Principles of Extrusion Processing

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Learning Objectives

- Learn about the basic principles of extrusion.
- Learn about the hardware needed for extrusion including drying and cooling.

What is Extrusion Process?

- It is a continuous process where the ingredients (cereals, oil seeds and its co-products) are cooked and plasticized by using a combination of temperature, pressure, mechanical force and water.
- It utilizes extrusion equipment that introduce mechanical and thermal energy to the ingredients to produce food or animal feed.

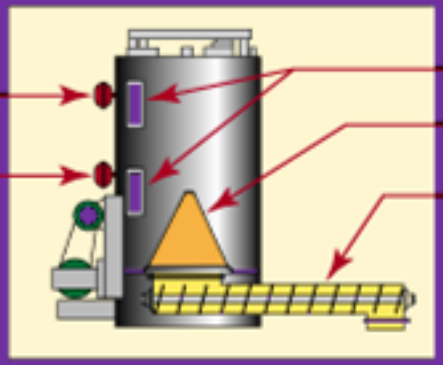
Why use Extrusion?

1) Cooks the starches and the other ingredients in the formula.
2) It can give shape and size to the product.
3) Controls the density of the final product (expansion).
4) Helps to sterilize the product by eliminating pathogens with the high temperature.
5) Makes feed more digestible (more cooked).

Example of Products Made Using Extrusion

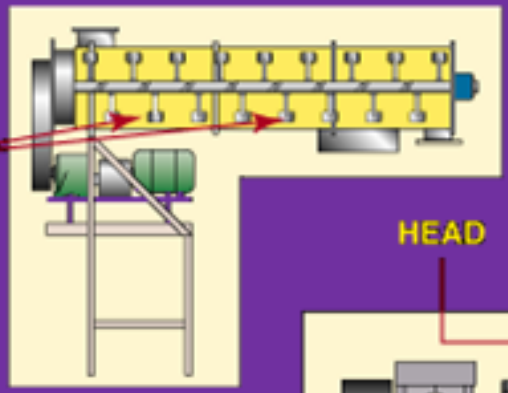
- Pet Food (co-extruded)
- Full Fat Soybean (texturized protein, full fat)
- Cereals, snacks, pastas
- Fish feed:
  - Tilapia, trout, salmon, bass, etc

