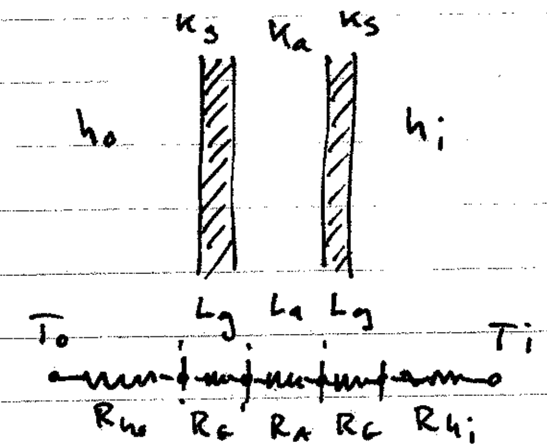


double glazed vs. single glazed window

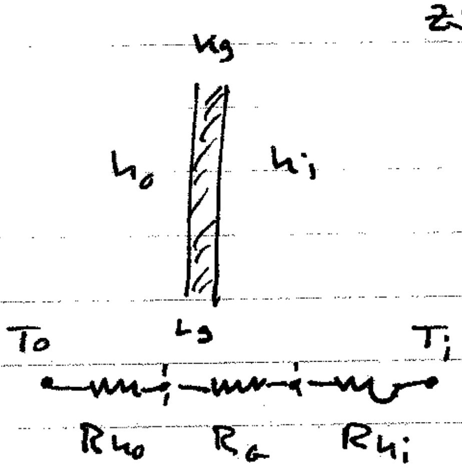
$h_o = 12\ W/m^2\text{-}K$

$h_i = 6\ W/m^2\text{-}K$

$k_g = 0.78\ W/m\text{-}K$

$k_a = 0.026\ W/m\text{-}K$

(see tables)



$$\dot{Q}_D = \frac{\Delta T}{R_D}\ ;\ R_D = \frac{1}{h_o} + \frac{2L_g}{k_g} + \frac{1}{h_i} + \frac{L_a}{k_a} \text{ (per unit area)}$$

$$\dot{Q}_S = \frac{\Delta T}{R_S}\ ;\ R_S = \frac{1}{h_o} + \frac{L_g}{k_g} + \frac{1}{h_i}$$

same $\Delta T = T_i - T_o$

Reduction in heat transfer: $\dfrac{\dot{Q}_S - \dot{Q}_D}{\dot{Q}_S} = \dfrac{\frac{1}{R_S} - \frac{1}{R_D}}{\frac{1}{R_S}} \equiv \Delta$

$$\Delta = 1 - \frac{1/h_o + L_g/k_g + 1/h_i}{1/h_o + 2L_g/k_g + L_a/k_a + 1/h_i}$$

$L_a = 0.005\ m$

$L_g = 0.004\ m$

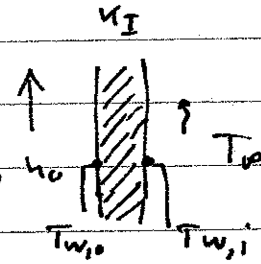
find $\underline{\Delta = 0.564}$

So heat transfer is reduced by 56.4% due to significantly higher resistance of air film

T19

16. Unified Sp 09 ZS

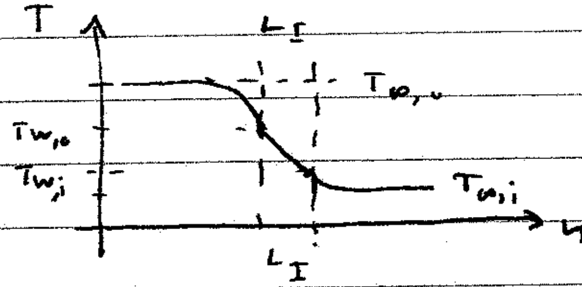
Cooled turbine blade no TBC



1-D model

a) h_o L_I/k_I h_i

$T_{\infty,o}$ $T_{w,o}$ $T_{w,i}$ $T_{\infty,i}$



b) Fourier: $\dot{q} = -k\dfrac{dT}{dx}$

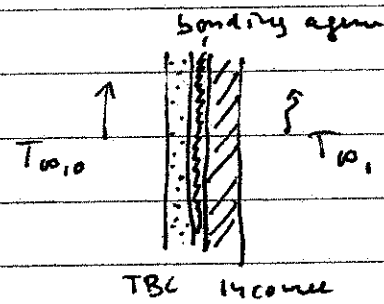
Newton: $\dot{q}_c = h(T_\infty - T_w)$

c) highest temp in blade: $T_{w,o}$, $\dot{Q} = \dfrac{T_{\infty,o} - T_{\infty,i}}{R_{tot}}$, 1st law: $\dot{Q}$ = const

