INTRODUCTION TO THE EXTRUSION PROCESS
SUMMARY

• Basic description of a twin screw extruder
• Introduction to the extrusion process
• Preconditioning
• Thermomechanical Cooking and Expansion
  ▪ Part 1: Extrusion variables and effects on the process/product
  ▪ Part 2: Screw profile design
  ▪ Part 3: Die-level expansion/texturing
HISTORY OF INNOVATION IN TWIN SCREW EXTRUSION TECHNOLOGY

TWIN SCREW EXTRUDER (TSE)  
SINGLE SCREW EXTRUDER (SSE)

COLD EXTRUSION  
PASTA PROCESS  

PLASTICS PROCESS  
in SSE

FOOD EXTRUSION-COOKING  
in SSE

PLASTICS PROCESS  
in TSE

FOOD EXTRUSION-COOKING  
in TSE

PAPER PULP PROCESS  
in TSE

EXTRUSION POROSIFICATION  
in TSE

30’s  
40’s  
50’s  
60’s  
70’s  
80’s  
90’s  
00’s

PASTA PROCESS

PLASTICS PROCESS

FOOD EXTRUSION-COOKING

PAPER PULP PROCESS

EXTRUSION POROSIFICATION
DEFINITION

- Extrusion is a **thermomechanical process** consisting in forcing a product through a small size hole, under pressure and temperature thanks to a mechanical device type Archimede screw.

- **Functions of an extruder**: feeding, conveying, compressing, cooking, shaping...

- Expansion is due to the water flash off caused by the pressure difference out of the die.
TWIN SCREW EXTRUSION (TSE) TECHNOLOGY: MAIN OPERATIONS

- MIXING
- EXTRUSION
- COOKING
- SHAPING
TWIN SCREW EXTRUDER: BASIC DESCRIPTION

- Heating collars
- Gearbox
- Operator Interface
- Motor
- Die assembly
- Barrel modules
- Cooling circuit
The module, which houses the screws, is comprised of several modular parts

Different types available:

- AB1 (First feeding barrel)
- FER (closed barrel)
- VAP (vapour injection barrel)
- ABF (lateral feeding barrel)

....
INDEPENDENT temperature control (cooling/heating) of each barrel of the extruder
BARREL COOLING SYSTEM

BC: Serial flow

Cooling fluid temperature

12 pass

ADVANTAGES:
- Homogenisation of the temperature
- Improvement of the thermal exchange

EV: Parallel flow

Cooling fluid temperature

2 pass
INTERPENETRATING SCREWS

Interpenetrating → SELF-CLEANING
SCREWS DETAILS

Screw elements mounted on splined shafts:

- Modular screw profile
- Perfect continuity of the profile

Wide range of screws available to optimize the thermomechanical cooking of the melt
MIXING IN THE TSE

VERY EFFICIENT MICRO-MIXING:

Intermeshing zone

Gap barrel-screws

Flow
The new standard for Extrusion Excellence
## Evolum Key Aspects

<table>
<thead>
<tr>
<th>Evolum Key Aspects</th>
<th>With improved benefits</th>
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<tbody>
<tr>
<td>Larger operation window: Torque power-RPM</td>
<td>Greater productivity: (Output: + 30-40%)</td>
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<tr>
<td>Optimal Cooling</td>
<td>Advanced Thermal Control</td>
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<tr>
<td>Direct Scaling</td>
<td>Hygienic Design</td>
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**EVOLUM+ Advanced Thermal Control (ATC)**

**Enhanced temperature control:**

- Continuous auto-adjustment to the recipe and variations = **Self-learning device**
- Optimum response when disturbance, no compromise between response time and stability
- Stability improved by 70 %
- Energy saving up to 20 %

*Availability depending on PLC brand*
Innovative hygienic design for optimal cleanability
EVOLUM+ hygienic design

- Use of open profile instead hollow body for main frame and all structures (beam excepted)

- Spacing between components

- Open corners
EVOLUM+ hygienic design

- Stainless steel cooling pipes or armoured flexible with elastomer cover
- Visual management
EVOLUM+ HMI