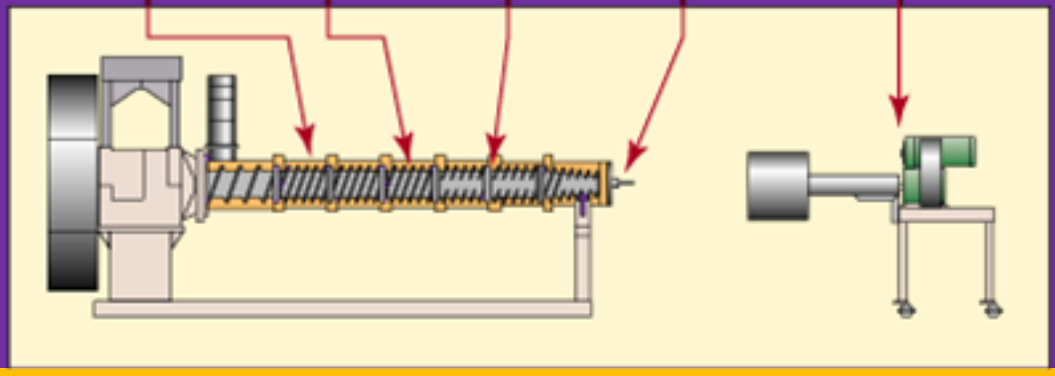
Extrusion Process



FEED DELIVERY SYSTEM

PRECONDITIONING PHASE



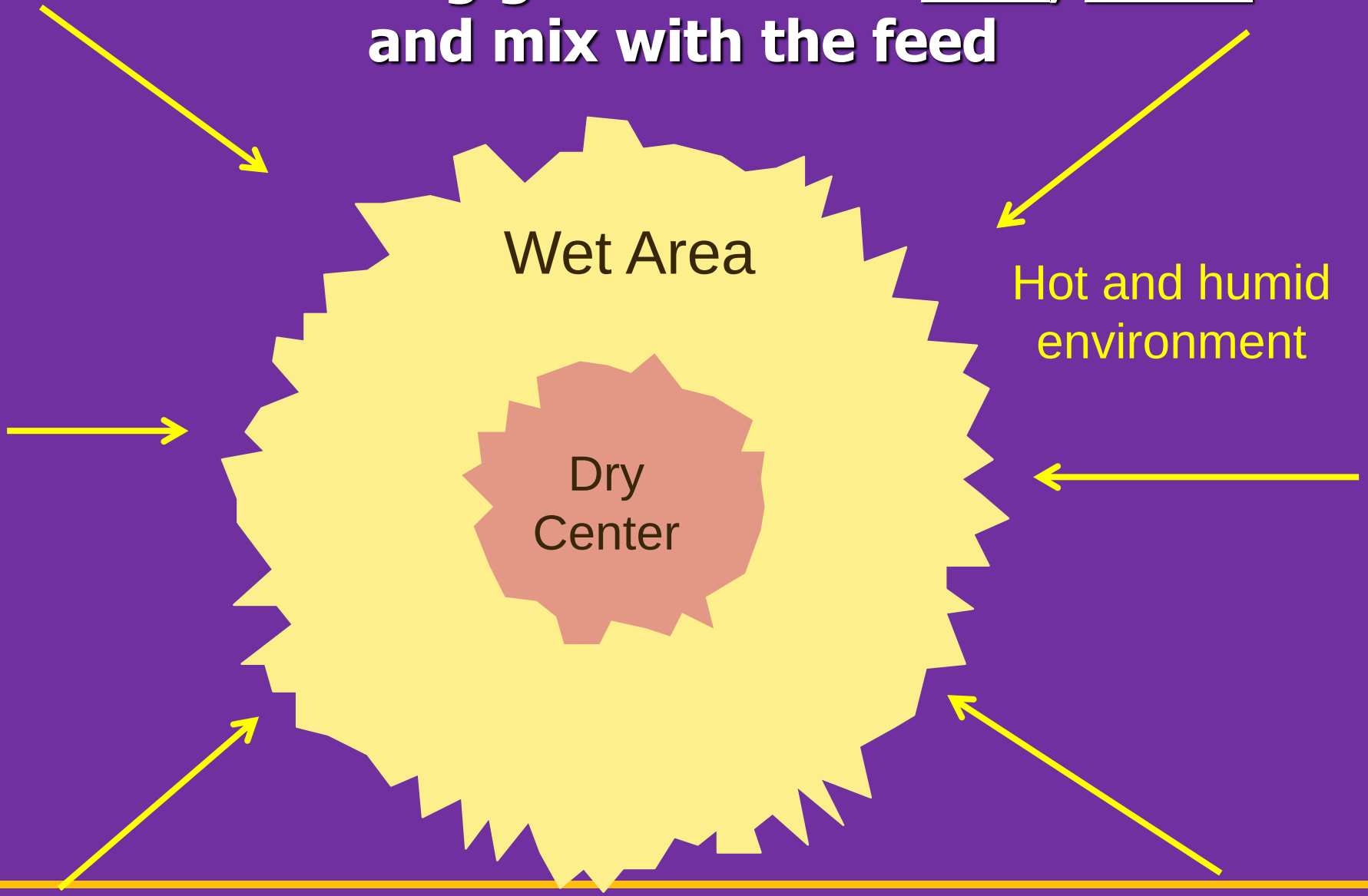


EXTRUDER BARREL COMPONENTS

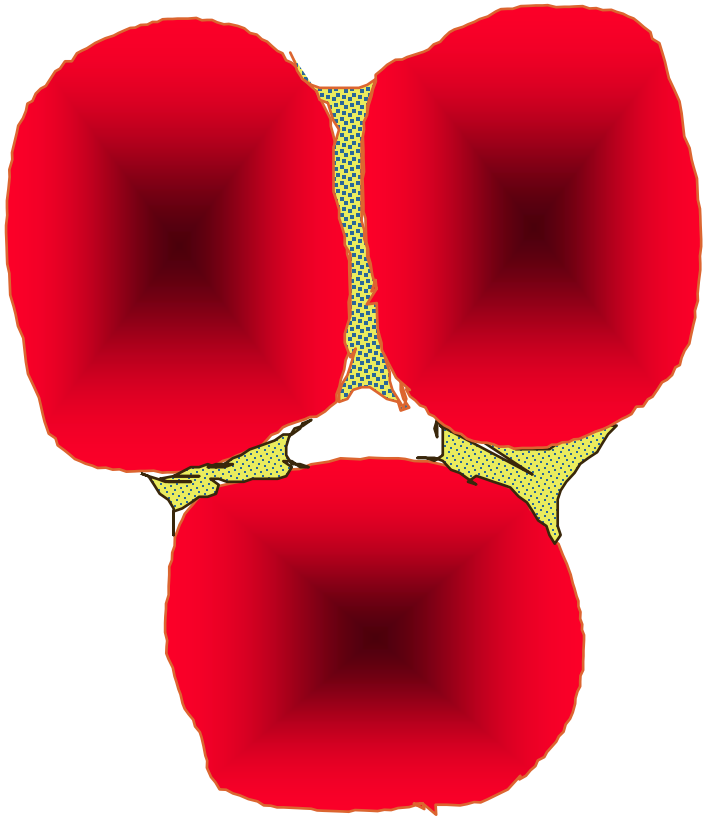
Benefits of a Good Conditioning System

1) Improve water absorption
2) Improve heat transfer
3) Higher level of gelatinization
4) Improves mixture of liquids-solids
5) Higher producing capacity of the extruder
7) Improves control of properties of floating/sinking
8) Improves taste of the final product

