If comprehensive material characterization during the development of innovative products is important to you, Thermo Electron Corporation opens new possibilities with the flexible, open-concept HAAKE PolyLab OS rheometer platform.

The system provides you with process-relevant material data including:

- Melting behavior
- Influence of additives
- Temperature stability
- Shear stability
- Melt viscosity

Furthermore, the rheometer supports you in process modeling activities such as:

- Compounding polymers with additives to reduce flammability, viscosity, etc.
- Scale-up extrusion processes by using different L/D ratios to extrapolate to your master process line.
- Simulating master processes using only as little as 50 g of material to optimize extrusion or mixing in respect to temperature and shear profile.
- Extrusion of strands, profiles or films in combination with rheological or optical measurements.

Consequently, you can optimize your process parameters, create test specimens or perform quality control on incoming and outgoing goods with regard to viscosity, dispersion or plasticizing behavior. With over 50 years of extensive experience in material characterization through our HAAKE product lines, Thermo Electron professionals are available worldwide to support you in the efficient development of your material and pilot processes.
RHEODRIVE
The basic unit of the HAAKE PolyLab OS system comprises all elements of a torque rheometer that are needed to drive the measuring system (precise speed controller) and to monitor the torque (accurate torque sensor) needed to process the test material.

- **Modularity**
  System architecture on the basis of an open industry standard for flexible connection of different sensors and systems

- **Ease of operation**
  Fast and simple connection of measuring attachments without changing application and operating software

- **Remote controller**
  Operate the system from a distance and observe the entire test from a different location.

- **Service & reliability**
  Reduce down-times with remote diagnostics and have the ability to change out components with pre-calibrated replacements.

- **Return on investment (ROI)**
  Time-saving instrument usage and meaningful results relative to the application increase product quality and reduce development time.

MEASURING SYSTEM
The measuring systems can be connected quickly to the RheoDrive and are equipped with a specific measuring, control and evaluation technology for the particular application.

Movable measuring attachments facilitate:

- **Handling** of heavy and hot parts (mixers, extruders, dies)
- **Integrated heating & cooling** to reduce plug-in connectors and thus the risk of wrong connections
- **Quick adaptation** of the system to simulate new process designs
- **True “plug & measure” concept** through multifunctional coupling in mechanical and electrical respects with an automatic software recognition system
- **Investment into the future**
  Open device concept ensures adaptability to future development needs

PERIPHERAL DEVICES
Peripheral devices such as feeding systems, application-specific screws, mixer rotors or extruder downstream equipment combine different modules to a complete downsized production line for the testing or small-scale production of new materials:

- **Extrudate cooling bath**
- **Take-off unit**
- **Blown film unit**
- **Inspection system**
- **Feeders**
- **Pelletizers**
- **Melt pumps**
- **Capillary rheometers**
EXPERIENCE COMBINED WITH THE LATEST TECHNOLOGY

The RheoDrive component of the HAAKE PolyLab OS system is state-of-the-art in respect to technology, connectivity and reliability. It controls all HAAKE measuring systems and monitors the results via host computer with proprietary software for Windows XP. Two RheoDrive versions are available. The RD 4 version has a 4 kW motor and is used primarily for standard "600" mixer and single-screw (19/25) experiments, whereas the more powerful RD 16 version with a 16 kW motor is recommended for all twin-screw experiments with the "24 mm PTW".

To test a material a defined speed (torque) is applied through a measuring system (mixer, extruder) and the material’s response is measured as torque. The torque measurement is performed via a special cell developed for the HAAKE PolyLab OS system that uses the proven measuring principle of high-resolution sensors of modern rotational rheometers. This provides high measuring accuracy combined with very high stability of the recorded signals. The optional multi-range torque sensor allows data gathering from very low to very high torque values without having to exchange transducers. If only informative torque values are needed, as in some extruder experiments, the standard data channel with motor current (calibrated to torque) may be sufficient.
MORE FLEXIBILITY THROUGH "PLUG & MEASURE"

The system architecture of the HAAKE PolyLab OS platform follows an open industry standard, which allows the connection of a variety of sensors and measuring systems. The standardized CANopen bus, a standard in the automotive industry, replaces the traditional instrument firmware. This guarantees a stable environment and the integration of external sensors to measure, e.g. electrical conductivity of a polymer melt during mixing, monitor the concentration of additives or humidity by means of optical spectroscopy (NIR), etc.

