Pendulum Impact Instruments and Melt Flow Plastometers with new functions

Helmut Fahrenholz
ZwickRoell, Ulm
Pendulum Impact for Plastics
Melt Flow Plastometers
The new controller
Agenda

Pendulum Impact

Melt Flow Rates
In the conventional method, impact resilience is measured by height difference and the mass of the pendulum hammer.

\[
E = m \cdot g \cdot h \\
E_1 = m \cdot g \cdot h_1 \\
E_2 = m \cdot g \cdot h_2 \\
E_{\text{specimen}} = m \cdot g \cdot (h_1 - h_2)
\]

- E  – energy
- m  – mass of the pendulum hammer
- h  – drop height
- g  – gravity acceleration (9.81 m/s\(^2\))
Pendulum Impact – Working principle

Four methods are currently applied: Charpy, Izod, tensile-impact and in the German automotive industry also Dynstat.

- **Charpy**
  - ISO 179-1, -2, ASTM D 6110

- **IZOD**
  - ISO 180, ASTM D 256

- **Tensile Impact**
  - Here: ISO 8256 method A

- **Dynstat**
  - DIN 53435
The type of break is an integral part of the result. Only same types of breaks supply comparable results.

Standardized types of break:

N – non-break (no valid result)
P – partial break
(H – hinge break)
C – complete break

The most frequent type of break within a test series determines the results to be used in the statistics.
Pendulum Impact – Working principle

There is not result without specimen break!

Guidance according ISO standards on how to obtain break

→ The preferred method is to use unnotched specimen
  if no valid break types can be achieved
→ Use specimen with type A notch (0.25 mm)
  If still no valid break types can be achieved
→ Use specimen with type C notch (0.1 mm)
  If still no valid break types can be achieved
→ Use the tensile-impact method
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Instrumented pendulum impact means force measurement during impact. This offers supplementary result acquisition.

- used in R&D, TS and QA
- Charpy
- Izod
- tensile impact
- Fracture mechanics
Instrumented Impact Testing

The force-travel diagram provides supplementary materials data obtained under high deformation rates.

\[ E_p = F \cdot s \]

- \( E \) – energy
- \( F \) – force
- \( s \) – travel

- The conventional method may show same results for completely different stress-strain behavior.
- Instrumented impact methods allow to distinguish such situations, while conventional impact can’t.
- Break types can automatically be detected.
- Information about fracture mechanical characteristics can be obtained.
Several points in a travel-deflection diagram are characteristic for instrumented Charpy tests.

The specimen's natural frequency has a square-root function with the material's tensile modulus.

- $F_M$ – maximum force
- $s_M$ – deflection at maximum force

$F_1$ – First impact maximum

No contact between pendulum hammer and specimen
A complete product range for pendulum impact testing

5.5 / 25 / 50 Joule universal, digital

5 Joule ISO

Notch cutting machine

Manual notch cutter

Instrumentation

Automation

Charpy

Izod

tensile impact

Dynstat

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HIT5P pendulum impact tester

The HIT5P is a compact pendulum impact instrument only for ISO tests

- Compact dimensions
- Maximum energy of 5 joules
- Covers Charpy tests to ISO standard (2.9 m/s)
- Covers tensile-impact up to 5 J to method A of the ISO standard (2.9 m/s)
HIT5.5P pendulum impact tester for up to 5.5 joules

- universal impact instrument
- covers ISO and ASTM
- Charpy, Izod, Tensile-impact, Dynstat
- 3 impact speeds up to 3.5 m/s
- potential energy up to 5.5 J

Key advantages:

- automatic pendulum identification
- low-vibration carbon twin-rod
- easy vice and pendulum change
- Option for instrumented testing
HIT25P and HIT50P pendulum impact tester

The HIT 25P and HIT 50 P cover all current standards

- Universal impact instrument
- covers ISO and ASTM
- Charpy, Izod, Tensile-impact, Dynstat
- 4 impact speeds up to 3.8 m/s
- potential energy up to 25 / 50 J

Advantages:

- pendulum identification
- low-vibration carbon twin-rods
- easy fixture and pendulum change
- Option for instrumented testing
The new controller uses the same user interface as testXpert III

- Stand alone function without PC
- Automatic recognition of the hammer and the attributed calibration
- Input of specimen dimensions and remaining width for notched specimen
- Input of the type of failure
- Visualisation of calculated results and statistics
- Visualisation of the test curve for instrumented tests
- Printing of test protocols
- Ethernet network connection
- Export of results to USB memory sticks
- User administration, access limitation
- Full integration with testXpert III software