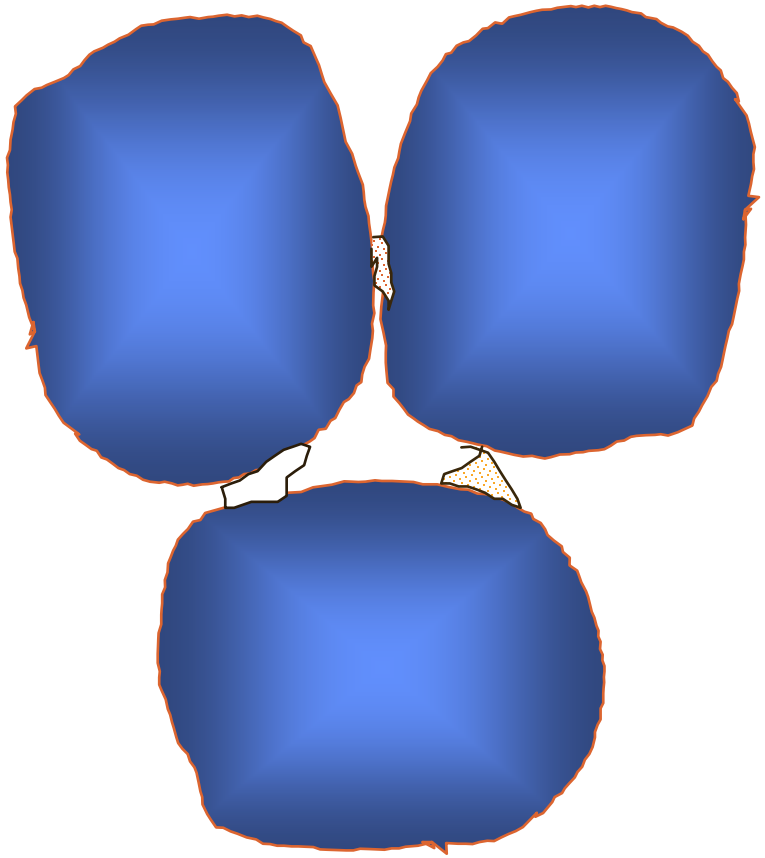
Conditioning goal is to add: heat, water and mix with the feed