SPECIAL FEATURES

- Integrated measuring and control electronics
- Non-contact signal transmission
- High reliability for continuous operation
- High power (16 kW) and high speed (550 rpm) drives

The "PolySoft" application software is run by Microsoft XP with pull-down menus and "drop and drag" technology.

### Torque Specifications

<table>
<thead>
<tr>
<th>Type</th>
<th>Torque range</th>
<th>Resolution</th>
<th>Accuracy *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor current</td>
<td>400 Nm</td>
<td>1.0 Nm</td>
<td>5 % FSD</td>
</tr>
<tr>
<td>Torque transducer</td>
<td>400 Nm</td>
<td>0.1 Nm</td>
<td>0.15 % FSD</td>
</tr>
<tr>
<td>Dual range torque transducer</td>
<td>60 / 400 Nm</td>
<td>0.01 / 0.1 Nm</td>
<td>0.045 / 0.15 % FSD</td>
</tr>
</tbody>
</table>

* Repeatability: same user, same sample and same instrument

### Speed Specifications

<table>
<thead>
<tr>
<th>Type</th>
<th>Speed range</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>RheoDrive 4 kW</td>
<td>250 min⁻¹</td>
<td>0.1 min⁻¹</td>
</tr>
<tr>
<td>RheoDrive 16 kW</td>
<td>550 min⁻¹</td>
<td>0.1 min⁻¹</td>
</tr>
</tbody>
</table>
COMMUNICATION MADE EASY

The RheoDrive’s measuring and control dialogue is achieved through the integrated CANopen bus, which communicates with all connected systems and sensors. A USB or optional TCP/IP interface connects to the host computer.

“Plug & measure” is optimal for anybody who does not want to bother with interfaces and software settings. This principle allows the fastest exchange of sensor units in the market and the reliable connection with known and unknown devices, often needed for advanced research environments. “Plug & measure” also guarantees the connection of sensors that may not yet be developed but will be needed in the future for existing polymer testing systems. This ensures that the PolyLab OS platform preserves your investment.

Once a measuring attachment such as an extruder, mixer or compounding is docked onto the RheoDrive component, the integrated control module recognizes the configuration and automatically sets all device-related limits and characteristic values. The measuring ranges of the sensors are loaded automatically, just like the visualization of the measuring sensor is identified for measurement and calibration. The coded identification of the respective measuring attachment guarantees correct interaction between system components.

The Windows-based “PolySoft” software suite is the user interface comprised of several modules based on the monitor software. This time-saving software is included in the standard version of the RheoDrive.
The monitor software allows access to all control functions and measured data in the "Run Mode". It also defines the setup of the measuring systems if not automatically recognized. This manual operation is used to find optimum control settings (speed, temperature) for new and unknown materials. If the response of the test material is understood, a test procedure can be programmed to run measurements automatically using the mixer- or capillary software with integrated data evaluation. Different user level settings can be defined to set up tests or only to run measurements.

**IT’S MAIN FEATURES ARE**

- Job stream function for automatic tests and data evaluation as a time saver
- Customer-defined user levels to secure data integrity
- Data dump to MS Excel to further process data
- Visualization of installed system and actual test runs
- "Hot plugging" of measuring systems to enhance flexibility
- Remote supervision of a test run with an internet browser
MIXING, KNEADING, COMPOUNDING AND PLASTICIZING

In conjunction with the HAAKE PolyLab OS system’s powerful RheoDrive, Thermo offers a comprehensive range of flexible measuring mixers to handle a range of different applications. A typical mixer test is run at a defined speed (shear rate) versus time, and the material’s response is recorded as torque. The mixing chamber is temperature-controlled precisely by independent heating and cooling zones, but due to the frictional heat in the mixing bowl, a change in the material’s melt temperature is observed and recorded as measuring signal. This “Rheogram” (torque, melt temperature vs. time at constant speed) is characteristic for different materials or blends and often used as a “fingerprint” in Quality Control for incoming or outgoing product inspection. Different additives in type and concentration can be measured and quantified objectively through the melting behavior, consumed energy or melt viscosity (recorded torque).

