Liquefier Thermal Transition

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Summary: The inlet to an FDM liquefier should be sufficiently cool that filament near the drive rollers does not soften. The liquefier, therefore, must support a steady state temperature gradient between its inlet and a subsequent hot zone. Thin walled stainless steel tubing is a good compromise between rapid radial heat conduction and pool axial heat conduction, so that a modest air flow across the liquefier inlet is sufficient to maintain the thermal transition.

In fused deposition modeling (FDM), a solid stock material such as a filament of ABS is fed using mechanical rollers into a mating liquefier, such as a heated thin walled stainless steel tube. The rollers act on the stock material in its solid phase to generate linear force. The liquefier converts the stock material to a fluid state, and the linear force into pressure. To create large forces without the filament buckling, the rollers are generally close to the entrance to the heated stainless steel tube.

The roller and liquefier just described are not in thermal equilibrium. Particularly when the rollers have stopped advancing, such as during a non-depositing tool path, the temperature of the filament near the rollers can soften, causing the rollers to 'spin out' when they next advance.

It is necessary for the transition from build envelope ambient temperature to extrusion temperature to occur well inside the liquefier. The entrance orifice of the liquefier should be cool enough that the stock material has good strength at that temperature. There is, therefore, a thermal transition zone inside the liquefier, usually within 2 inches of the entrance. The liquefier body should have sufficient thermal conductivity to radially conduct heat into the filament in the hot zone below the transition zone. The liquefier body should have sufficient thermal resistance that axial conduction from the hot zone into the transition zone is modest. For example, 3 mil wall stainless steel tubing offers sufficient axial thermal resistance that a shear air flow of less than 20 inches per second normal to the axis of a one inch transition zone is sufficient to cool the inlet to the transition zone.