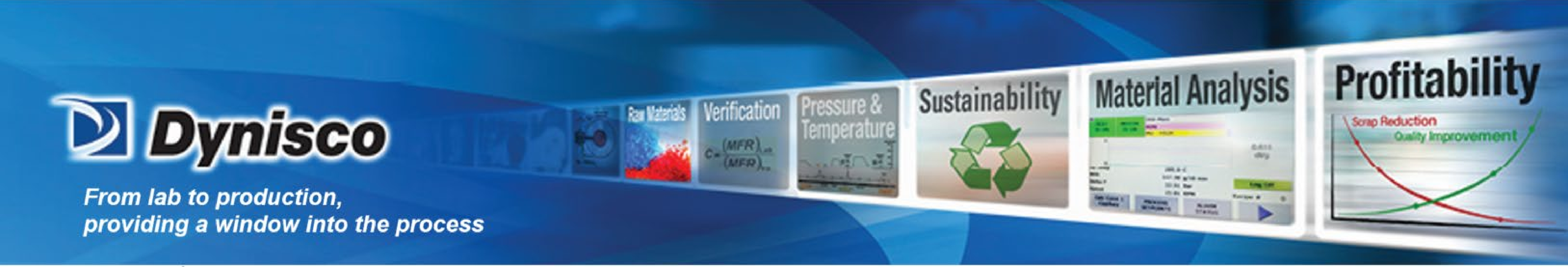

LMI Melt Flow Rate Test

Applications & Calculation

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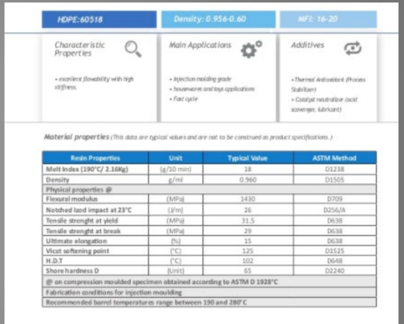
Outline

- ❖ Melt Flow Rate Test Applications
- ❖ LMI Melt Flow Rate Tester
- ❖ Method A
- ❖ Method B
- ❖ Method A to B Conversion
- ❖ Operation Points
- ❖ Other Applications (Shear thinning behavior, intrinsic viscosity, and thermal stability)

Melt Flow Rate Test Applications & Benefits

Standardized measure of flow characteristic of polymer melts at a single point specific condition

ASTM D1238
ISO 1133



HDPE:60518 | Density: 0.956-0.60 | MFI: 16-20

Characteristic Properties
- excellent flowability with high stiffness

Main Applications
- Injection molding grade
- housewares and toys applications
- Fast cycle

Additives
- Thermal Antioxidant (Process Stabilizer)
- Catalyst neutralizer (acid scavenger, lubricant)

Material properties *(This data are typical values and are not to be construed as product specifications.)*

Resin Properties	Unit	Typical Value	ASTM Method
Melt Index (190°C/ 2.16Kg)	(g/10 min)	18	D1238
Density	g/ml	0.960	D1505
Physical properties @			
Flexural modulus	(MPa)	1430	D709
Notched Izod impact at 23°C	(J/m)	26	D256/A
Tensile strenght at yield	(MPa)	31.5	D638
Tensile strenght at break	(MPa)	29	D638
Ultimate elongation	(%)	15	D638
Vicat softening point	(°C)	125	D1525
H.D.T	(°C)	102	D648
Shore hardness D	(Unit)	65	D2240
@ on compression moulded specimen obtained according to ASTM D 1928°C			
Fabrication conditions for injection moulding			
Recommended barrel temperatures range between 190 and 280°C			