The new controller is operated by a touchscreen.
testXpert III

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1. Pendulum Impact
2. Melt Flow Rates
Standards

ZwickRoell extrusion plastometers fulfill all commonly used global testing standards

- ISO 1133 (part 1 and part 2)
- ASTM D 1238
- JIS K 7210
  (Version 10/1999, identical to ISO 1133)
- ASTM D 3364 (specific for PVC)
Operating principle

Melt flow rates represent the speed of extrusion of a polymer under defined temperature, through a defined die and under a defined constant pressure.

www.zwickroell.com
Method A

The melt-mass flow-rate is determined by weighting extrudates cut-off in known intervals.

Method A – MFR (Melt Mass Flow Rate)

The extrudates are cut off at constant time intervals.

- cut-off lengths between 10 and 20mm
- the time interval must not exceed 240s
- maximum test time 25 min.

The cut-offs are weighed on analytical scales and the result is stated in g/10min.

Range of application

- simple manual testing (low specimen volumes)
- filled plastics
The melt volume rate is determined from piston travel measurement.

Method B – MVR (Melt Volume Rate)

Measurement of piston travel per time and conversion to extruded volume per time

- measurement interval can be travel or time-controlled
- time interval shall not exceed 240s
- maximum test time 25 min.

The result is stated in cm³/10min.

Range of application

- medium to high specimen volumes
- more automatic test sequences
### ISO versus ASTM

ISO and ASTM procedures are different in several conditions, but the same equipment can be used for both standards.

<table>
<thead>
<tr>
<th>Topic</th>
<th>ISO 1133-1</th>
<th>ISO 1133-2</th>
<th>ASTM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ISO 1133-1</strong></td>
<td>(moisture sensitive &amp; time dependend materials)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Filling Quantity</strong></td>
<td>3 to 5 g for flowrates 0.1 to 0.5 g/10min</td>
<td>not standardized</td>
<td>2.5 to 3 g for flowrates 0.15 to 1 g/10min</td>
</tr>
<tr>
<td></td>
<td>4 to 6 g for flowrates &gt; 0.5 g/10min</td>
<td>4 - 5 g for flowrates 10 to 20 g/10min</td>
<td>3 to 5 g for flowrates &gt; 1 g/10min</td>
</tr>
<tr>
<td></td>
<td>4 to 8 g for flowrates &gt; 3.5 g/10min</td>
<td>5 - 6 g for flowrates &gt; 20 g/10min</td>
<td>4 to 8 g for flowrates &gt; 3.5 g/10 min</td>
</tr>
<tr>
<td><strong>Preheat</strong></td>
<td>loading of the material charge within 1 min</td>
<td>loading of the material charge within 1 min</td>
<td>loading of the material charge within 1 min</td>
</tr>
<tr>
<td></td>
<td>5 min of preheat time, followed by the time</td>
<td>5 min of preheat time, start position 50 mm must be</td>
<td>7 ± 0.5 min until start of measurements at a</td>
</tr>
<tr>
<td></td>
<td>needed to reach the start position 50 mm (no exact tolerance for the maximum preheat time)</td>
<td>reached at 5.75 ± 0.25 min after charging was</td>
<td>position of 46 ± 2 mm (double condition!)</td>
</tr>
<tr>
<td><strong>Pre-compaction</strong></td>
<td>Piston may be loaded, unloaded of partly loaded during pre-heat. Purging must be completed latest 2 min before measurements begin and shall not take longer 1 min.</td>
<td>No specific limitations. Piston may be loaded, unloaded of partly loaded during pre-heat.</td>
<td>Purging must be completed latest 2 min before measurements begin.</td>
</tr>
<tr>
<td><strong>Method A</strong></td>
<td>Maximum time per measurement = 240 s</td>
<td>Maximum time per measurement = 240 s</td>
<td>Measurement at fixed time intervals:</td>
</tr>
<tr>
<td></td>
<td>Maximum time in the barrel = 25 min</td>
<td>Maximum time in the barrel = 25 min</td>
<td>6 min for MFR 0.15 to 1 g/10min</td>
</tr>
<tr>
<td></td>
<td>Any cutting time allowed, preferred filament length is 10 to 20 mm</td>
<td>Any cutting time allowed, provided that the filament length is &gt; 10 mm. Use all cut filaments within the avail. 30 mm of piston travel for the result calculation.</td>
<td>3 min for MFR 1 to 3.5 g/10min</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 min for MFR 3.5 to 10 g/10min</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.5 min for MFR 10 to 25 g/10 min</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.25 min for MFR &gt; 25 g/10 min</td>
</tr>
<tr>
<td><strong>Method B</strong></td>
<td>Maximum time per measurement = 240 s</td>
<td>Maximum time per measurement = 240 s</td>
<td>MVR up to 10 --&gt; 6.35 ± 0.25 mm</td>
</tr>
<tr>
<td></td>
<td>Maximum time in the barrel = 25 min</td>
<td>Maximum time in the barrel = 25 min</td>
<td>MVR &gt; 10 --&gt; 25.4 ± 0.25 mm</td>
</tr>
<tr>
<td></td>
<td>Every possible measurement travel and times are allowed. Standard indicates preferred values.</td>
<td>Fixed measurement travel between 20 and 30 mm</td>
<td></td>
</tr>
</tbody>
</table>
Extrusion plastometers

