LyondellBasell Cincinnati Technical Center Capabilities at a Glance

Cincinnati Technology Center

260,000 square feet

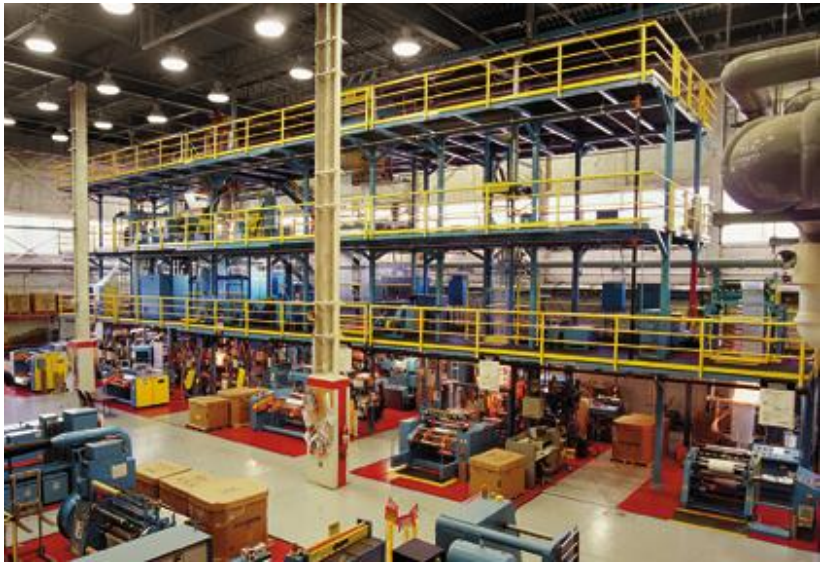
- **Technical Service**
- **Application Development**
- **Product Development**
- **Material Properties Development**
- **Catalyst Systems Scale-up**
- **Processing, Testing, and Characterization**

