FIMMTECH

Frontier Injection Molding and Material Technologies, Inc -:- Inspiring Passion

OPTIMIZING VENTING IN INJECTION MOLDS

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1

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INTRODUCTION:

Suhas Kulkarni:
- 19 years of experience as a Process Engineer
- Worked for a garden products manufacturer and an automotive insert molder
- Bachelors in Polymer Engineering (India)
- Masters in Plastics Engineering (UMASS Lowell)

FIMMTECH:
- Started in 2004
- Requests for training after a few SPE lectures
- Need for processing help in Southern California
- Need for applied research to improve processes and productivity

2

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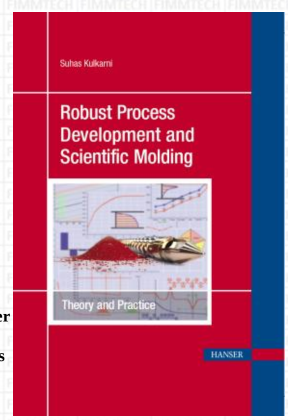
FOCUS AREAS:

1. CONSULTING
   - Process Optimization
   - Mold Transfers
   - 'Art To Part' Project – Concurrent Engineering
2. PROCESSING SEMINARS
   - Scientific Processing and Scientific Molding
   - Public and In-House Seminars
   - Courses at UC San Diego and UMASS Lowell
3. SOFTWARE
   - Scientific Molding
   - Design of Experiments
   - Tools for Production, Documentation and Analysis
4. RESEARCH
   - Material Overdrying
   - Vent Sizes
   - Applications of DOE techniques to Injection Molding

3

Author of the Book published in October 2010 by Hanser Publications



4

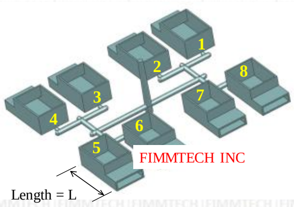
INTRODUCTION TO SCIENTIFIC PROCESSING

AIM OF A MOLDING OPERATION

- TO MOLD PARTS CONSISTENTLY
- TO MOLD PARTS THAT MEET ALL THE QUALITY REQUIREMENTS
- TO RUN AN EFFICIENT PROCESS

CONSISTENCY – 3 TYPES

• CAVITY TO CAVITY CONSISTENCY
PARTS FROM EACH CAVITY ARE IDENTICAL IN QUALITY



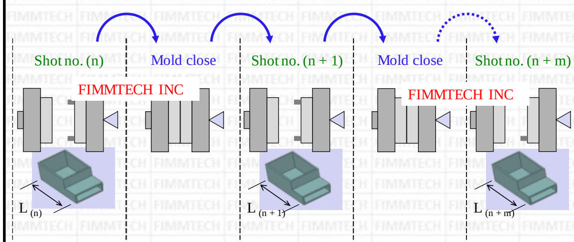
CAVITY TO CAVITY CONSISTENCY:

$L_{(CAV1)} = L_{(CAV\ 2)} = L_{(CAV\ 3)} = L_{(CAV\ 4)}$

$= L_{(CAV\ 5)} = L_{(CAV\ 6)} = L_{(CAV\ 7)} = L_{(CAV\ 8)}$

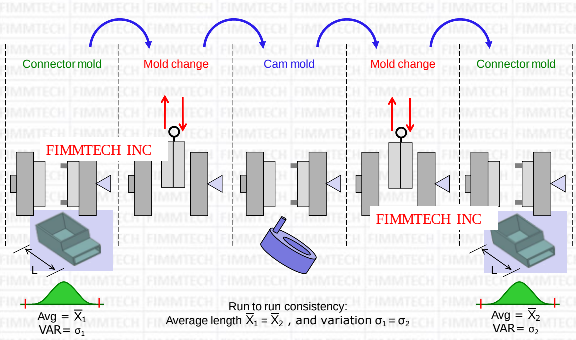
5

• SHOT TO SHOT CONSISTENCY
EVERY CONSECUTIVE PART THAT FALLS OUT OF THE MOLD IS IDENTICAL IN QUALITY



Part length, $L_{(n)} = L_{(n+1)} = L_{(N+\ldots)} = L_{(n+M)}$

• RUN TO RUN CONSISTENCY
DURING EVERY CONSECUTIVE RUN, THE MOLDED PARTS HAVE AN IDENTICAL QUALITY AS THE PREVIOUS RUNS

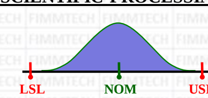


Run to run consistency:
Average length $\overline{X}_1 = \overline{X}_2$, and variation $\sigma_1 = \sigma_2$

