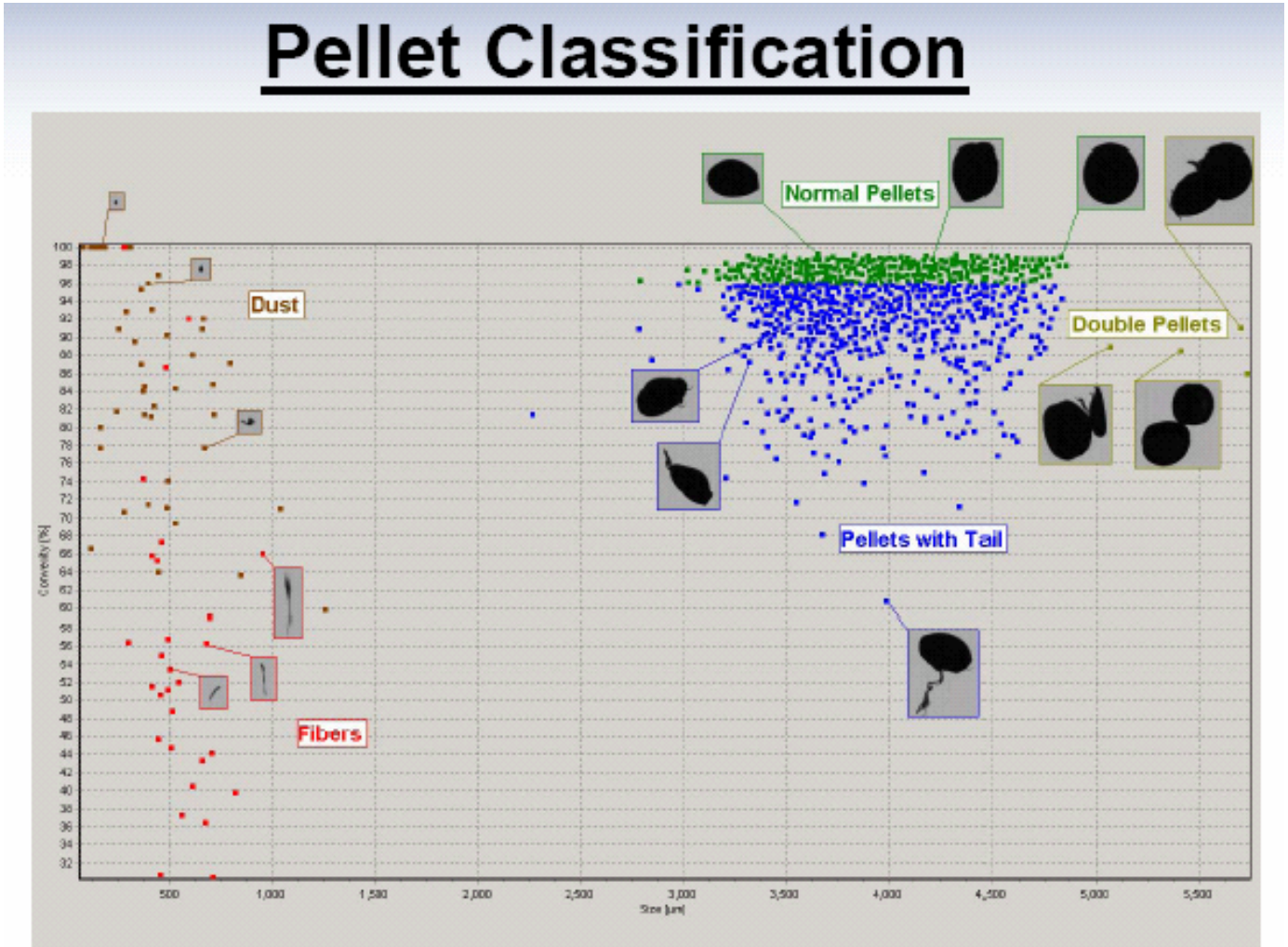
With CCD cameras the pellets can be monitored:
a pellet size & distribution graph from a PS sample



With CCD cameras the pellets can be monitored:
just another example



With CCD cameras the pellets can be monitored:
Also a direct classification is possible

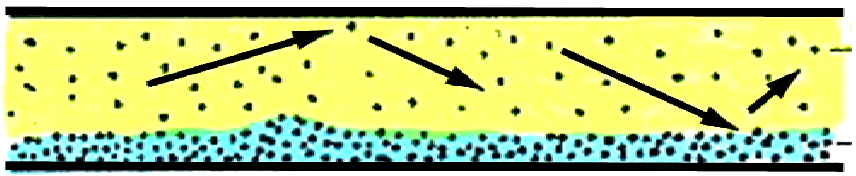
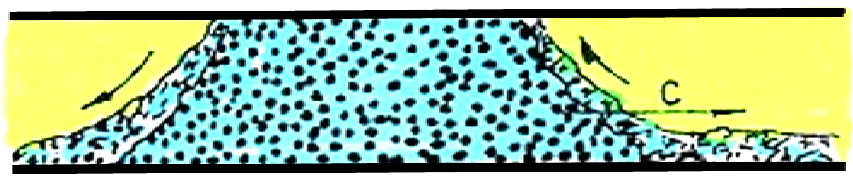


