For steady onedimensional gas flow with friction in a pipe of length $L$ and hydraulic diameter $D_h$ the upstream and downstream Mach numbers are related by

$$\Lambda(M_d) - \Lambda(M_u) = -2\frac{\lambda L}{D_h}$$

with

$$\Lambda = \frac{2}{\gamma M^2} + \frac{\gamma + 1}{\gamma} \ln \left( \frac{M^2}{1 + \frac{\gamma - 1}{2} M^2} \right).$$