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Numerical and experimental investigation of fluid flow in tapered orifices for needle-free injectors.[1] YATISH RANE, JEREMY MARSTON, Texas Tech University — Transdermal drug delivery using spring-powered jet injection has been studied for several decades, and is an attractive option for delivery of highly viscous and non-Newtonian fluids. In particular, third-generation vaccines such as DNA-vaccines have shear-thinning behaviour, which dictates the need to study the influence of fluid rheology in jet injection. Here, numerical simulations are performed with steady state flow and turbulence modelling based on the system Reynolds number at the orifice to generate characteristic curves of dimensionless pressure drop (Euler number) versus generalized Reynolds number. The results are experimentally validated for a given geometry over a wide range of Reynolds numbers (10^1 - 10^4), and we find shear-thinning (Carreau) fluids with high zero-shear viscosities can be injected due to the presence of high shear (~10^6) regions near the orifice. In addition to fluid rheology, the orifice geometry (e.g. conical, multi-tier tapers and sigmoid contraction) is varied to study boundary layer thickness, which also affects jet collimation. Ultimately, our results indicate there may be optimal geometries for creating jets to target specific tissue depths.

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