INTRODUCTION TO SCIENTIFIC PROCESSING

QUALITY REQUIREMENTS –

- MEETING SPECIFICATIONS



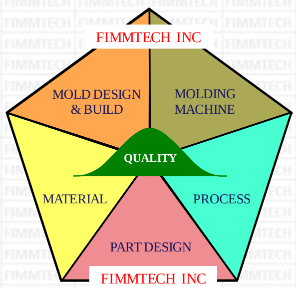
NOT ACCEPTABLE

EFFICIENT OPERATION -

- OPTIMIZED CYCLE TIMES
- REDUCED SCRAP AT STARTUP
- REDUCED SCRAP DURING PRODUCTION

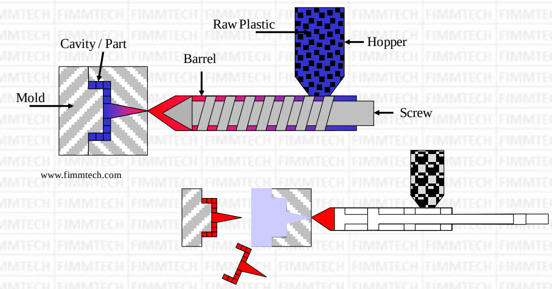
8

THE FIVE PILLARS TO SUCCESSFUL MOLDING



9

INJECTION MOLDING

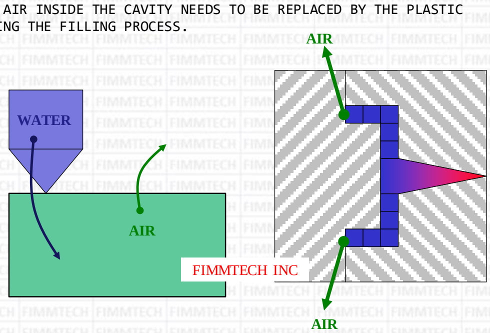


History:
1868: John Hyatt injection molds Celluloid billiard balls.
1872: Patent
1946 James Hendry build first Screw Injection Molding Machine.

10

VENTING:

THE AIR INSIDE THE CAVITY NEEDS TO BE REPLACED BY THE PLASTIC DURING THE FILLING PROCESS.