Cincinnati Technology Center Laboratories

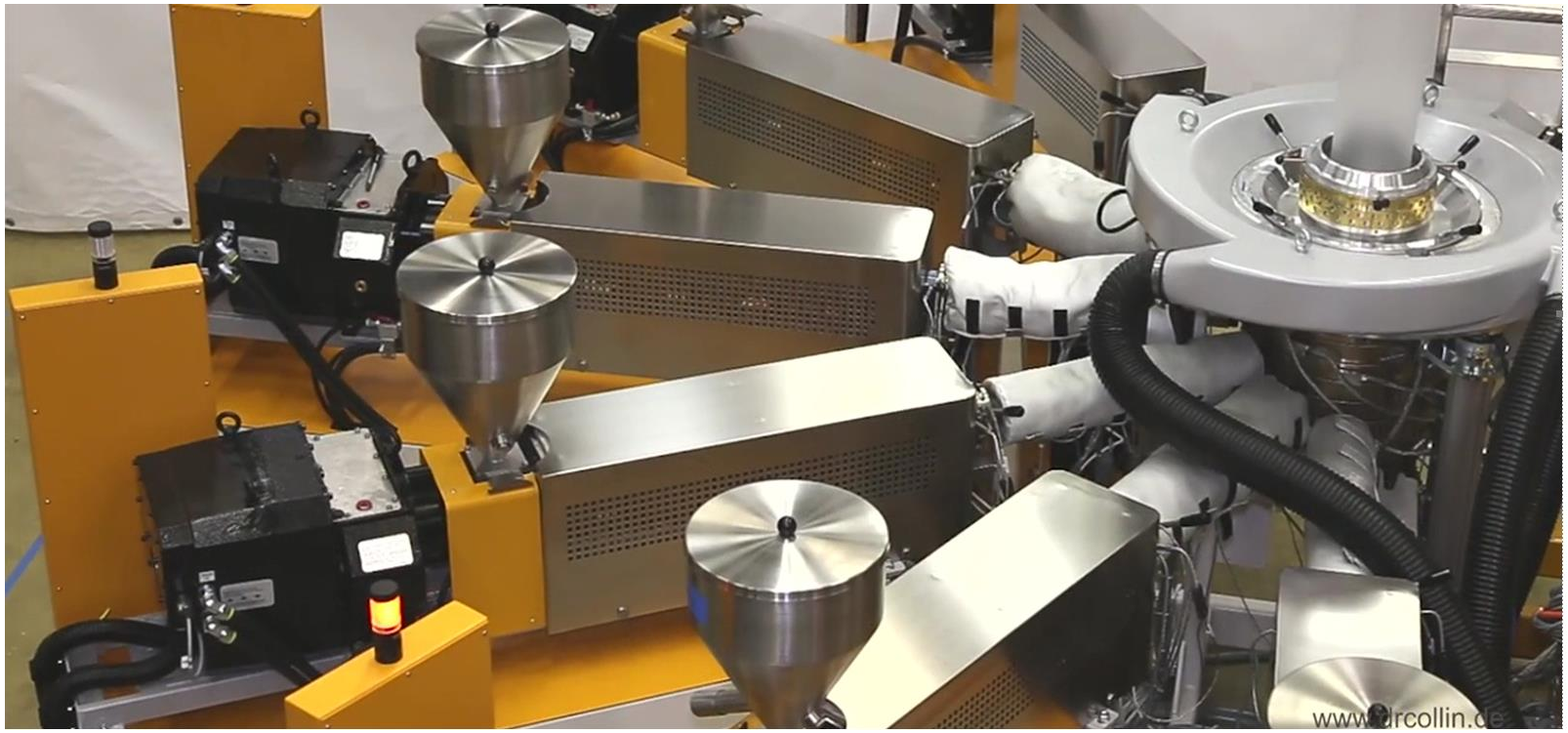
- **Applications Laboratory**
  - Broad range of plastics processing lines used for…
    - New resin development
    - Applications/structure development
    - Technical support of existing resins and applications
- **Analytical Laboratory**
  - Fundamental polymer chemistry testing
- **Polymer Testing Laboratory**
  - Physical property testing

Flexible Applications Laboratory Equipment

- Multi-layer Blown Film Lines
- Single-layer Blown Film Lines
- Coextrusion Cast Film Line
- Extrusion Coater/Laminator
- Machine Direction Orientation Line



7-Layer Blown Film Line

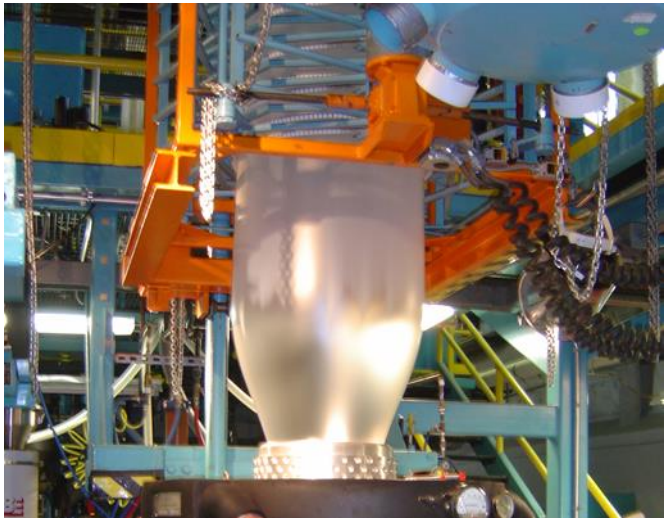


Photograph supplied courtesy of Collin GmbH,Germany

2018 Addition

- **Barrier Film Structure Development and Customer Support**
- ***Plexar* Tie Layer Resin Development**
- **High Barrier HDPE Development**

3-Layer Blown Film Line



- 3 Layer Coextrusion, 20/60/20 layer distribution
- Die size: 6 inches
- Maximum output: 200 lbs./hr.
- Maximum lay-flat width: 36 inches
- Primarily for LLDPE, LDPE and MMW-HDPE Coextrusions

