# Injection molding considerations for trial planning

*Evaluating resins for increased life expectancy in medical devices.*

Manufacturers of medical devices continue to face challenges brought on by more frequent disinfection with aggressive chemicals and increased portability. While effectively reducing the incidence of health care-associated infections (HAIs), these stringent protocols can shorten the lives of devices and electronic housings made with incumbent polycarbonate (PC) resins and PC/ABS blends.

In an effort to increase life expectancy of medical devices and housings, Eastman has introduced the Eastman™ MXF compounded products portfolio, beginning with Eastman™ MXF121 copolyester and Eastman™ MXF221 copolyester.

Eastman MXF products have been successfully used in clear and opaque applications that demand:

- Unsurpassed chemical resistance to lipids and harsh disinfectants
- Superior impact strength—even after disinfection*
- Product longevity in medical devices as well as housings, enclosures, and covers
- Uniform color matching
- Fully compounded one-pellet solution
- Ease of processing
- Biocompatibility
- EPP compliance—supports hospital Environmentally Preferable Purchasing guidelines
- Flame retardant compliance—UL 94 V2 flame rating

Injection molding trials provide critical information, whether an Eastman MXF product is being considered for use in an existing tool that was designed for a polymer with similar shrinkage behavior or when a new tool build is possible. While the approaches for existing and new molds have differences, both can be most effective when key information is known as early as possible.

This whitepaper reviews several components of the injection molding operation that should be considered when conducting a mold trial with MXF materials.

**In testing that measures notched Izod impact strength, Eastman MXF221 copolyester retained more than 90% of its original impact strength after exposure to stringent disinfectants—far superior to traditional materials such as PC blends.*

## A. Simulation

Conducting a Mold Filling Analysis for a part, runner, and tool being considered to run an Eastman MXF material provides valuable pretrial information, including:

- Part and Runner geometry complexity—especially when a nonuniform wall thickness is encountered
- An understanding of injection unit and clamp tonnage needed
- Conditions that favor a specific resin for the application
- Insight into pressure drops (nozzle, sprue, runner, gate, full part, rib, etc.)
- Insight into gate location, fill time, flow restrictions, air traps, venting, temperatures, and weld lines

ALSO CONSIDER:

- For new molds, simulation is most helpful before steel is cut.
- For existing molds, further insight into material flow vs. pressure drop is important to know to guide processing. (There is also an opportunity to compare the incumbent material with an MXF grade being considered.)
- Including the tool and the runner (melt delivery system) in the simulation provides valuable information.
- The chance for success is increased when the part designer, the toolmaker, the molder (processor), and an Eastman representative can communicate prior to the trial (ideally these contacts are established from the beginning of the project).

## *B. Drying*

Eastman™ MXF compounded products are all hygroscopic, so regenerative desiccant drying is a must—tray dryers relying only on heated air do not work. It is important to prevent moisture from reacting with the molten polymer and reducing its molecular weight which leads to lower mechanical properties and reduced chemical resistance.

Multibed dryers work best and must be able to consistently deliver dry air at a minimum dew point of –29°C (–20°F).

Drying conditions are:

- 85°C (185°F) for 4 hours minimum with throughput rate as the guide to hopper sizing. Dryer heat up time does not count as part of the 4 hours.
- Should the material dry overnight, a reduced temperature of 80°C (175°F) should be used.
- Desiccant bed regeneration temperature must be at least 205°C (400°F) to efficiently drive off the collected moisture prior to coming back on-line.
- Process airflow is typically 0.06 cubic meters of hot dry air per minute for each kilogram of material processed per hour (0.06 $m^3$/min per kg/h or 1 $ft^3$/min per lb/h).
- Target moisture content in the range of 0.005%–0.015%.

ALSO CONSIDER:

- Desiccant dryers simultaneously dry the resin and regenerate the desiccant. The moving parts, filters, and motors are covered by metal panels and are not seen and can be easily forgotten.
- Frequent inspection and following a preventive maintenance schedule will save time and money, minimizing downtime and reducing scrap.
- Poor air filtration can lead to contaminated desiccant which reduces its efficiency.
- Regular cleaning of filters should be a priority.

## *C. Screw design*

Eastman™ MXF products perform satisfactorily with the broadly described "general-purpose" GP screws that injection molding machine OEMs will supply with the machine. One exception is the polyolefin screw, which presents a compression ratio that is too great for the essentially amorphous MXF resins. When exposed to these screws, the material suffers excessive shearing and inconsistent melt quality.