11

DEFECTS DUE TO POOR VENTING

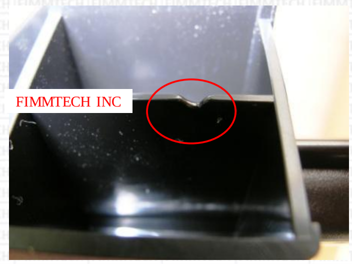
BEFORE VENTING **AFTER VENTING**

DEFECTS DUE TO POOR VENTING

BEFORE THE ADDITION OF VENTS

AFTER THE ADDITION OF VENTS

DEFECTS DUE TO POOR VENTING

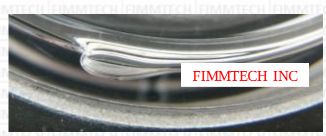


SHORTS

DEFECTS DUE TO POOR VENTING

SPLAY

DEFECTS DUE TO POOR VENTING



BUBBLES IN PARTS

DEFECTS DUE TO POOR VENTING

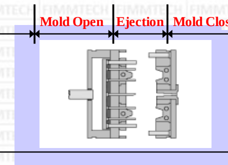
DEBRIS IN VENTS

THE INJECTION MOLDING CYCLE

Injection | Pack & Hold | Cooling | Mold Open | Ejection | Mold Close

Screw Fwd Time | Screw Recovery

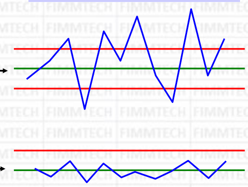
Complete Cycle



- MELT TEMP
- MOLD TEMP
- INJ SPEED
- PACK & HOLD PRESS
- PACK & HOLD TIME
- SCREW SPEED
- BACK PRESS

UNOPTIMIZED

OPTIMIZED



18

SCIENTIFIC MOLDING - THE 6-STEP STUDY

(4) WINDOW STUDY

(5) GATE FREEZE STUDY

(1) VISCOSITY CURVE

(6) COOLING STUDY

INJECTION | PACK & HOLD | COOLING

SCREW FORWARD TIME | SCREW RECOVERY

(2) CAVITY BALANCE DETERMINATION

(3) PRESSURE DROP STUDY

AIM: TO DEVELOP A **ROBUST PROCESS** AND **ACHIEVE CONSISTENCY**

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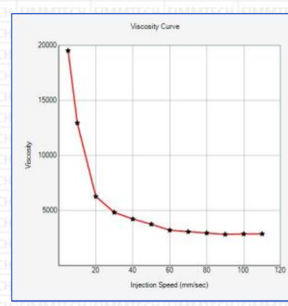
19

Viscosity = Fill Time X Peak Hydraulic Pressure X Intensification Ratio

Intensification Ratio = 10

Injection Speed	FillTime (sec)	Peak Inj Press	Viscosity
5	6.2	315	19530
10	4.05	320	12960
20	2.03	310	6293
30	1.5	323	4845
40	1.21	351	4247
50	0.99	381	3772
60	0.82	394	3231
70	0.73	424	3095
80	0.66	450	2970
90	0.6	475	2850
100	0.58	499	2894



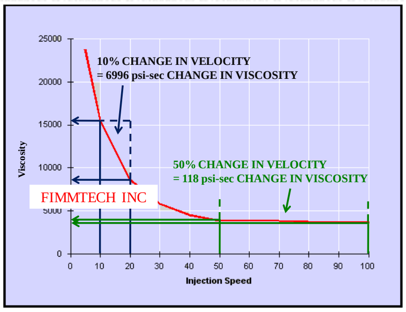
- HOLD PRESS = 0
- HOLD TIME = 0
- SCREW DELAY TIME = 'X' SECONDS
- AT THE HIGHEST SPEED, PARTS MUST BE JUST SHORT. ONCE HERE, SHOT SIZE AND TRANSFER POSITION MUST NOT BE CHANGED.

20

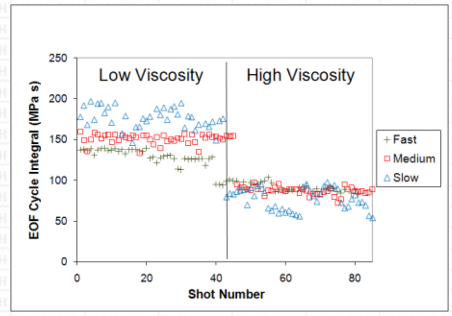
STEP NO 1

SENSITIVITY OF THE INJECTION TO VISCOSITY

Viscosity = Peak Hyd Pressure X Fill Time X Intensification Ratio



STEP NO 1



End of fill Cycle Integral data at various injection speeds for two polypropylenes of different viscosities [Mertes, Bozzelli – ANTEC paper]

