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MOLDMAX®
MOLD ALLOYS

SUMMER 2005

Robert E. Kusner

Dr. Robert Kusner presented "Dramatic Cost Reductions through Managing Thermal Mold Properties" at the MoldMaking Expo 2005

The thirty-plus attendees to the "Dramatic Cost Reductions through Managing Thermal Mold Properties" seminar during the MoldMaking Expo in Chicago, April 19, came to hear Brush Wellman's Bob Kusner speak on the factors affecting the thermal properties of a mold. Maximizing these properties can reduce cycle time and scrap rates, offering some of the greatest returns for capital invested in the plastic parts manufacturing process today.

Attendees learned about Thermal Transport and Fluid Transport, including ***Heat Capacity***;

1-2 tons of refrigeration is required per 100 lb/hr of molding. As a rule of thumb, enough water should run through the system so the water temperature rises no more than 5° F. Therefore, for a maximum of a 5° F temperature rise, a flow of at least 5-10 gpm is required per 100 lb/hr of molding.

as well as ***Thermal Diffusivity***;

Temperature decays exponentially with a time constant equal to the square of the distance divided by the thermal diffusivity.

- PET, with a diffusivity of about 1.7 x 10-4 in2/sec., has a time constant of 15 seconds for 0.1" thick material.
- P-20, with a diffusivity of about 1.25 x 10-2, has a time constant of 80 seconds for a waterline 1" below the surface.
- Copper Beryllium (C17200), with a diffusivity of 5.3 x 10-2, has a time constant of 19 seconds for a water line 1" below the surface.

and ***Thermal Permeability***;

When two bodies at different temperatures come into contact, their surfaces must come to the same temperature. Because of its higher heat permeability, a mold cools the surface of molten plastic immediately to a temperature several degrees above the mold's pre-injection surface temperature.

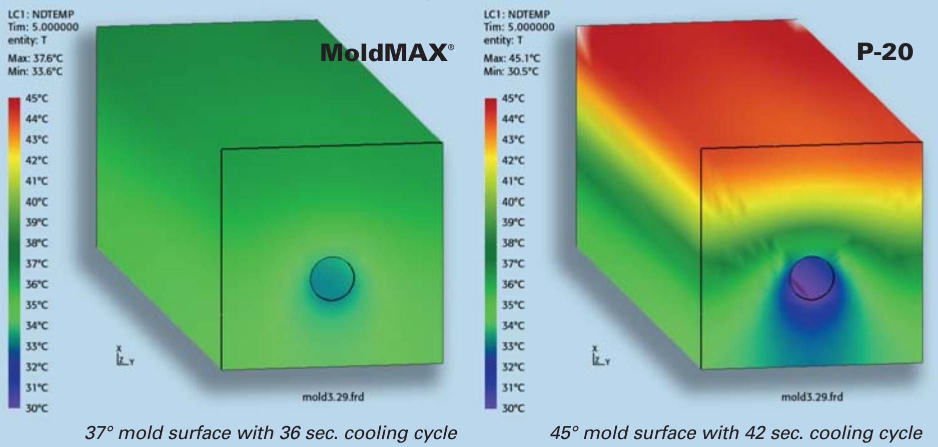
- The heat permeability ratio for P-20 with respect to PET is 17. 500° F PET hitting 70° F P-20 heats the mold/plastic surface to 94° F.

