$Pv = R^*T$

$de = \delta q + \delta L$

$$a = \sqrt{\left(\frac{dp}{d\rho}\right)_{Scos}} = \sqrt{\gamma RT}$$

$$V_{at} = \sqrt{\frac{2 * \varepsilon_t}{m}} = \sqrt{\frac{3 * K_t}{m}} = \sqrt{\frac{3 * R * T}{M}}$$

$\varepsilon_{int} = \frac{L}{2} * RT$ $\bar{\varepsilon}_{mediamol} = \frac{L}{2} k_b T$ con $k_b = 1.38062 * 10^{-23}$

$$\beta = \frac{1}{V} * \frac{dV}{dp}$$

Gradi di libertà			
	Traslazionali	Rotazionali	Vibrazionali
Monoatomiche	3	0	0
Biatomiche	3	2	2(3n-5)
Poliatomiche	3	3	2(3n-6

$C_p = \frac{L+2}{2} R$ $C_v = \frac{L}{2} R$

$$x_i = \frac{N_i}{N_t} = \frac{P_i}{P_t} = \frac{V_i}{V_t} = \frac{\frac{c_i}{m_i}}{\Sigma\left(\frac{c_i}{m_i}\right)}$$

$$c_i = \frac{m_i}{m_t} = \frac{x_i N_i}{\Sigma x_i N_i}$$

	Unità mole	Unità massa
Energia	$\epsilon_{misc} = \sum x_i \varepsilon_i$	$e_{misc} = \sum c_i e_i$
Entalpia	$\boldsymbol{h}_{misc} = \sum x_i \boldsymbol{h}_i$	$\boldsymbol{h}_{misc} = \sum c_i \boldsymbol{h}_i$
Cv	$C_{v_{misc}} = \sum x_i C_{v_i}$	$c_{v_{misc}} = \sum c_i c_v$
Cp	$C_{p_{misc}} = \sum x_i C_{p_i}$	$c_{p_{misc}} = \sum c_i c_p$
γ	$\gamma_{misc} = \frac{\Sigma x_i (L_i + 2)}{\Sigma x_i L_i}$	$\gamma_{misc} = \frac{c_{p_{misc}}}{c_{v_{misc}}}$

$$C_{pmis} = \sum Cp_i N_i$$

Aria standard	
T	15°=288 K
P	760mm HG =101325 Pa
ρ	1.225 kg/m^3

μ	$1.781*10^{-5}$ kg/ms = Pas
ν	$1.454*10^{-5}$ m²/s

$\mu = S\frac{T^{\frac{3}{2}}}{(\chi + T)}$ con S=$1.46*10^{-6}$ kg/(m s $K^{0.5}$) e $\chi =$ 110K per aria

$\mu = \mu_{rif} * \left(\frac{T}{T_{rif}}\right)^{w}$ con $w = 0.75$ per l'aria

$$\mu_{mis} = \sum_{i=1}^{n} \mu_i \left(1 + \sum_{k=1,k\neq i}^{n} G_{ik}\frac{X_k}{X_i}\right)^{-1}$$

$\mu_{mis} = \frac{\mu_1}{1 + G_{12} * \frac{x_2}{x_1}} + \frac{\mu_2}{1 + G_{21} * \frac{x_1}{x_2}}$ con $G_{12} = \frac{\left(1 + \left(\frac{\mu_1}{\mu_2}\right)^{\frac{1}{2}} * \left(\frac{M_2}{M_1}\right)^{\frac{1}{4}}\right)^2}{2^{\frac{2}{3}} * \left(1 + \left(\frac{M_1}{M_2}\right)\right)^{\frac{1}{2}}}$

$$ds = C_v * \frac{dT}{T} + \frac{R}{M}\frac{dV}{V}$$

$$C_p = \frac{\gamma}{\gamma - 1} * \frac{R}{M}$$

$$\frac{P_1}{P_2} = \left(\frac{T_1}{T_2}\right)^{\frac{\gamma}{\gamma-1}}$$

$$\frac{\rho_1}{\rho_2} = \left(\frac{T_1}{T_2}\right)^{\frac{1}{\gamma-1}}$$

Equazioni di continuità

$\frac{\partial}{\partial t}\int_{vol} \rho\, dvol = -\int_S \rho(\bar{V}\cdot\bar{n})dS$ massa