3-Layer High Stalk Blown Film Line

- 3 Layer coextrusion, equal layer distribution
- Die: 200 mm with IBC
- Output range: 500-600 lbs./hr.
- Maximum lay-flat: 60 Inches
- Film gauge: 0.25 mil-8.0 mils
- Grooved feed
- High-stalk or in the-pocket
- Primarily for HMW-HDPE

Coextrusion Cast Film Line

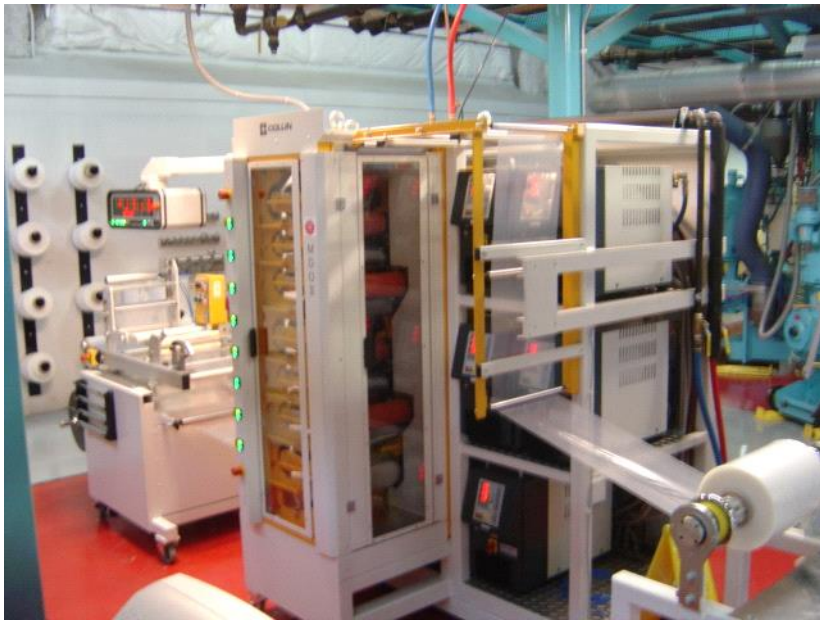
- **Up to 5 layers**
  - 3 extruders
  - A Extruder: 2.5 in., 28:1 L/D
  - B,C Extruders: 2.0 in., 28:1 L/D
- **Plugs: AAAAA, AAACC, CAABB, AACBB, ABCBA**
- **Maximum output: 600 lbs./hr.**
- **Maximum width: 30 inches**
- **Film gauge: up to 6.0 mils**
- **Tension ranges: 0.2 to 2.0 PLI**
- **Maximum roll diameter: 24 in.**

5-Layer Extrusion Coating/Lamination Line

- **Up to 5 layers (3 extruders)**
- **Substrate widths up to 30 inches**
- **Maximum line speed: 3000 fpm**
- **Substrate pre-treatment**
  - Flame, Corona, Plasma, Primer
- **Ozone treatment of melt curtain**
- **Post-treatment**
  - Corona, Plasma

Machine Direction Orientation Line

- **12” wide unit**
- **Non-commercial size**
  - Prototype production
  - Structure development
  - Technology development
- **Capable of orienting blown film, cast film and sheet**
- **Dual stretching stage capability**
- **Commercial scale-ability**
- **Data acquisition software**



In-line Film Gel Inspection

- **Optical Control Systems (OCS) cameras analyze for gels/defects during film production**
- **Camera systems are similar to what are used at many Equistar plants for QC Gel testing**
- **Used on various film lines**
  - OCS cast film line (4-inch die)
  - Monolayer blown line (4-inch die, smooth-bore extruder)
  - 3-layer HMW-HDPE blown line