TYPICAL INVESTIGATIONS

■ Testing the melting and degradation behavior of polymer melts
■ Quantifying viscosity when adding nano-particles or other additives
■ Testing the gelation- and plasticizing behavior of PVC dry-blends
■ Measuring the flow- and curing behavior of thermosetting plastics
■ Characterizing the influences of different additives such as carbon black, fillers, lubricants, accelerators or sulphur for rubber mixtures
■ Recording the masticating and vulcanizing behavior of elastomers
■ Measuring the oil absorption of carbon black
■ Quantifying the absorption of DOP for PVC dry-blends
■ Measuring the stable torque in regard to individual and combined influences of fillers and additives such as stabilizers, lubricants and color pigments
■ Testing high performance plastics to check processability
■ Performing electric conductivity measurements for rubber mixtures
Depending on the application, the Rheomix series measuring mixers are configured as follows:

- Exchangeable rotors with different geometries as standard
- Standard 3-piece measuring chamber for easy cleaning (front plate – center bowl – back stand)
- Conical mixer bowl and rotors for thermosetting plastics (easy removal of the cured mold through conical design)
- Large measuring chamber for producing approx. 500 g
- Air cooling and/or liquid temperature control
- Pneumatic or manual feeding
- Gas volume sensor
- Special surface treatments against wear or chemically aggressive materials

Different and new applications may require special setups that should be discussed with a Thermo application specialist. This will ensure the best measuring system for your site based on the comprehensive variety of available accessories for this product line.

### Technical Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Rheomix 600</th>
<th>Rheomix 610</th>
<th>Rheomix 540</th>
<th>Rheomix 3000</th>
<th>Rheomix 3010</th>
<th>Planetmix OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chamber volume</td>
<td>120 cm³</td>
<td>120 cm³</td>
<td>130.6 cm³</td>
<td>625 cm³</td>
<td>625 cm³</td>
<td>2500 cm³</td>
</tr>
<tr>
<td>– with rotors</td>
<td>69-90 cm³</td>
<td>69-90 cm³</td>
<td>58-100 cm³</td>
<td>310-541 cm³</td>
<td>310-541 cm³</td>
<td>2460 cm³</td>
</tr>
<tr>
<td>Material</td>
<td>Stainless steel</td>
<td>Stainless steel</td>
<td>Stainless steel</td>
<td>1.4301</td>
<td>1.4301</td>
<td>Stainless steel</td>
</tr>
<tr>
<td>Gear ratio</td>
<td>3:2 (optional 2:3)</td>
<td>1:1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. speed</td>
<td>250 min⁻¹</td>
<td>250 min⁻¹</td>
<td>250 min⁻¹</td>
<td>250 min⁻¹</td>
<td>250 min⁻¹</td>
<td>200 min⁻¹</td>
</tr>
<tr>
<td>Max. torque</td>
<td>160 Nm</td>
<td>160 Nm</td>
<td>160 Nm</td>
<td>300 Nm</td>
<td>300 Nm</td>
<td>50 Nm</td>
</tr>
<tr>
<td>Max. temperature</td>
<td>400 °C (opt. 500 °C)</td>
<td>350 °C (opt. 500 °C)</td>
<td>400 °C (opt. 500 °C)</td>
<td>400 °C (opt. 500 °C)</td>
<td>350 °C (opt. 500 °C)</td>
<td>150 °C</td>
</tr>
<tr>
<td>Temperature control</td>
<td>3 zones electric heating and air cooling</td>
<td>Heated with thermal liquid, circulator required</td>
<td>3 zones electric heating and air cooling</td>
<td>3 zones electric heating and air cooling</td>
<td>Heated with thermal liquid, circulator required</td>
<td>Heated with thermal liquid, circulator required</td>
</tr>
</tbody>
</table>
INDIVIDUAL APPLICATIONS REQUIRE SPECIAL SOLUTIONS