$\frac{\partial}{\partial t}\int_{vol} \rho\bar{V} dvol = -\int_S \rho\bar{V}(\bar{V}\cdot\bar{n})dS - \int_S p(\bar{n})dS - \int_{vol} \rho\bar{F} dvol$ qdm

$\frac{\partial}{\partial t}\int_{vol} \rho\left(e + \frac{\bar{V}^2}{2}\right)dvol = -\int_S \rho\left(e + \frac{\bar{V}^2}{2}\right)(\bar{V}\cdot\bar{n})dS + \int_{vol} \rho\dot{q}dvol + \dot{Q}_{visc} - \int_S p(\bar{V}\cdot\bar{n})dS - \int_{vol} \rho(\bar{F}\cdot\bar{V})dvol$

energia

Forma conservativa

$\frac{\partial p}{\partial t} + \frac{\partial \rho u}{\partial x} + \frac{\partial \rho v}{\partial y} + \frac{\partial \rho w}{\partial z} = 0$ massa

$\frac{\partial \rho u}{\partial t} + \frac{\partial \rho uu}{\partial x} + \frac{\partial \rho vu}{\partial y} + \frac{\partial \rho wu}{\partial z} = -\frac{\partial p}{\partial x} + \rho f_x$ quantità di moto lungo x

$\rho\frac{D\left(e + \frac{\bar{V}^2}{2}\right)}{Dt} = -\nabla(\rho\bar{V}) + \rho\dot{q} + \rho\bar{F}\cdot\bar{V}$ energia

Equazioni di continuità
Forma non conservativa

$$\frac{\partial \rho}{\partial t}+u\frac{\partial \rho}{\partial x}+v\frac{\partial \rho}{\partial y}+w\frac{\partial \rho}{\partial z}=0$$ massa

$$\frac{\partial \rho u}{\partial t}+u\frac{\partial \rho u}{\partial x}+v\frac{\partial \rho u}{\partial y}+w\frac{\partial \rho u}{\partial z}=-\frac{\partial p}{\partial x}+\rho f_x$$ quantità di moto lungo x

Grandezze totali

$$\rho_0=\rho\left(\frac{T_0}{T}\right)^{\frac{1}{\gamma-1}}=\left(1+\frac{\gamma-1}{2}M^2\right)^{\frac{1}{\gamma-1}}$$

$$p_0=p\left(\frac{T_0}{T}\right)^{\frac{\gamma}{\gamma-1}}=\left(1+\frac{\gamma-1}{2}M^2\right)^{\frac{\gamma}{\gamma-1}}$$

$$\frac{T_0}{T}=1+\frac{\gamma-1}{2}M^2$$

$$\frac{V_l^2}{2}=\frac{a_0}{\gamma-1}$$

Grandezze critiche

$$a_*=V_1V_2$$

$$M_{1*}*M_{2*}=1$$

$$M_{1*}^2=\frac{1+\frac{\gamma-1}{2}M_1^2}{\gamma M_1^2-\frac{\gamma-1}{2}}$$

$$\frac{a_*^2}{a_0^2}=\frac{2}{\gamma+1}=\frac{T_*}{T_0}$$

$$\frac{P_*}{p_0}=\left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{\gamma+1}}$$

$$\frac{\rho_*}{\rho_0}=\left(\frac{2}{\gamma+1}\right)^{\frac{1}{\gamma}-1}$$

$$T_0=\frac{\gamma+1}{\gamma-1}\frac{V_{cr}^2}{2c_p}$$

$$T\nabla S=\nabla H-\nabla\times\nabla\times\bar{V}$$ teorema di crocco

Relazioni di Rankine-Hugoniot

$$M_2^2=\frac{1+\frac{\gamma-1}{2}*M_1^2}{\gamma M_1^2-\frac{\gamma-1}{2}}$$

$$\frac{P_2}{P_1}=1+\frac{2\gamma}{\gamma+1}(M_1^2-1)$$

$$\frac{\rho_2}{\rho_1} = \frac{v_1}{v_2} = \frac{(\gamma+1)M_1^2}{2+(\gamma-1)M_1^2}$$