The Xflow series – the ideal extrusion plastometer for every testing situation.

- **Cflow Compact**
  - manual instrument for goods inwards checks
  - fast, reliable testing to Method A

- **Mflow Modular**
  - modular instrument for higher testing volumes
  - low-cost entry, capable of successive expansion
  - method A and method B

- **Aflow All-round**
  - handy all-rounder for 24-hour operation
  - optimum test sequence - efficient and reliable
  - Method A, B, C and D

Higher testing volume, higher level of automation, greater convenience
Next generation Xflows – modern and designed for tomorrow’s technology.

- Flexible use with or without a PC
- Intuitive and workflow-based right from the start!
- Quick familiarization with user management
The new controller
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Configure test
Run test

Time: -- -- s
Temperature: 0.0 °C
Travel: -- -- mm

Default
○ Target temperature 50.0 °C

10:07
User: Tester
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<table>
<thead>
<tr>
<th>Time</th>
<th>- - - s</th>
<th>Temperature</th>
<th>0.0 °C</th>
<th>Travel</th>
<th>- - - mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default</td>
<td>Target temperature 50.0 °C</td>
<td>10:07</td>
<td>User: Tester</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Configure test
Run test
Manage Results
<table>
<thead>
<tr>
<th>Time</th>
<th>s</th>
<th>Temperature</th>
<th>°C</th>
<th>Travel</th>
<th>mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default</td>
<td></td>
<td></td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Target temperature 50.0 °C

User: Tester
### TEST CONFIGURATION

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extrusion test method</td>
<td>B inclusive A</td>
</tr>
<tr>
<td>Test conditions</td>
<td>Free input</td>
</tr>
<tr>
<td>Target temperature</td>
<td>50.0 °C</td>
</tr>
<tr>
<td>Test load</td>
<td>2.16 kg</td>
</tr>
<tr>
<td>Permissible temperature deviation</td>
<td>1.0 °C</td>
</tr>
</tbody>
</table>

Default: Target temperature 50.0 °C  | 10:07 | User: Tester
**TEST CONFIGURATION**

- **Compaction and pre-heating**
- **Measurement**
- **Specimen data**

- **Measurement begin**
  - Position
  - Time

- **Position at measurement begin**
  - 50.0 mm

- **Number of extrudates**
  - 5

- **Measurement**
  - Travel
  - Time

- **Measurement travel Δs**
  - 2.0 mm

**Target temperature 50.0 °C**

**User: Tester**

**Default**

**Date:** October 2019
<table>
<thead>
<tr>
<th>TEST CONFIGURATION</th>
<th>re-heating</th>
<th>Measurement</th>
<th>Specimen data</th>
<th>End of test</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔️ Number of extrudates</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✔️ MFR mean value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>g/10 min</td>
</tr>
<tr>
<td>✔️ MFR single values</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>g/10 min</td>
</tr>
<tr>
<td>✔️ MVR mean value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>cm³/10 min</td>
</tr>
<tr>
<td>✔️ MVR single values</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>cm³/10 min</td>
</tr>
<tr>
<td>✔️ Density single values</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>g/cm³</td>
</tr>
</tbody>
</table>

