

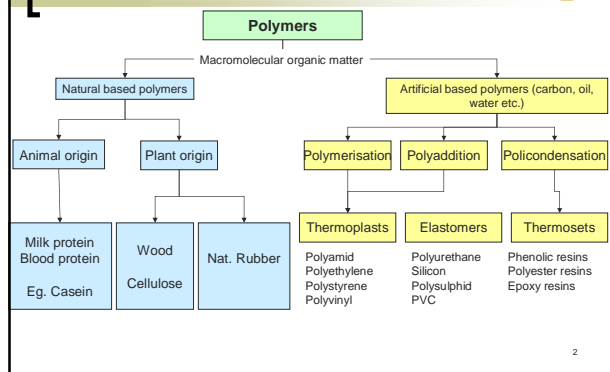


Design and manufacturing of plastic injection mould

02 – Plastic materials Mould design project

1

Classification of polymers



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Classification of polymers

- Production:
 - Polymerisation (PE, PP, PVC, PS)
 - Polycondensation (PA, PET)
 - Polyaddition (PUR, EP)
 - Natural polymers (cellulose, glas, basalt, asbestos)
- Composition:
 - Homo-polymer (consists of same monomer (PE, PP, PVC, PS))
 - Copolymer (mix (ABS))
- Processing:
 - Thermoplasts
 - Thermosets

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Classification of polymers

- Shape:
 - Linear
 - Branched-chain
 - Net
- Structure:
 - Semi-crystalline
 - Amorphous
- Chemical components:
 - Organic
 - Inorganic

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Properties

- Density (g/cm³)
- Tensile strength (MPa), Elongation, Hardness, Ütőmunka
- Thermal expansion, Thermal resistant
- Processing temperature
- Shrinkage
- Flame test (color, smell ...)

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Shrinkage

Mould shrinkage:

$$\frac{L_o - L_1}{L_o} \times 100$$

L_o : dimension in the mould
 L_1 : dimension on the product

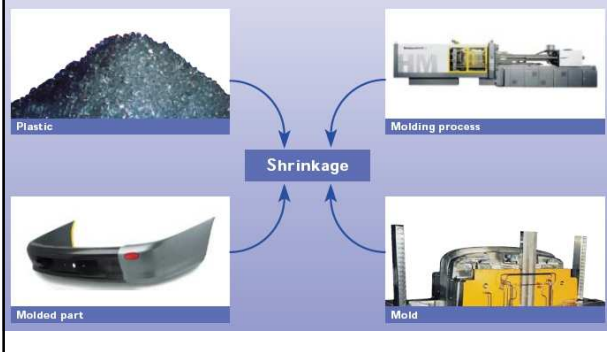
Influence factors:

- Plastic material (type, manufacturer)
- Direction to the injection
- Part shape
- Wall thickness
- Additives (color, flame retardants, reinforce materials ...)
- Processing parameters



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Influence factors



Influence factors

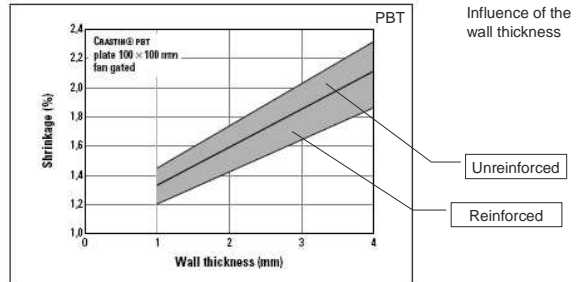


Fig 5.2 Shrinkage of unreinforced (e.g. S600F10) and filled (e.g. S0655) CRASTIN® types as a function of wall thickness. Not valid for toughened grades

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Influence factors

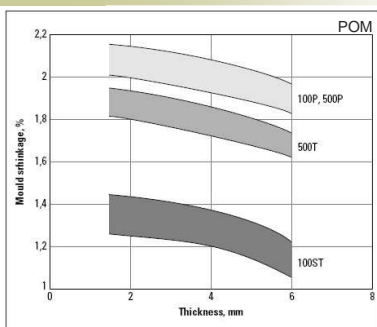


Fig. 6.03 Average mould shrinkage vs. thickness, for various DELRIN® compositions