$$\frac{T_2}{T_1} = \left(1+\frac{2\gamma}{\gamma+1}((M_1^2-1))\right)\left(\frac{2+(\gamma-1)M_1^2}{(\gamma+1)M_1^2}\right)^{\gamma}$$

$$\frac{p_{02}}{p_{01}} = \frac{\rho_{02}}{\rho_{01}} = \left(1+\frac{2\gamma}{\gamma+1}((M_1^2-1))\right)^{\frac{-1}{(\gamma-1)}} * \left(\frac{2+(\gamma-1)M_1^2}{(\gamma+1)M_1^2}\right)^{\frac{-\gamma}{(\gamma-1)}}$$

$$S_2 - S_1 = C_v \ln\left(\left(1+\frac{2\gamma}{\gamma+1}((M_1^2-1))\right)\left(\frac{2+(\gamma-1)M_1^2}{(\gamma+1)M_1^2}\right)^{\gamma}\right)$$

$$\frac{S_2-S_1}{R^*} = -\ln\frac{p_{02}}{p_{01}} = \frac{\gamma}{\gamma-1}\ln\frac{T_2}{T_1} - \ln\frac{P_2}{P_1}$$

Flusso di fanno

$$\frac{4FL^*}{D_i} = \left(\frac{1-M^2}{\gamma M^2}\right) + \left(\frac{\gamma+1}{2\gamma}\right)\ln\left(\frac{M^2}{\left(\frac{2}{\gamma+1}\right)\left(1+\frac{\gamma-1}{2}M^2\right)}\right)$$

$$\frac{p}{p^*} = \frac{1}{M\sqrt{\left(\frac{2}{\gamma+1}\right)\left(1+\frac{\gamma-1}{2}M^2\right)}}$$

$$\frac{\rho}{\rho^*} = \frac{1}{M}\sqrt{\left(\frac{2}{\gamma+1}\right)\left(1+\frac{\gamma-1}{2}M^2\right)}$$

$$\frac{T}{T^*} = \frac{1}{\left(\frac{2}{\gamma+1}\right)\left(1+\frac{\gamma-1}{2}M^2\right)}$$

$$\frac{V}{V^*} = \frac{M}{\sqrt{\left(\frac{2}{\gamma+1}\right)\left(1+\frac{\gamma-1}{2}M^2\right)}}$$

$$\frac{P_*}{p_0} = \frac{1}{M}\left(\left(\frac{2}{\gamma+1}\right)\left(1+\frac{\gamma-1}{2}M^2\right)\right)^{\frac{\gamma+1}{2(\gamma-1)}}$$

flusso di raylegh

$$H_{01} + q = H_{02}$$

$$\frac{P_2}{P_1} = \frac{1+\gamma M_1^2}{1+\gamma M_2^2}$$

$$\frac{T_2}{T_1} = \frac{1+M_1^2}{1+M_2^2}\left(\frac{M_2}{M_1}\right)^2$$

$$\frac{\rho_2}{\rho_1} = \frac{1+\gamma M_1^2}{1+\gamma M_2^2}\left(\frac{M_2}{M_1}\right)^2$$

$$\frac{p_{02}}{p_{01}} = \frac{P_2}{P_1} * \left(\frac{1+\frac{\gamma-1}{2}M_2^2}{1+\frac{\gamma-1}{2}M_1^2}\right)^{\frac{\gamma}{\gamma-1}}$$

$$\frac{T_{02}}{T_{01}} = \frac{T_2}{T_1} * \left(\frac{1+\frac{\gamma-1}{2}M_2^2}{1+\frac{\gamma-1}{2}M_1^2}\right)$$