The proven single-screw laboratory extruders deliver reliable data captured during the extrusion process to verify process parameters (speed, energy, temperature) for unknown materials or to manufacture smaller quantities of a new polymer (as strands, sheet, pellets, blown films) during R&D. The extruders are equipped with measuring ports for melt pressure and melt temperature to study the process parameters along the extruder barrels. These barrels are available in different lengths (length/diameter ratio). A die can be connected to the end of the extruder barrel to form the polymer melt as strand or film. Special rheological dies (slit, rod, x-die) allow the determination of shear- and elongational viscosity at defined shear rates. Thermo offers a variety of screw geometries to customize the extrusion process with different compression ratios, venting and mixing sections. Wear-reduced screws and barrels increase the lifetime of the system. Standard feeders for pellets and special feeding systems for powders, pastes, liquids or highly viscous rubber complete the set up.

The following tests are typically performed with these laboratory extruders

- Testing melting behavior
- Testing individual and combined influences of additives (stabilizer, lubricant) and functional additives (anti-oxidation, UV-stabilizers, pigments and fillers)
- Extrudability of newly developed materials
- Manufacturing homogeneous melts
- Manufacturing films, foils, strands and profiles for optical and mechanical testing as well as outdoor exposure tests
- Measuring rheological behavior (viscosity, elasticity)
- Foam extrusion

Typical applications for single-screw extruders

- Extrusion of PVC compounds
- Blown films
- Thin flat films
- Rheological testing with special dies
- Extrusion of ceramic materials or PIM-compounds
**SPECIFICATIONS AND APPLICATIONS**

**Plasticizing and extrusion with single-screw measuring extruders**

A variety of single-screw extruders is available for diverse applications:

<table>
<thead>
<tr>
<th>Item</th>
<th>Rheomex 19/10</th>
<th>Rheomex 19/25</th>
<th>Rheomex 19/33</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screw diameter</td>
<td>19.05 mm (3/4”)</td>
<td>19.05 mm (3/4”)</td>
<td>19.05 mm (3/4”)</td>
</tr>
<tr>
<td>L/D</td>
<td>10</td>
<td>25</td>
<td>33</td>
</tr>
<tr>
<td>Material</td>
<td>Stainless steel nitrided DIN 1.8550</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. temperature</td>
<td>450°C</td>
<td>450°C</td>
<td>450°C</td>
</tr>
<tr>
<td>Max. pressure</td>
<td>700 bar</td>
<td>700 bar</td>
<td>700 bar</td>
</tr>
<tr>
<td>Max. speed</td>
<td>250 min⁻¹</td>
<td>250 min⁻¹</td>
<td>250 min⁻¹</td>
</tr>
<tr>
<td>Max. torque</td>
<td>160 Nm</td>
<td>160 Nm</td>
<td>160 Nm</td>
</tr>
<tr>
<td>Heating zones</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Cooling</td>
<td>Air</td>
<td>Air</td>
<td>Air</td>
</tr>
<tr>
<td>Application</td>
<td>Profile extrusion and rheological tests on unvulcanized rubber or elastoplastics</td>
<td>Profile and sheet extrusion, rheological tests for standard thermoplas materials</td>
<td>Extended barrel and screws for special applications e.g. foaming.</td>
</tr>
<tr>
<td>Options</td>
<td>Separate controllable feed roller for rubber</td>
<td>Additional sensor ports, back force sensor, wear resistance material, chemical resistance material</td>
<td>Additional sensor ports, back force sensor, wear resistance material, chemical resistance material</td>
</tr>
</tbody>
</table>
CONTINUOUS COMPOUNDING WITH TWIN-SCREW EXTRUDERS

Twin-screw laboratory extruders from Thermo have a proven record in continuous compounding with feed-dosing of different additives (liquid or solid) along the extruder barrel. The combination of a twin-screw extruder unit with additional sensors offers the ability to measure material properties of the melt during processing. The following properties and data can be derived from an experiment or test run in the early part of the lifecycle of a new product:

- Viscosity and flow behavior of the compound
- Extrudability and scale-up data
- Predictions for the injection molding process
- Morphology of polymer and nano-composites
- Recycling properties and re-usability of the polymer
- Influence of screw geometry on processability
- Decomposition of biopolymers
### TYPICAL APPLICATIONS FOR TWIN-SCREW EXTRUDERS

- Compounding of master batches
- Filling and reinforcing plastics
- Metering additives and venting volatile components
- Food processing
- Color matching of powder coatings
- Processing high performance and engineering polymers
- Extruding and mixing ceramic compounds
- Integrated rheometry with add-on melt pump and rheological dies

A variety of twin-screw extruders is available for these applications:

<table>
<thead>
<tr>
<th>Item</th>
<th>PTW 16/25</th>
<th>PTW 16/40</th>
<th>PTW 24/28</th>
<th>PTW 24/40</th>
<th>CTW 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screw diameter</td>
<td>16 mm</td>
<td>16 mm</td>
<td>24 mm</td>
<td>24 mm</td>
<td>Conical</td>
</tr>
<tr>
<td>L/D</td>
<td>25</td>
<td>40</td>
<td>28</td>
<td>40</td>
<td>- -</td>
</tr>
<tr>
<td>Screw setup</td>
<td>Variable</td>
<td>Variable</td>
<td>Variable</td>
<td>Variable</td>
<td>3 options</td>
</tr>
<tr>
<td>Gear ratio</td>
<td>1:5.4</td>
<td>1:5.4</td>
<td>1:2</td>
<td>1:2</td>
<td>1:1</td>
</tr>
<tr>
<td>Rotating direction</td>
<td>Co</td>
<td>Co</td>
<td>Co</td>
<td>Co</td>
<td>Counter</td>
</tr>
<tr>
<td>Max. screw speed</td>
<td>1100 min^{-1}</td>
<td>1100 min^{-1}</td>
<td>1100 min^{-1}</td>
<td>1100 min^{-1}</td>
<td>250 min^{-1}</td>
</tr>
<tr>
<td>Max. temperature</td>
<td>350 °C (opt. 450 °C)</td>
<td>350 °C (opt. 450 °C)</td>
<td>350 °C (opt. 450 °C)</td>
<td>350 °C (opt. 450 °C)</td>
<td>450 °C</td>
</tr>
<tr>
<td>Max. pressure</td>
<td>100 bar</td>
<td>100 bar</td>
<td>100 bar</td>
<td>100 bar</td>
<td>700 bar</td>
</tr>
<tr>
<td>Max. screw speed</td>
<td>1100 min^{-1}</td>
<td>1100 min^{-1}</td>
<td>1100 min^{-1}</td>
<td>1100 min^{-1}</td>
<td>250 min^{-1}</td>
</tr>
<tr>
<td>Max. torque</td>
<td>130 Nm</td>
<td>130 Nm</td>
<td>180 Nm</td>
<td>180 Nm</td>
<td>200 Nm</td>
</tr>
<tr>
<td>Heating zones</td>
<td>7</td>
<td>10</td>
<td>7</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Cooling</td>
<td>Convection</td>
<td>Convection</td>
<td>Internal water circuit</td>
<td>Internal water circuit</td>
<td>Air</td>
</tr>
<tr>
<td>External heaters</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Feeding zone</td>
<td>Cooled</td>
<td>Cooled</td>
<td>Cooled</td>
<td>Cooled</td>
<td>Cooled</td>
</tr>
<tr>
<td>Additional Feeding / Venting</td>
<td>2 Top</td>
<td>3 Top</td>
<td>2 Top, 1 Side</td>
<td>3 Top, 2 Side</td>
<td>- -</td>
</tr>
<tr>
<td>Sensor ports</td>
<td>(1/2” UNF)</td>
<td>(1/2” UNF)</td>
<td>(1/2” UNF)</td>
<td>(1/2” UNF)</td>
<td>2 (1/2” UNF)</td>
</tr>
<tr>
<td>Options</td>
<td>15 L/D extension, additional feeding ports, additional sensor ports</td>
<td>Additional feeding ports, additional sensor ports</td>
<td>Additional feeding ports, additional sensor ports</td>
<td>Additional feeding ports, additional sensor ports</td>
<td>Backforce sensor, additional sensor ports</td>
</tr>
</tbody>
</table>
MODERN SENSORS FOR ON-LINE CHARACTERIZATION

Sensors with CAN bus can be connected directly to the PolyLab OS system, and sensors without CANopen bus can be integrated using a special adapter to convert the analog measuring signals.

