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HOT RUNNER INSULATION

Mr. Joy Doctor

+91- 9879478105

joydoctor@selplast.in

Temperature Variation of Hot Runners

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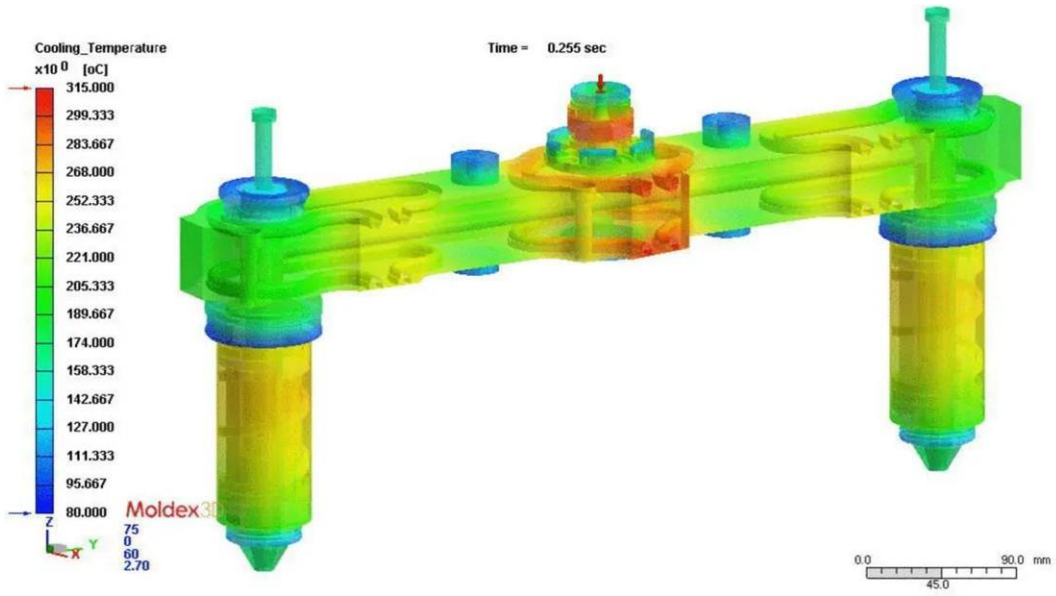
Modern Hot Runner Systems:

- Modern Hot Runner Systems are highly engineered to be as thermally balanced as possible using heaters layered into the surface of the steel of the manifold in custom shapes
- The 'insulation' used in these systems to isolate the hot runner from the mold base is an air gap and titanium cylinders
- Depending on design and allowed air gap, temperature variation can range from 10% in the best of systems to 30% in the most challenged systems
- Hot runner temperature settings must be set to adjust for the coldest sections
- Temperature settings are often set in the upper limits of the recommended processing range for the resin
- The more heat required to move the resin means the more heat required to remove during cooling, causing a longer cycle time

Hot Runner Thermal Analysis

Temperature Variance



Thermal Mapping

- Blue areas in direct contact with the mold base
- Green areas are the coldest sections relevant to the process which drives the temperature setting
- Yellow areas are now 'hot' relative to ideal for the material

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Cycle Time Advantages & Lower Energy Requirement

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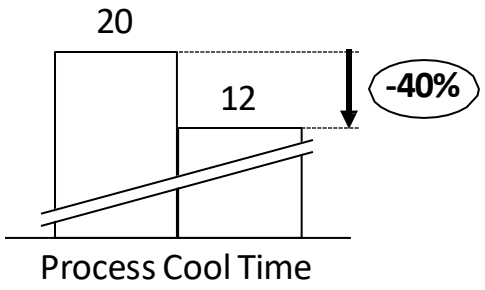
Minimize Thermal Variation:

- Yes, energy is saved in the hot runner by not running so 'hot' but that is small relative to total cycle time
- After injection the mold cools the part until solid enough to be ejected - i.e., Tg
- This cooling is roughly 40% from melt temp
  - Polymer and additive dependent
- The cooler the polymer is when injected, the less heat is required to remove - i.e., cool time to reach Tg

Simple Scenario - PP part with mold cool time of 20 seconds

Assumes Tm of 200° & Tg of *125*° (Part temp on eject)

- ❑ 250° to *125*°: 125°Δ in 20 seconds for Current Process
- ❑ 200° to *125*°: 75°Δ in 12 seconds for Insulated HR



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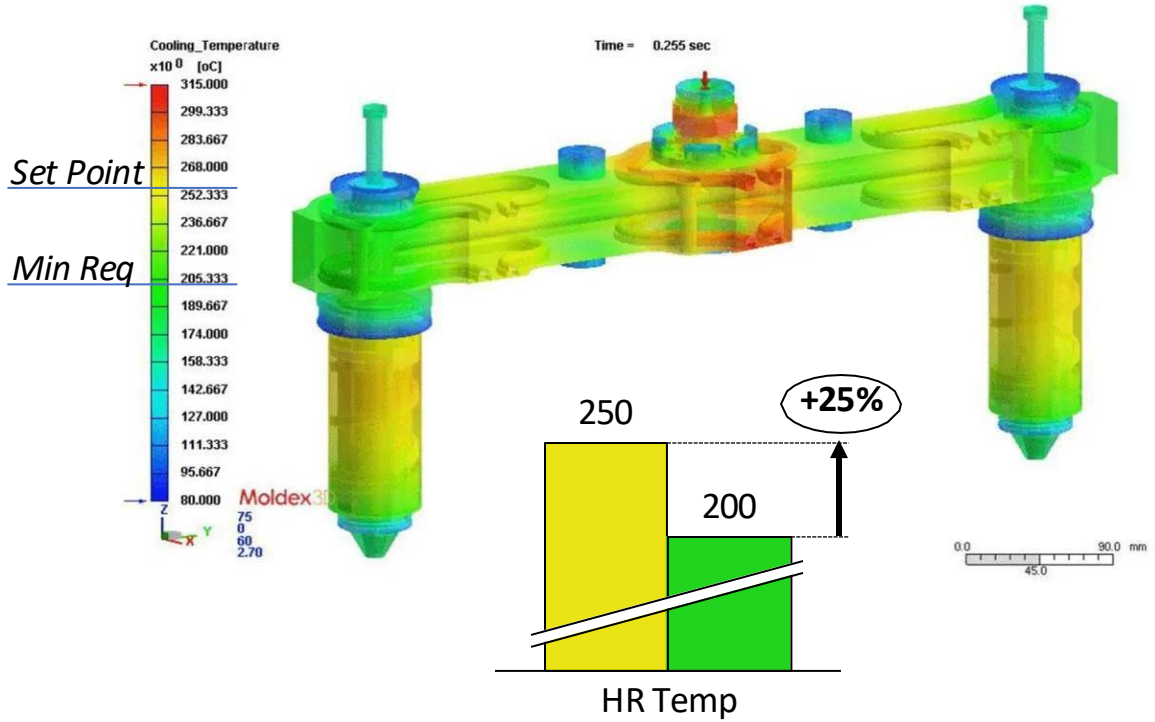