$$S_2 - S_1 = -\ln\frac{p_{02}}{p_{01}} = C_p \ln\left(\frac{1+M_1^2}{1+M_2^2}\left(\frac{M_2}{M_1}\right)^2\right) - \frac{R}{M}\ln\left(\frac{1+\gamma M_1^2}{1+\gamma M_2^2}\right)$$

urtoobliquo

$$M_2^2 = \frac{1}{\sin(\beta-\theta)} * \frac{2+(\gamma-1)M_1^2(\sin\beta)^2}{2\gamma M_1^2(\sin\beta)^2-(\gamma-1)}$$

$$\tan\theta = \frac{2}{\tan\beta} * \left(\frac{M_1^2(\sin\beta)^2-1}{M_1^2(\gamma+\cos(2\beta))+2}\right)$$

$$\nu = \sqrt{\frac{\gamma+1}{\gamma-1}}\tan^{-1}\left(\sqrt{\frac{\gamma-1}{\gamma+1}*(M^2-1)}\right) - \tan^{-1}\sqrt{M^2-1}$$

Condotto senza riflessioni

$$\frac{l}{h} = M_1\left(\frac{1+\frac{\gamma-1}{2}M^2}{1+\frac{\gamma-1}{2}M_1^2}\right)^{\left(\frac{\gamma}{\gamma-1}+\frac{1}{2}\right)}$$

Teoria PP

Equazione del potenziale di perturbazione linearizzata

$$(1-M^2_\infty)\frac{\partial\phi^2}{\partial x} + \frac{\partial\phi^2}{\partial y} + \frac{\partial\phi^2}{\partial z} = 0$$

Coefficienti regime subsonico compressibile

$$C_{P_{inc}} = \frac{2u'}{V_\infty}$$

$$C_{P_{comp}} = C_{P_{inc}}\frac{1}{\beta} = C_{P_{inc}}\frac{1}{\sqrt{1-M^2_\infty}}$$

$$C_{P_{comp}} = \frac{C_{P_{inc}}}{\sqrt{1-M^2_\infty} + \left(\frac{M^2_\infty\left(1+\frac{\gamma+1}{2}M^2_\infty\right)}{2\sqrt{1-M^2_\infty}}\right)C_{P_{inc}}}$$ approssimazione di Laitone

$$C_{P_{comp}} = \frac{C_{P_{inc}}}{\sqrt{1-M^2_\infty} + \left(\frac{M^2_\infty}{1+\sqrt{1-M^2_\infty}}\right) C_{P_{inc}}}$$ approssimazione di Karman Tsen

$$C_L = \int_0^1 \left(C_{P_{ventre}} - C_{P_{dorso}}\right)\frac{dx}{c}$$

$$C_{L\,comp} = C_{L\,inc}\frac{1}{\beta} = C_{L\,inc}\frac{1}{\sqrt{1-M^2_\infty}}$$

$$C_{M\,comp} = C_{M\,inc}\frac{1}{\beta} = C_{L\,inc}\frac{1}{\sqrt{1-M^2_\infty}}$$

$$C_{P_{cr}} = \frac{2}{\gamma M^2_\infty}\left[\frac{1+\frac{\gamma-1}{2}M^2_\infty}{1+\frac{\gamma-1}{2}}\right]^{\frac{\gamma}{\gamma-1}}$$

$$C_{P_{inc_{min}}} = \sqrt{1-M^2_{cr}}\frac{2}{\gamma M^2_{cr}}\left[\left(\frac{1+\frac{\gamma-1}{2}M^2_{cr}}{1+\frac{\gamma-1}{2}}\right)^{\frac{\gamma}{\gamma-1}} - 1\right]$$