Part 2

Transportation of pellets in pipes

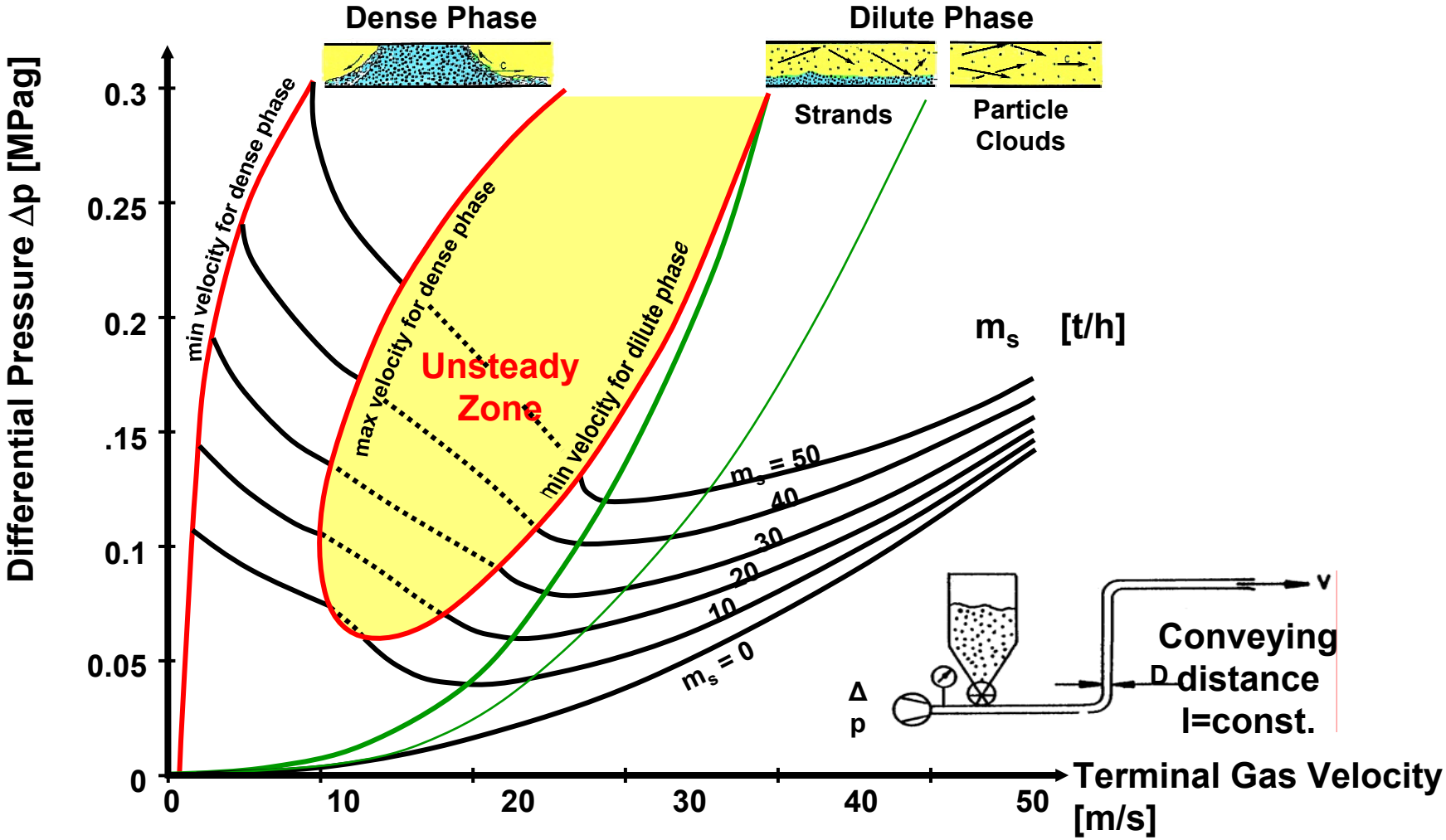
Another source of dust is the transportation itself:

Different conveying modes for pellets

Conveying Mode		Terminal Air Velocity
Dilute Phase	 continuous solid movement	20-35 m/s
Dilute Phase with strand formation	 continuous solid movement	15-25 m/s
Dense Phase	 intermitted solid movement	3-8 m/s

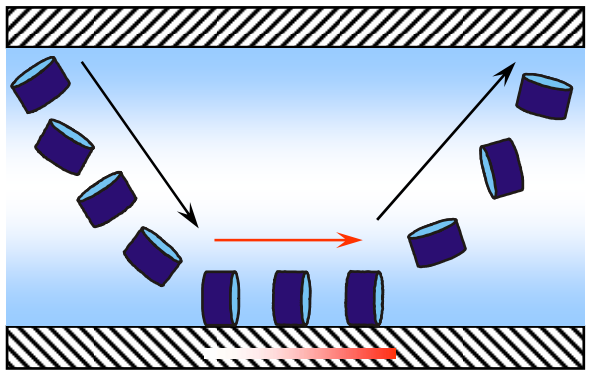
Another source of dust is the transportation itself:

State diagram of pneumatic conveying system

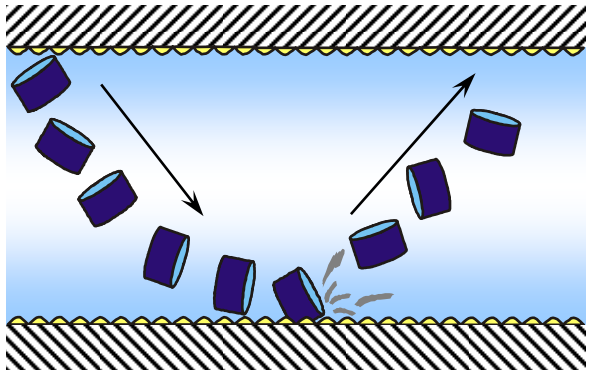


Another source of dust is the transportation itself:

mechanism of dust and Angel Hair generation



Plastic pellets colliding with and bouncing off a smooth pipe wall



Plastic pellets colliding with and bouncing off a rough pipe wall

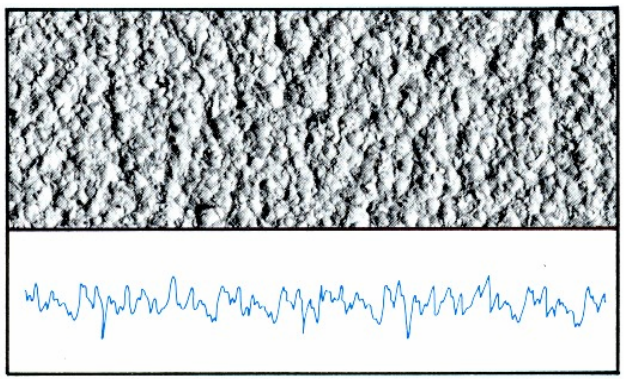
Result: plastic pellets covered with more streamer and less dust

Result: plastic pellets covered with more dust, much easier to remove the dust

Another source of dust is the transportation itself:

The internal surface treatment of conveying pipe is very important, the rough shot-peened pipes are recommended

Execution: shot-peened



Characteristics (guide number)	Aluminium	Stainless Steel
R_t min (µm)	50	40
R_t max achievable (µm)	200	70
R_a min (µm)	8-20	5-10
Depth of impression (cm²)	50	50

The fact that pipes change their surface after the transportation of thousands of tons of polymer is nearly everywhere not taken into account!

