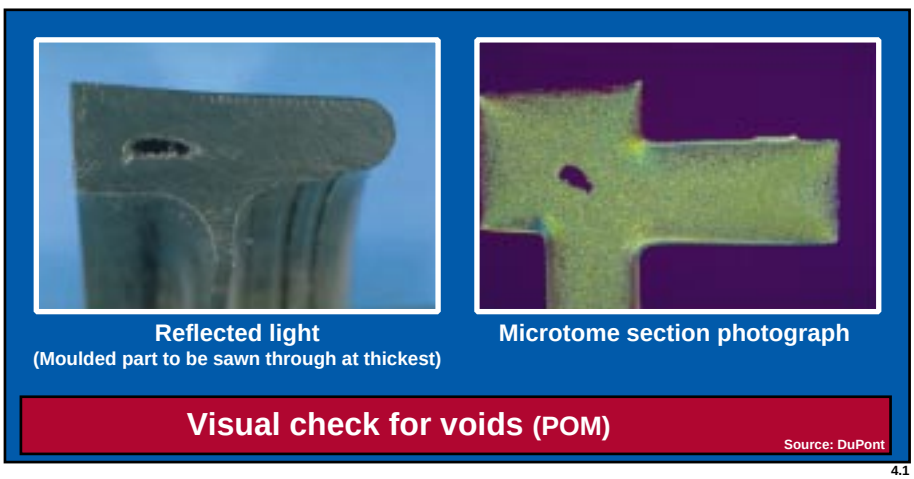
ENGINEERING POLYMERS: THE ‘TOP TEN’ MOULDING PROBLEMS

By R. Wilkinson, Roger Wilkinson, E. A. Poppe, Karl Leidig, Karl Schirmer

Chapter 4: Hold Time Too Short

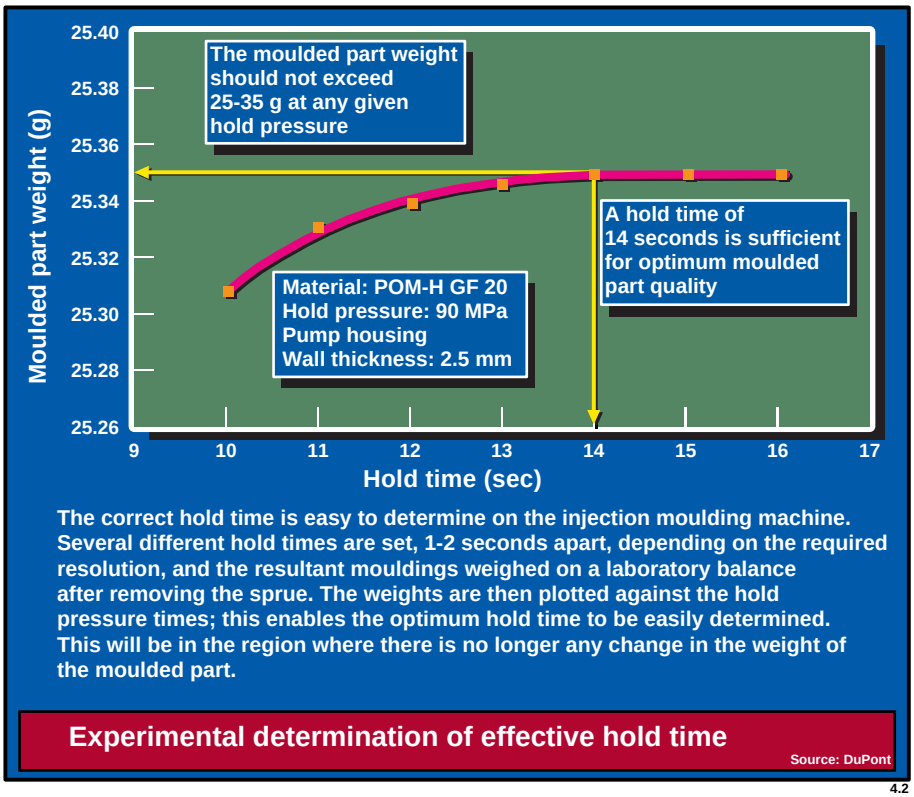
1. Moisture in the granules
2. Feed system too small
3. Wrong gate position
4. Hold time too short
5. Wrong melt temperature
6. Wrong tool temperature
7. Poor surface finish
8. Problems with hot runners
9. Warpage
10. Mould deposit