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Influence factors

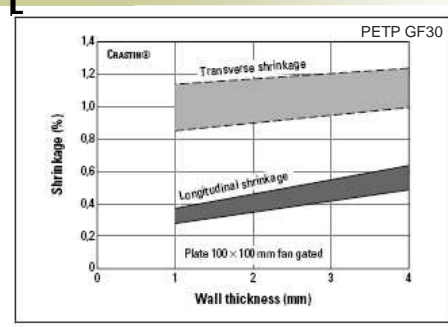


Fig 5.3 Shrinkage of 30% glass-fibre reinforced CRASTIN® types (e.g. SK605, SK655FR1) as a function of wall thickness

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Influence factors

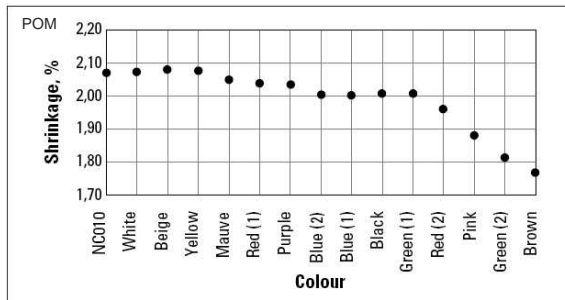
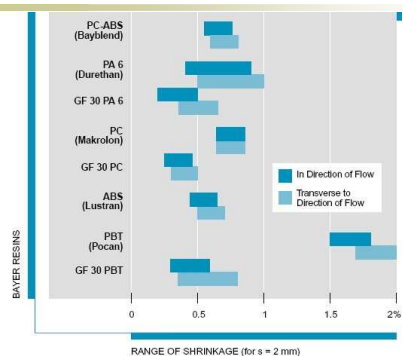


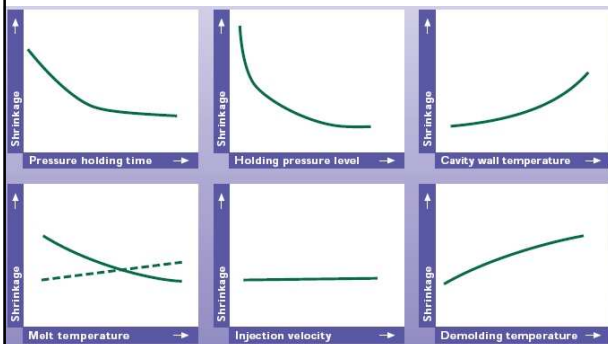
Fig. 6.04 Effect of selected pigments on mould shrinkage of DELRIN® 500. Part thickness 2 mm

Influence factors



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Influence factors

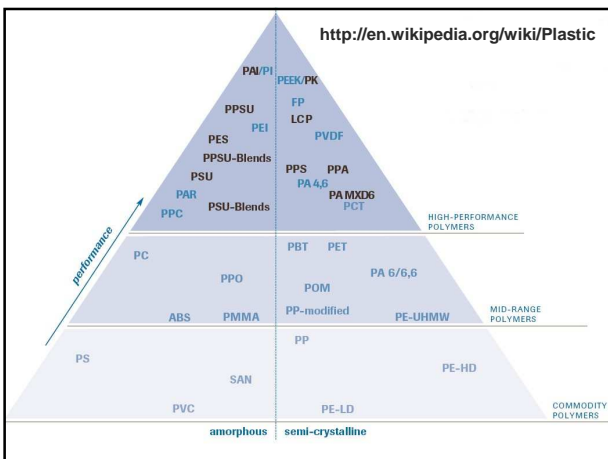


Manufacturers



<http://www.rutlandplastics.co.uk>
<http://www.polymerweb.com>

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LDPE

- Low-density polyethylene, 1933 ICI
- Lupolen, Stamylan, Tipolen,
- Semi-crystalline
- Density (g/cm^3): 0.910 – 0.940
- Flow length in 1 and 2 mm runner: 170 / 720
- Drying: -
- Melt temperature: 180 – 240 °C
- Mould temperature: 20 – 40 °C
- Part temp. at ejection: 80 °C
- Shrinkage: 2,6 %, with GF - %

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LDPE

- Not rigid (soft), Could resistant to -40°C, Impact resistant, Acid, alkaline, oil, alcohol resistant, Not injurious to health
- Poor resistance for use with halogenated hydrocarbons, Combustible (flash into flame),
- Plastic bag, Cable insulation, Soft hoses