Another source of dust is the transportation itself:

Comparison of product abrasion

Product abrasion in ppm / 100 meter of pipe length*

Polymer	Dilute phase conveying	Dense phase conveying	Difference
PP-Homopolymer	120 - 200	20 - 40	>81%
LDPE	150 - 200	80 - 120	>43%
HDPE	120 - 200	20 - 40	>81%
PA	90 - 150	20 - 40	>75%
PET	80 - 120	15 - 25	>70%
PMMA	100 - 180	20 - 40	>78%
PC	100 - 180	20 - 40	>78%

* broken pellets from granulation not included / dust < 500 µm

Note: The a.m. fines are only applicable for standard pellets;
variation on MFI, temperature etc. will influence the abrasion rates.

Unfortunately dense phase conveying needs much higher investment!

Part 3

Polymer cleaning at suppliers site

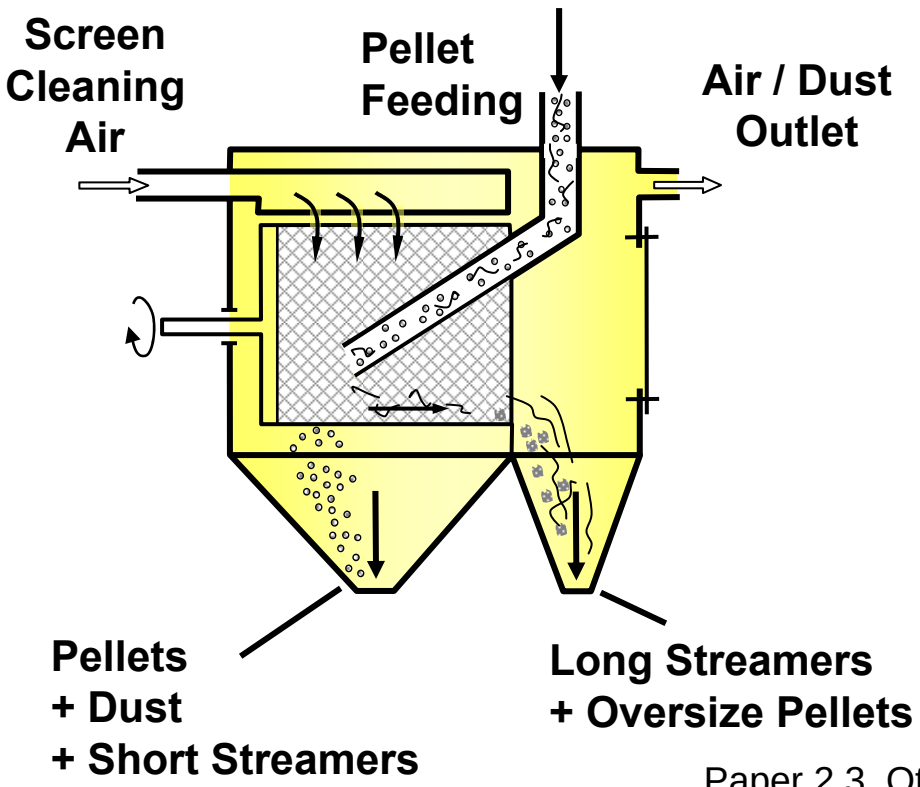
Based on the facts that we have always dust present and generate more dust during transportation, all polymer suppliers have some cleaning systems before the filling and/or loading lines.