MATERIAL	Condition	Cooling Time	Temperature of the mold surface	Temperature of plastic mid-plane	Maximum plastic temperature	Temperature difference between water and mold at cooling line	Temperature difference between mold surface and waterline surface	Temperature difference between plastic surface and mid-plane	Temperature difference across mold surface
CuBe	Low coolant temperature	33	30.6	69.8	70.2	15	5	40	1.3E-01
CuBe	More cooling lines	33	33.3	72.1	72.3	8	3.5	38	3.8E-03
CuBe	Shallow cooling line	35	36.1	70.9	71.7	14	3	34	8.2E-01
CuBe	Baseline	36	38.5	71	71.3	14	4.5	30	1.1E-01
P-20	Low coolant temperature	37	40.1	71.6	72.3	12	19	31	3.8E-01
P-20	Shallow cooling line	38	39.8	69.8	72.3	12	10	32	2.6E+00
P-20	More cooling lines	38	41.7	71.4	71.7	6	12	30	1.7E-02
P-20	Baseline	42	46.2	70.3	71	11	16	25	3.4E-02
CuBe	Low heat transfer	45	53.9	72.7	72.9	31	3	20	9.0E-02
CuBe	High coolant temperature	50	71.7	85.3	85.5	9	3	13	7.5E-02
CuBe	Low flow rate	52	57.5	70.8	71.6	34	3	14	7.9E-02
P-20	Low heat transfer	52	57.4	71.6	72	25	13	14	2.5E-01
P-20	Low flow rate	58	60.2	70.9	72.6	28	11	12.5	2.2E-01
P-20	High coolant temperature	60	75.9	85.1	85.5	7	10	10	2.3E-01

FEA Results Overview (Temperature in °C)

Temperature distribution in a mold with turbulent cooling (20 °C water)

(Temperature in °C)



37° mold surface with 36 sec. cooling cycle *45° mold surface with 42 sec. cooling cycle*

MoldMAX® has a lower temperature differential (4°C) versus P20 (14.6°C) even though MoldMAX is running at a 6 seconds faster cycle.

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- The heat permeability ratio of Copper Beryllium w.r.t. PET is 30. 500° F PET hitting 70° F Copper Beryllium heats the mold/plastic surface to 84° F.

Finally, the attendees were presented with Finite Element Analysis (FEA) computer modeling results, which explored these four factors used in managing the thermal properties of a mold:

1. Core & cavity material
2. Temperature of the cooling water
3. Cooling water flow rate and heat transfer coefficient
4. Cooling line location and density

Through the FEA results, attendees saw that:

- Cycle time correlates directly with mold surface temperature
- Shallow cooling lines result in greatest thermal gradients across plastic and mold surface
- Copper Beryllium cycle time is about 10-40% less than P-20 cycle time
- Thermal gradients across a Copper Beryllium mold surface are about 70% less than those across a P-20 mold surface
- Large temperature differences occur between the cooling water and surface of the cooling channels in a mold

Additional information about the topic of this seminar can be gathered at **www.MoldMAX.com** or by calling **1-800-375-4205**.

To receive a copy of this presentation, please visit **www.MoldMAX.com/seminars**

Robert E. Kusner is a Market Application Development Engineer for Brush Wellman's Alloy Products group responsible for new product development, fabrication of custom engineered components and supporting the technical service group. He is a graduate of Case Western Reserve University with a Ph.D. in condensed matter physics. His areas of expertise include metallurgy, phase transitions, computer modeling of physical systems, and vacuum, thin film coating technologies.

MEET YOUR BRUSH WELLMAN PLASTICS TEAM MEMBER

Profiled: Febian Mak


Febian Mak

Febian Mak, Product Manager for Brush International's mold alloys, has primary responsibility for the development of new applications and products in the plastics industry throughout Asia. In addition, Febian has a secondary responsibility supporting Brush's aerospace and oil & gas industries in the Asia region. She is located at Brush Wellman's Hong Kong office.

Prior to joining Brush Wellman, Febian's experience includes positions with Baker Hughes Mining Tools, Alcoa and Assab Steels (HK) Ltd. She has been with Brush Wellman for 3 years.

Febian earned her Bachelors of engineering in Materials Engineering from the University of Wales, Swansea College, in the UK.

Brush Wellman's Growing Global Network

Brush Wellman is located strategically around the globe to support our customers in every region. The Global Plastics Team works jointly to ensure that our customers' needs are met in an effective and timely manner.

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