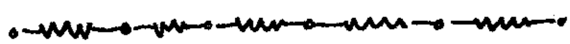
$R_{tot} = \dfrac{1}{h_o} + \dfrac{L_I}{k_I} + \dfrac{1}{h_i} = 0.0033\ K/W \cdot m^2$ $\dot{Q} = \dfrac{T_{\infty,o} - T_{w,o}}{R_o}$

$T_{w,o} = T_{\infty,o} - \dfrac{T_{\infty,o} - T_{\infty,i}}{R_{tot}} \cdot \dfrac{1}{h_o}$, find $T_{w,o} = 1306\ K > 1250\ K$!

blade will melt!



d)

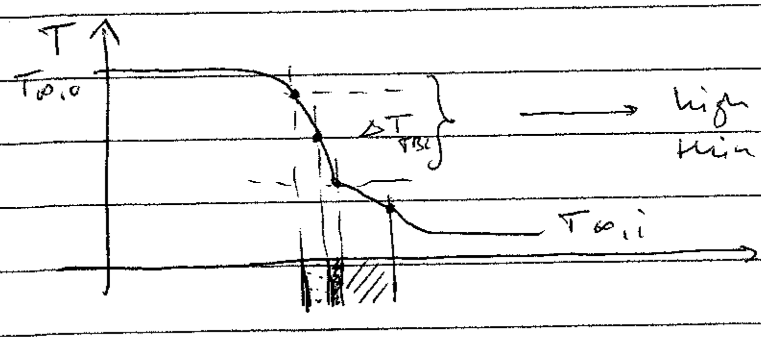


$T_{\infty,o}$ T_{TBC_o} T_{TBC_i} $T^{TBC}_{w,o}$ T_{w_i} $T_{\infty,i}$

$\dfrac{1}{h_o} + \dfrac{L_{TBC}}{k_{TBC}} + \dfrac{L_B}{k_B} + \dfrac{L_I}{k_I} + \dfrac{1}{h_i} = R_{tot}^{TBC}$

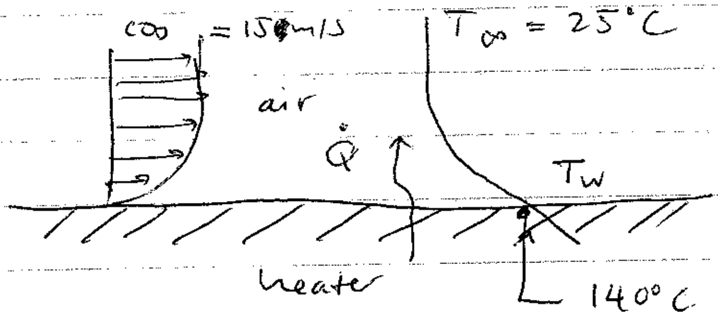
$T_{w,o}^{TBC} = T_{\infty,o} - \dfrac{T_{\infty,o} - T_{\infty,i}}{R_{tot}^{TBC}} \left(\dfrac{1}{h_o} + \dfrac{L_{TBC}}{k_{TBC}} + \dfrac{L_B}{k_B}\right)$ $\Rightarrow R_{tot} = 0.00373\ \dfrac{K}{W} m^2$

$T_{w,o}^{TBC} = 1{,}183\ K$ $< 1250\ K$ blade is protected and will not melt



→ high resistance in TBC and thin bonding agent yields significant ~~temperature drop~~

T20 | 16. Unified Sp 09 ZS



$D = 0.25$ N

$A = 0.25$ m^2

concept: Reynolds analogy, convective heat x-fr

Re-analogy: $St = \frac{c_f}{2}$, $D = \frac{1}{2} c_f A \rho_\infty c_\infty^2$

$St = \frac{h}{\rho_\infty c_\infty c_p}$ so $\frac{h}{\rho_\infty c_\infty c_p} = \frac{D}{A \rho_\infty c_\infty^2}$, $h = \frac{D c_p}{A c_\infty}$

find $h = 66.9$ W/m^{2}K

Newton's law of cooling: $\dot{Q} = A h (T_w - T_\infty) = \dot{Q}_{el}$

find $\underline{\dot{Q}_{el} = 2{,}093 \text{ W}}$ of electrical power required to maintain surface temperature