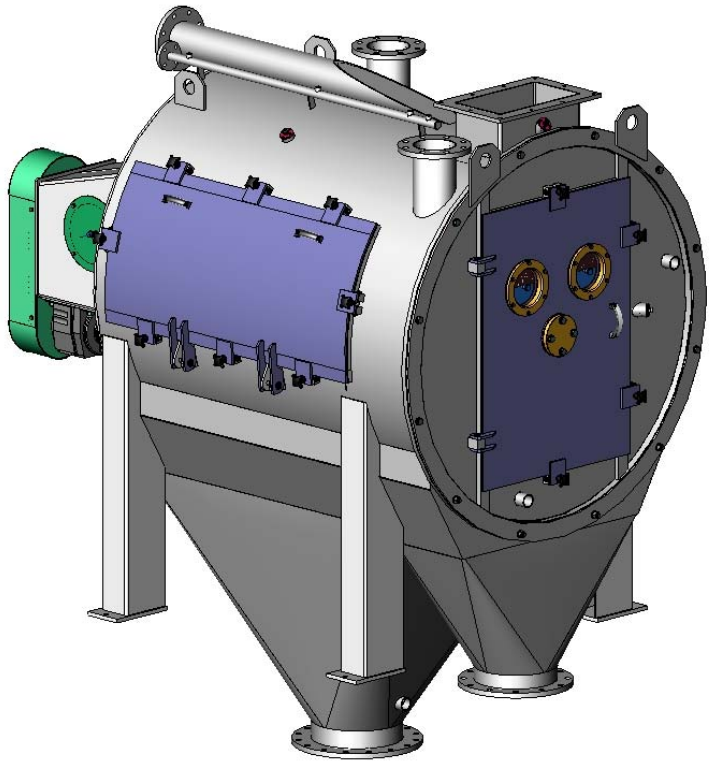
<u>Here some packaging types:</u>

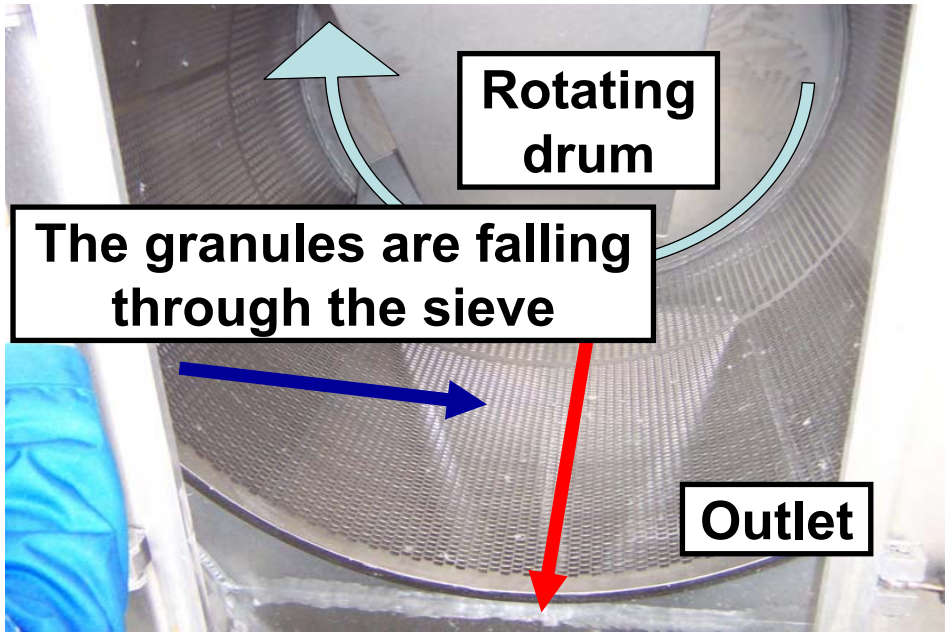
- **bags**
- **octabin – boxes – bigbags**
- **bulk in pressure silo truck / container**
- **bulk in pressure less container with inliner**
- **…….**

For dust and angel hair there are different ways to remove them from the pellets

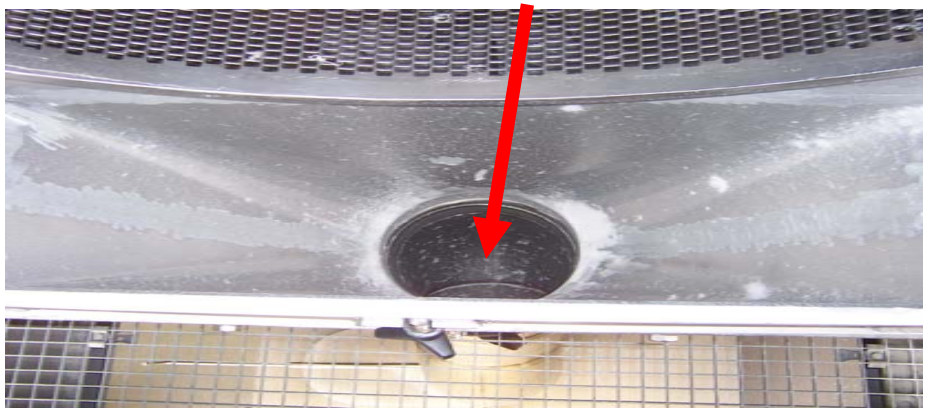
Step 1 angel hair in a drum sieve







Here some pictures from reality



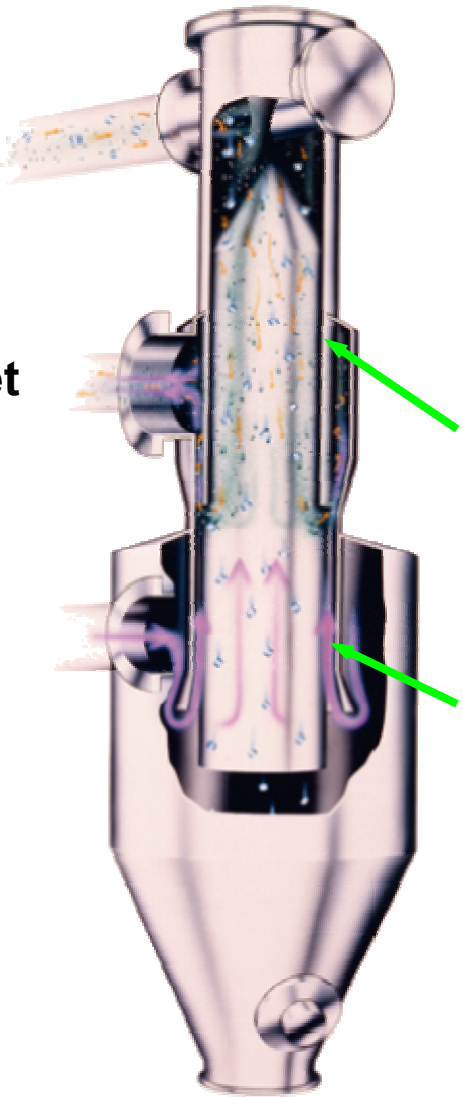
The way of the angel hair down to the waste bin

Step 2 Dust in a counter flow elutriator

Product Inlet

Dust Gas Outlet

Washing Gas Inlet



Product Acceleration in annular Gap

High Relative Cleaning Velocity

Pellet outlet

The general industry target is, to be below 100 ppm of dust, when the polymer is loaded

What does 100 ppm mean?

→100 g of dust per 1.000 kg polymer
or 2.500 g of dust per silo truck

Remember 1.000 kg of polymer are 25-50 million pellets a huge surface where the dust can stick on.

By experience we know:
If the dust is well distributed,
there is no extrusion or blockage problem.

But, how to measure dust?

There is a test method FEM 2482,
but it is not so easy to use for a huge number of samples

- **small quantity to be tested**
- **long time of measurement**

So in reality many companies use their own test method!

The biggest problem is when, where and how a sample is taken.

Electrostatic is also a problem, as it collects dust and gives non-reproducible results.

Part 4

Polymer handling at converter side

Unloading - Storage - Extrusion

As there are many different ways of packaging, only 2 different ways of unloading are discussed here.

Pressurized silo truck or container

In this case the pellets are blown by compressed air into the storage silo.