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Hot Runner Insulation – Minimize Thermal Variation

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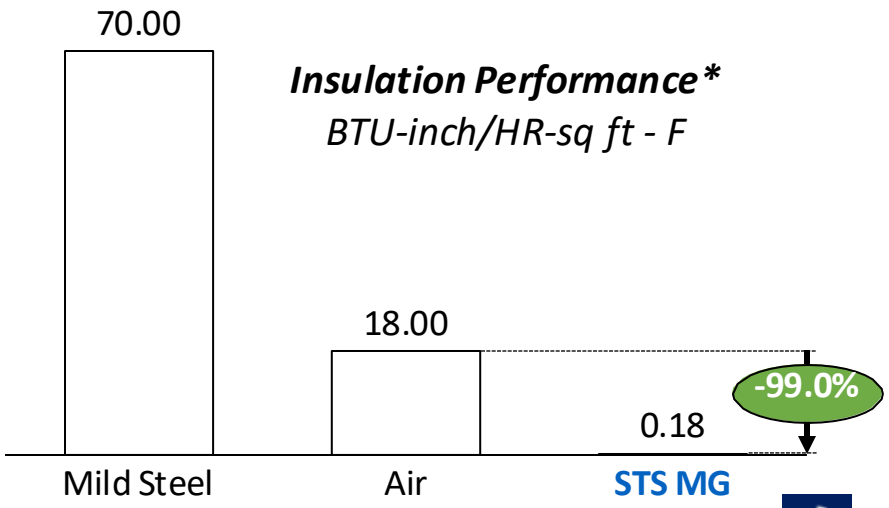
***Air Gap** (Standard):*

- Hot Runner is isolated from direct steel-to-steel contact by titanium pads
- Air gap is used as the insulation method
- Hot runner manufacturers have been searching for a non-asbestos material

Military Grade Insulation:

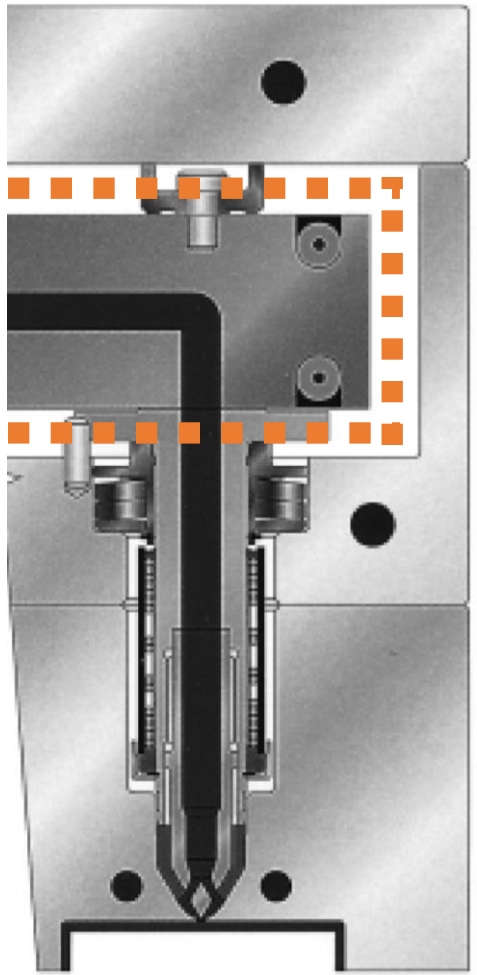
- High level insulation used in military, black box and space applications industrialized for high volume production efficiency
- STS MG packaged into panels or batts for assembly in as thin as 5mm
- Current engagement with several Hot Runner Manufacturers
- Tip & Nozzle to use a thin-wall formed sleeve - TBD
- ***Faster start up, lower cycle time & energy savings***



Insulation Performance*
BTU-inch/HR-sq ft - F

STS MG Panel
Silica base material

Current Insulation
Air Gap



Insulation Performance - Values approximate, actual thermal loss dependent on medium state*

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3 Competitive Position – Injection Molding Technologies – 03/03/23

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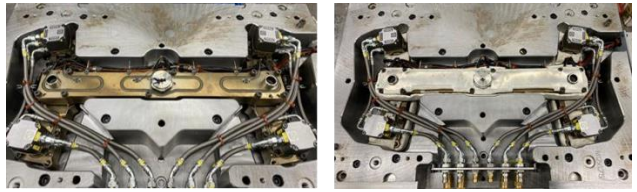
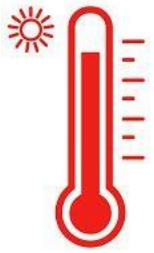
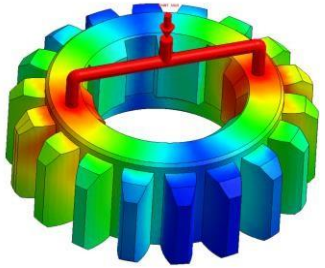
Heating of the Polymer
Precision Control