DYNAMIC RHEOLOGICAL SPECTRUM

The Institute for Dynamic Material Testing at the University of Ulm (IdM) has developed a new rheometer sensor that implements dynamic squeeze flow with a piezoelectric actuator. With this sensor it is now possible to record over four decades of frequency of the material spectrum of a polymer melt in a few minutes. The typical results from laboratory rheometers, e.g. $G'$, $G'' = f$ (frequency) and the relaxation spectrum are captured on-line during the compounding process. Molecular weight and molecular weight distribution can be determined with proprietary HAAKE software. The specific advantage over conventional devices is the small size of the rheometer and the user-friendly, quick-connection made possible via a pressure sensor port (1/2” UNF).

BETTER PRODUCTS THROUGH INNOVATIVE SENSORS

A variety of on-line sensors is available for the characterization of products during processing.

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torque sensor</td>
<td>Viscosity, degradation, energy consumption</td>
</tr>
<tr>
<td>Pressure sensor</td>
<td>Extrudability, flow resistance</td>
</tr>
<tr>
<td>Temperature sensor</td>
<td>Melt temperature, frictional heat</td>
</tr>
<tr>
<td>Conductivity sensor</td>
<td>Electric conductivity of compound</td>
</tr>
<tr>
<td>Gas volume sensor</td>
<td>Gas evolution during processing</td>
</tr>
<tr>
<td>PAV sensor (squeeze-flow rheometer)</td>
<td>Rheological spectra, MW, MWD</td>
</tr>
<tr>
<td>Optical spectroscopy (NIR)</td>
<td>Concentration of additives, humidity</td>
</tr>
<tr>
<td>Color sensor</td>
<td>Color code ($L^<em>, a^</em>, b^*$)</td>
</tr>
</tbody>
</table>
COLOR MEASUREMENT ON-LINE
An optical color sensor delivers readily color-metric information (L*, a*, b*) on-line in the melt with the help of a UV/VIS spectrometer. The intelligent software correlates color data on-line and avoids time- and labor-intensive laboratory analyses of the finished product.

OPTICAL SPECTROSCOPY WITH CHEMO-METRIC SOFTWARE (NIR)
Optical methods often used in the laboratory can now be transferred to the processing environment (e.g. to an extruder or mixer). Near infrared spectroscopy (NIR) or Raman Spectroscopy are the preferred methods to analyze polymers during processing. This testing delivers on-line data about the changes in concentration and purity of additives or humidity during material processing.
REMOTE MONITORING
The monitoring of a running test series via web browser on a PC or handheld organizer (PDA) is possible with this powerful rheometer platform, as is the definition and composition of the entire test setup in a "job stream". These tasks can then be executed automatically by the software. The "job stream" includes the setup, the test run, and any desired data evaluation and report output. Alarms, error messages and hints for the operator are displayed automatically via pop up windows. Consequently, safe test runs can be guaranteed, along with substantial flexibility and information for laboratory personnel.