https://www.slideshare.net

Quality control / lot to lot consistency

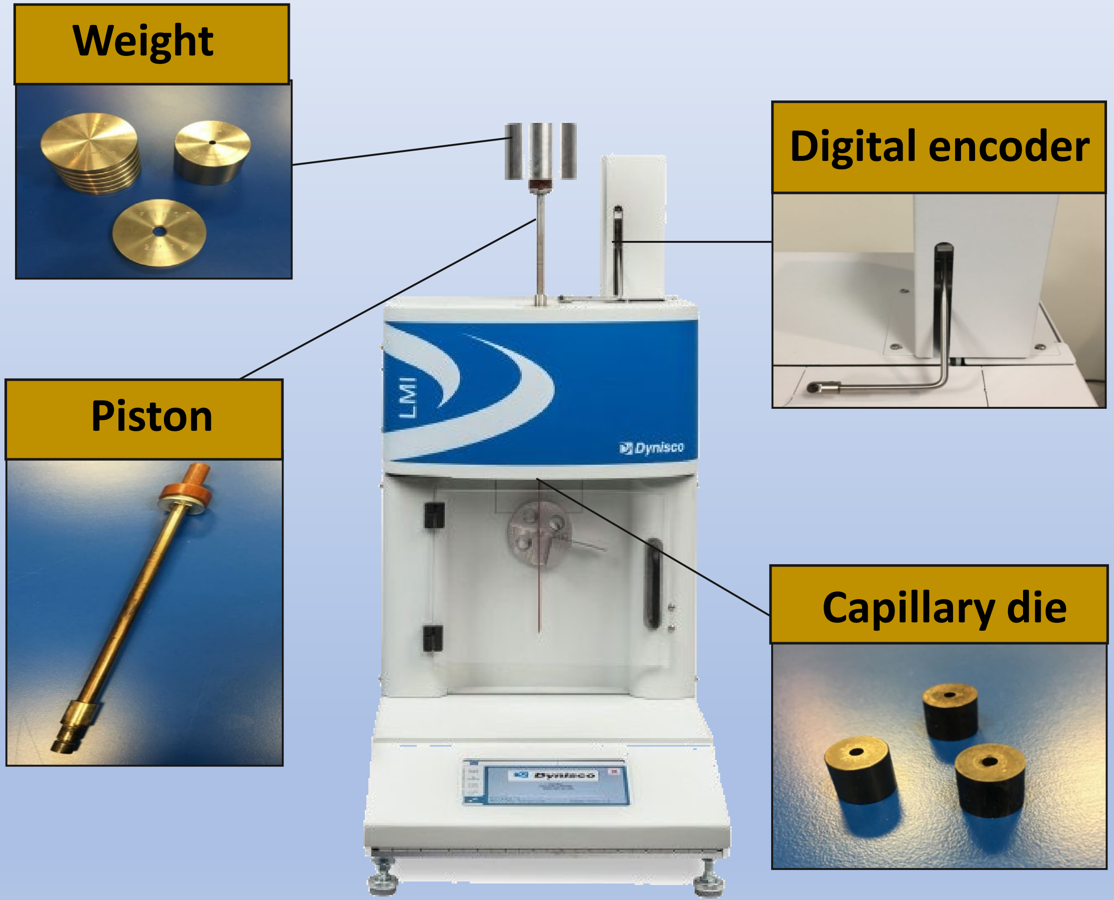
http://www.freedigitalphotos.net

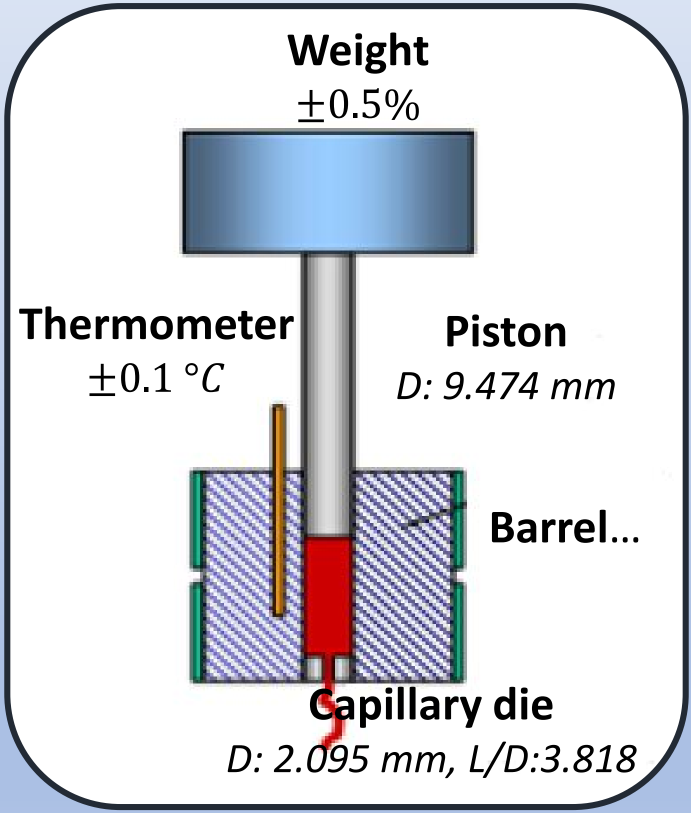
Minimizing waste

http://westextrusion.com

https://home.plasticsnews.com

LMI Melt Flow Rate Tester





Standardized Testing Condition

D1238 – 13

TABLE X4.1 Suggested Test Conditions for Select Materials

Material	Temperatures	Weights
Acetals (copolymer and homopolymer)	190	1.05
	190	2.16
Acrylics	230	1.2
	230	3.8
Acrylonitrile-butadienestyrene	200	5.0
	220	10
	230	3.8
Acrylonitrile/butadiene/styrene/polycarbonate blends	230	3.8
	250	1.2
	265	3.8
	265	5.0
Cellulose esters	190	0.325
	190	2.16
	190	21.6
	210	2.16
Ethylenechlorotrifluoroethylene copolymer	271.5	2.16
	271.5	5.0
Ethylene-tetrafluoroethylene copolymer	297	5.0
Polyamide	235	1.0
	235	2.16
	235	5.0
	275	0.325
	275	5.0
Perfluoro(ethylenepropylene) copolymer	372	2.16
Perfluoroalkoxyalkane	372	5.0
Polycaprolactone	80	2.16
	125	2.16
Polychlorotrifluorethylene	265	12.5
Polyetheretherketone (PEEK)	400	2.16
Polyether sulfone (PESU)	360	10
	380	2.16
Polyethylene	125	0.325
	125	2.16
	190	0.325
	190	2.16
	190	5
	190	10
	190	21.6
	250	1.2
	310	12.5
Polycarbonate	300	1.2
