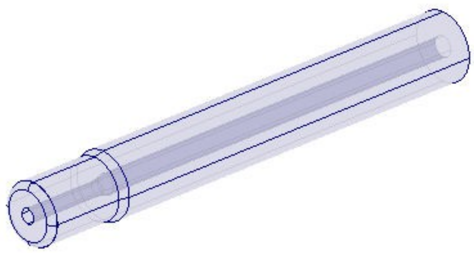
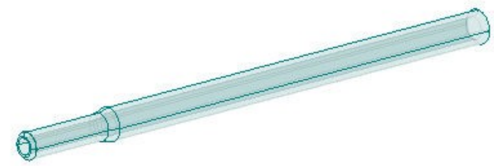
# Hot Air Heat Transfer Comparison of Catheter Tipping Dies & Forming Molds

## Glass Tipping Dies -vs- NiColoy™ Tipping Dies





Glass Die (0.090” wall) NiColoy™ Die (0.015” wall)

| Property | Glass (Borosilicate) | NiColoy™ |
|---|---|---|
| Density (ρ) | 2225 kg/m^3 | 8900 kg/m^3 |
| Heat Transfer Coeff. (h) | 100 W/(m^2 °C) | 100 W/(m^2 °C) |
| Thermal Conductivity (k) | 1.4 W/mK | 90.7 W/mK |
| Specific Heat (Cp) | 835 J/kgK | 444 J/kgK |
| Volume (V) | 6.88e-7 m^3 | 1.19e-7 m^3 |
| Surface Area (As) | 6.38e-4 m^2 | 3.0e-4 |

NOTE: The heat transfer coefficient is *assumed* to model the Beahm Designs hot air tipping machine.

Used for the calculations was the lumped capacitance model. It is based on the 1st Law of Thermodynamics, $\dot{E}_{in} - \dot{E}_{out} = \dot{E}_{stored}$, where $\dot{E}$ = energy . It can be shown that the equation for lumped capacitance heat transfer reduces to $\frac{T - T_\infty}{T_i - T_\infty} = e^{-hA_s t / \rho V C p}$ where, T = final temp, $T_i$ = initial temp, $T_\infty$ = temp at a distance, and t = time. For the lumped capacitance model to be accurate, the Biot number must be << 1. The Biot number represents the ratio of the conductive resistance to the convective resistance and needs to be smaller than 0.01. The calculated values for the two cases, glass and NiColoy™ are 0.003 and 0.004, respectively, based on the equation $B_i = Vh / A_s k$.

Two assumptions were needed to perform the calculations. Firstly that the air flowing over the tipping dies will be 250 °C ($T_\infty$) and the initial temperature of the tipping die will be 20 °C ($T_i$). These assumptions were made based on the information received from the vendor, Lumend Inc’s Jose Garcia who reported that the heating cycle currently takes 15 seconds to perform.

**Results show that the use of a Nicoloy™ tipping die will reduce the heating cycle for Lumend from 15 seconds to 8 seconds when a 0.015” wall thickness is used.**