Binding of Particles



Hot and humid

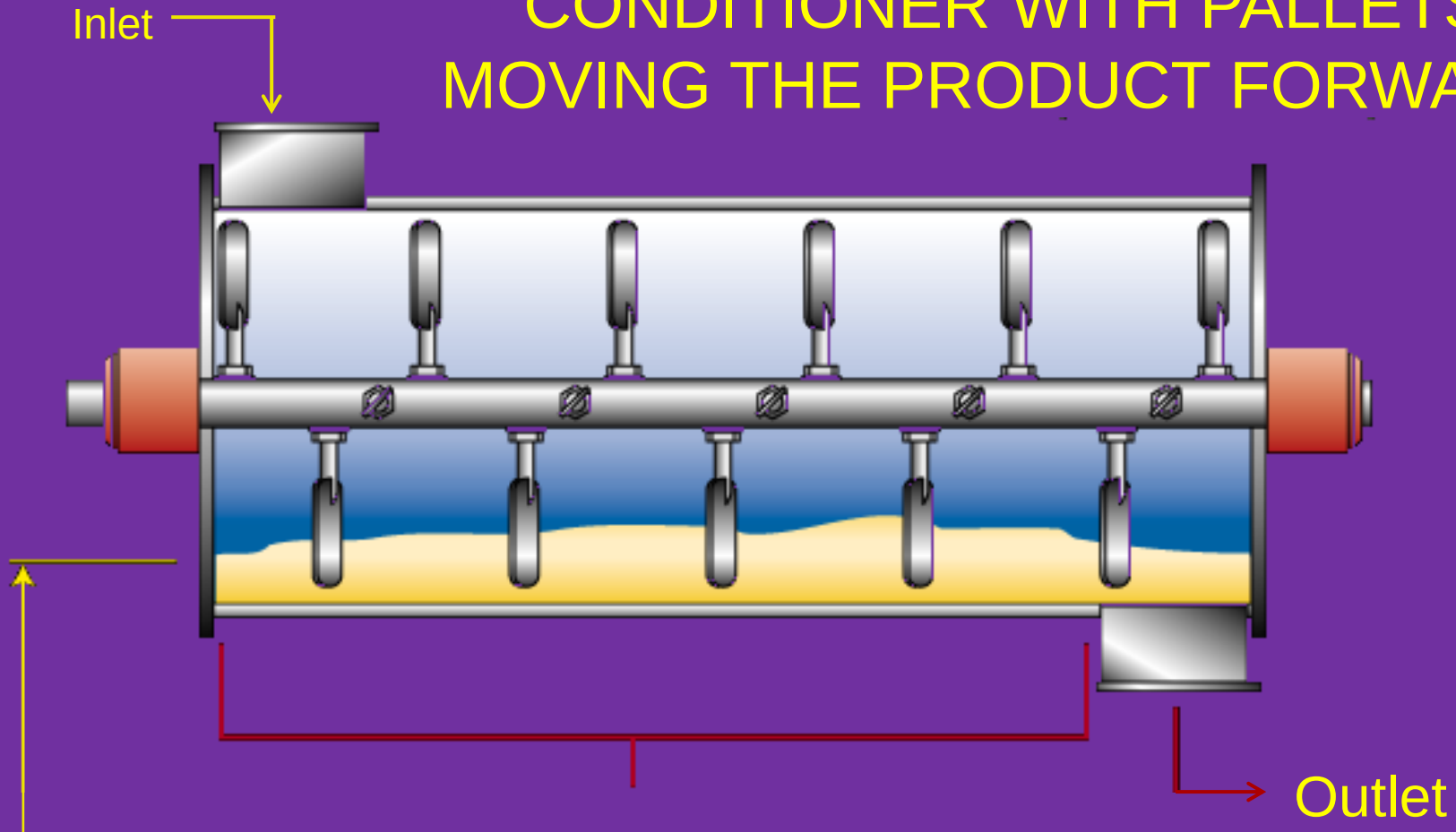


Dry & cold

Options to Increase Retention Time in the Conditioner

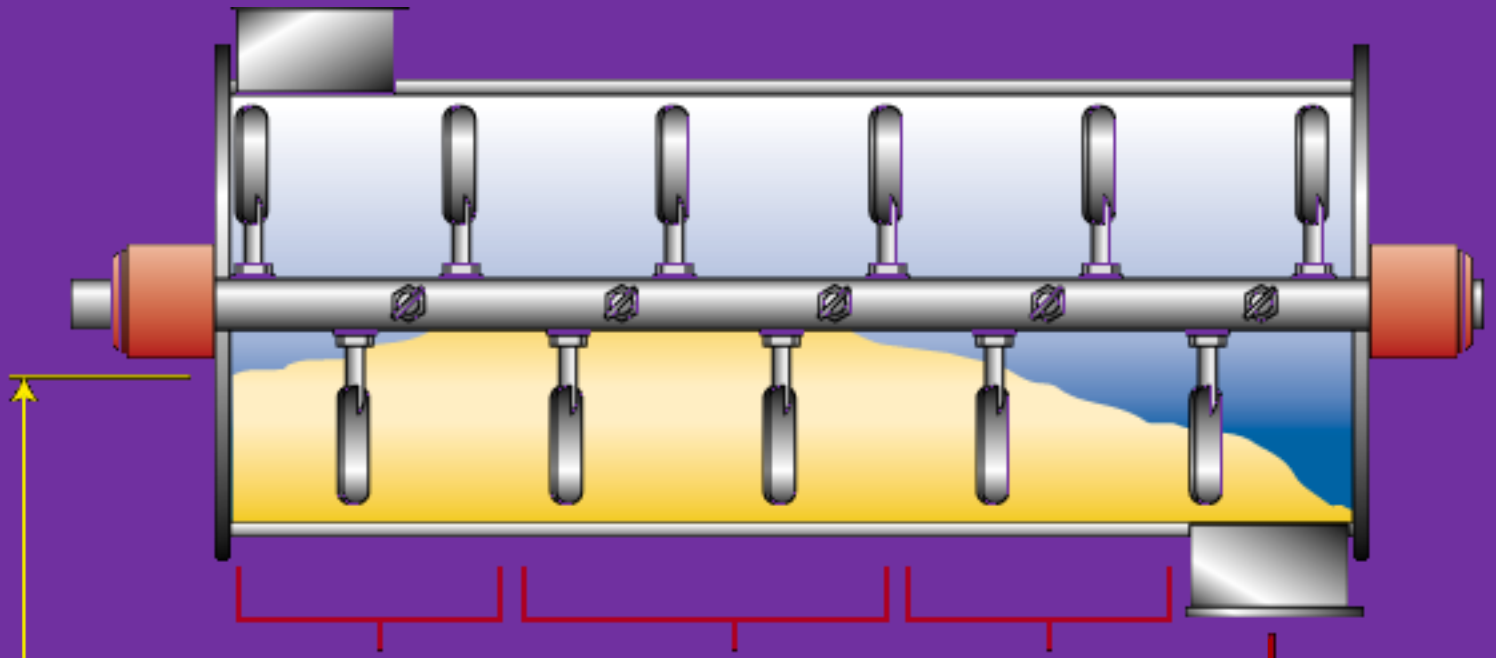
1. Increase conditioner volume - L x W
2. Move (rotate) paddle angle
3. Reduce shaft rotational speed