Polymonochlorotrifluoroethylene	265	21.6
	265	31.6
Polypropylene	230	2.16
Polyphenyl sulfone (PPSU)	365	5.0
	380	2.16
Polystyrene	190	5.0
	200	5.0
	230	1.2
	230	3.8
Polysulfone (PSU)	343	2.16
Polyethylene terephthalate (PET)	250	2.16
	285	2.16
Poly(vinyl acetal)	150	21.6
Polyvinyl chloride (PVC), rigid compound[A]	190	21.6
Poly(vinylidene fluoride)	230	5.0
	230	21.6
Poly(phenylene sulfide)	315	5.0
Styrene acrylonitrile	220	10
	230	3.8
	230	10
Styrenic Thermoplastic Elastomer	190	2.16
	200	5.0
Thermoplastic Elastomer-Ether-Ester	190	2.16
	220	2.16
	230	2.16
	240	2.16
	250	2.16
Thermoplastic elastomers (TEO)	230	2.16
Vinylidene fluoride copolymers[B]	120	5.0
	120	21.6
	230	2.16
	230	5.0

ASTM D1238 / ISO 1133 to specify:

- Testing conditions (temperature and weight)
- Testing time
- Sample mass
- Piston travel
- Die dimensions
- Precision

TABLE 2 Standard Test Conditions, Sample Mass,[A] and Testing Time[B]

Flow Range, g/10 min	Suggested Mass of Sample in Cylinder, g	Time Interval, min	Factor for Obtaining Flow Rate in g/10 min
0.15 to 1.0	2.5 to 3.0	6.00	1.67
>1.0 to 3.5	3.0 to 5.0	3.00	3.33
>3.5 to 10	4.0 to 8.0	1.00	10.00
>10 to 25	4.0 to 8.0	0.50	20.00
>25	4.0 to 8.0	0.25	40.00