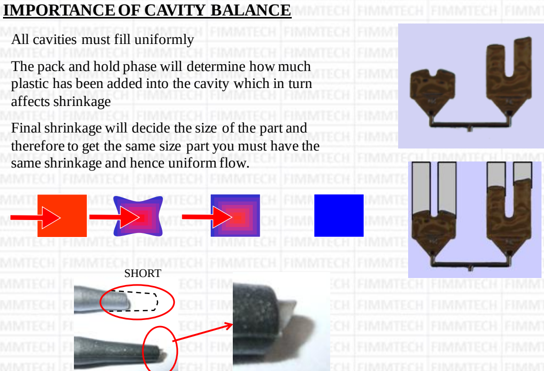
STEP NO 2

IMPORTANCE OF CAVITY BALANCE

All cavities must fill uniformly

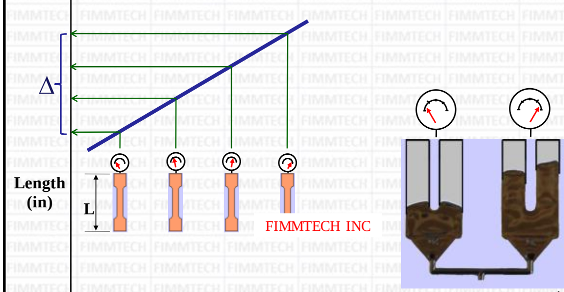
The pack and hold phase will determine how much plastic has been added into the cavity which in turn affects shrinkage

Final shrinkage will decide the size of the part and therefore to get the same size part you must have the same shrinkage and hence uniform flow.



23

EFFECT OF HOLDING PRESSURE ON THE PART DIMENSIONS

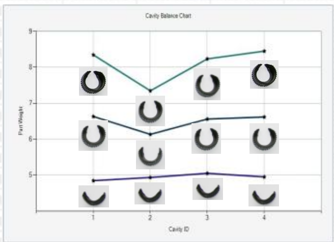


24

STEP NO 2

DETERMINATION OF CAVITY BALANCE

MAKE A SERIES OF SHORT SHOTS AND WEIGH THE PARTS.

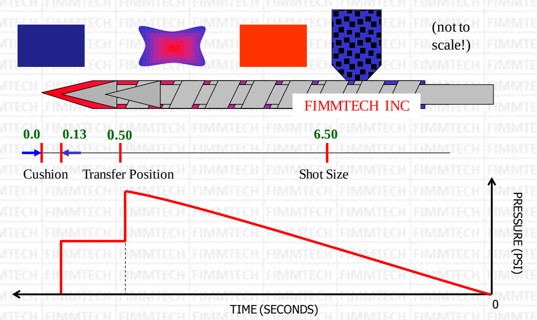


- MAKE A SERIES OF SHORT SHOTS AND WEIGH THE PARTS
- HOLD PRESS = 0
- HOLD TIME = 0
- SCREW DELAY TIME = 0

Cavity No	Fill 1	Fill 2	Fill 3
1	4.845	6.632	8.346
2	4.934	6.134	7.345
3	5.050	6.560	8.234
4	4.950	6.618	8.450

DECOUPLED MOLDING[SM]

(Decoupled Molding is a Service Mark of RJG Inc.)



MACHINE PRESSURE (HYDRAULIC)

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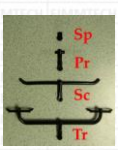
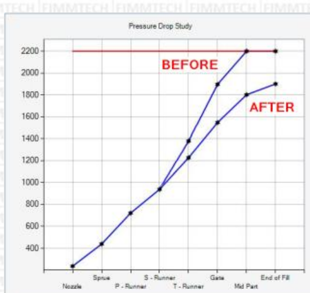
STEP NO 3

PRESSURE DROP STUDY

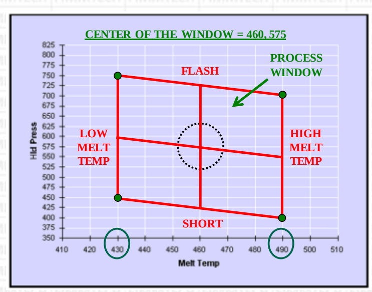
Flow Area	Peak Pressure 1	Peak Pressure 2
Nozzle	236	236
Sprue	438	438
P - Runner	721	721
S - Runner	938	938
T - Runner	1379	1227
Gate	1897	1548
Mid Part	2200	1802
End of Fill	2200	1901