Coefficienti regime supersonico compressibile linearizzato

$$C_P = \frac{2\theta}{\gamma} = \frac{2\theta}{\sqrt{M^2_\infty - 1}}$$ con $\begin{cases}\theta < 0 \ ventre \\ \theta > 0 \ dorso\end{cases}$

$$C_L = \frac{4(\alpha-\alpha_0)}{\sqrt{M^2_\infty - 1}}$$

$$C_D = \frac{4(\alpha-\alpha_0)^2}{\sqrt{M^2_\infty - 1}} + \frac{2}{c\sqrt{M^2_\infty - 1}}\int_0^c \left(\left(\frac{dy}{dx}\right)_l^2 + \left(\frac{dy}{dx}\right)_u^2\right)dx$$

$$C_{Ma} = -\frac{2(\alpha-\alpha_0)}{\sqrt{M^2_\infty - 1}} - \frac{2}{\sqrt{M^2_\infty - 1}}\frac{(S_u - S_l)}{c^2}$$

$$C_{Mo} = -\frac{2}{\sqrt{M^2_\infty - 1}}\frac{(S_u - S_l)}{c^2}$$

$$\frac{C_{L_{ala}}}{C_{L_{teorico}}} = 1 - \frac{1}{2A\sqrt{M^2_\infty - 1}}$$

$$Re = \frac{L * V * \rho}{\mu} = \frac{L * V}{\nu}$$

$$Pr = \frac{\mu * C_p}{\lambda} = \frac{2L+4}{2L+9} = \frac{4\gamma}{9\gamma - 5} \propto \frac{\delta_v}{\delta_t}$$ per aria =0.71

Flusso di Couette

$$P_r * \frac{u^2}{2} + h = cost = P_r * \frac{U_e{}^2}{2} + h_e$$

$$T_w = T_e + \frac{U_e{}^2}{2C_p} = T_\infty + \frac{U_\infty{}^2}{2C_p} = T_\infty\left(1 + \frac{\gamma - 1}{2} M^2{}_\infty\right)$$ Se Pr=1

$$T = T_e + \frac{U_e^2}{2C_p} - \frac{u^2}{2C_p} = T_e + \frac{U_e^2}{2C_p}\left(1 - \frac{u^2}{U_e^2}\right) = T_e + \frac{U_e^2}{2C_p}(1 - \varphi^2)$$ se adiabatico

Strato limite termico

$$T_{rec} = T_e\left(1 + R\frac{\gamma - 1}{2} M^2{}_e\right)$$

$$H_{rec} = h_e + R\frac{U_e{}^2}{2}$$

	Laminare	Turbolento	Couette
R	$P_r^{\frac{1}{2}}$	$P_r^{\frac{1}{3}}$	P_r
A	$\frac{2}{3}$	0.6	1

$$\frac{u_e}{U_e} = \frac{H - H_w}{H_e - H_w} = \frac{h + \frac{U^2}{2} - h_w}{h_e + \frac{U_e{}^2}{2} - h_w}$$

$$T = T_w(1 - \varphi) + T_\infty\varphi^2 + T_{rec}(\varphi - \varphi^2)$$ profilo parabolico di T

$$\frac{\tau_w(x)}{V_\infty} = -\frac{A * q_w(x)}{h_\infty + R\frac{V_\infty{}^2}{2} - h_w} = \frac{A * q_w(x)}{(T_{rec} - T_w)}$$ Analogia di Reynolds

$$K = \frac{c_D * \rho_\infty * V_\infty * C_p}{2A}$$ con C_p calore specifico

Metodo della sezione rappresentativa

$$T^* = T_w * 0.5 + T_\infty * 0.25 + T_{rec} * 0.25$$

cd		
Laminare	$\frac{1.328}{\sqrt{R_{e\infty}}}$	$R_e < 5 * 10^5$
Turbolento	$\frac{0.074}{R_{e\infty}^{1/5}}$	$R_e > 5 * 10^5$
Alto turbolento	$\frac{0.0295}{R_{e\infty}^{1/7}}$	

$$C_{D_{incomp}} = \frac{\overline{\tau_{w\,incomp}}}{\frac{1}{2}\rho_\infty V^2{}_\infty}$$

$$\overline{\tau_{w\,incomp}} = C_{D_{incomp}}\frac{1}{2}\rho_\infty V^2{}_\infty$$