TABLE 5 Precision, Procedure B (Values in g/10 min)

Material	Condition	Average	S_r[A]	S_R[B]	I_r[C]	I_R[D]	Number of Laboratories
Polyethylene	190/2.16	0.27	0.009	0.014	0.026	0.039	8
Polyethylene	190/2.16	0.40	0.016	0.027	0.045	0.076	8
Polyethylene	190/2.16	2.04	0.040	0.094	0.112	0.266	9
Polyethylene	190/2.16	43.7	0.997	1.924	2.819	5.443	8
Polypropylene	230/2.16	2.25	0.052	0.214	0.1466	0.604	8
Polypropylene	230/2.16	7.16	0.143	0.589	0.4051	1.666	8
Polypropylene	230/2.16	32.6	0.693	0.945	1.959	2.672	8
Polystyrene	200/5	1.65	0.037	0.166	0.106	0.470	4
Polystyrene	200/5	8.39	0.144	0.423	0.406	1.197	4
Polystyrene	200/5	13.0	0.108	0.387	0.306	1.097	4

[A] S_r = within-laboratory standard deviation of the average.
[B] S_R = between-laboratories standard deviation of the average.
[C] I_r = 2.83S_r, and
[D] I_R = 2.83S_R.

Dynisco

Method A

Method A
Manual Operation

- Mass measurement of extrudate collected over time
- Cut-n-weigh method
- Piston in proper position at end of pre-heating time
- Results:

$$MFR_{Method\ A} = \frac{10\ M}{t_A}$$

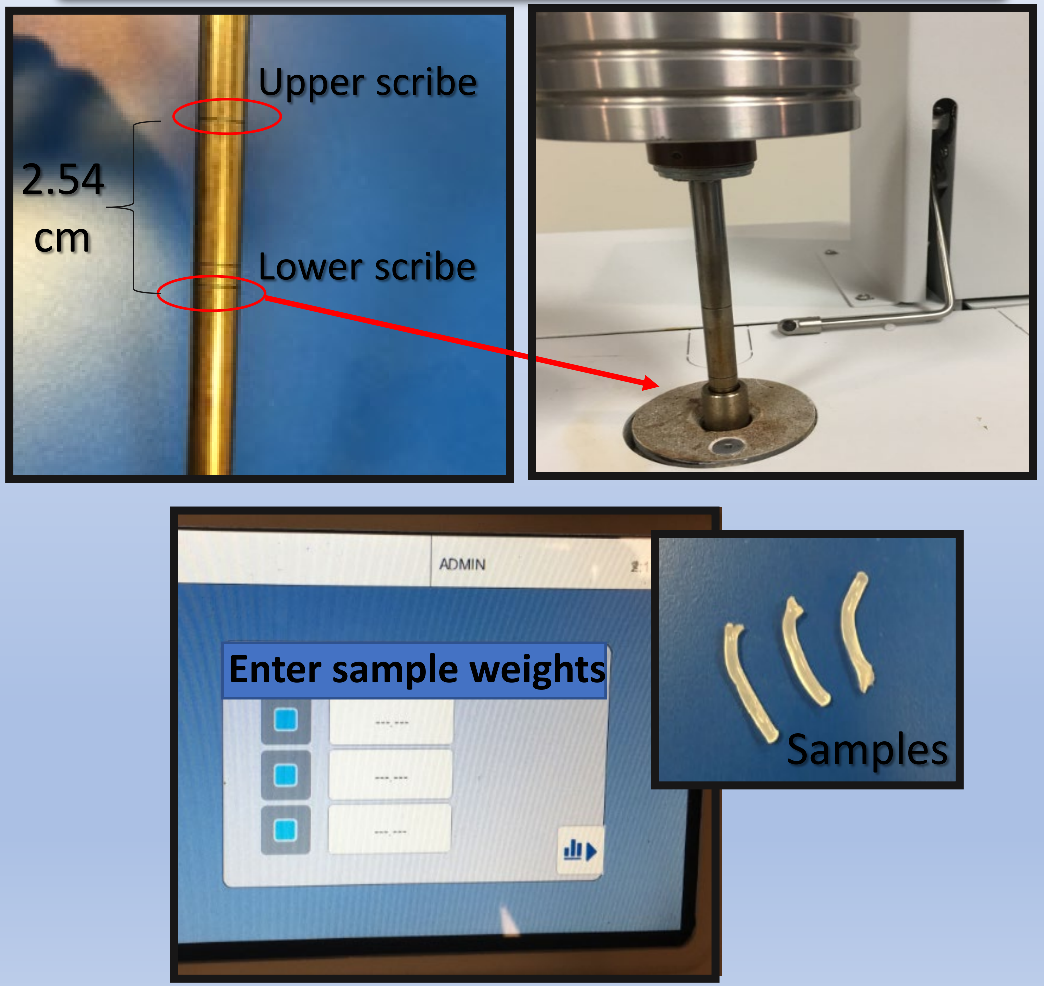
where

$MFR\ ({}^{g}/_{10min})$: *Melt flow rate*

$M\ (g)$: *Extrudate mass*

$t_A(min)$: *Cutting time*

Mass measurement for MFR



Method B

Method B

Automatically Timed Flow Rate Measurement

- Volumetric displacement of polymer melt over time
- No cutting and weighing (simpler method)
- More precise for routine analysis
- Piston in proper position at end of pre-heating time to activate calibrate encoder
- Results:

$$MVR = \frac{10\pi R^2 L}{t_B}$$

where

$MVR\ (cm^3/_{10min})$: Melt volume − flow rate

$R\ (cm)$: Barrel radios (0.477 cm)

$L(cm)$: Length of piston travel(0.635 cm)

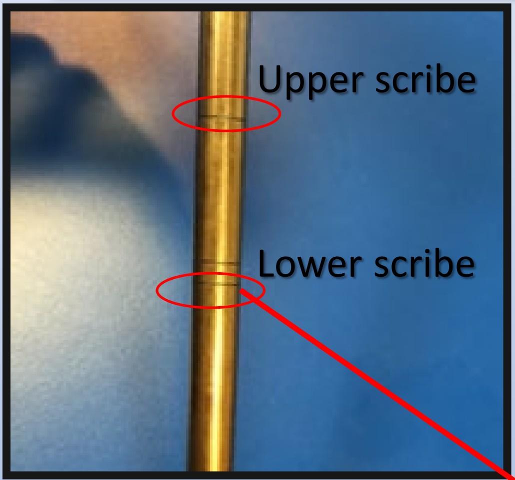
$t_B(min)$: Piston travel time

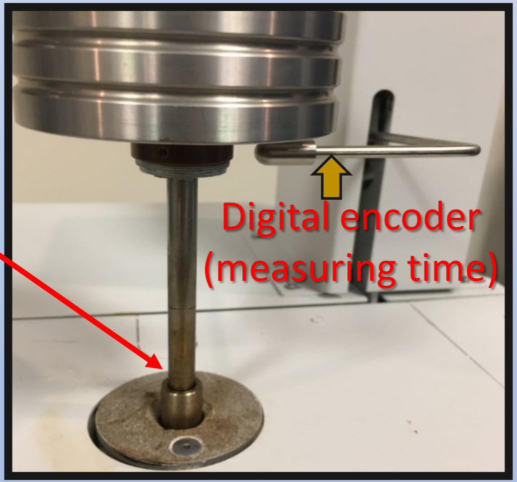
$$MFR = MVR \times \rho_m$$

where

$\rho_m(^g/_{cm^3})$: Mlet density at test temperature

Volumetric displacement measurements for MVR





Method A to B Conversion

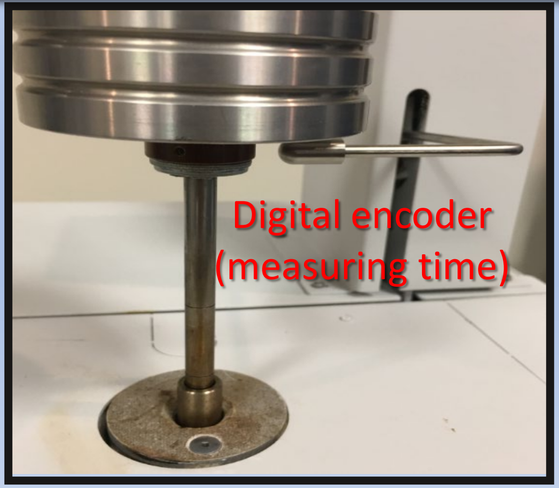
<u>Method A/B</u>
<u>For calculation of apparent melt density</u>

