Pellet Cooling and Crumbling

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Pellet Cooling/Drying

A dynamic process that involves simultaneous heat & mass transfer between the pellets and the cooling air.
Pellet cooling occurs as a result of both evaporative and convective cooling.

Evaporative cooling is the transfer of water in the product to the air, and at the same time cooling occurs.

Convective cooling depends on the temperature difference between the pellets and the air, pellet surface area, and heat transfer coefficient.
Pellet Cooling/Drying

Requirements:

• Effective cooling of a range of products
• Moisture removal for safe storage
• Avoid under-drying ($$$)
• Reliable operation
• Gentle product handling
• No condensation in exhaust ducts
• Fines removal from exhaust air
• Improve/maintain pellet quality
Cooler Performance Variables

- Air temperature
- Air relative humidity
- Air flow
- Pellet temperature
- Pellet moisture content
- Residence time
- Pellet size & density
- Pellet quality
- Cooling bed depth
- Pellet bed uniformity
- System design
Ambient & Product Conditions

- Air Temperature...
- Air Relative Humidity...
- Pellet Temperature...
- Pellet Moisture...
- Air flow...
# Pellet Diameter/Pellet Density

<table>
<thead>
<tr>
<th>Pellet diameter, mm</th>
<th>Airflow, m³/hr</th>
<th>Residence time, min</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1,200</td>
<td>6-8</td>
</tr>
<tr>
<td>4</td>
<td>1,500</td>
<td>8-10</td>
</tr>
<tr>
<td>6</td>
<td>1,600</td>
<td>10-12</td>
</tr>
<tr>
<td>8</td>
<td>1,600</td>
<td>12-14</td>
</tr>
<tr>
<td>12</td>
<td>1,800</td>
<td>14-16</td>
</tr>
</tbody>
</table>

↑ Pellet Diameter = ↑ Airflow/Residence Time

↑ Pellet Density = ↑ Airflow/Residence Time
Pellet Quality

- Pellet fines impede air passage through the pellet bed (↑ static pressure).
- Reduce bed depth
- May need to reduce airflow rate to prevent fines from being pulled into the cooling duct

Cooling effects on pellet quality

- Uneven cooling
- Inadequate cooling
- Cooling too fast
Bed Depth/Uniformity
Bed Depth/Uniformity

↑ Pellet bed depth = ↑ air-pellet contact time = ↓ CFM = ↑ static pressure

The deeper the pellet bed depth...
... the higher the final pellet temperature
... the lower the final pellet moisture
**Vertical Cooler**

- Simple design
- Small foot print
- Ease of operation

↑ Airflow
↑ Convective cooling

Less flexible (bed depth)
Bridging problems

- Warm, Moist
- Product In

- Drying Zone

- Cooling Zone

- Cool, Dry
- Product Out
Vertical Cooler – Cross Flow

Maximum Air Velocity = 350 feet per minute
Horizontal Cooler

- Single or Double Pass
- Low Height
- High Capacity
- Flexible operation
- Ineffective at beginning and end of run

Warm, Moist product in

Drying Zone

Cooling Zone

Cool, Dry product out
Horizontal Cooler

Air

Pellets

Air

Pellets

Air

Air Velocity 4000 feet/min.

Air Velocity 600 feet/min.

Air Requirements
450 +/- CFM/Ton
Counter Flow Cooler

Compact footprint.
Low maintenance.
Lower CFM of air/ton
Higher HP required
Counter Flow Cooler

Warm, Moist Product In

Drying Zone

Cooling Zone

Cool, Dry Product Out

Air Requirements
350 +/- CFM/Ton
Counter Flow Cooler

Diagram showing various components of a counter flow cooler:
- Fan
- Damper actuator
- Fan motor
- Cyclone
- Discharge air temperature RTD
- Product inlet temperature RTD
- Plenum static pressure sensor
- Ambient air temperature RTD
- High level sensor
- Operating level sensor
- Discharge drive motor
- Cool air intake
- Product discharge temperature RTD
Air System Flow

Cooler

Airlock

Cyclone Separator

Air Velocity 4000 fpm min.

Fan
System Design

• Cooler air systems should be designed using the correct amount of air (cfm/tph) for the type of cooler used.

• The recommended air velocity in the duct should be 4000 ft/min in order to keep the inside surface of the duct clean.

• Fan design, rotation, speed, & belt slippage.

• Check for leaks in ductwork, blockage in ducts, or if the damper is closed.
Trouble Shooting Cooler Operation and Performance

What Do I Do Now?