Default

Target temperature 50.0 °C

User: Tester

10:08
<table>
<thead>
<tr>
<th>Time</th>
<th>- - - s</th>
<th>Temperature</th>
<th>0.0 °C</th>
<th>Travel</th>
<th>- - - mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default</td>
<td></td>
<td>Target temperature 50.0 °C</td>
<td></td>
<td>10:07</td>
<td>User: Tester</td>
</tr>
</tbody>
</table>
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October 2019

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RUN TEST  Temperature-Travel  Live MVR  Results

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>Temperature (°C)</th>
<th>Travel (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default</td>
<td>0.0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>☀ Target temperature 190.0 °C</td>
<td>10:09</td>
</tr>
</tbody>
</table>
Pendulum Impact Instruments and Melt Flow Plastometers with new functions

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RUN TEST | Temperature-Travel | Live MVR | Results

<table>
<thead>
<tr>
<th>Kolbengeschw. in cm³/10 min</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0,00</td>
<td>0,00</td>
</tr>
<tr>
<td>10,00</td>
<td>100,00</td>
</tr>
<tr>
<td>20,00</td>
<td>200,00</td>
</tr>
<tr>
<td>30,00</td>
<td>300,00</td>
</tr>
<tr>
<td>40,00</td>
<td>400,00</td>
</tr>
<tr>
<td>50,00</td>
<td>500,00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Prüfzeit in s</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0,00</td>
<td>0,00</td>
</tr>
<tr>
<td>100,00</td>
<td>100,00</td>
</tr>
<tr>
<td>200,00</td>
<td>200,00</td>
</tr>
<tr>
<td>300,00</td>
<td>300,00</td>
</tr>
<tr>
<td>400,00</td>
<td>400,00</td>
</tr>
<tr>
<td>500,00</td>
<td>500,00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>- - - s</th>
<th>Temperature</th>
<th>0.0 °C</th>
<th>Travel</th>
<th>- - - mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default</td>
<td>- - -</td>
<td>Target temperature 190.0 °C</td>
<td>10:09</td>
<td>User: Tester</td>
<td></td>
</tr>
<tr>
<td>Index</td>
<td>MFR g/10 min</td>
<td>Mean MFR g/10 min</td>
<td>MVR cm³/10 min</td>
<td>Mean MVR cm³/10 min</td>
<td>Density g/cm³</td>
</tr>
<tr>
<td>-------</td>
<td>--------------</td>
<td>--------------------</td>
<td>---------------</td>
<td>---------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>1</td>
<td>31.339</td>
<td>30.772</td>
<td>21.916</td>
<td>21.519</td>
<td>1.430</td>
</tr>
<tr>
<td>2</td>
<td>24.157</td>
<td></td>
<td>16.893</td>
<td></td>
<td>1.430</td>
</tr>
<tr>
<td>3</td>
<td>30.205</td>
<td></td>
<td>21.123</td>
<td></td>
<td>1.430</td>
</tr>
<tr>
<td>4</td>
<td>22.767</td>
<td></td>
<td>15.921</td>
<td></td>
<td>1.430</td>
</tr>
</tbody>
</table>

**Time**

Default

○ Target temperature 190.0 °C
- Einfaches Schwenken vom Vorkompaktieren in die Prüfposition
<table>
<thead>
<tr>
<th>Time</th>
<th>- - - s</th>
<th>Temperature</th>
<th>0.0 °C</th>
<th>Travel</th>
<th>- - - mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default</td>
<td>- - -</td>
<td>- - -</td>
<td>- - -</td>
<td>- - -</td>
<td>- - -</td>
</tr>
</tbody>
</table>

- Target temperature 50.0 °C  
- 10:07  
- User: Tester  

Zwick/Roell  

Configure test  
Run test  
Manage Results
<table>
<thead>
<tr>
<th>Time</th>
<th>Temperature</th>
<th>Travel</th>
<th>Target temperature</th>
<th>Time</th>
<th>User</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.0 °C</td>
<td></td>
<td>190.0 °C</td>
<td>10:09</td>
<td>Tester</td>
</tr>
</tbody>
</table>
### Units

<table>
<thead>
<tr>
<th>Stroke units</th>
<th>mm</th>
<th>in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>°C</td>
<td>°F</td>
</tr>
<tr>
<td>Date</td>
<td>DD:MM:YYYY</td>
<td>YYYY/MM/DD</td>
</tr>
</tbody>
</table>

### Settings

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>Temperature</th>
<th>Travel</th>
<th>Distance (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default</td>
<td>0.0 °C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Target temperature 190.0 °C

User: Tester

Date: 10:10
Plastometer product range