- Measuring **melt mass-flow rate** ***(MFR)*** and **melt volume-flow rate** ***(MVR)*** on the same charge of sample
- The ratio of the two values is a measure of the melt density of the polymer in g/cm^3
- Piston in proper position at end of pre-heating time to activate calibrate encoder
- Results:

$$\boldsymbol{Melt\ density\ (\rho_m) = \frac{MFR}{MVR}}$$

Mass measurement for MFR

Volumetric displacement measurements for MVR



Method C & Method D

Method C
Automatically Timed Flow Rate Measurement for High Flow Rate Polyolefins Using "Half" Die

- Using a modified die (D: 1.048 mm, L/D: 3.818)
- For testing POs with a MFR of 75 or greater
- Improve the reproducibility of results by reducing the flow rate
- procedures same as Method B with 2.540 cm length of piston travel

Method D
Multi-Weight Using Automatically Timed Flow Rate Measurements

- Flow Rate Ratio (FRR) test
- Using two/three different test loads on one charge of material
- Results:

$$FRR = \frac{MFR_{Higher\ test\ load}}{MFR_{Lower\ test\ load}}$$

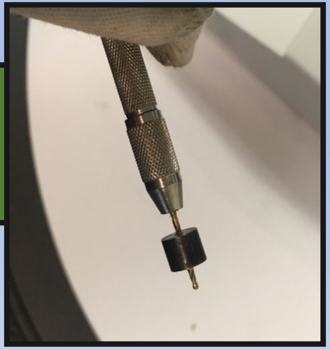
- For comparison of MWD (higher FRR means broader MWD)

Operation Points

❖ Stabilizing the temperature of barrel with piston and die in place for ~ 15 min prior to testing

❖ Swabbing out the barrel using cotton patches and barrel cleaning tool

❖ Cleaning the die using a proper die cleaning tool

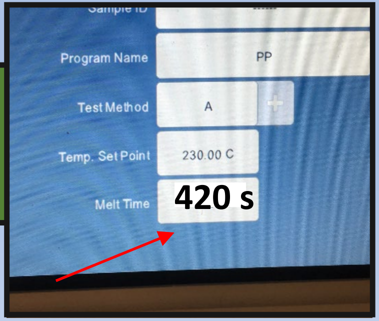


Operation Points

❖ Using a die plug for materials with very high MFR

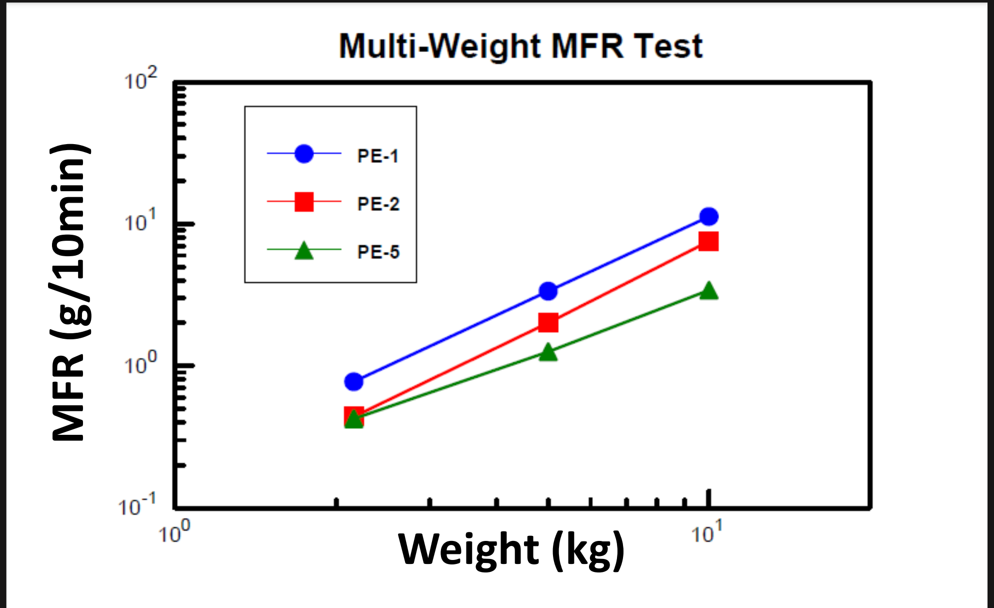
❖ Properly drying the hygroscopic samples (e.g. PET, PA, PC, PU, PBT, PEEK, ABS)