SINGH THERMAL SYSTEMS

Cooling
50% - 80% of Cycle Time





Polymer Flow
Machine into Mold

RJG MOLD SMART

Pressure and Flow at the Mold

iMFLUX » FEARLESS INNOVATION

Pressure and Flow at the Machine

Pressure
Pack & Hold until Solid

STS Technologies
Insulation minimizes heat energy required which means less heat energy to remove in cooling

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Injection Mold Hot Runner Insulation – Retrofit Example

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Packaging Mold – Caps:

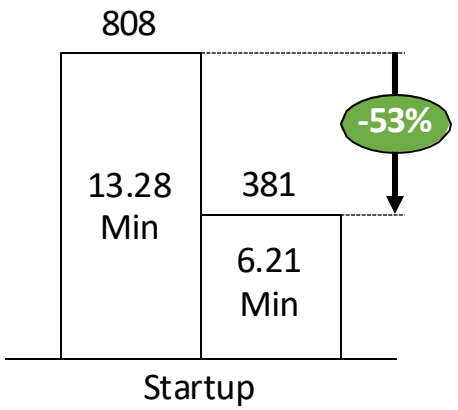
- 8 cavity cap mold runs in 250 ton press
- Material: Exxon LDPE
- Husky Hot Runner System
- Hot runner temp 425 F with barrel temps at 450 F

STS MG Insulation:

- Insulation applied to main hot runner only as a retrofit, hot drops not insulated
- Set temps at original target of 375 F manifold, 390 F barrel temps; short shot study identical to 425 F setting before insulation
- Able to increase injection speed without sacrificing quality

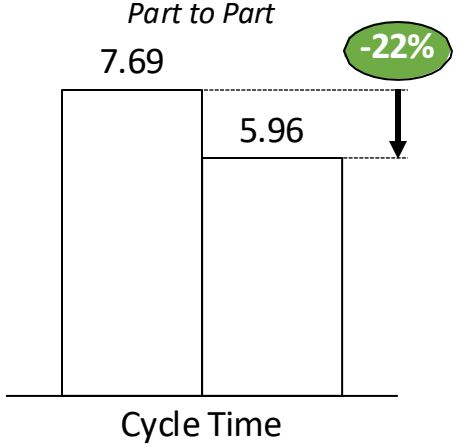
Time to Temp:

Ambient to set point (Sec.)



Cycle Time:

Part to Part

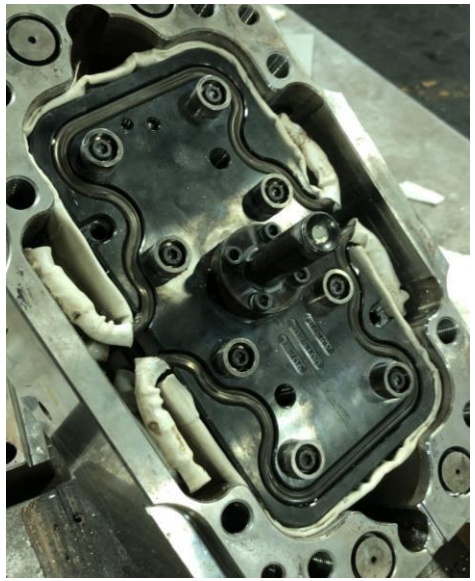


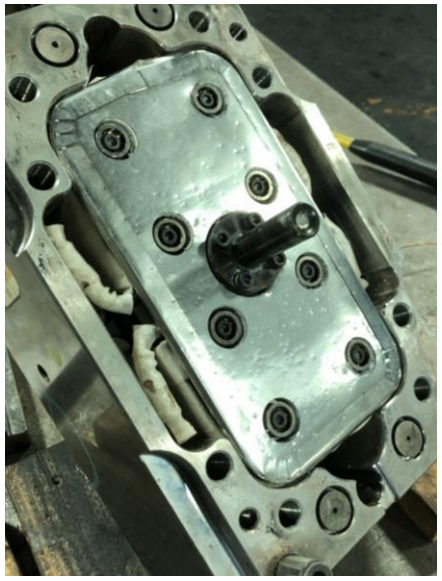
Additional Parts –

- 20 / min
- 1,200 / hr
- 28,800 / 24 hrs
- 576,000 / month*
- 6,912,000 / year

Payback: < 1 Month!

**Based on 20 working days / month*





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Injection Mold Hot Runner Insulation Types

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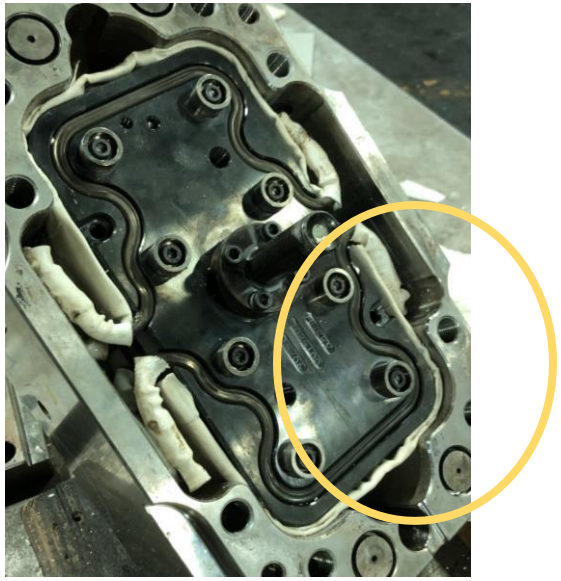
Construction & Encapsulation :