CONDITIONER WITH PALLETS MOVING THE PRODUCT FORWARD

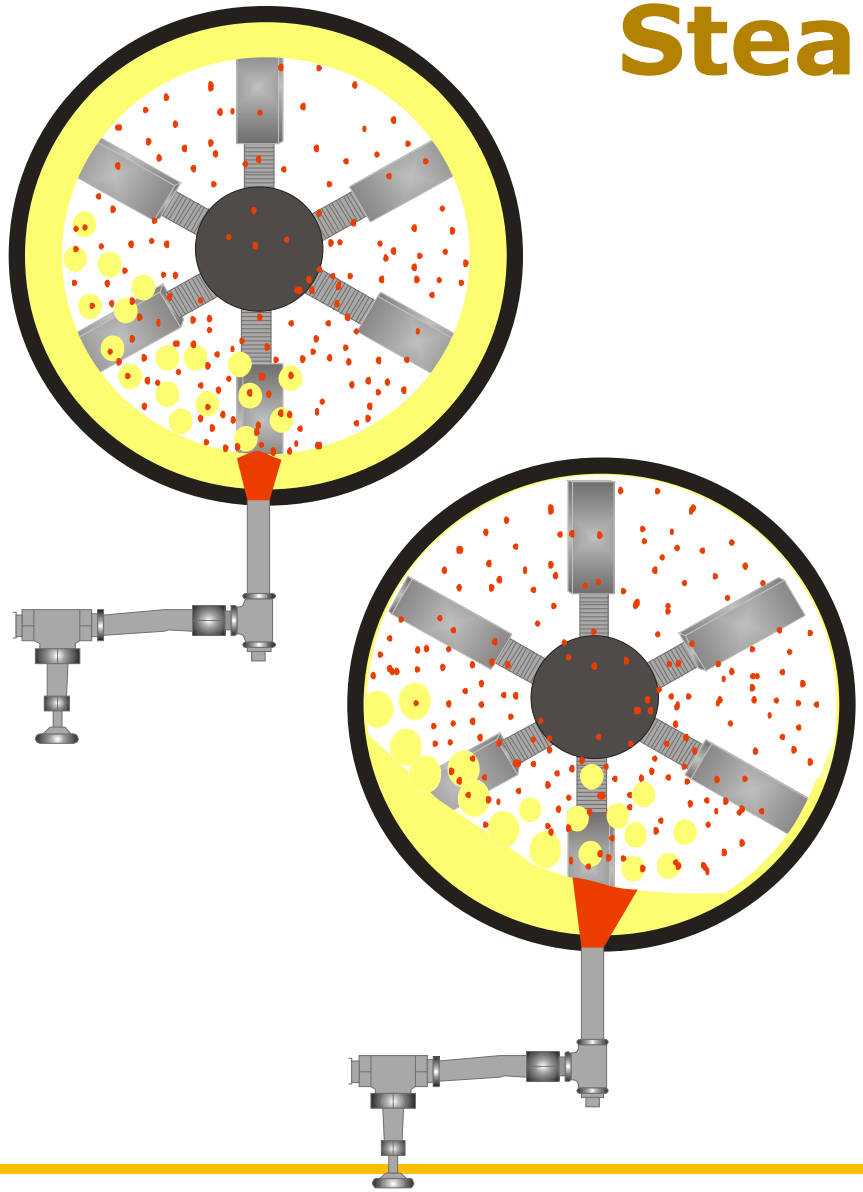


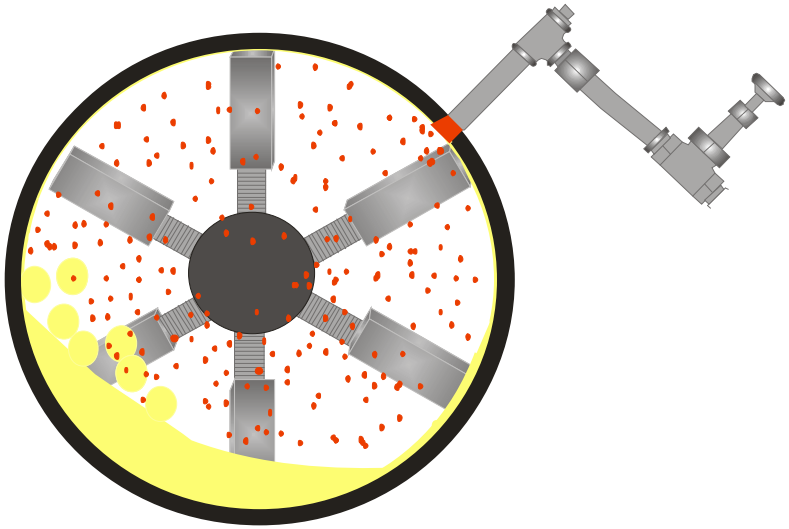
All paddles with forward pitch to move the product forward faster

CONDITIONER WITH OPTIMAL PADDLE ANGLE TO INCREASE RETENTION TIME



Steam Injection





Problems with steam absorption

- Non-uniform heating
- Low retention times
- Steam addition 4 to 6% (max)

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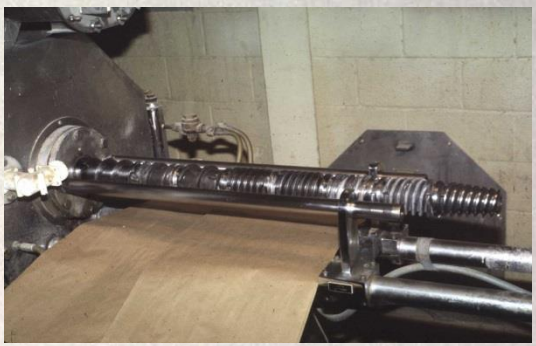
Boiler

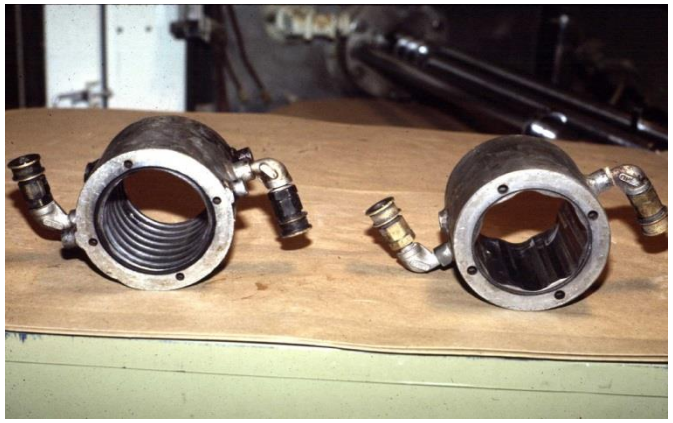
- Heats up the water to its saturation temperature to produce steam.
- Steam goes through the distributor (manifold) and then to each application (extruder, pellet mill).

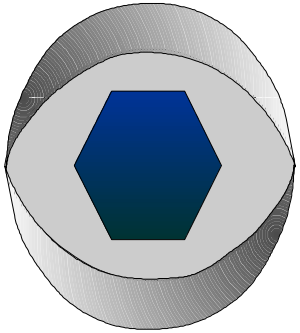
Extruder

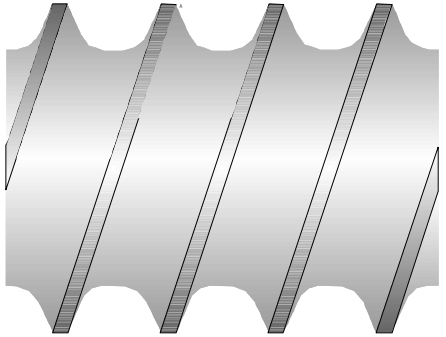


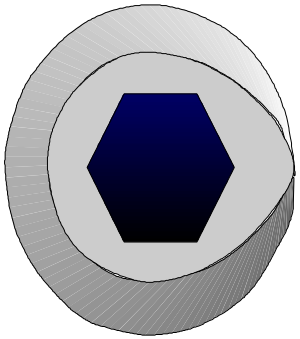
Water Addition
Steam Addition
Water Addition
Steam Injection
120-135C
Pressure
300-600 PSIG
Moisture 19-23%
Temperature 250-275°F
Density 20-15 lb/ft3
%Cook 90-95
Moisture 15-20%
Temperature 190°F
% Cook 25-30
88C
TEMP
COOK
1.5-2 Minutes
Pressure Curve
15-20 Sec.
5-
10
Sec.
TIME