Main parameters are:

- **air pressure**
- **air temperature**
- **minimum unloading time**

The metal pipe from the handover flange to the silo is in the converter‘s responsibility!

Unloading - Storage - Extrusion

Pressureless container

In this case the pellets are falling to a rotary valve and then they are blown to the storage silo.

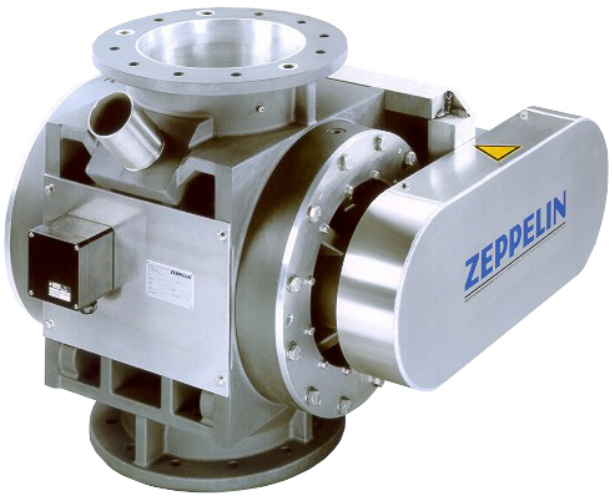
Main parameters are: **air pressure**
air temperature

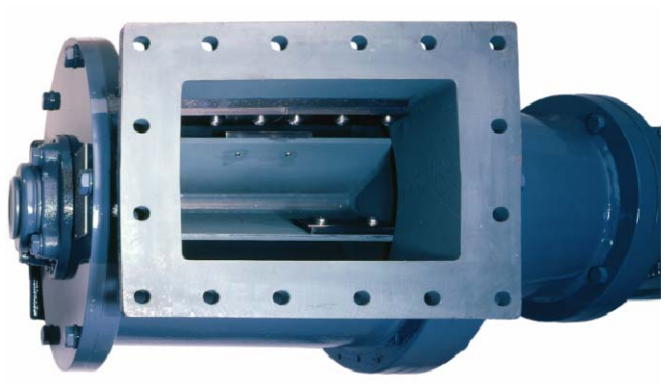
volume flow by rotary valve
speed leakage air removal

Unloading - Storage - Extrusion

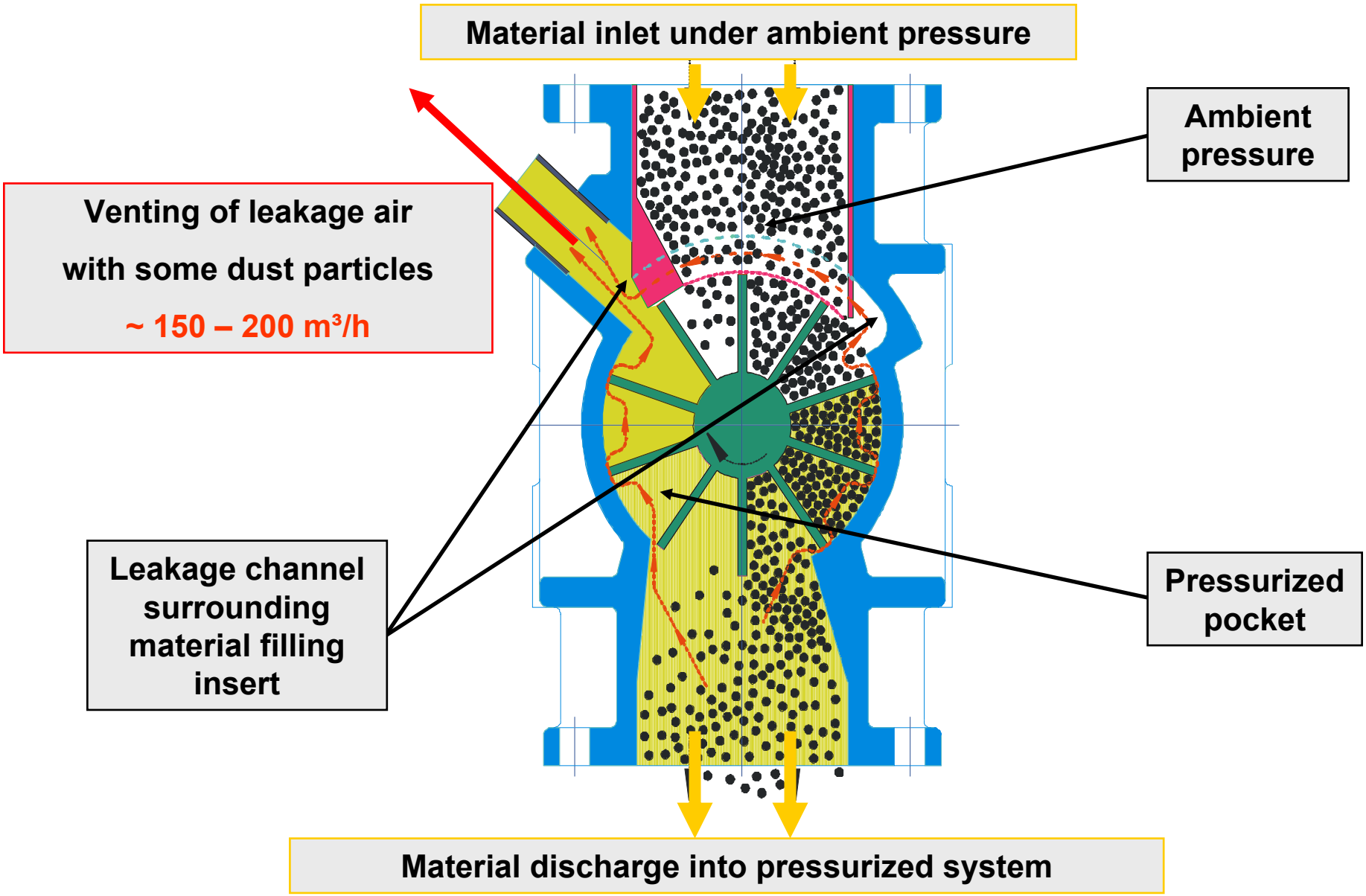
The task of a rotary valve:

- to dose a certain pellet volume flow to the transporting pipe
- to separate the ambient pressure from the transportation pressure

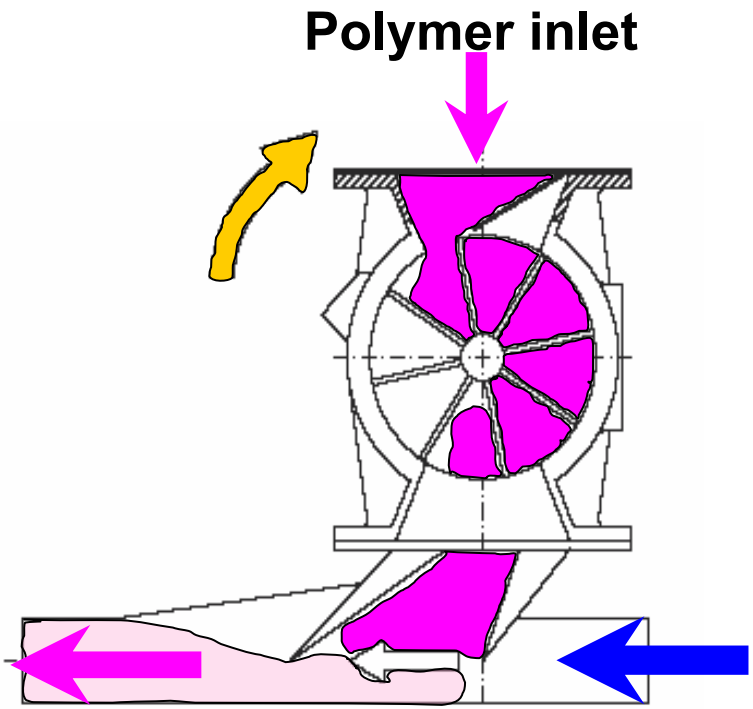




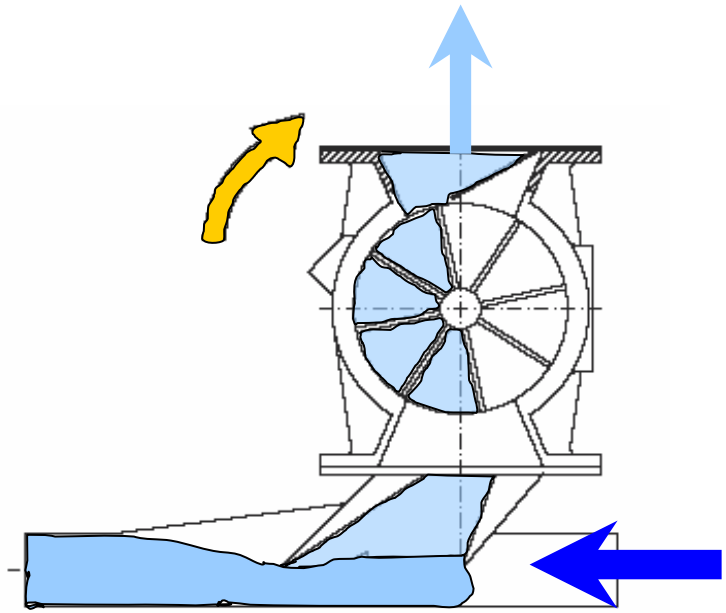
Rotary valve with leakage air removal



Rotary valve without leakage air removal

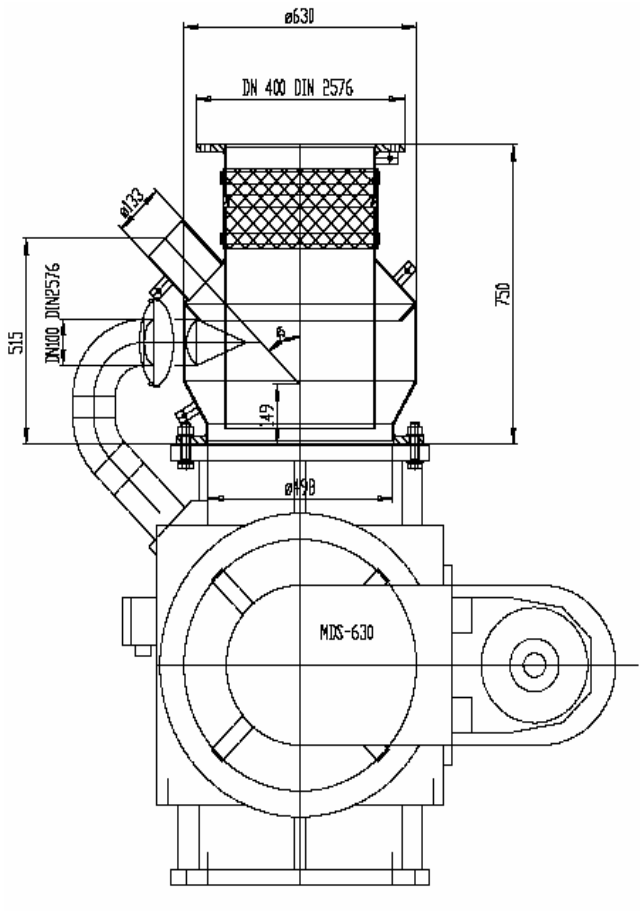


The high volume flow of ~200m³/h blows constantly against the granules and accumulates the dust above the rotary valve.



The accumulated dust often leads to problems.

New rotary valve design with leakage air removal



With this system pellets in the leakage air are brought back to the main flow and only the dust and fines are separated.

Unloading - Storage - Extrusion

From the storage silo to the daybin or extruder hopper it is very often a long way.

Vacuum system and blowing systems (only dilute phase) are used for this transportation up to 500 meter distance.

