

$$W_n = W_e + W_f$$

$$\begin{aligned}
 &= \tau_e \cdot [\cot \phi + \tan(\phi - \alpha)] + \frac{F_t \cdot \sin \phi}{A_c \cdot \cos(\phi - \alpha)} \\
 &= \frac{(F_c \cdot \cos \phi - F_t \cdot \sin \phi) \cdot \sin \phi}{A_c} \cdot \left[\frac{\cos \phi}{\sin \phi} + \frac{\sin(\phi - \alpha)}{\cos(\phi - \alpha)} \right] \\
 &\quad + \frac{[F_t \cdot \cos \alpha + F_c \cdot \sin \alpha] \cdot \sin \phi}{A_c \cdot \cos(\phi - \alpha)} \\
 &= \frac{(F_c \cdot \cos \phi - F_t \cdot \sin \phi) \cdot \cancel{\sin \phi}}{A_c} \cdot \frac{\cos \phi \cos(\phi - \alpha) + \sin \phi \cdot \sin(\phi - \alpha)}{\cancel{\sin \phi} \cdot \cos(\phi - \alpha)} \\
 &\quad + \frac{F_t \cdot \cos \alpha \cdot \sin \phi + F_c \cdot \sin \alpha \cdot \sin \phi}{A_c \cdot \cos(\phi - \alpha)} \\
 &= \frac{(F_c \cdot \cos \phi - F_t \cdot \sin \phi) \cdot \cos(\phi - \phi - \alpha) + F_t \cdot \cos \alpha \cdot \sin \phi + F_c \cdot \sin \alpha \cdot \sin \phi}{A_c \cdot \cos(\phi - \alpha)} \\
 &= \frac{F_c \cdot (\cos \phi \cdot \cos \alpha + \sin \phi \cdot \sin \alpha) - F_t \cdot \cancel{\sin \phi} \cdot \cos \alpha + F_t \cdot \cancel{\sin \phi} \cdot \cos \alpha}{A_c \cdot \cos(\phi - \alpha)} \\
 &= \frac{F_c \cdot \cos(\phi - \alpha)}{A_c \cdot \cos(\phi - \alpha)} = \frac{F_c}{A_c}
 \end{aligned}$$

OR

$$W_n = W_e + W_f = \tau_e \cdot \varepsilon + W_f$$

$$\begin{aligned}
 &= \frac{(F_c \cdot \cos \phi - F_t \cdot \sin \phi) \cdot \cancel{\sin \phi}}{A_c} \cdot \frac{\cos \alpha}{\cancel{\sin \phi} \cdot \cos(\phi - \alpha)} + \frac{(F_t \cdot \cos \alpha + F_c \cdot \sin \alpha) \cdot \sin \phi}{A_c \cdot \cos(\phi - \alpha)} \\
 &= \frac{F_c \cdot (\cos \phi \cdot \cos \alpha + \sin \phi \cdot \sin \alpha) - F_t \cdot \cancel{\sin \phi} \cdot \cos \alpha + F_t \cdot \cancel{\sin \phi} \cdot \cos \alpha}{A_c \cdot \cos(\phi - \alpha)} \\
 &= \frac{F_c \cdot \cos(\phi - \alpha)}{A_c \cdot \cos(\phi - \alpha)} = \frac{F_c}{A_c}
 \end{aligned}$$