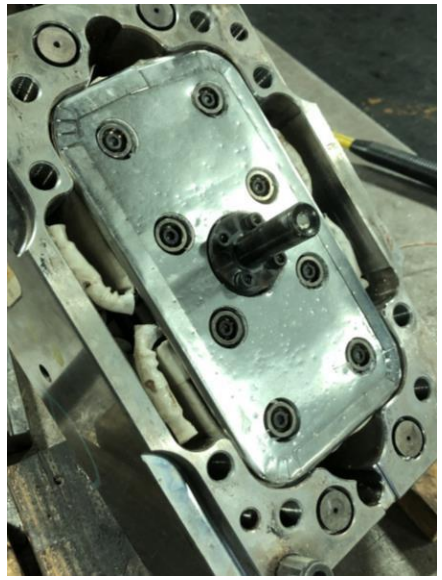
- Raw insulation material can be formed or encapsulated in several ways
- Raw material is excellent in compression but poor tensile strength alone.
- Injection molds have been insulated best using two methods: quilted & stainless-steel foil - both laser cut to shape
  - Quilted uses a fireproof cloth and the insulation is quilted in between two layers that are flexible around tight areas
  - Stainless construction is best suited for hot drops and areas needing a rigid or low friction material for ease of assembly

STS MG Quilt
Encapsulated - Flexible



Quilted laser cut material wrapped around the edges

STS MG Stainless
Encapsulated - Rigid



Stainless foil laser cut material for ridged application like hot drops and panels

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Mold Insulation – Two Shot Mold

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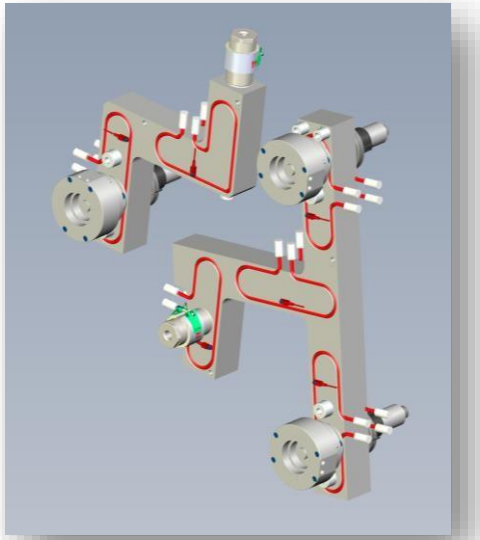
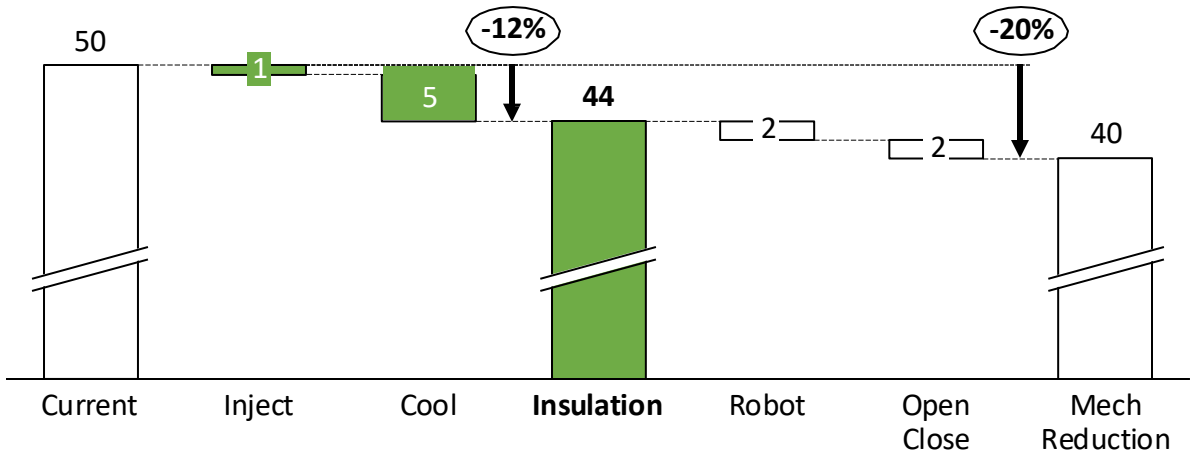
Process Changes:
Better Heat Retention & Thermal Balance Means the Following:

- Lower Hot Runner Temp
  - Faster time-to-temp on startup
  - Shear heat available for faster injection
  - Less heat to remove from the part after Injection for faster cooling time

- **Cycle time improvements 10-20% is common!**
- **Goal is to run in 5 days vs 6 – eliminating overtime**

