How to Use and Understand Effective Melt Temperature

What It Is

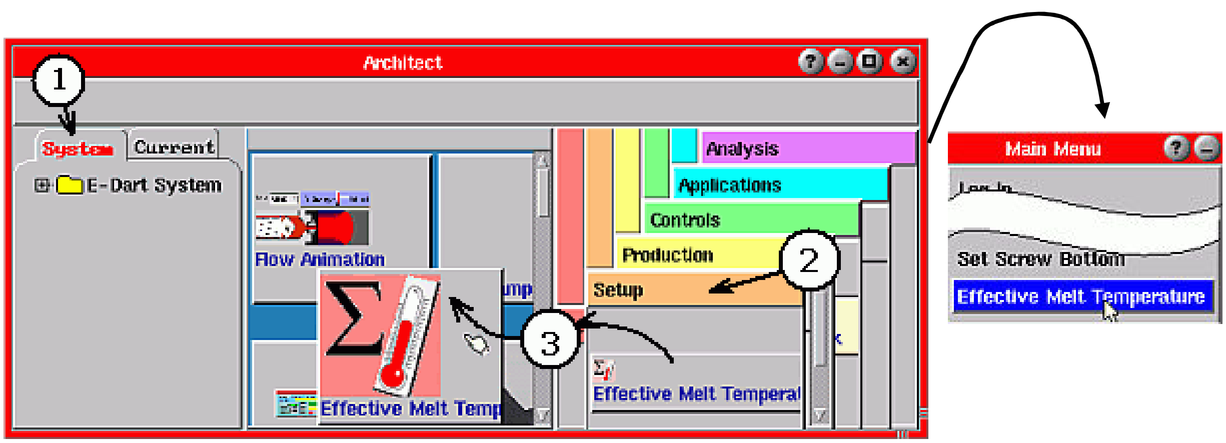
"*Effective Melt Temperature*" is a summary value that the *eDART*™ computes on each shot if it sees data from a cavity temperature sensor. Cavity temperature sensors are installed in the wall of the cavity where the flow front contacts the sensor as it passes by.

The number uses a calibration factor to make it read out something close to the actual melt temperature (usually barrel temperature). Because we set the factor by experiment the *Effective Melt Temperature* it will never read out the actual temperature of the melt. But if the value changes over time or when transferring a mold between machines you can suspect a change in melt temperature.

We will use "*EMT*" as an abbreviation for "Effective Melt Temperature".

How to Use It

1. Install cavity temperature sensors in the cavity walls according to best practices.
    a. Flow front must contact the sensor.
    b. Wires buried in channels in the mold or inside shielding up into the bottom of the Lynx Quad Temperature module.
    c. The Lynx Quad Temperature module is grounded to the mold.
    d. Ensure that noise on the data is very, very low; generally 1 digital bit or 0.1 °F. Items b and c above are designed to ensure this.
2. Set up the software for calibrating[1] the *EMT* value. The graphic below shows how you add the EMT software to the eDART's Main Menu.



Note that you need to close the Architect and open the Main Menu twice to see the EMT.

3. On Sensor Locations name all cavity temperature sensors with in-cavity names: *Mold Temperature / Post Gate, Mid Cavity* or *End of Cavity.*
4. On the Sequence Settings, "Other" tab set the integration limit as late as possible that will still allow sorting automation to work. We recommend using Mold Clamped if the automation can still sort or a fixed time if not.

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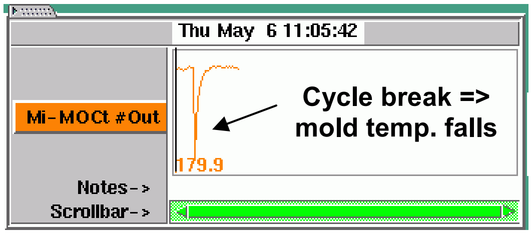
[1] "Calibrating" is also called "Normalizing". This means making the eDART pick a constant so that the Effective Melt Temperature calculation produces a value close to a number that you choose.