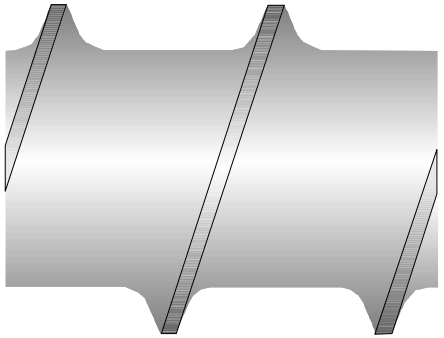
Extruder Barrels



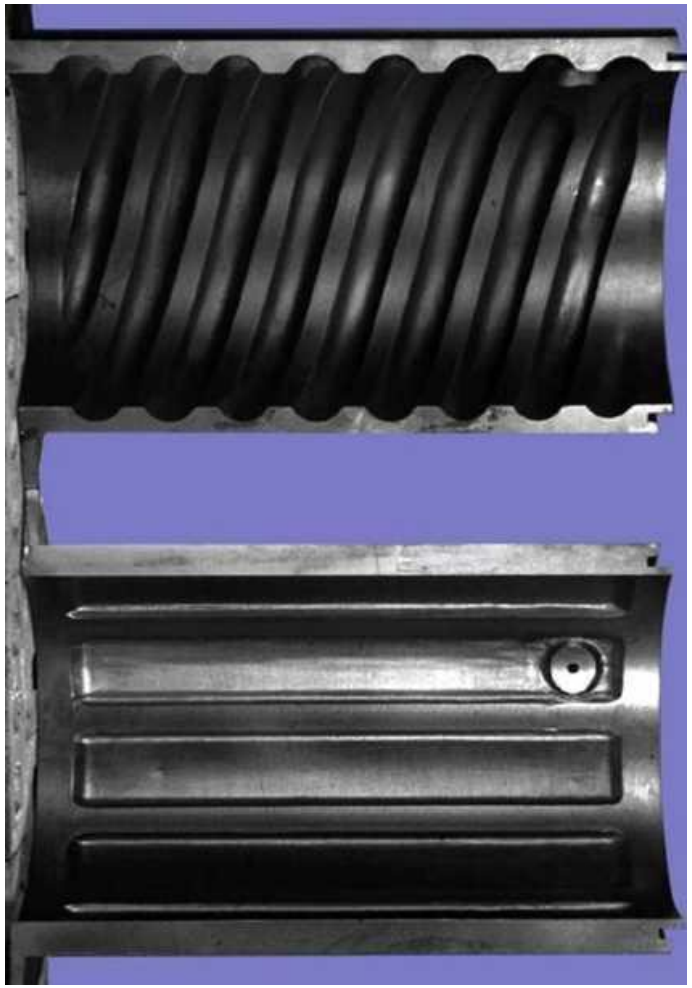






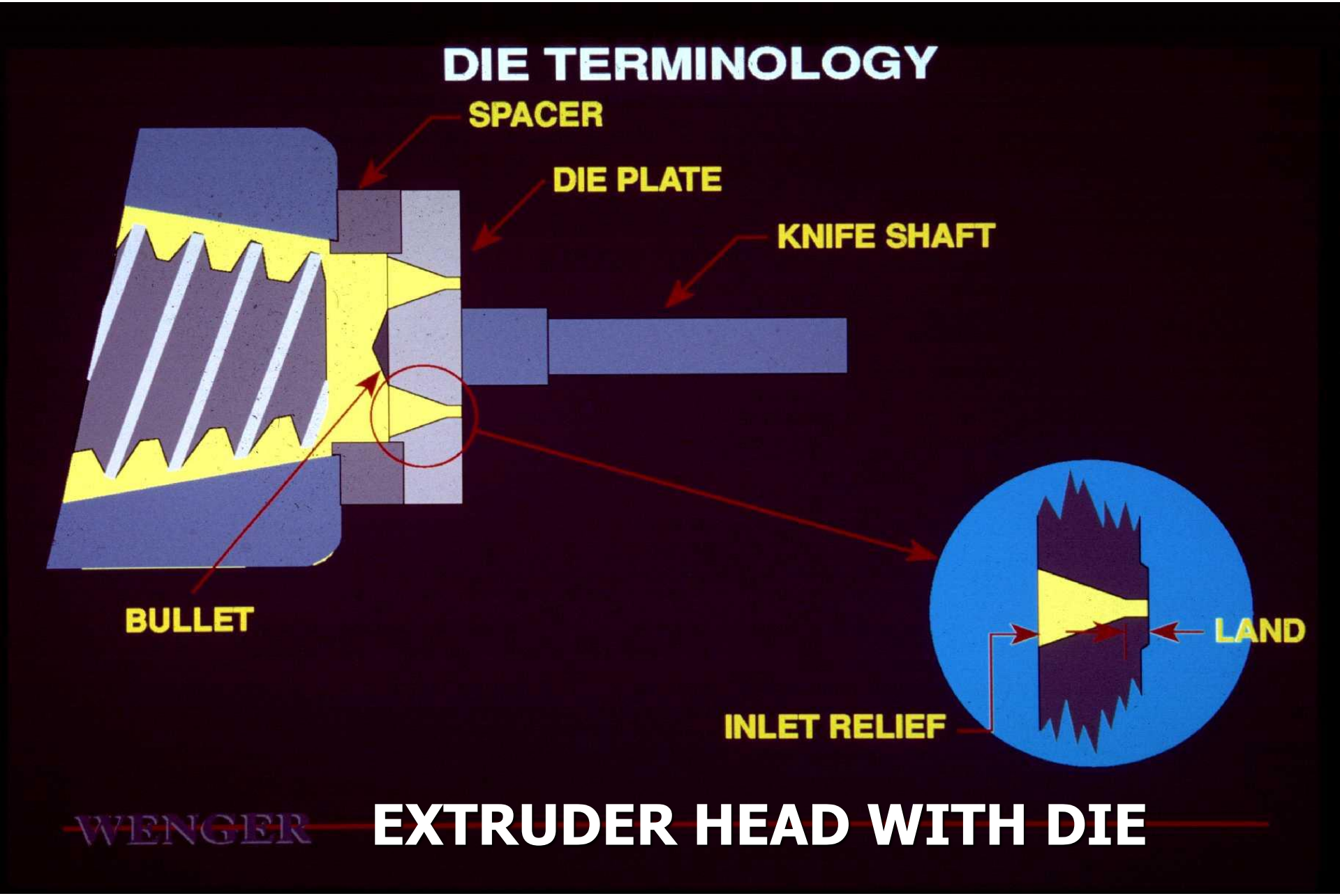


Barrel Sleeves



Spiral Ribbed Liner

Straight Ribbed Liner
(Longitudinal Grooves)



EXTRUDER HEAD WITH DIE

Knife Blades of Extruder

Extruder – Die Considerations