STEP NO 4

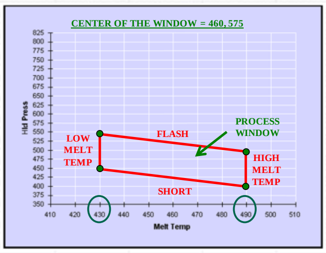
THE PACK & HOLD PHASE – THE COSMETIC PROCESS WINDOW

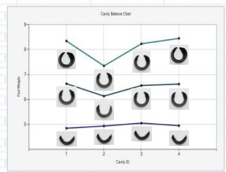


Process Window Study for Amorphous materials
– Hold Pressure vs Melt Temperature

STEP NO 4

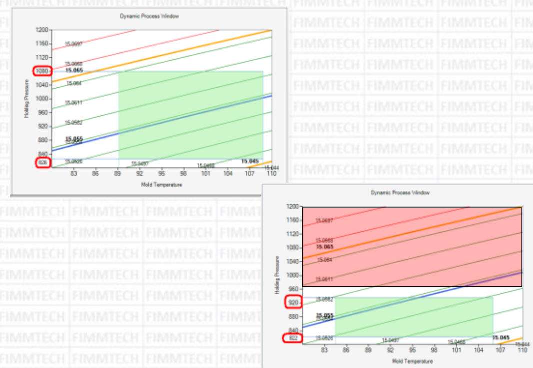
THE PACK & HOLD PHASE – THE COSMETIC PROCESS WINDOW





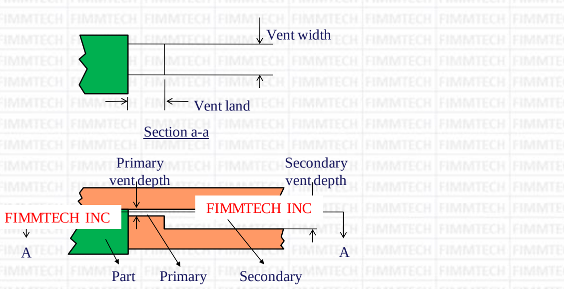
Process Window Study for Amorphous materials
– Hold Pressure vs Melt Temperature

OPERATING PROCESS WINDOW:



VENTING:

The air inside the cavity needs to be replaced by the plastic during the filling process.
Typical vent sizes can range from 0.0005” to 0.0025” depending on the material viscosity.
Poor Venting can lead to short shots and burning of the plastic especially at the end of fill.



31

VENTING:

TYPES OF VENTS:

- SPOT VENTS: THESE COME OUT PERPENDICULAR TO THE CAVITY ON THE PARTING LINE OF THE MOLD.
- RING VENTS: THIS IS ONE LARGE VENT THAT ENCOMPASSES THE WHOLE PARTING LINE AROUND THE CAVITY.
- VENT PINS: THESE ARE PINS PLACED IN AREAS WHERE THE END OF FILL IS NOT ON THE PARTING LINE SURFACE. EXAMPLES ARE POSTS OR RIBS.
- EJECTOR PIN VENTS: THE EJECTOR PINS ARE VENTED.
- FORCED VENTING: EXTERNAL VACUUM IS APPLIED TO GET THE AIR OUT BEFORE INJECTION. MOLD VAC SYSTEM.