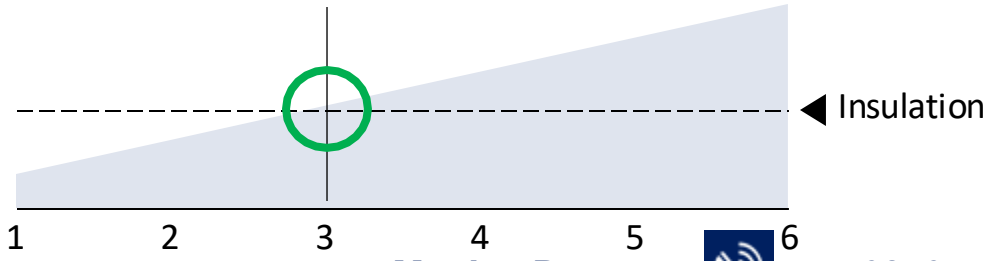


Cycle Time Summary in Seconds



Cost to Benefit Over Months

Overtime in Months vs Insulation Cost



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Concept to Insulated

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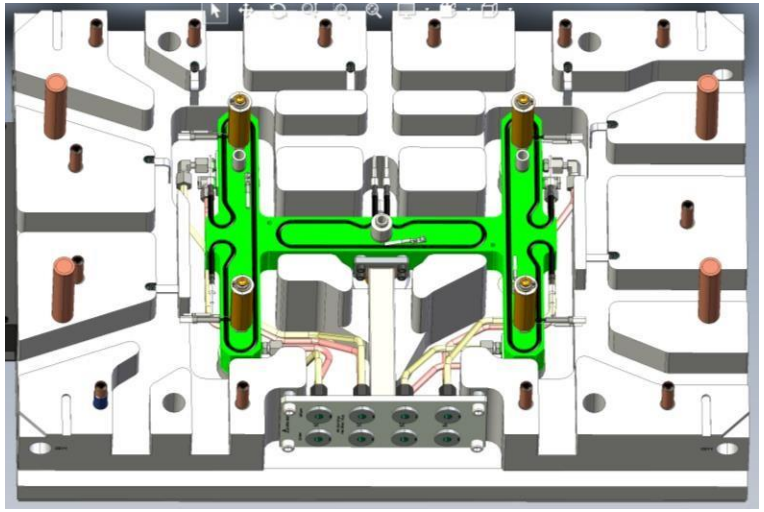
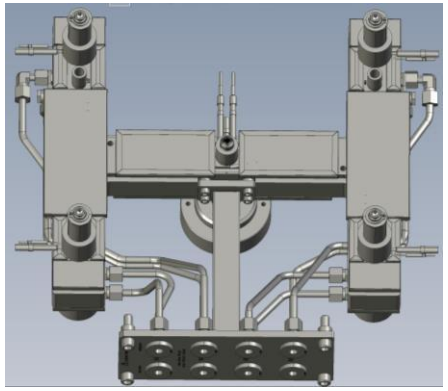
Design Construction & Encapsulation *:*

- STS engineering begins with CAD of both mold base and hot runner at a minimum
- Clearance must be verified or can be planned at the design stage
- STS designs around necessary components or features such as lift holes
- Design to panel fabrication is 2-3 weeks and is then kitted with each panel identified for assembly to a supplied layout
- Insulation can be installed as a retrofit onsite or shipped as a kit to a designated tool shop or select hot runner manufacturers

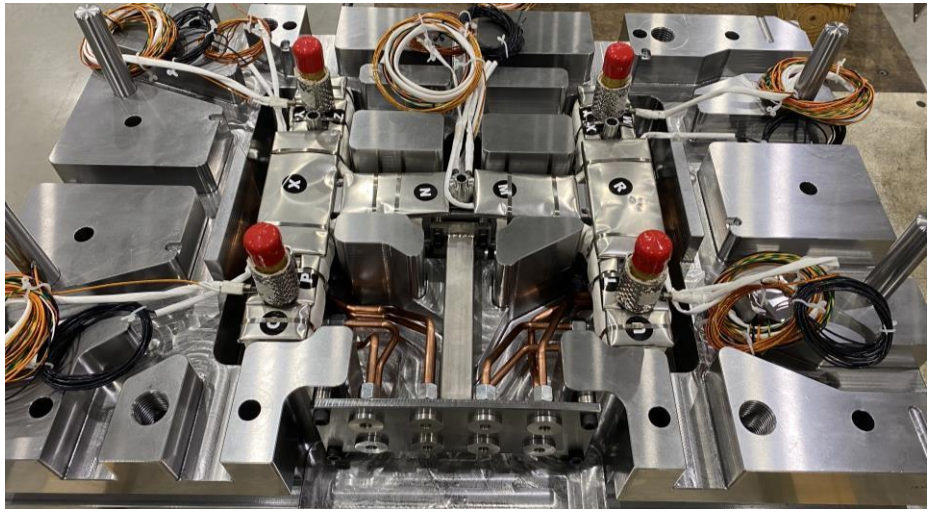
CAD Received
Standard HR Design



STS Panel Design
Unique to Each HR



Final Installation
Kitted or Installed by STS



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Mold Insulation Advantages – Technical

Blended Materials: e.g., TPE's & TPO's

- Blends are not chemically bonded polymers, and those polymers have differing molecular weights
- Thermal variation in the hot runner can lead to those blends separating causing common quality issues such as delamination
- Insulation allows for larger process window for quality and cycle time improvements

Minimize Shrink: Target Thick Sections, high tolerance parts and 'flat parts' using highly crystalline materials (PP, PA6, PA66)

- Running the process 'cooler' means running closer to the material's Tg, the point where the polymer stops moving (shrinking)
- Plastics are poor thermal conductors, thick sections sees the outside of the part freeze before the inner portion, this leads to dimensional challenges with technical parts, sink and even structural voids
- Examples include:
  - Structural parts like cam covers, oil pans, IP structures, battery trays - complex geometries that need to be flat with thin to thick sections throughout
  - Interior trim components where sink creates a cosmetic defect like air bag covers, glove box doors, A pillars - molded in color components are especially challenging

Thermal Degradation & Polycarbonate Lenses – Optical components that are color critical

- PC lenses and light guides, material is chosen for impact and heat resistance vs Acrylics
- PC is notorious for color shift (yellowing) when exposed to UV or extended heat where the polymer begins to break down
- Automotive requirements for clarity with lenses and light guides means molders of these components see scrap rates exceeding 10% in normal operation
- Ability to run cooler means less thermal stress which translates to lower color shift (yellowing) and longer component life in the field for color shift. Yellowing of headlamp lenses in high UV states is a problem without a solution - clear safety issue

Inflationary Pressures

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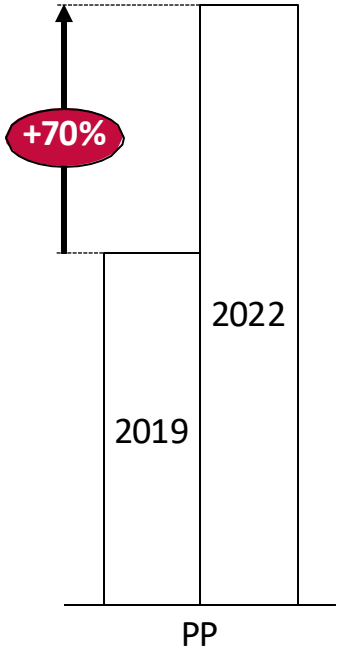
Some things we can impact:

We can't help you with resin pricing, but we can help offset the other effects of inflation

- Faster cycle times means more parts per hour means ability to offset inflationary pressures in Energy & Labor