In practice many injection moulders, working from their experience of amorphous polymers, tend to use shorter hold pressure times and longer cooling times. Unfortunately, this approach also tends to be used for semi-crystalline polymers such as POM (acetal), PA (nylon), PBT and PET (polyesters). This article discusses the most important points to help machine setters chose the most suitable hold pressure time.



What exactly happens during the hold pressure phase?

Once the mould cavity has been filled, the polymer molecules start to crystallise, i.e. the molecule chains become aligned with respect to each other, resulting in higher packing density. This process starts in the outer zone and ends in the centre of the wall (see diagrams). The volume shrinkage caused by this can be as much as 14 %, as in the case of POM, and has to be made up again by further amounts of melt which are injected into the mould cavity during the hold pressure phase. If the hold pressure time is too short, it causes small voids to be formed (microporosity), which can have an adverse affect on moulded part properties in many ways.



The correct hold time is easy to determine on the injection moulding machine. Several different hold times are set, 1-2 seconds apart, depending on the required resolution, and the resultant mouldings weighed on a laboratory balance after removing the sprue. The weights are then plotted against the hold pressure times; this enables the optimum hold time to be easily determined. This will be in the region where there is no longer any change in the weight of the moulded part.

Experimental determination of effective hold time Source: DuPont

4.2

Material	Crystallisation time per mm wall thickness
POM - H	7,5 - 8,5 $\frac{s}{mm}$
PA 66	3,5 - 4,5 $\frac{s}{mm}$
PA 66 (impact modified)	3,0 - 4,0 $\frac{s}{mm}$
PA 66 GF 30	2,5 - 3,5 $\frac{s}{mm}$
PET GF 30	3,0 - 4,0 $\frac{s}{mm}$
PBT	3,5 - 4,5 $\frac{s}{mm}$
PBT GF 30	2,5 - 3,5 $\frac{s}{mm}$

Crystallisation rate for a wall thickness of 3 mm Source: DuPont

4.3

How to find out whether the hold time is too short

Parts made in this way often show excessive shrinkage, warpage, sink marks, voids and, in some cases, enormous loss of mechanical properties. In addition, there may be considerable dimensional variations. In some cases a misguided attempt is made to compensate for these shortcomings by increasing the cooling time. This results in unnecessarily long cycle times.

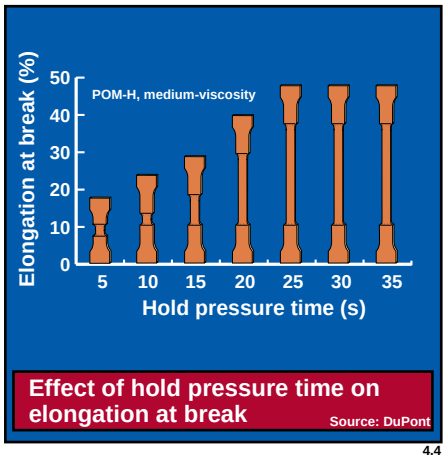
One way of recognising the effects of inadequate hold pressure times, for unreinforced moulding compounds, consists of cutting through the moulded part at a point where there is maximum wall thickness. The polished cut surface can then be checked for voids and pinholes. A magnifying glass or reflected-light microscope are sufficient to form a first opinion. A more elaborate method consists of preparing microtome sections (see diagram). In these, even the finest defects can be made visible with a transmitted-light microscope.

With reinforced moulding compounds, defects can be easily detected on a fracture surface where there is maximum wall thickness. If the hold time is too short, there will be a foam-like structure in the fracture region and an enlarged fracture photomicrograph will show exposed fibres which are not embedded in polymer.