Krauss-Maffei Pressure Pipe Extrusion Line

2018 Addition

- **1 and 4 Inch Pipe Capability**

Bekum Large Part Blow Molder Blow Molder

2018 Addition

- Gerry Cans
- L-Ring Drum

Uniloy Single Head and 4-Head Blow Molders

- **Reciprocating Screw Machines**
- **Taste and Odor Panel Testing**
- **High Shear Processing Studies**
- **Dairy School Milk Bottle Training**
  - Operation/Optimization
  - Maintenance/Troubleshooting

Injection Molding Capability

- **Injection Molding Machines**
  - Battenfeld 65 Ton
  - Battenfeld 67 Ton
  - Van Dorn 170 Ton
  - Van Dorn 120 Ton
  - Engel 300 Ton
  - Husky 300 Ton

- **Primary Uses**
  - Thin-wall molding
  - Heavy-wall containers
  - ASTM & ISO test specimens
  - Spiral flow measurements

Additional Applications Laboratory Equipment

- **Wire and Cable Extrusion Lines**
  - Constant Vulcanization Line
  - Davis-Standard Cable Coating Line
- **Rotomolding Machine**
- **Fiber Line**
- **Bi-axial Orienter**
- **Batch and Continuous Extrusion Compounders**

Analytical Laboratories

- **Thermal Methods**
  - Differential Scanning Calorimetry (DSC)
    - Tm, Tc, Oxidation, crystallization kinetics
  - Dynamic Thermal Analysis (DMA)
    - Glass transition, stiffness over wide temperature range
  - Thermogravametric Analysis (TGA)
    - Mass loss (reaction, degradation), filler, calcium carbonate and carbon black content

- **Spectroscopic Methods**
  - Fourier Transform Infrared Spectroscopy (FTIR) Micro, ATR and Transmission
    - Identification of unknowns, contaminants, gels and polymers
  - Raman – Micro
    - ID layers in packaging and thin films (1 micron spatial resolution capability), unknowns and contaminants
  - Nuclear Magnetic Resonance (NMR)
    - Blend composition, comonomer content, branching content, unsaturation level and identification of unknowns
  - X-Ray Diffraction (XRD)
    - Crystalline content/structure
  - Inductively Coupled Plasma (ICP)
    - Identification and quantification of elemental composition – low detection limits
  - X-Ray Fluorescence (XRF)
    - Identification and quantification of elemental composition

Analytical Laboratories

- **Rheological Methods**
  - Strain control rotational rheometer
    - Low shear viscosity, storage and loss moduli, melt elasticity
  - Stress control rheometer
    - Creep and recoverable compliance
  - Capillary rheometer
    - High shear viscosity, die swell, melt fracture
  - Extensional rheometers
    - Extensional viscosity and melt tension

- **Solution Methods**
  - Gel Permeation Chromatography (GPC-IR & Multi-Angle Light Scattering)
    - Molecular weight, molecular weight distribution, long-chain branching
  - Crystallization Elution Fractionation (CEF)
    - Chemical Composition Distribution Characterization, Comonomer Content
  - Flow Injection Polymer Analysis (FIPA)
    - Xylene Solubles
  - Intrinsic Viscosity (IV)

Analytical Laboratories

- **Chromatography Methods**
  - Gas Chromatography (GC) and Gas Chromatography / Mass Spectrometry (GC/MS)
    - Analyses: Identification as well as qualitative and quantitative analyses of volatile and semi-volatile compounds in solid, liquid and gaseous samples
    - Inlets: Static and dynamic headspace samplers, solid phase micro-extraction (SPME), liquid auto-injectors, gas sampling valves
    - Detectors: Flame ionization, thermal conductivity, mass spectrometer (transmission quadrupole and time-of-flight)
  - Liquid Chromatography
    - High Performance Liquid Chromatography (HPLC)
      - Quantitation of additives, unknowns, contaminants
    - High Performance Liquid Chromatography / Mass Spectrometry (HPLC/MS)
      - Quadrupole/time of flight (QtoF): molecular identification and quantitation, extremely high mass accuracy, excellent selectivity and sensitivity
      - Ion Trap (QIT): capable of multiple MS/MS experiments, detailed molecular structural information, excellent selectivity and sensitivity