5. Start the process and stabilize the mold temperatures. This can be seen by looking at the Summary Graph "*Minimum*" summary value for the cavity temperature sensors. You can also



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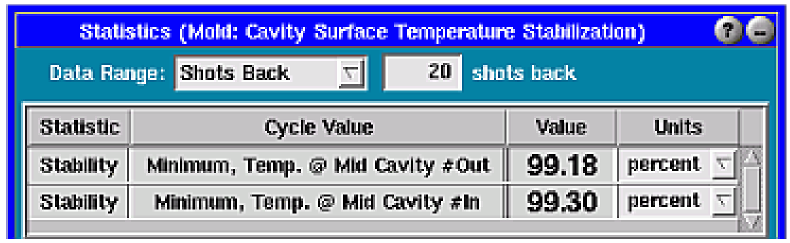
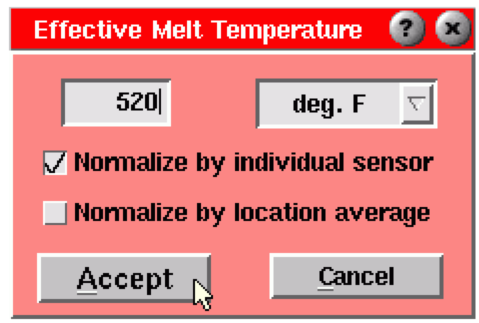


add the "Stability" number to the Statistics tool for each "*Minimum / Temp. @ …*". Wait for the stability number over 10 or 20 shots to reach about 97 percent.

6. Select a value you think reasonably close to the actual melt temperature. Using the barrel temperature settings is easiest. You can also use a 30 – 30 melt test. But be sure the process has stabilized again before continuing.



7. On the eDART's Main Menu open EMT. Enter the value from step 6 as shown here.

   Generally use the "Normalize by individual sensor" so that each sensor reads EMT with the value entered. The "by average" switch is for research (see "How It Works" below).

8. After one more shot add the EMT values to the Cycle Values window and watch them for a few shots. If they are a little off you can repeat step 7. In the end the EMT AT each sensor should read close to the number you entered.

9. Now you can use the EMT value like any other in the eDART: Add to the Summary Graph, set warnings or alarms, do statistics and so forth.

   Note that the EMT values will be a little noisier than most. This is because the EMT calculation is very, very sensitive to changes in the minimum melt temperature. We had thought of smoothing it with a filter but decided that it is too risky.

<u>EMT Behavior and Cautions</u>

- Until you complete step 7 above the EMT numbers mean nothing and should not be used.
- EMT does <u>not</u> show you actual melt temperature. It only shows you the change relative to the value you set into it.
- For the EMT to show real change the rest of the process must be generally similar. For example making a dramatic change in hold pressure or time can cause the temperature calculation to get confused. Thus comparing EMT between fill-only and packed parts is meaningless.
- Sudden changes in mold temperature (as in cycle breaks) cause errors in EMT calculation. Since the mold temperature is unstable (changing over the cycle) the EMT math does not have a good number to use for the cold mold temperature. EMT works best with a stable process.
- The normalized constants that the EMT saves are saved with the material. If you change the material on the Job Setup then you will need to normalize again.
- If you change materials, stop the job and create a new job with the new material. Otherwise the normalization will be wrong because the constants apply to the old material.

How It Works

By performing some math on the cavity temperature sensor curve the eDART can make an estimate as to how much heat has been pulled out at the sensor location. Given the right constant (set above) and the cold mold temperature (minimum before the flow front arrives) it can induce what the melt temperature was. The actual, physical constants for the plastic, the mold and the conductivity between the two are so approximate as to be unusable.

The material properties have a large effect on the way heat is conducted out of the part. Changes in colorant or fillers will make the EMT calculation useless unless it is re-normalized. This is why a different job setup should be used for different materials. Each one has its own set of constants saved with the material.

There are a number of limitations to this approach. First we must assume that the part is removed with approximately as much heat in it on every cycle. This is reasonably true as long as you don't make dramatic changes in mold clamped time.

Another factor is that pressure affects the heat flow into the sensor. Dramatically changing pressures can cause the conduction to be better or worse. And higher pressures create adiabatic heat that then disappears when the pressure drops.

Furthermore, the way the sensor is installed and the ability to conduct heat from the local steel to the surrounding steel or coolant can affect the math behind EMT. Thus when you normalize EMT the standard method is to let the eDART compute a separate constant value for each sensor. Thus if you started with an EMT of 520 °F then EMT at each sensor should read about 520 °F unless there is a change.