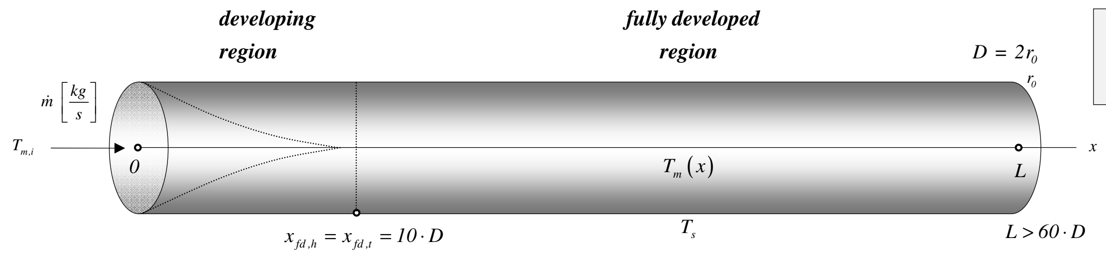
# INTERNAL FLOW – CORRELATIONS – TURBULENT

circular tube

**TURBULENT** $Re_D > 2300$




**properies at** $\bar{T}_m = \dfrac{T_{m,i} + T_{m,o}}{2}$

$\mu_s$ **at** $T_s$

***We consider long pipes for which :***

$$Re_D = \frac{\rho u_m D}{\mu} = \frac{4\dot{m}}{\pi \mu D}$$

$$Nu_D = \frac{hD}{k}$$

$$h = \frac{k \cdot Nu_D}{D}$$

$$\overline{Nu}_D = Nu_D$$

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**Dittus** (8.60)

*for* $T_s = const$ *smooth pipe, small to moderate temperature difference*

$$Nu_D = 0.023 \cdot Re_D^{4/5} \cdot Pr^n$$

$n = 0.4$ if $T_s > T_m$ (heating of fluid)
$n = 0.3$ if $T_s < T_m$ (cooling of fluid)

$0.7 < Pr < 160$
$Re_D > 10{,}000$
$L > 60D$

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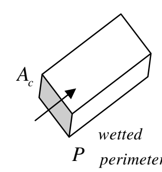
**Sieder** (8.61)

*for* $T_s = const$ or $q_s'' = const$ *smooth pipe, large property variation*

$$Nu_D = 0.027 \cdot Re_D^{4/5} \cdot Pr^{1/3} \cdot \left(\frac{\mu}{\mu_s}\right)^{0.14}$$

$0.7 < Pr < 16{,}700$
$Re_D > 10{,}000$
$L > 60D$

can be applied for non-circular tubes with $D_h = \dfrac{4A_c}{P}$

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**Gnielinski** (8.62)

*for* $T_s = const$ or $q_s'' = const$

$$Nu_D = \frac{(f/8)\cdot(Re_D - 1000)\cdot Pr}{1 + 12.7\cdot(f/8)^{1/2}\cdot(Pr^{2/3} - 1)}$$

$0.5 < Pr < 2000$
$3000 < Re_D < 5e6$
$L > 60D$

*for smooth pipes* (8.21):

$$f = \frac{1}{(0.79 \ln Re_D - 1.64)^2}$$

*for rough pipes use Moody charts*

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## Liquid Metals

**Skupinski** (8.64)

*for* $q_s'' = const$ *smooth pipe, fully developed*

$$Nu_D = 4.82 + 0.0185 Pe_D^{0.287}$$

$100 < Pe_D < 10000$ $\quad Pe_D = Re_D \cdot Pr$
$3.6e3 < Re_D < 9.05e6$

**Seban** (8.65)

*for* $T_s = const$

$$Nu_D = 5.0 + 0.025 Pe_D^{0.8}$$

$Pe_D \geq 100$

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## Short Tubes

(8.63)

$$\overline{Nu}_D = Nu_D \cdot \left[1 + \frac{C}{(x/D)^m}\right]$$

$Nu_D$ is calculated for fully developed flow

coefficients C and m depend on the shape of inlet

Example: sharp-edged