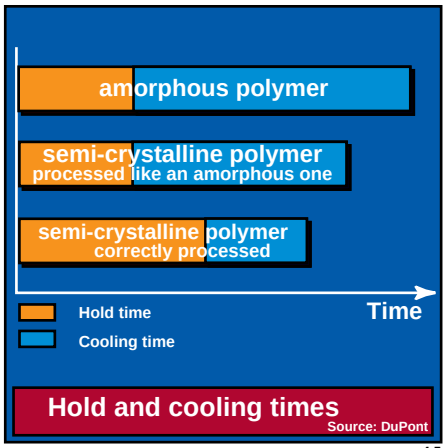
Another method consists of preparing a photomicrograph of a polished section, in which pinholes can be detected with a microscope.

The effective hold time can be determined on the injection moulding machine by weighing a number of mouldings (see description). This is the best way of determining the hold pressure time for a given moulding under practical conditions.

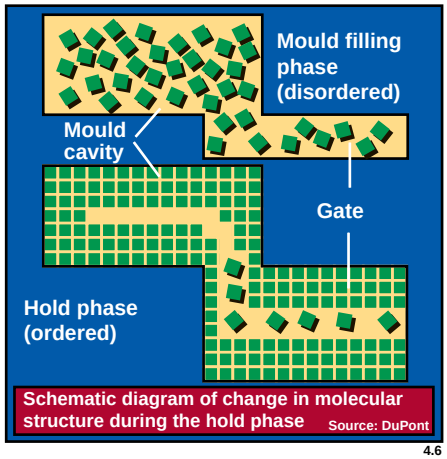
A guideline for the optimum hold time can also be obtained by using actual figures as comparison (see table). These apply only for a given wall thickness and cannot be applied to other factors such as temperature, nucleating additives and pigments, mould filling time, etc. For thinner walls, the figures will be lower, for thicker ones higher.



4.4



4.5



4.6

Correct setting procedure

To obtain optimum moulded part properties, the hold time should be determined by the weighing method, and the cooling time should be reduced to the required minimum (which is usually just above the plasticising time). This presupposes that the gate has been correctly positioned and designed (cf. parts 2 and 3 of this series, Plastverarbeiter 46 [1995] 6 and 7). It is also important to keep the pressure constant during the hold time. The correct pressure varies between 60 and 100 MPa, depending on the material used.

EUROPE/MIDDLE EAST/AFRICA

Belgique / België
Du Pont de Nemours (Belgium)
Antoon Spinoystraat 6
B-2800 Mechelen
Tel. +32 15 44 14 11
Telefax +32 15 44 14 09

Bulgaria
Serviced by
Biesterfeld Interowa GmbH & Co. KG.
See under Österreich.

Ceská Republika a
Slovenská Republika
Du Pont CZ, s.r.o.
Pekarska 14/268
CZ-155 00 Praha 5 – Jinonice
Tel. +42 257 41 41 11
Telefax +42 257 41 41 50-51

Danmark
Du Pont Danmark ApS
Skjøtevej 26
P.O. Box 3000
DK-2770 Kastrup
Telefax +45 32 47 98 05
Telefax +45 32 47 98 05

Deutschland
Du Pont de Nemours
(Deutschland) GmbH
DuPont Straße 1
D-61343 Bad Homburg
Tel. +49 6172 87 0
Telefax +49 6172 87 27 01

Egypt
Du Pont Products S.A.
Bldg no. 6, Land #7, Block 1
New Maadi
ET-Cairo
Tel. +202 754 65 80
Telefax +202 516 87 81

España
Du Pont Ibérica S.A.
Edificio L'Illa
Avda. Diagonal 561
E-08029 Barcelona
Tel. +34 227 60 00
Telefax +34 227 62 00