Resin Inflation

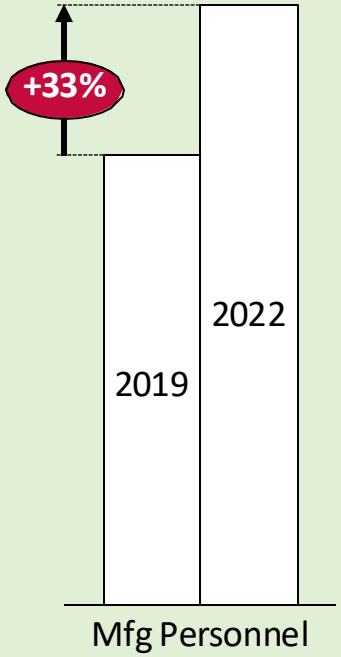
PP Co-Polymer Injection Grade



▶ PlasticsNews.com

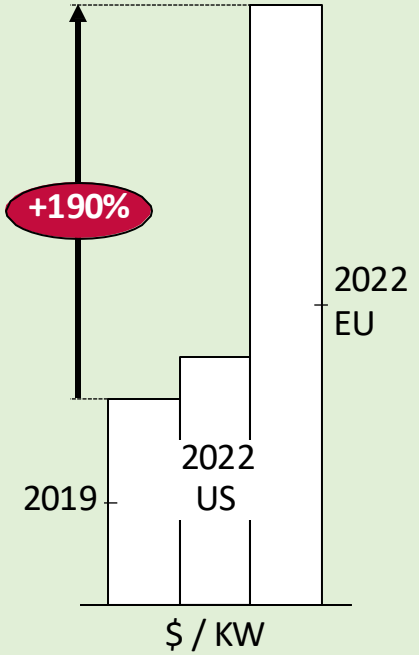
Labor

Hourly Rate



Energy

Electricity Rates



Energy Means Carbon

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Mold Insulation Advantages – Energy & CO2

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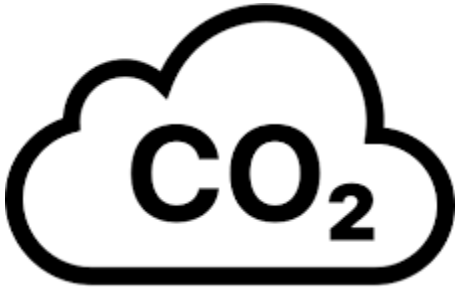
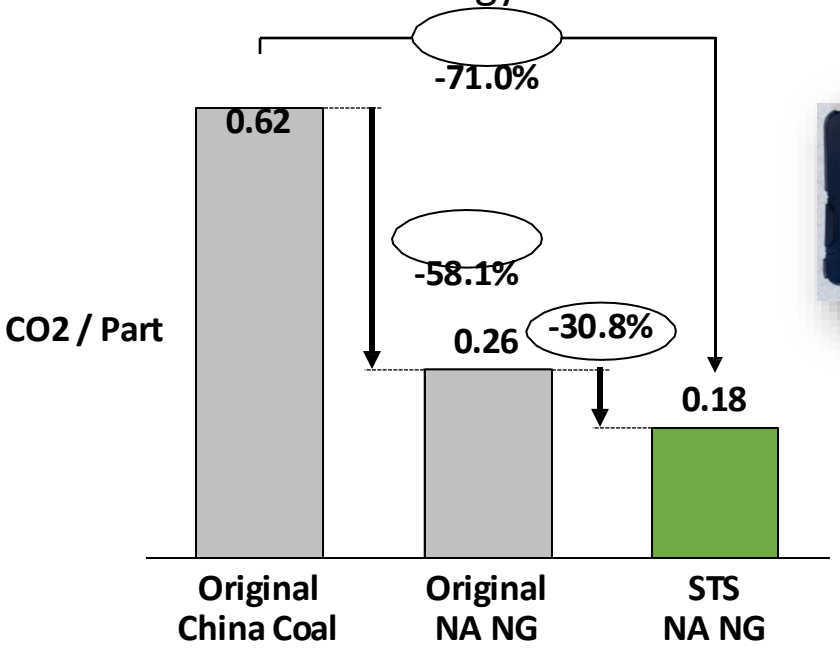
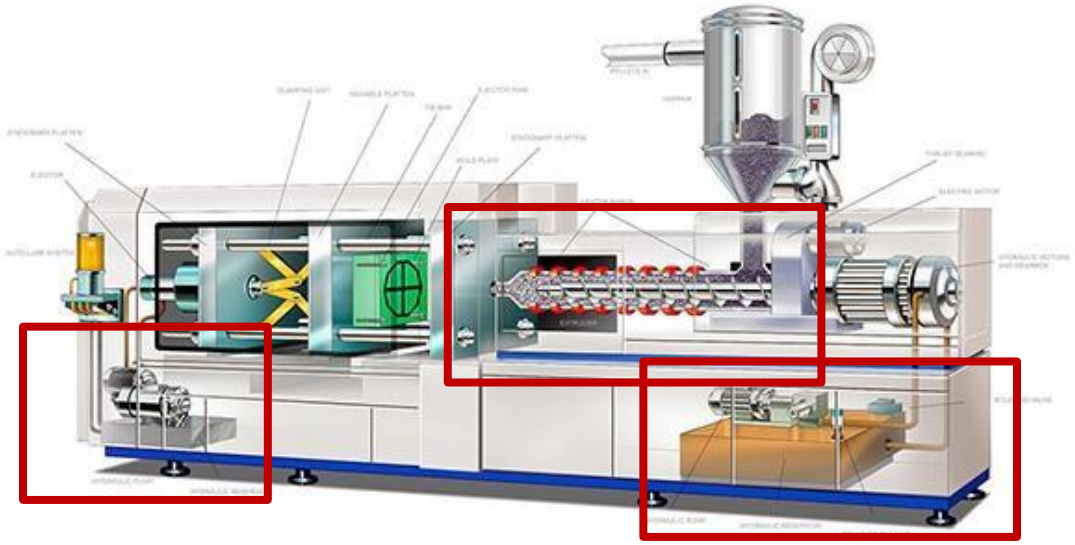
Heat & Pressure:
Whether 5 parts or 50 parts are molded, often requires the same amount of energy to ensure pressure is available for motion and heats are on to keep the polymer molten.