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HDPE

- High-density polyethylene
- Hostalen, Stamylen
- Semi-crystalline
- Density (g/cm^3): 0.92 – 0.96
- Flow length in 1 and 2 mm runner: 100 / 400
- Drying: -
- Melt temperature: 200 – 300 °C
- Mould temperature: 20 – 60 °C
- Part temp. at ejection: 110 °C
- Shrinkage: 1.5 – 2.5 %, with GF - %

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LDPE

- Not rigid (soft), Could resistant to -40°C, Impact resistant, Acid, alkaline, oil, alcohol resistant, Not injurious to health
- Poor resistance for use with halogenated hydrocarbons, Combustible (flash into flame),
- Containers, Packaging boxes, Bottles, Pipes, Snowboards, Cable insulation



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PP



- Polypropylene, 1951. Hoechst AG Germany
- Borealis, Tipplon
- Semi-crystalline
- Density (g/cm³): 0.905
- Flow length in 1 and 2 mm runner: 200 / 870
- Drying: 80 °C / 1 h
- Melt temperature: 220 – 280 °C
- Mould temperature: 20 – 70 °C
- Part temp. at ejection: 65 °C
- Shrinkage: 1.2 – 2.5 %, with GF – %

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PP

- Hard, Hard to break, Not injurious to health, Better than PE in hardness and heat resistance, but worst in cold resistance, Resist to acid, alkaline and benzine
- Poor resistance for use with halogenated hydrocarbons, Combustible (flash into flame), React chemically with the copper
- Containers, Accumulator box, Instrument panel, Bumper



PA6 / PA66

- Polyamid 6 - Nylon 1939 Du Pont
- Ultramid B3K, Zytel, Danamid
- Semi-crystalline
- Density (g/cm³): 1.13
- Flow length in 1 and 2 mm runner: 120 / 510 (130/560)
- Drying: 80 °C / 4 h
- Melt temperature: 230 – 250 °C (250 - 290)
- Mould temperature: 60 – 100 °C
- Part temp. at ejection: 200 °C
- Shrinkage: 0.7 – 2.2 %, with GF 0.3 – 1.0 %

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PA6

- Hard in dry state, Resistant to wear, Good slip skill, Heat resistant, Stickable,
- Poor resistant to acids, Flammable, Not transparent
- Bearings, Plugs, Gears, Pipes for benzene



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POM

- Poliacetal, Polyoxymethylene
- Delrin, Ultraform, Hostaform, Celcon
- Semi-crystalline
- Density (g/cm³): 1.42
- Flow length in 1 and 2 mm runner: 80 / 350
- Drying: 80 °C / 4 h
- Melt temperature: 180 – 230 °C
- Mould temperature: 50 – 120 °C
- Part temp. at ejection : 150 °C
- Shrinkage: 1.0 – 3.5 %, with GF 0.4 – 0.9 %

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POM

- Hard, Rigid, Resistant for cold (-40°C), wear, Good slip skill, Not injurious to health
- Poor resistant for strong acids and alkaline, Flammable
- Gears, Pneumatic elements, Plugs, Machine parts



PPS

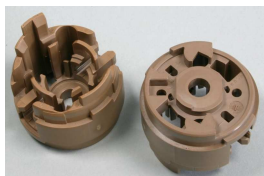
Polyphenylene sulfide

- Fortron, Ryton
- Semi-crystalline
- Density (g/cm^3): 1.65
- Flow length in 1 and 2 mm runner: 60 / 240
- Drying: 150°C / 6 h
- Melt temperature: $300 - 360^{\circ}\text{C}$
- Mould temperature: $80 - 120^{\circ}\text{C}$
- Part temp. at ejection : 225°C
- Shrinkage: 0.2 – 0.8 %, with GF – %

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PPS

- Hard, High mechanical strength, Good slip and wear skills in high temperature, Resistant for heat (350°C) and radioactive ray
- Not transparent
- Pump houses, filters, chemical resist parts