France
DuPont de Nemours (France) SAS
Défense Plaza
23/25 rue Delarivière Le Foullon
Défense 9
92 064 La Défense Cedex
Phone: +33 (0)1 41 97 44 00
Telefax +33 1 47 53 09 67

Hellas
Biesterfeld Hellas Intralink S.A.
Trading Establishment
149, AG. Triados Menidi Acharnes
GR-13671 Athens
Tel. +30 210 24 02 900
Telefax+30 210 24 02 141

Israël
Gadot Chemical Terminals (1985) Ltd.
16 Habonim Street
Netanya – South Ind. Zone
IL-42504 Netanya
Tel. +972 3 526 42 41
Telefax +972 3 528 27 17

Italia
Du Pont de Nemours Italiana S.r.L.
Centro Direzionale "Villa Fiorita"
Via Piero Gobetti, 2/A
20063 Cernusco s/N (MI)
Tel. +39 02 92629.1 (switchboard)
Fax +39 02 36049379

Magyarország
DuPont Magyarország Kft.
HU - 2040 Budaörs
Neuman J.u. 1
Tel. +36 23 509 400
Telefax: +36 23 509 432

Maroc
Deborel Maroc S.A.
40, boulevard d'Anfa – 10°
MA-Casablanca
Tel. +212 227 48 75
Telefax +212 226 54 34

Norway / Norge
Distrupol Nordic
Ostenssjoveien 36
N-0677 Oslo
Tel. +47 23 16 80 62
Telefax +47 23 16 80 62

Österreich
Biesterfeld Interowa GmbH & Co. KG
Bräuhausgasse 3-5
P.O. Box 19
AT-1051 Wien
Tel. +43 1 512 35 71-0
Fax +43 1 512 35 71-31
e-mail: info@interowa.at
internet: www.interowa.at

Polska
Du Pont Poland Sp. z o.o.
ul. Powazkowska 44C
PL-01-797 Warsaw
Tel. +48 22 320 0900
Telefax +48 22 320 0910

Portugal
Biesterfeld Iberica S.L.
Rua das Matas
P-4445-135 Alfena
Tel. +351 229 698 760
Telefax +351 229 698 769

Romania
Serviced by
Biesterfeld Interowa GmbH & Co. KG.
See under Österreich.

Russia
DuPont Russia LLC.
ul. Krylatskaya 17/3
121614 Moscow
Tel. +7 495 797 22 00
Fax. + 7 495 797 22 01

Schweiz / Suisse / Svizzera
Biesterfeld Plastic Suisse GmbH
Dufourstrasse 21
Postfach 14695
CH-4010 Basel
Tel. +41 61 201 31 50
Telefax +41 61 201 31 69

Slovenija
Serviced by
Biesterfeld Interowa GmbH & Co. KG.
See under Österreich.

Suomi / Finland
Du Pont Suomi Oy
PO Box 54 (Keilaranta 12)
FI-02150 ESPOO
Tel: +358 207 890500
Fax: +358 207 890501

Sverige
Serviced by
Du Pont Danmark ApS.
See under Danmark.

Türkiye
Du Pont Products S.A.
Buyukdere Caddesi No. 122
Ozsezen Ismerkezi, A block, Kat: 3
Esentepe, 34394 Istanbul
Tel. +90 212 340 0400
Telefax +90 212 340 0430

Ukraine
Du Pont de Nemours
International S.A.
Representative Office
3, Glazunova Street
Kyiv 252042
Tel. +380 44 294 96 33 / 269 13 02
Telefax +380 44 269 11 81

United Kingdom
Du Pont (UK) Limited
Wedgwood Way
Stevenage
Hertfordshire SG1 4QN
Tel. +44 1438 734000
Telefax ++44 1438 734109

South Africa
DuPont de Nemours
Societe Anonyme
South African Branch Office
4th Floor Outspan House
1006 Lenchen Avenue North
Centurion
Pretoria 0046
Tel. +27 0 12 683 5600
Telefax +27 0 12 683 5661