❖ Sufficient melting time (7 minutes)



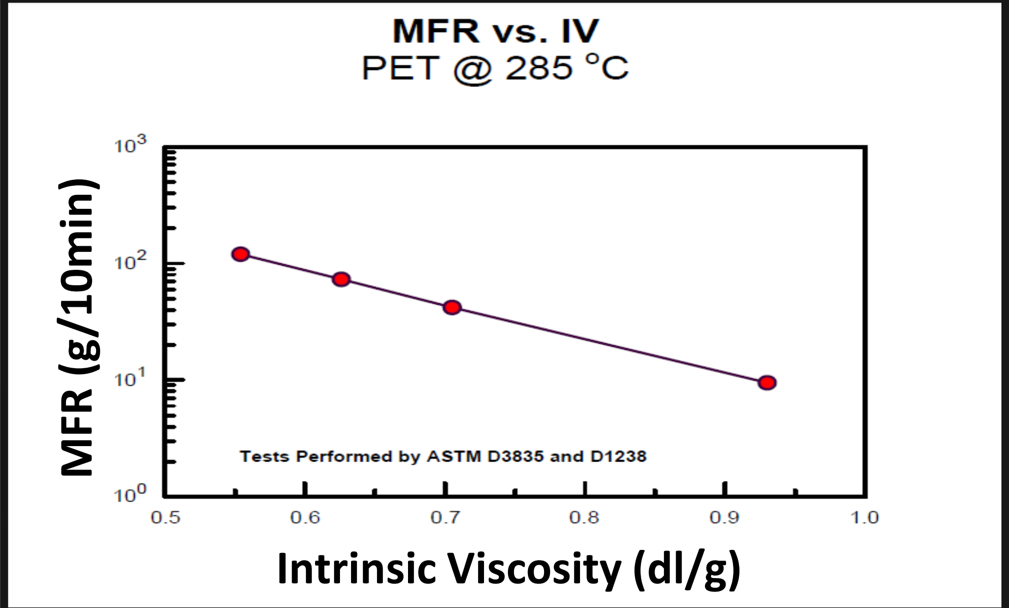
Other Applications

Shear thinning of the polymer melt



- Measuring MFR using various weights
- Graph of MFR vs Weight
- Describing the polymer flow behavior
- Higher slope ⟶ more shear thinning
- For comparing the MWD