- Fitsys+ V2: user-friendly

### Historical data management

### Automatic Start-up & Shutdown

- Process optimization via repeatable start sequences
- Independent of the operator know-how
- Optimized lifetime on screws & barrels
- Recipes management
EVOLUM+ frame options

Type

- **F**: Fixed frame
  Trade-off for the best technical and economical compromise

- **D**: Direct opening or **H**: 2-step opening
  Hydraulic barrel opening for easy maintenance and cleaning

Materials

- **Paint coating**: RAL 9006
- **Stainless steel**
MAIN FEATURES OF EVOLUM+ EXTRUDERS

- Proven features of the EVOLUM® Extruder
- High capacity due to increased Do/Di effect
- Heat transfer management thanks to Advanced Thermal Control
- Food safety achieved with a specific Hygienic Design

Range

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<tr>
<th>EV44+</th>
<th>EV56+</th>
<th>EV72+</th>
<th>EV93+</th>
<th>EV119+</th>
<th>EV153+</th>
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![Image of EVOLUM+ Extruder]
2 FAMILIES OF EXTRUDED PRODUCTS

DIRECTLY EXPANDED = DX

NON-EXPANDED / INDIRECTLY EXPANDED
**PRECONDITIONING**
- Pre-humidification and heating of raw materials
- Biopolymer preparation (glass-rubber transition) to improve the process (max flow; shearing, product quality, wear, etc.)

**THERMOMECHANICAL COOKING** (Et & Em)
- **Starches**: loss of crystallinity and of the whole state of the starch granules, depolymerisation, formation of the amylose-lipid complex
- **Proteins**: denaturalisation and aggregation, possibility of forming covalent bonds

**TEXTURING**
- **Expansion**: Mechanism dependent on the flash off
- **Die face cutting** or remote cutting

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**TYPICAL CONFIGURATION OF AN EXTRUDER**

![Diagram showing the typical configuration of an extruder](Diagram)
DIRECTLY EXPANDED PRODUCTS

Snacks, Breakfast Cereals and Ingredients

Textured Vegetable Protein

Pet Food and Fish feed
MULTIPLE SECTIONS OF A SERIAL PROCESS thanks to the various restrictions generated by the work of the screws. High mixing levels, heat transfer and shearing.
EXPANSION AT THE FRONT PLATE ASSEMBLY OUTPUT - MATRIX: definition

Water evaporation

SEI

LEI
DX CHARACTERISTICS

- Airy texture - cellular structure - crunchy texture
- Expansion or texturing (cell structure vs. fibrated structure)
- Expansion factor > 1.5 to 5.
- Low density:
  - Snacks and cereals: from 30g/L to 150 g/L
  - Pet food and Fish feed: from 300g/L to 700 g/L
DIRECT EXPANDED SNACKS

Raw material preparation  Twin screw extruder  Belt dryer  Coating device

350 – 1 700 kg/h
NON-EXPANDED OR INDIRECTLY EXPANDED

- Pellet snacks
- Extruded flakes
- Ingredients
- Fruit pieces/rolls
- Cheese
- Pet treats
- High Moisture Extrusion Cooking (HMEC)
WORK STAGES IN AN EXTRUDER
Non-Expanded Products

RAW MATERIALS

VAPOUR

WATER

WATER / LIQUIDS

VAPOUR

DEGASIFICATION

TEXTURED PRODUCT

Conveying & Compression Section

Mixing & Cooking Section

Cooling Section

Compression, Shaping & Texturing Section

Axial Distance

P

Motor (E_m)
CHARACTERISTICS OF NON-EXPANDED PRODUCTS

- Dense Structure
- Limited or non-existent expansion
  - Expansion factor < 1.5
  - High density (> 600 g/L)
- May need additional treatment
FLAKES

Twin screw extruder → Conveyor & nib cutter → Tempering drum → Flaker → Dryer toaster → Coater dryer → Cooler

250 – 1 200 kg/h

optional
PET TREATS

Twin screw extruder  Cutter  Cooler  Dryer  200 – 1 200 kg/h
Thank you for your attention

www.clestral.com