Temperature O.K. but Moisture is too high
- Reduce Air Flow, Increase Bed Depth

Temperature is high and Moisture is high
- Increase Bed Depth, Increase Air Flow

Temperature O.K. but Moisture is too low
- Reduce Bed Depth, Increase Air Flow

Temperature is low but Moisture is high
- Increase Bed Depth, Reduce Air Flow

Temperature is low and Moisture is low
- Reduce Air Flow

Source: CPM
Pellet Cooling

QUESTIONS

???????
Pellet Crumbling

• Crumbling of pellets done by cutting/shearing of whole pellets into smaller pieces.
• A specially designed roller mill is used to accomplish this function.
Pellet Crumbling

Inlet

Differential Gearbox

Roll Adjustment

Slow Roll

Fast Roll

Motor and V-belt Drive
Pellet Crumbling

Crumbling Rolls
Single Pair w/Automatic Gap Adjustment
Pellet Crumbling

Crumbling Rolls
w/Inlet Feeder Roll
Pellet Crumbling

• The crumbling action is done by passing whole pellets between a pair of rolls set up to operate in a sharp to sharp cutting action.

• The cutting action is accomplished by turning one roll faster than the other.

• This difference in speed is called the speed differential.

• Differential is the ratio of the speed of the faster roll divided by the speed of the slower roll.
Pellet Crumbling

• The size of the crumbles is dependent on the space between the rolls and the treatment of the roll surfaces.
• The space is known as the “roll gap”.
• The smaller the space, the more severe the crumbling action, the smaller the crumble pieces.
Pellet Crumbling

- The treatment of the roll surface is called the roll “corrugation”.
- Corrugations are grooves cut into the roll surface to help in the cutting and sizing of the pellets into crumbles.
- In crumbling rolls the grooves run parallel to the roll length and may have some small degree of spiral or wrapping around the roll.
## Pellet Crumbling

### Standard Roll Speeds

<table>
<thead>
<tr>
<th>Roll Dia.</th>
<th>Speed Differential</th>
<th>Slow Roll Speed (rpm)</th>
<th>Fast Roll Speed (rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8”</td>
<td>1.3:1*</td>
<td>453</td>
<td>584</td>
</tr>
<tr>
<td>10”</td>
<td>1.5:1</td>
<td>533</td>
<td>799</td>
</tr>
</tbody>
</table>

* Other differentials available: 1.4 : 1, 1.5 : 1

California Pellet Mill Co.
# Pellet Crumbling

## Standard Roll Corrugations

<table>
<thead>
<tr>
<th>Roll Dia.</th>
<th>Corrugation Type</th>
<th>Slow Roll Spacing</th>
<th>Fast Roll Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>8”</td>
<td>LePage</td>
<td>10/inch</td>
<td>10/inch</td>
</tr>
<tr>
<td>10”</td>
<td>Round Bottom “V”</td>
<td>8/inch</td>
<td>6/inch</td>
</tr>
</tbody>
</table>

California Pellet Mill Co.
Pellet Crumbling

After Horizontal or Old Style Vertical Cooler:

• Roll length matches width of cooler.
• Flow rate to rolls from cooler discharge is constant and uniform and same width as crumbling rolls inlet.
• Feeder roll above crumbling rolls not required.
Pellet Crumbling

After Counter Flow Cooler:

• Roll length does not match the width of cooler.
• Flow rate to rolls from cooler discharge is in surges and is not of uniform width.
• Feeder roll required above crumbling rolls to spread pellets uniformly across length of crumbling roll inlet.
Pellet Crumbling

Roll Gap
(looking down from above)

Correct
(Uniform Spacing)

Incorrect
(Varied Spacing)

Rolls Must Be Parallel
Pellet Crumbling

Roll Tram
(looking from front of machine)

Correct
(Rolls Aligned)

Incorrect
(Rolls Not Aligned)

Rolls Must Be In Alignment (Tram)
Pellet Crumbling

All crumbling rolls must be equipped with a method to bypass the rolls:

• Old style crumbling rolls had a built-in diverter valve at inlet.

• Newer crumbling rolls are equipped to spread roll gap full open to allow whole pellets to pass through while crumbling rolls are not running.
Pellet Crumbling

Summary:

• Roll surfaces must be corrugated for the size of pellets and size of crumbs to be made.

• Proper speed differential must be chosen for best control of crumble size range.

• Crumbling rolls must be fed uniformly across the entire inlet length.

• Gap setting must be uniform and rolls in tram.
Pellet Crumbling

QUESTIONS ???