Intrinsic/solution Viscosity of PET

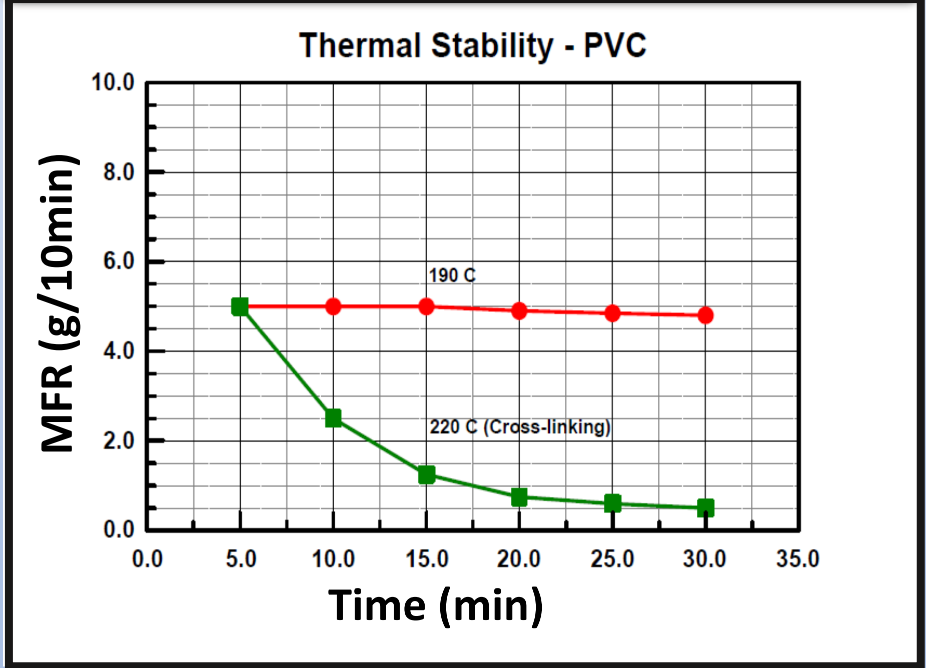


- Determinning of IV of PET at 285 °C by melt rheometer (avoid using of noxious solvents)
- Both viscosity/MFR and IV are related to the polymer molecular weight[1]. So, they can be correlated to each other!

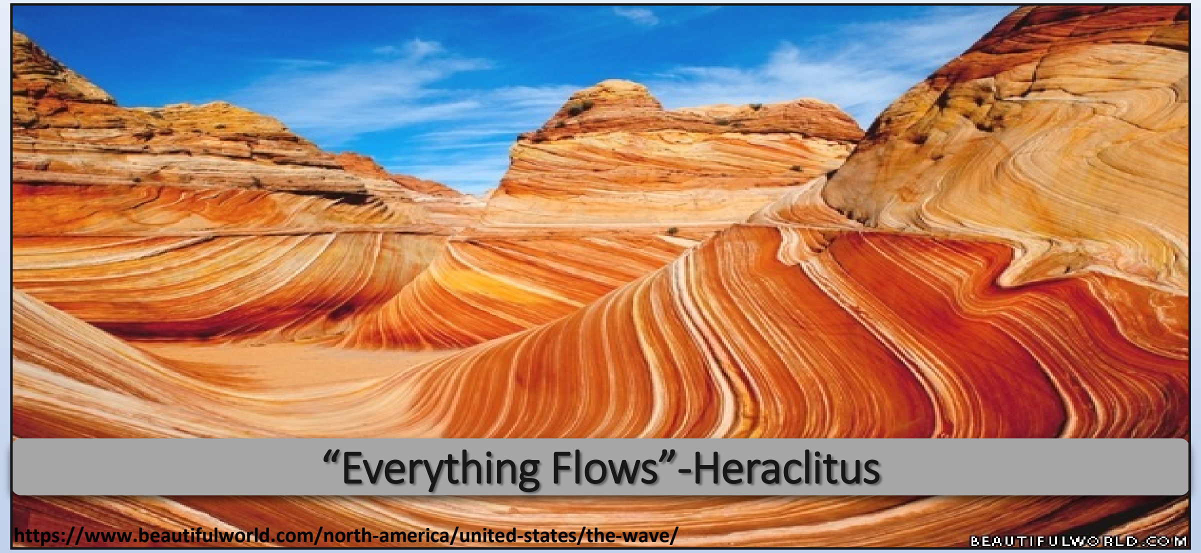
[1]Fox-Flory and Mark-Houwink relationships

Other Applications

Thermal stability



- resistance of polymer to a change in MFR at the test temperature over specific period of time
- Can show the presence of moisture or reactive chemicals in polymer.
- can measure the degradation rate or reactivity of polymer
- Repeating the test at various temperatures to give "processing window" of the polymer



"Everything Flows"-Heraclitus

https://www.beautifulworld.com/north-america/united-states/the-wave/

Thank You !