PBT

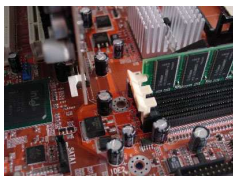
Polybutylene terephthalate

- Pohan, Valox, Celanex
- Semi-crystalline
- Density (g/cm^3): 1.3
- Flow length in 1 and 2 mm runner: 50 / 220
- Drying: 120°C / 4 h
- Melt temperature: $250 - 290^{\circ}\text{C}$
- Mould temperature: $60 - 100^{\circ}\text{C}$
- Part temp. at ejection : 200°C
- Shrinkage: 1.4 – 2.0 %, with GF 0.4 – 0.6 %

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PBT

- Hard, High mechanical strength, Resistant for heat (200°C), light acids and alkaline, benzene, oils, Good slip and wear skills, Not flammable, Not injurious to health
- Poor resistant for strong acids and alkaline, Not Transparent
- Electric switches, plugs and sockets, Machine parts



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PET

Polyethylene terephthalate

- Rynite, Arnite, Crastin, Petra
- Semi-crystalline (but amorphous types exist too)
- Density (g/cm^3): 1.35
- Flow length in 1 and 2 mm runner : 100 / 420
- Drying: 120°C / 4 h
- Melt temperature: $230 - 280^{\circ}\text{C}$
- Mould temperature: $120 - 140^{\circ}\text{C}$
- Part temp. at ejection : 150°C
- Shrinkage: 1.2 – 2.0 %, with GF 0.4 – 0.6 %

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PET

- Hard, Strong and impact resistant, High transparent, Good flow skill, Not Flammable
- Not resistant for strong acid and alkaline
- Bottles and machine parts (GF30%)



PS

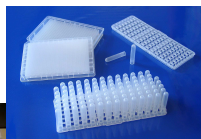


- Polystyrene – 1839 Eduard Simon (Ger.)
- Polystyrol, Edistir
- Amorphous
- Density (g/cm³): 1.05
- Flow length in 1 and 2 mm runner : 160 / 670
- Drying: 80 °C / 1 h
- Melt temperature: 180 – 260 °C
- Mould temperature: 15 – 50 °C
- Part temp. at ejection : 80 °C
- Shrinkage: 0.3 – 0.6 %, with GF – %

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PS

- Hard, Rigid, Transparent, Smell and taste inert, Resistant to acids and alkaline and alcohol
- Fragile, Not resistant to benzene, Flammable
- Covers, Foam, Boxes



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PC

- Polycarbonate
- Makrolon, Lexan, Calibre
- Amorphous
- Density (g/cm³): 1.2
- Flow length in 1 and 2 mm runner : 40 / 160
- Drying: 20 - 130 °C / 3 h
- Melt temperature: 270 – 340 °C
- Mould temperature: 80 – 120 °C
- Part temp. at ejection : 200 °C
- Shrinkage: 0.6 – 0.8 %, with GF 0.2 – 0.4 %

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PC

- Hard and rigid, Impact resistant (-100°C), High heat resistant, Transparent, Weather resistant, Not flammable
- Not resistant for acid and alkaline
- CD, Optic lens, Windscreen, Eyeglasses, Medical devices, Electric plugs



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ABS

- Acrylonitrile butadiene styrene
- Novodur, Cyclocac, Terluran, Lustran, Magnum
- Amorphous
- Density (g/cm³): 1.06 – 1.19
- Flow length in 1 and 2 mm runner : 90 / 370
- Drying: 80 °C / 2 h
- Melt temperature: 200 – 250 °C
- Mould temperature: 50 – 80 °C
- Part temp. at ejection : 80 °C
- Shrinkage: 0.4 – 0.9 %, with GF 0.1 – 0.3 %

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ABS

- High tensile strength, Resistant to cold (-40°C), acid, oil, alcohols, Noise reduce effect, Cheap, Shiny surface, Good processing, Ability to galvanizing works, Scratch resistant
- Not transparent, Not resistant to weather, Flammable, GF decrease the impact resistant
- Automotive and electronic parts



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ABS/PC

- Acrylonitrile Butadiene Styrene / Polycarbonate
- Bayblend
- Amorphous
- Density (g/cm^3): 1.15
- Flow length in 1 and 2 mm runner : 80 / 320
- Drying: 100°C / 2 óra
- Melt temperature: $210 - 270^{\circ}\text{C}$
- Mould temperature: $70 - 90^{\circ}\text{C}$
- Part temp. at ejection : 115°C
- Shrinkage: $0.5 - 0.7\%$, with GF $0.2 - 0.4\%$