- The more velocity the extruder has, the more gelatinization that will occur in the starches.
- The more velocity the extruder has, the less density the final product will have.
- Factors that affect density: moisture content, temperature, number and area of die openings.

Drying and Cooling

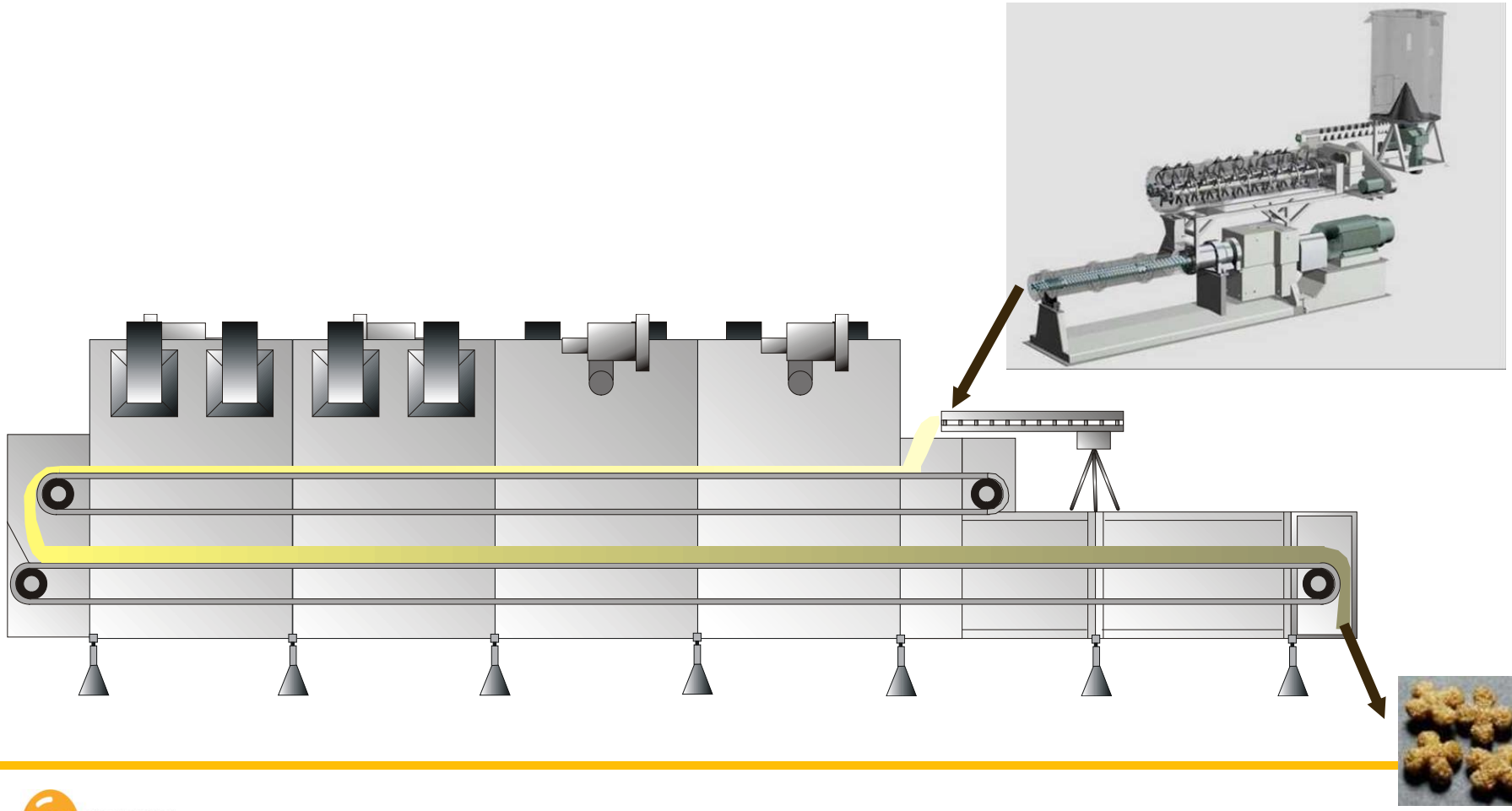
Important Concepts about Drying And Cooling