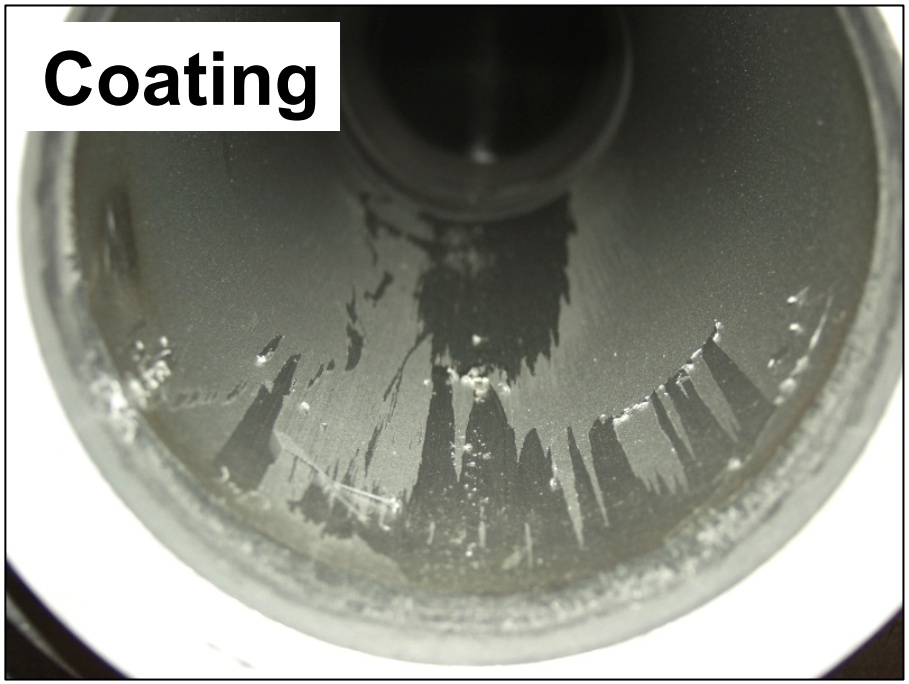
Depending on the technology different demands are there.

In case of dilute phase transportation the rotary valves have again to be equipped with a leakage air removal system.

Depending on the design of the pipework another problem can be generated, the angel hair!

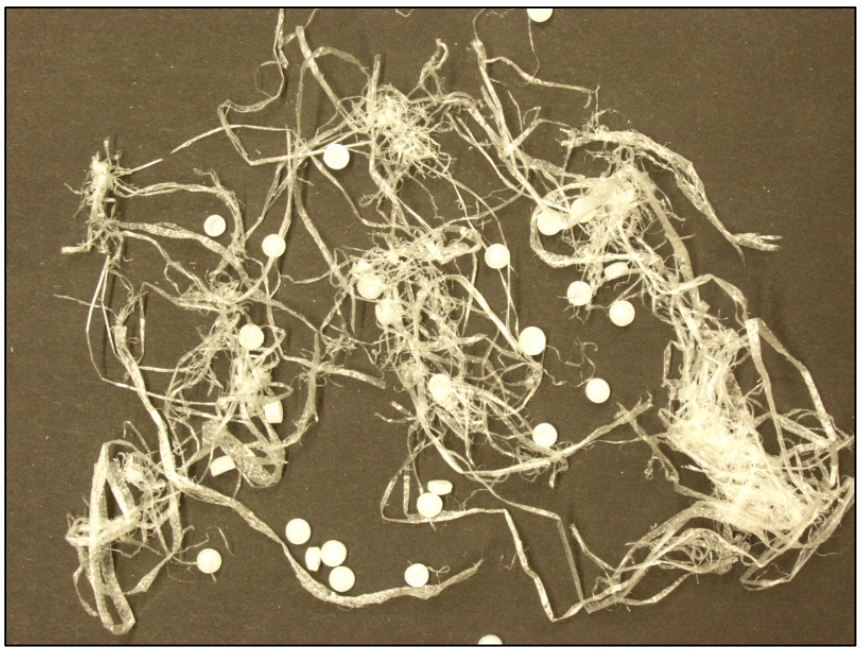
Unloading - Storage - Extrusion

There is a certain coating of the conveying pipes, which can later be peeled off and create „nice“ blockages in the system

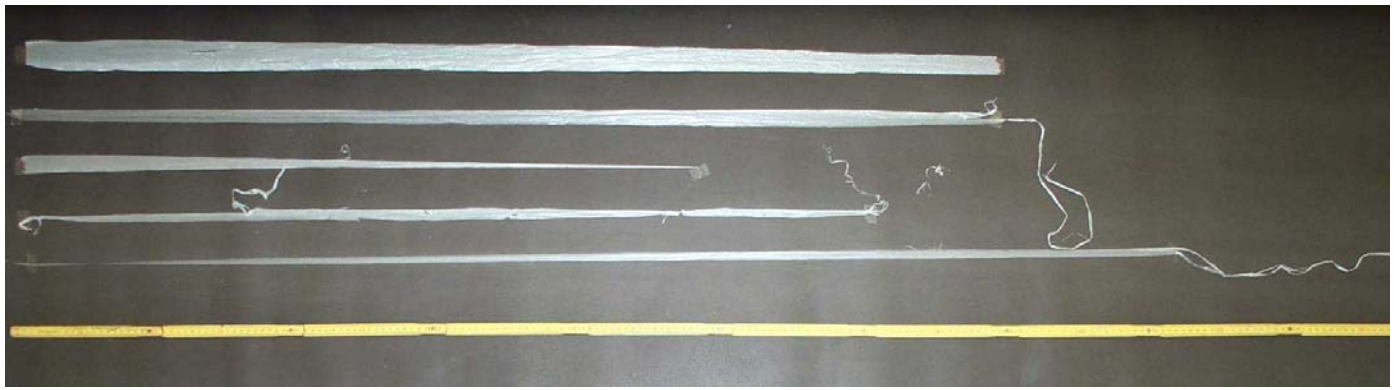


Different polymers inside the same pipe can create a nice angel hair mix!!