MORE SAFETY
Instrument downtime during process development can have serious cost consequences both in terms of costly repairs and project delays. Remote diagnosis of the HAAKE PolyLab OS System by Thermo-trained engineers can determine when an on-site service call is needed for preventive maintenance. This can eliminate machine failure and speed the problem-solving process to reduce costs. The PolyLab OS System incorporates a comprehensive log- or history function that stores all alarm/error messages with real-time data in order to be able to reconstruct events. Log data can be read out via safe network connections or mailed directly to the support center. The support center can either correct the problem remotely or ensure that on-site service is provided. Calibrated assemblies can be shipped immediately and be replaced easily by the user or local engineers. Downtime risk is reduced dramatically to ensure project deadlines are preserved.
SIMULATING PRODUCTION CONDITIONS IN THE PILOT PLANT

Dies and post-extrusion units are used in addition to extruders for testing the rheological characteristics and processability of polymers and for producing laboratory test samples. Dies enable the defined geometries for profiles, films or rheological measurements. The post-extrusion HAAKE Postex can transport the extruded material downstream and prepare it for further tests. Both dies and Postex units closely resemble their larger-scale "big brothers" to ensure production-like testing is guaranteed. Integrated measuring sensors further enhance the application possibilities in the laboratory or pilot plant.

MEASURING DIES IN LABORATORY APPLICATIONS

Measuring dies create profiles of a defined geometry to make special test specimens that may be inspected with other techniques or to simulate a production process such as film blowing, wire coating or catheter extrusion. Temperature and pressure probes in the die monitor the behavior of the sample on-line. The flow geometries accommodate the behavior of different polymer types during extrusion. A variety of dies is available for the range of HAAKE extruders:

- blown film
- flat film
- pellet
- pipe
- fibre
- coated wire
- screen life test
- catheter

The PolyLab OS System can be transformed into a powerful extrusion capillary rheometer when used together with rheological dies. Rheological data such as shear stress and viscosity functions can be evaluated. These are of great importance for the design of injection molds, extruders and extruder screw design. The shear rate ranges experienced during polymer processing can be fully covered using both rod and slit capillary dies.
POSTEX = POST-EXTRUSION

The handling of the often hot and still formable extruded material is an important part of extrusion testing. This greatly influences the material characteristics and surface finish. These tasks are carried out by the Postex systems to ensure that your requirements for the extruded material are fulfilled. Apart from the defined take-off and preparation of extrudate for further analysis, Postex systems also enable the laboratory and processing technician to carry out tests in conditions similar to those experienced during production. The production of small batches of finished products is a frequent application for the HAAKE Postex systems, especially when alterations to the formulation and product processing need to be evaluated.

The Postex family consists of

- Blown film take-off
- Sheet, tape and ribbon take-off
- Wire coating take-off
- Cooling water bath
- Conveyor belt
- Pelletizer/face-cut pelletizer
HAAKE POLYLAB OS, THE COMPLETE MEASURING SYSTEM FOR PLASTICS

The PolyLab OS system has been designed to measure polymers and similar processable materials under process relevant conditions:

- in the process
- at the end of the process
- after the process

Having complete information about characteristics in the polymer’s processing behavior, its molecular behavior and even in its macroscopic appearance as a solid is critical to sufficiently define the material.

- **in the process**

  The measurement possibilities and examples of results are described on page 14.

- **at the end of the process**

  Examples of capabilities have been mentioned on page 18, but there are many more options, e.g. a special x-die to quantify the elongational properties of a material, a rod die to monitor the behaviour under very high shear rates up to $10^5$ and/or slit dies to make the molecular behavior more visible. In the transition from a melt to a solid material, right after the die, the built up stress/shear in the melt can be monitored as die swell (elastic material properties), shark skin (shear-related properties) or melt fracture.

- **after the process**

  Polymers as solid materials are usually shaped as a thin film for inspection of dispersion quality, detection of impurities and sometimes even to check the mechanical strength by stretching the foil.

  For many of these new techniques, technical reports and product flyers are available on request.
Thermo Electron Corporation –
Control Technologies

Thermo’s Control Technologies business unit is a global provider of Temperature Control and Material Characterization products. The Temperature Control product line comprises precision liquid temperature control equipment that includes recirculating baths, chillers and heat exchangers for laboratory and process applications. For more information, please visit www.thermo.com/tc. Thermo’s Material Characterization products analyze and measure viscosity, elasticity, processability and temperature-related mechanical changes of plastics, food, cosmetics, pharmaceuticals and coatings, plus a wide variety of liquids or solids. Detailed information is provided at www.thermo.com/mc.

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