- In dryers, air is heated up using an energy source (steam coil, o direct fire).
- The warmer the air, the higher the moisture level that the air can absorb from the product.
- Normal air-drying temperatures are between 100 - 200°C and a velocity between 30 - 60 m/min
- When air is saturated, it cannot absorb more moisture from the product.
- Cooling is done with ambient air temperature.

Types of Dryers

- Rotational
- Horizontal
- Vertical

Two Steps Horizontal Dryer



Vertical Dryer

Rotational Dryer

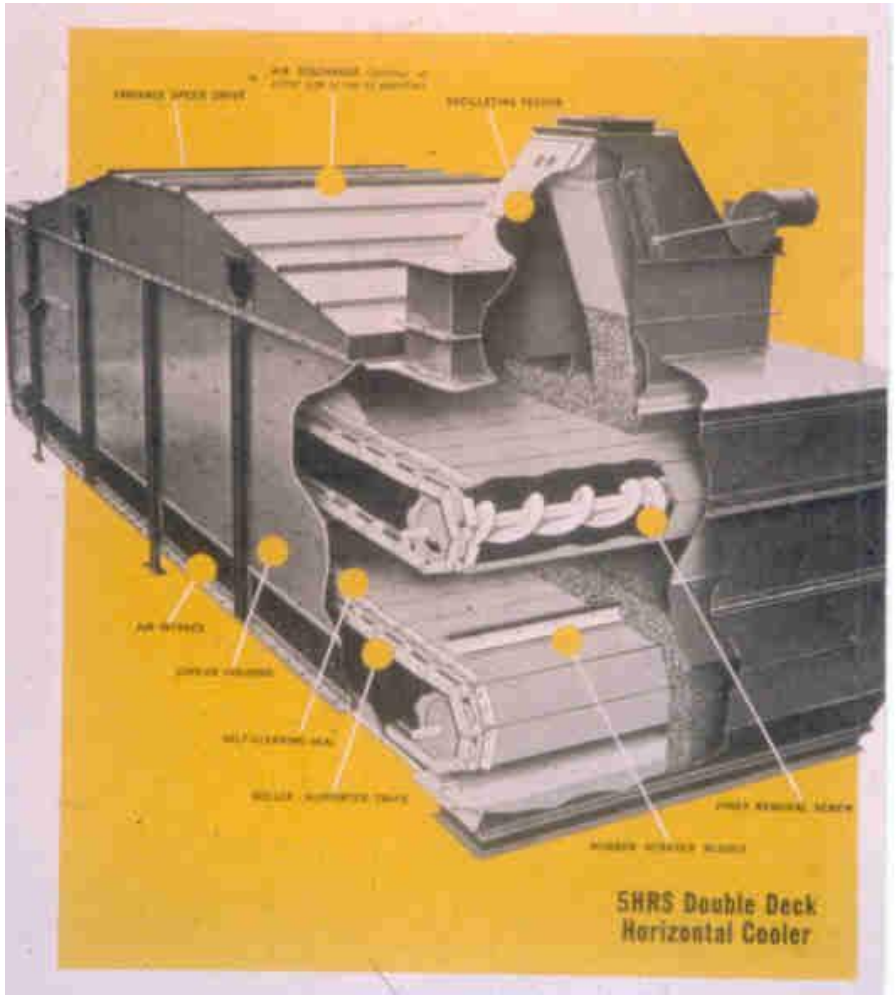
Drying Considerations:

- Process time should be uniform.
- Amount of air into the dryer should be uniform.
- Temperature should be uniform (100 a 200 °C).
- Final moisture content before cooling should be between 11 - 14% (will depend on the ingredients, fat content, etc).
- Apply fat or liquid flavors before cooling the product.

Types of Coolers

- Rotational
- Horizontal
- Vertical (don’t use for delicate and sticky pellets)

Types of Coolers



Rotational Cooler

Cooling Considerations

- Final moisture content between 8-11%
- Product at inlet with temperature at 88°C
- If product is not properly cool down, it will absorb from condensation.
- Product should be cool down to 3 - 5°C above ambient temperature.

Cooling Considerations

- Coolers that stir and move the product are more efficient.
- Fines should not accumulate inside the cooler.
- Coolers should be capable to modify their retention time.
- Coolers will take out between 1-2.5% of the moisture content of the product.

Summary

- Extruders use water, heat and pressure through mechanical force to make more complex types of feed.
- It is essential to have a good drying and cooling system to reduce the moisture and temperature of the extruded products.
- Extruders are complex equipment that required more controls than other feed manufacturing equipment.

THANK YOU!

QUESTIONS???

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