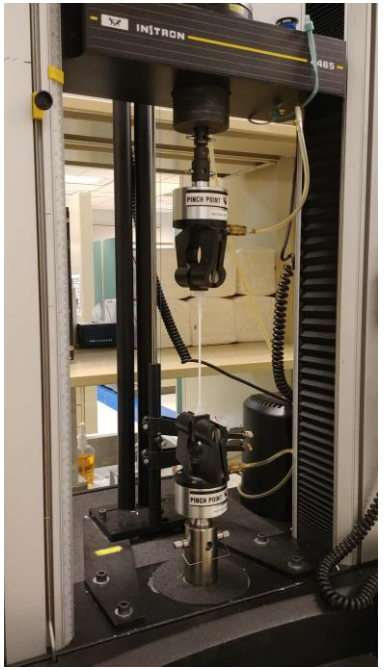
Analytical Laboratories

- **Microscopy Methods**
  - Field Emission Scanning Electron Microscope (FESEM) with scanning transmission electron microscope (STEM) accessory
  - Variable Pressure Scanning Electron Microscope (SEM) with energy dispersive x-ray spectrometry (EDS)
  - Ultra-Microtome with Cryo-Stage
  - Hot Stage Microscope
  - Optical Microscopy
  - Raman
  - Fourier Transform Infrared (FTIR)

Physical Testing Lab

- **Polymers (Resin) Testing**
  - Melt Index, Density, Ash
  - Lab Color
  - ASTM Type IV Physicals

- **Product Testing (Film, Pipe, Molded Articles)**
  - Physical Properties (tensile, impact, tear, COF, thickness, strain-hardening)
  - ESCR (NCLT, Bent Strip, 3-pt Bend)
  - Pipe (PENT, FNCT, LTHS)
  - Optics (Haze, Gloss, NAS)
  - Permeability (O2, WVTR)
  - Aging, Weathering
  - Adhesion, Heat Seal/Seal Strength



Physical Testing Lab – Pressure Pipe Testing

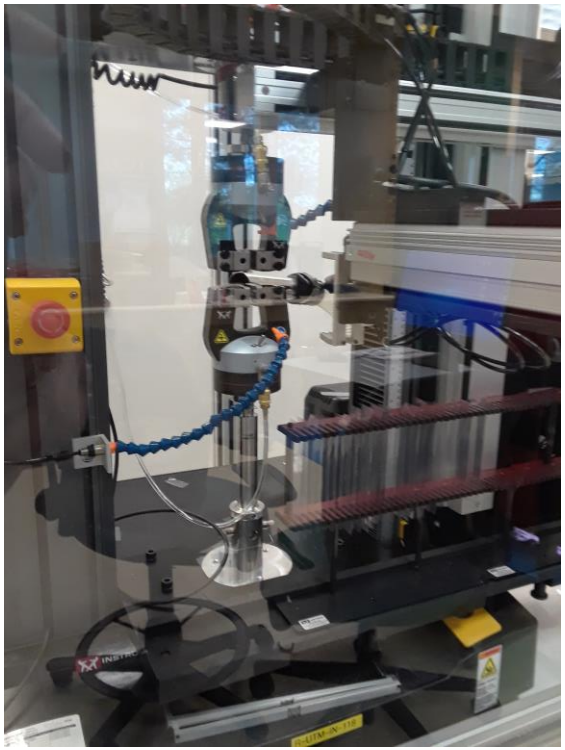
- PENT Testing Equipment
  - Slow Crack Growth Resistance

- FNCT Testing Equipment
  - Environmental Slow Crack Growth Resistance

Physical Testing Lab – Robotic Test Stations

- 3 Point Bend Flex Testing

- Film Tensile Properties Testing



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