- Energy consumption per part is a function of yield
  - Faster time-to-temp on startup means less wasted energy warming up
  - Faster cycle time means more parts per hour, means less energy per part
  - Less energy per part means less CO2
  - Source of energy matters in amount of CO2



Cell Phone Case – On Shoring & CO2



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Carbon Reduction Goals

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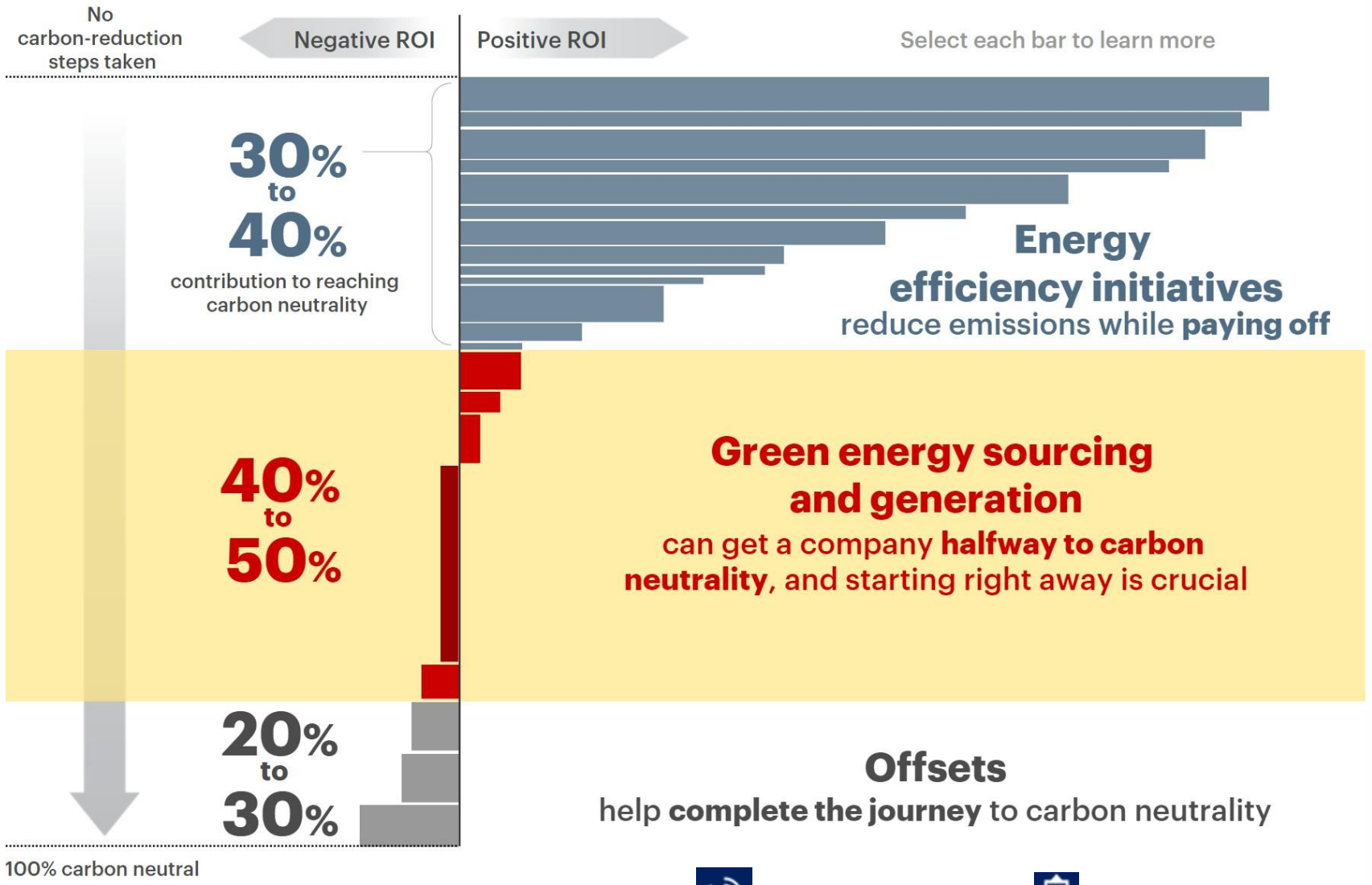

Consulting Studies:
Steps in efficiency have an outsize effect on carbon reduction goals

STS insulation systems are engineered specifically to address efficiencies in injection molding

Positive ROI's mean these should be the first projects undertaken before reaching for negative ROI's in energy sourcing & offsets

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Thermal Loss

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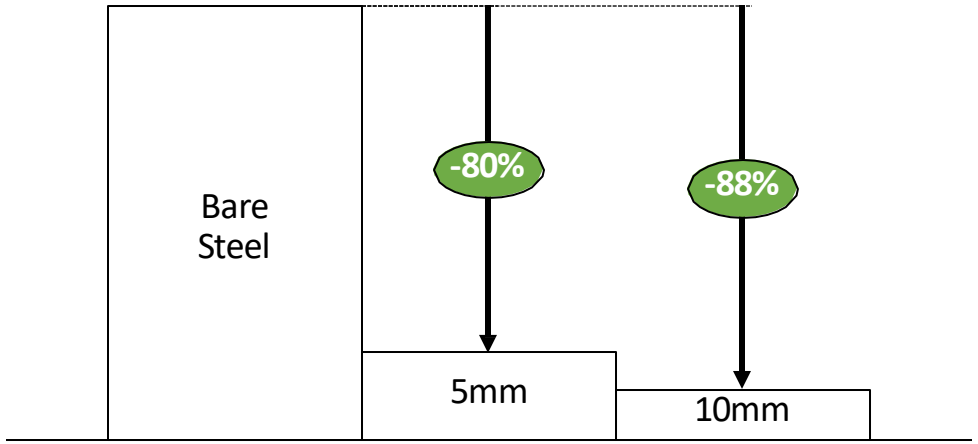
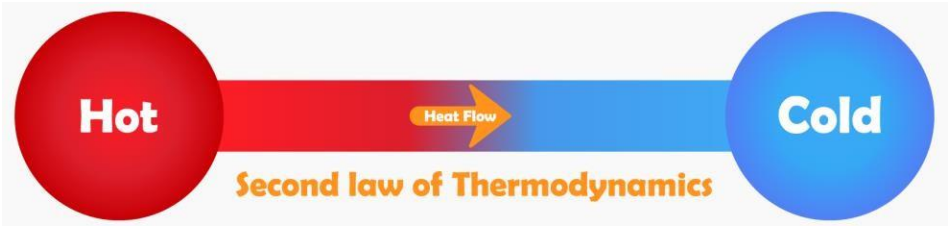
Hot Runner Surface Temp at Thermocouple