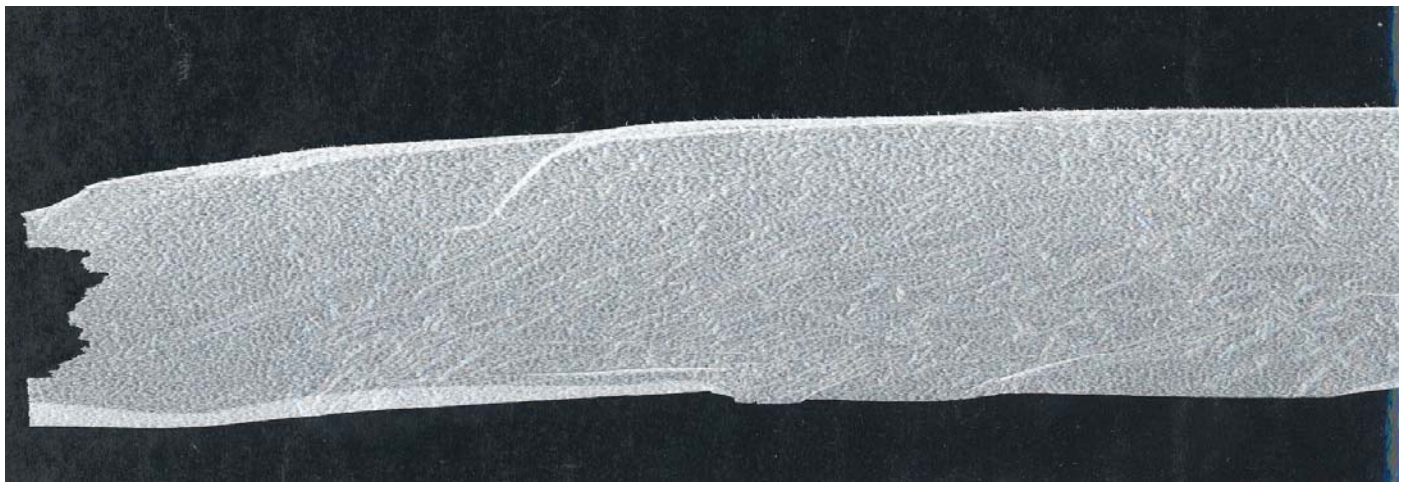
Here some short angel hair



Here some „mega angel hair“ or „angel mega hair“ or better „snake skin“



This mega hair was 7 m long before cutting

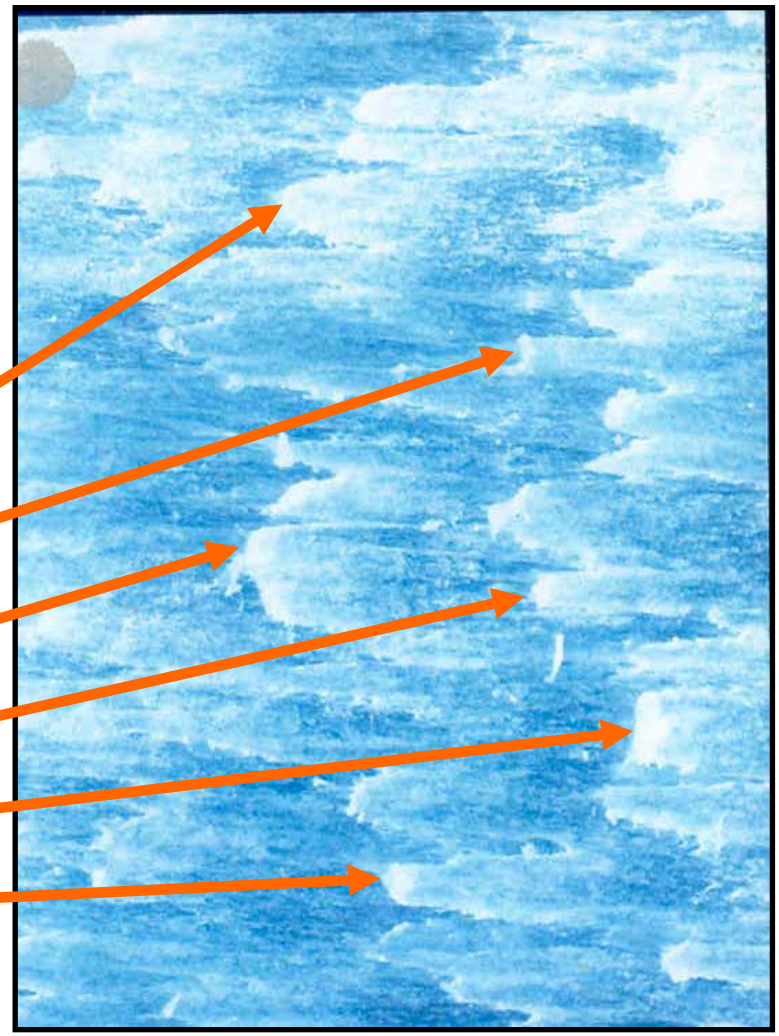


and 50 mm wide

The “mega hair“ under the microscope

Picture from the rough surface

Flow of the granules inside the pipe



Here the granules touched
the surface of the pipe wall
and built-up some deposits,
covering the pipe walls
on a long distance with polymer.

The final dedusting before extrusion

If the pipes have a rough surface and create more dust than angel hair, a dedusting station in a smaller scale is available to clean the material before extrusion.

<u>The cascade separator:</u>

Pellet cleaner for 1 t/h includes a magnetic separator and an ionizer

Summary 1/2

- Dust is a given fact in polymers
- Well distributed, the dust is no problem, (up to a certain level)
- Every pipe transportation generates dust, angel hair and more

Summary 2/2

- **The unloading hardware and pellet storage and handling system is much more important than expected**

- **The pellet handling system should be in the focus, to avoid time and production loss, especially on extremely high sophisticated extrusion lines!**

Special Acknowledgment

- **Oliver Hissmann** — **OCS – Witten Germany**
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- **Hans Schneider** — **Zeppelin – Friedrichshafen Germany**
  hans.schneider@zeppelin.com

Thank you for your Attention!

Sorry, but it was a dusty story!

Let‘s have a coffee or something else.

Otto Plassmann
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2007
European PLACE Conference
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