NORTH AMERICA

USA
DuPont Engineering Polymers
Barley Mill Plaza, Building 26
P. O. Box 800026
Wilmington, Delaware 19880
Tel. +1 302 992 4592
Telefax +1 302 992-6713

DuPont Automotive
950 Stephenson Highway
P.O. Box 7013
Troy, MI 48007-7013
Tel. +1 248 583-8000

Canada
DuPont Engineering Polymers
P.O. Box 2200
Streetsville, Mississauga
Ontario, Canada L5M 2H3
Tel. +1 905 821-5953

Mexico
DuPont S.A. de C.V.
Homero 206
Col. Chapultepec Morales
11570 Mexico D.F.
Tel. + 525 557 221 000

SOUTH AMERICA

Argentina
Du Pont Argentina S.A.
Avda. Mitre y Calle 5
(1884) Berazategui-Bs.As.
Tel. +54 11 4239-3868
Telefax +54 11 4239-3817

Brasil
DuPont do Brasil S.A.
Al. Itapecuru, 506 Alphaville
06454-080 Barueri-Sao Paulo
Tel. + 5511 7266 8229

ASIA-PACIFIC

Australia
DuPont (Australia) Ltd.
168 Walker Street
North Sydney NSW 2060
Tel: +612 9923-6111
Fax: +612 9923 6011

Hong Kong/China
DuPont China Ltd.
26/F, Tower 6, The Gateway,
9 Canton Road
Tsimshatsui, Kowloon, Hong Kong
Tel: +852 2734 5345
Fax: +852 2724 4458

Shanghai/China
DuPont China Holding Co. Ltd.
15/F., Shui On Plaza
333 Huai Hai Road (Central)
Shanghai 200021
Tel: +86 21 6386 6366
Fax: +86 21 6386 6333

India
E.I. DuPont India Limited,
"Arihant Nitco Park" Sixth floor,
90, Dr. Radhakrishnan Salai,
Mylapore,
Chennai 600 004
Tel: +91 44 28472800
Fax: +91 44 28473800

Japan
DuPont Kabushiki Kaisha
Sanno Park Tower, 11-1
Nagata-cho 2-chome
Chiyoda-ku, Tokyo 100-6111
Japan.
Tel: +81 3 5521 8500
Fax: +81 3 5521 2595

Korea
DuPont (Korea) Ltd.
4/5 Floor, Asia Tower
#726, Yeoksam-dong, Kangnam-Ku
Seoul 135-082
Tel: +822 2222-5200
Fax: +822 2222-5470

Singapore
Du Pont Company (S) Pte Ltd
1 HarbourFront Place #11-01
HarbourFront Tower One
Singapore 098633
Tel: +65 6586 3688
Fax: +65 6272 7494

Taiwan
DuPont Taiwan Ltd.
Hung Kuo Building, 13th floor
#167 Tun Hwa North Road
Taipei 105
Tel: +8862 2719-1999
Fax: +8862 2719-0852

Thailand
DuPont (Thailand) Limited
6-7th Floor, M. Thai Tower
All Seasons Place
87 Wireless Road
Lumpini, Phatumwan
Bangkok 10330
Tel : +66 2 659 4000
Fax : +66 2 659 4001

CRASTIN® PBT
THERMOPLASTIC POLYESTER RESIN

DELRIN®
ACETAL RESIN

HYTREL®
THERMOPLASTIC POLYESTER ELASTOMER

MINLON®
MINERAL REINFORCED NYLON RESIN

RYNITE® PET
THERMOPLASTIC POLYESTER RESIN

THERMX® PCT
HIGH PERFORMANCE POLYESTER

TYNEX®
NYLON MONOFILAMENT

VESPEL®
PARTS AND SHAPES

ZYTEL®
NYLON RESIN

ZYTEL® HTN
HIGH PERFORMANCE POLYAMIDE

ZENITE® LCP
LIQUID CRYSTAL POLYMER

DUPONT™ ETPV
THERMOPLASTIC RUBBER THAT RESISTS OIL & HEAT

www.plastics.dupont.com

The miracles of science™