230C / 450F – Thermal Transfer Rate



Heat Loss by Insulation Thickness

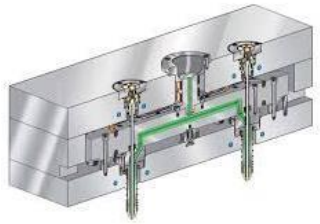


Heat Transfer:

Thermocouple positioned on the surface

Uninsulated the heat flows internal & external (air & mold base / cavity block)

Insulated the heat flows internal for even heat balance for the polymer & reduced energy required to run



Metric – Insulation 5mm & 10mm

Variable Insulation Thickness	Surface Temp (°C)	Heat Loss (W/m^2)	Efficiency (%)
Bare	231.7	3879.00	
Layer 1 (5.0)	91.4	782.60	79.83

Variable Insulation Thickness	Surface Temp (°C)	Heat Loss (W/m^2)	Efficiency (%)
Bare	231.7	3879.00	
Layer 1 (10.0)	69.1	448.30	88.44

Standard – Insulation 0.20” & 0.40”

Variable Insulation Thickness	Surface Temp (°F)	Heat Loss (BTU/hr/ft^2)	Efficiency (%)
Bare	449.2	1230.00	
Layer 1 (0.2)	195.4	245.20	80.07

Variable Insulation Thickness	Surface Temp (°F)	Heat Loss (BTU/hr/ft^2)	Efficiency (%)
Bare	449.2	1230.00	
Layer 1 (0.4)	155.7	140.20	88.60

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Change in Mindset

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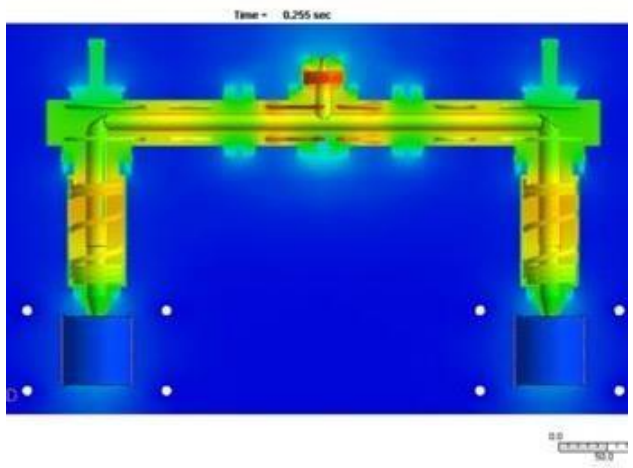
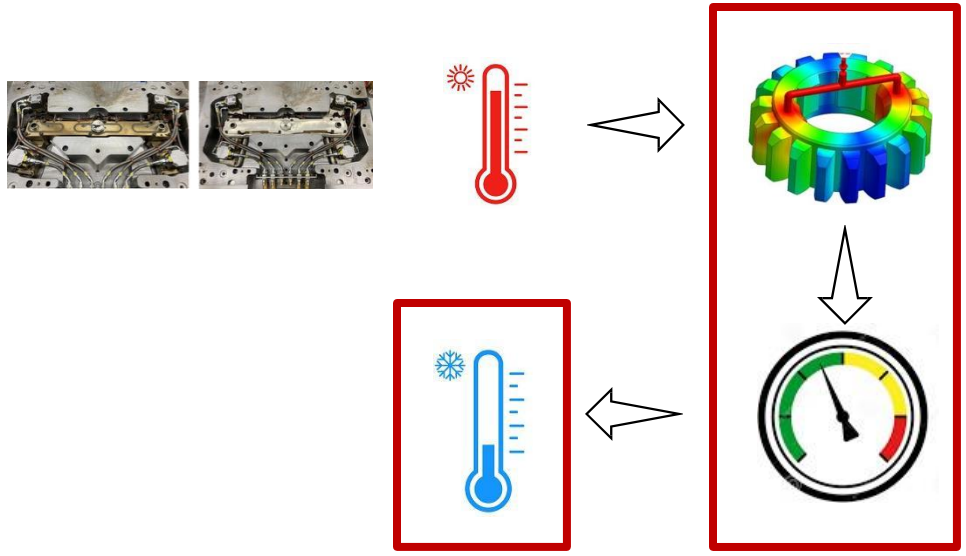
Injection Mold Process Training:

Past & process training focuses on flow and pressure exclusively - historically a focus due to high variation in batch resin quality and poor machine control on early hydraulics - today process control for both polymer & molding machine are high

Polymer suppliers provide recommended temp settings well above actual melt temps to protect from flashing and damaging molds - no incentive for cycle time

Thermal focus and money applied today is purely on cooling - "More Water", copper alloys for cores, conformal cooling





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SELPLAST EXPORTS P. LTD.
301, 3rd Floor, Popular House, Near Income Tax, Ashram Road, Ahmedabad - 380009, Gujarat, INDIA.
www.selplast.com

Mr. Joy Doctor +91- 9879478105 joydoctor@selplast.in