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ABS/PC

- Impact, heat and light resistant, Ability to galvanising, Shiny
- Not resistant to keton, chlorinated hydrocarbon, ester
- Cockpit elements



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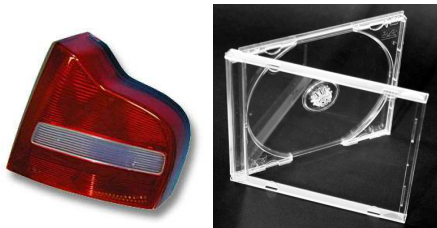
PMMA

- Poly(metil-metakrilát) – 1933 Röhm und Haas
- Plexiglas, Acrilglas, Vedril, Oroglass
- Amorphous
- Density (g/cm^3): 1.19
- Flow length in 1 and 2 mm runner : 90 / 380
- Drying: 80°C / 4 h
- Melt temperature: $190 - 290^{\circ}\text{C}$
- Mould temperature: $40 - 90^{\circ}\text{C}$
- Part temp. at ejection : 80°C
- Shrinkage: $0.3 - 0.7\%$, With GF - %

40

PMMA

- Hard, rigid, high strength, Etch and weather resistant, Complete clear (transparent), Easy to coloring
- Not resistant to acid and alkaline, Flammable,
- Lamp cover, CD case, rearview mirror, optic parts



PPO

- Poli(dimetil-fenilén-éter)
- Noryl
- Amorphous
- Density (g/cm^3): 1.1
- Flow length in 1 and 2 mm runner : 250 / 500
- Drying: 110°C / 1 h
- Melt temperature: $260 - 300^{\circ}\text{C}$
- Mould temperature: $50 - 120^{\circ}\text{C}$
- Part temp. at ejection : 140°C
- Shrinkage: $0.7 - 1.5\%$, with GF $0.1 - 0.4\%$

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PPO

- Hard and rigid, Good slip and wear skills, Etch resistant, Temperature resistant
- Not transparent, Easy to fire, but the flame goes out
- Products with contact to hot water, Cases, Handles, Switches



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TPE

- Thermoplastic elastomer
- Termoflex, Elexar, Monprene, Tekbond, Tekron
- Amorphous
- Density (g/cm³): 0.8 – 1.2
- Flow length in 1 and 2 mm runner : - / -
- Drying: -
- Melt temperature: 180 – 250 °C
- Mould temperature: 30 – 45 °C
- Part temp. at ejection : 80 °C
- Shrinkage: 1.0 – 4.0 %

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TPE

- Resistant to acids and alkaline, weather, UV radiation; Flexible to -40°C, Heat-proof to 110°C
- Sealing edge, Tubes, Ergonomic handles



Ability to combination with other plastic materials

Hőre lágyuló műanyagok		PP	PMMA	ABS	PC/ABS PC/PBT	PC	PA- blend	PA	PBT	PS
TPE-osztály										
	TF	4	-	0	0	0	2	0	0	-
TPE-S SEBS és SEPS	TF/A1	-	3	3	2-3	2	-	-	-	-
	TF/A2	-	-	-	-	-	3	-	-	-
	TF/A3	-	-	-	-	-	-	3	-	-
	TF/A4	-	-	-	-	-	-	-	-	2-3
TPE-O	poliolefin bázis	3-4	-	0	0	0	2	0	0	0
TPE-A	poliamid bázis	0	-	0	0	0	1-2	1-2	0	0
TPE-U	hőre lágyuló poliuretán	0	-	3-4	2-3	3-4	-	2-3	1-2	0
TPE-E	poliszter elastomer	0	-	0	0	0	-	1-2	2	0

TF = PTS-THERMOFLEX (SEBS/SEPS)

TF/A1 = PTS-THERMOFLEX kötési-modifikált az ABS, PC/ABS, PC/PBT, PC, PMMA anyagokra

TF/A2 = PTS-THERMOFLEX kötési-modifikált a PA blendekre

TF/A3 = PTS-THERMOFLEX kötési-modifikált a PA anyagra

TF/A4 = PTS-THERMOFLEX kötési-modifikált a PS anyagra

0 = nincs kötés

1 = használható kötés

2 = jó kötés

3 = nagyon jó kötés

4 = oldhatatlan kötés (kohéziós törés)

- = nem lett vizsgálva

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