32

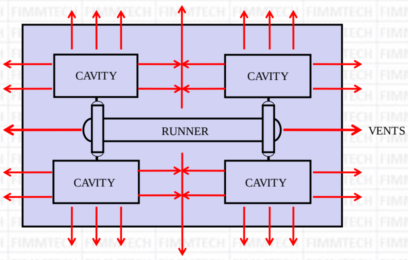


Figure 12.11 Possible location of vents on the parting line

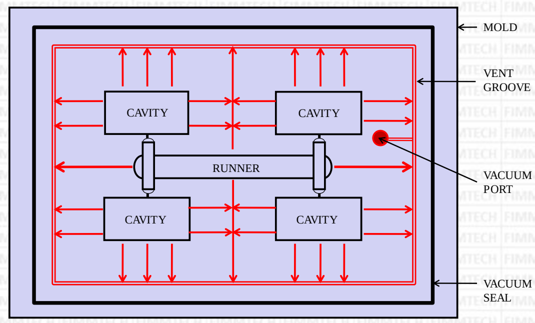
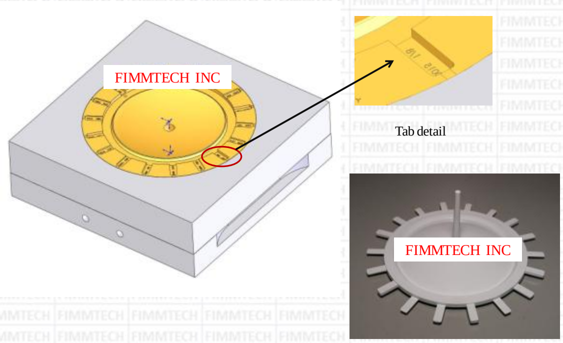
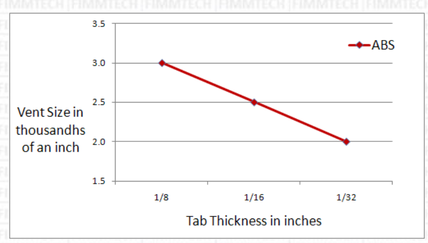


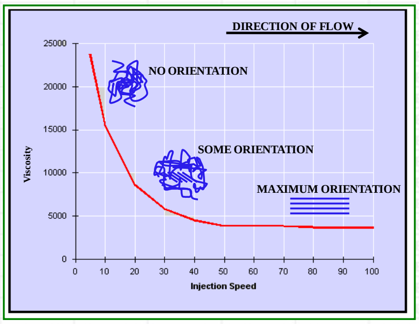
Figure 12.12 Venting using vacuum



VENT MOLD FOR STUDYING VENT SIZES



Graph showing the combination of tab thickness and vent depth where flash begins to occur for ABS (medium flow)



Tab Thickness = 0.125”
Vent Depth = 0.0025”
No flash

Tab Thickness = 0.125”
Vent Depth = 0.0030”
Evidence of flash

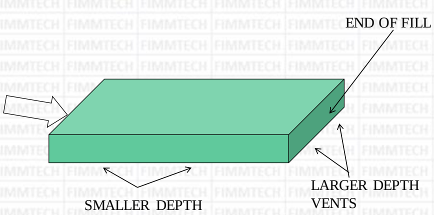
Tab Thickness = 0.03125”
Vent Depth = 0.0015”
No flash

Tab Thickness = 0.03125”
Vent Depth = 0.0020”
Evidence of flash

Pictures of Tab – Vent combinations showing no flash and evidence of flash

CONCEPT OF VARYING VENT SIZES

ALONG THE LENGTH OF THE FLOW

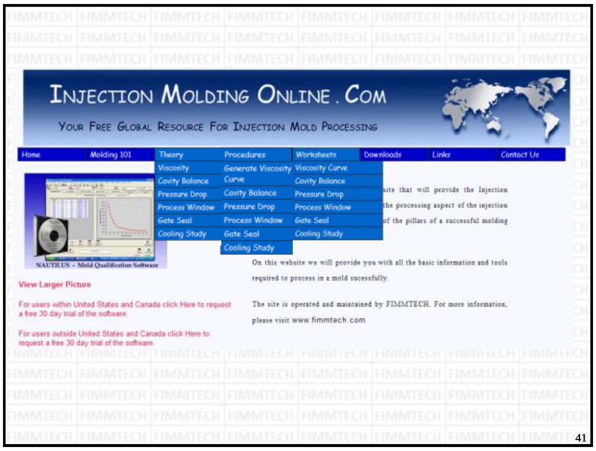


39

RECOMMENDATIONS FOR VENTING

- THERE IS NOTHING SUCH AS ‘TOO MUCH VENTING’
- EJECTOR PINS CAN BE USED AS VENT LOCATIONS – SELF CLEANING ADVANTAGE
- VENTS MUST BE DRAW POLISHED IN THE DIRECTION OF AIR TRAVEL OUT OF THE MOLD.
- RUNNERS MUST BE VENTED TO THE MAX – FLASHED RUNNERS ?? (ARE OK!)
- ALL VENTS MUST GO OUT TO THE ATMOSPHERE.

40



CONTACT INFORMATION:

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42