ALSO CONSIDER:

Typical parameters to look for when deciding whether a screw design is workable are:

- Compression ratio in the 2.8:1 to 3.1:1 range
- Feed flight depths in the 0.30–0.375 in. (7.6–9.5 mm) range
- Metering flight depths in the 0.1–0.125 in. (2.5–3.175 mm) range
- Length to diameter (L/D) ratio in the 18:1 to 22:1 range
- Possesses 5–7 flights/turns of transition to keep the shear heating in control
- Overall, if roughly 1/3 of the total flights are taken by each of the Feed, Transition, and Metering zones, this screw will do a better job of heat management.
- In situations where a salt and pepper blend is being considered, a Z-mixer or possibly a different screw might have to be considered as we have learned that there is a risk of poor mixing of the color concentrate. Do not overlook the use of a higher back pressure to assist with mixing.
- Check for the presence of a sliding ring nonreturn valve at the screw's tip to ensure minimal shear-induced heating of the material. Other styles risk more degradation due to dead spots and excessive shear.

## D. Mold design

The two most significant considerations when introducing an MXF product into an older tool built for another resin are:

(1) material flow length and (2) heat management to facilitate part ejection. This is especially true when an MXF product will be replacing a PC-containing incumbent material.

Geometric part features such as long flow lengths, thin cross sections, and regions that don't allow close proximity of cooling lines can be a challenge for the MXF grades. This is due to lower heat deflection temperature (HDT) and increased coefficient of friction against tool steels. Also keep in mind the relatively low modulus, which can combine with reduced coefficient of friction to alter part ejection.

ALSO CONSIDER:

- Keep material flow from thick to thin sections gradual—not so sharp as to induce unwanted stress into the material.
- Compare the predictive mold filling analysis with what you are seeing in the tool geometry. Let this be a trial reference so stall points and imbalances can be anticipated.
- If ribs and bosses are present, see how thick they are compared to the overall part thickness (65% is a good guideline). This will give a clue to potential sink spots.
- Make sure ribs are generally parallel to the material flow to minimize shear and potential air trapping.
- Make sure the rib-to-part junction is radiused.
- Make sure draft angles sufficient and that there enough material present to allow the demolding mechanism (sleeves or pins) to engage and remove the part. Sleeves are needed for bosses.
- Deep ribs will usually require direct placement of ejector pins.
- Determine the tool steel type used in mold construction and whether there are any potential hot spots in the mold. Look for opportunities to insert higher heat transfer alloys as a potential fix if problems arise.

## E. Gates, runners, and sprues

Gating very often has a significant impact on the successful molding of MXF materials because of the lower HDT. These directly affect pressure drop and temperature, meaning that polymer flow and ejection are being affected.

Different gating styles are acceptable, and the choice is usually driven by aesthetic concerns; but be very cautious of cashew gates, pinpoint gates, diaphragm gates, and sub gates, all of which can cause extreme pressure drop and excessive shear. With more viscous MXF materials, the enhanced toughness can lead to unacceptable vestige which needs to be monitored.

ALSO CONSIDER:

- Minimal flow length of the resin is best to fill the part
- Where will the weld line(s) be?
- Be aware that incumbent "higher flow" materials may have smaller gates in the tool than what we would suggest and that the tool-making industry is a "steel safe" group, especially when it comes to newer resins. Gate enlargement can often be a workable option.
- For larger parts, a complex runner system might be a significant source of pressure drop. Filling analysis on the entire system, not just the part, proves valuable here. This is a reminder to obtain the full tool plan in addition to the part model ahead of time.
- Do not forget about the value that a cooled sprue bushing can bring when running our materials. Oftentimes this is a cheap fix to a sticky sprue that either is too long or does not have enough draft on it. Overpacking the sprue can result from trying to achieve a full part, especially with our more viscous materials as compared to the incumbent.

## F. Part cooling

When comparing the MXF grades to a polycarbonate-containing resin, thermal behavior plays a huge role in the success of a trial. We know that cooling time is the overall cycle time parts/hour determining step and that the material must solidify enough for ejection during this time. Cooling time also plays a role in material shrinkage, which can complicate ejection especially when ribs, bosses, and minimal draft angles are present. When you combine this with the lower HDT of the MXF materials compared to PC-containing materials for which the mold was built, there will be differences despite similar shrinkage rates.

ALSO CONSIDER:

- Using PC/ABS as a specific example: it possesses an HDT of 98°C (208°F) at 0.46 MPa (66 PSI) compared to MXF121 with an HDT of 94°C (201°F) at the same conditions. It is a smaller difference compared to neat PC, but it is lower.
- Considering part geometry, the coefficient of friction of Eastman copolyesters against steel peaks is higher than PC around the HDT as the material cools. It is expected that additional force will be required to eject the part made in an MXF grade.
- MXF121 possesses a flexural modulus of 1748 MPa ($2.53 \times 10^5$ psi) compared to 2620 MPa ($3.8 \times 10^5$ psi) for PC. Near HDT, the difference is larger and cannot be ignored when setting ejection parameters.

Remember, early communication between the part designer, toolmaker, molder, and technical experts from Eastman will improve injection molding trials and increase opportunities for success.

For the latest application information and specifications on processing and visual troubleshooting, please contact your Eastman representative or go to **www.eastman.com/Markets/MedicalEquipment/**

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