$C_{D_{comp}} = \chi * C_{D_{incomp}}$

$\frac{\mu^*}{\mu_\infty} = \left(\frac{T^*}{T_\infty}\right)$ $\frac{\rho^*}{\rho_\infty} = \left(\frac{T^*}{T_\infty}\right)^{-1}$

$\chi = \left(\frac{\rho^*\mu^*}{\rho_\infty\mu_\infty}\right)^{\frac{1}{2}}$ $\chi = \left(\frac{T^*}{T_\infty}\right)^{\frac{w-1}{2}}$ per aria $\chi = \left(\frac{T^*}{T_\infty}\right)^{-0.125}$ con $\frac{T^*}{T_\infty} = 0.5\frac{T_w}{T_\infty} + 0.25 + 0.25\frac{T_{rec}}{T_\infty}$

$\chi_{Lam} = \left(\frac{T_w + T_\infty}{2T_\infty} + R\frac{\gamma-1}{2}\frac{M_\infty}{4}\right)^{-0.125}$ per aria flusso laminare

$\chi_{Lam} = \left(1 + R\frac{\gamma-1}{2} * \frac{3M_\infty}{4}\right)^{-0.125}$ se adiabatico

$\chi_{Turbo} = \left(\frac{T_w + T_\infty}{2T_\infty} + R\frac{\gamma-1}{2}\frac{M_\infty}{4}\right)^{-0.65}$ per aria flusso turbolento

$\chi_{Turbo} = \left(1 + R\frac{\gamma-1}{2} * \frac{3M_\infty}{4}\right)^{-0.65}$

Cono

$C_f(x)_{cono} = \sqrt{3}C_f(x)_{p.p.}$ Lamiare

$C_f(x)_{cono} = (1.1:1.5)C_f(x)_{p.p.}$ Turbolento

Metodi integrali

$\delta^* = \int_0^\infty \left(1 - \frac{u}{U_e}\right) dy$ Spessore di spostamento

$\vartheta^* = \int_0^\infty \frac{u}{U_e}\left(1 - \frac{u}{U_e}\right) dy$ Spessore di quantità di moto

$H = \frac{\delta^*}{\vartheta^*} = \begin{matrix} 2.5\ laminare \\ 1.3\ turbolento \end{matrix}$

Metodo di Thwaites (laminare noto U_e)

$\vartheta^2 = \frac{0.45\nu}{(U_e)^6}\int_0^x (U_e)^5 dx$ $\vartheta^2 = \frac{0.45\nu}{6k}$ nel punto d'arresto

$\lambda = \frac{\vartheta^2}{\nu}\left(\frac{dU_e}{dx}\right)$ $\lambda = 0.075$ nel punto di arresto

$l = \left(\frac{du}{dy}\right)_{y=0} * \frac{\vartheta}{U_e(x)}$

$l = 0.22 + 1.57\lambda - 1.8\lambda^2$ per flussi accelerati $l = 0.328$ nel punto di arresto

$$l_{pa} = \frac{\tau_w}{\mu}\sqrt{\frac{0.45\nu}{6k}\frac{1}{kx}} = 0.328$$

Cilindro

$U_e \approx 2V_\infty \sin(\varphi)$ con $\varphi = \frac{x}{R}$ ascissa curvilinea

$$K = \left(\frac{dU_e}{dx}\right)_{x=0} = \frac{4V_\infty}{D}$$

$$\tau_{w_{incomp}} = 1.232\sqrt{\rho_\infty \mu_\infty U_e^2 \left(\frac{dU_e}{dx}\right)}$$

$$q_w = 0.57 P_r^{-0.6} (\rho_e \mu_e K)^{\frac{1}{2}} \left(\frac{\rho_w \mu_w}{\rho_e \mu_e}\right)^{0.1} (H_e - h_w)$$

Sfera

$U_e \approx \frac{3}{2} V_\infty \sin(\varphi)$ con $\varphi = \frac{x}{R}$ ascissa curvilinea

$$K = \left(\frac{dU_e}{dx}\right)_{x=0} = \frac{3V_\infty}{D}$$

$$\tau_{w_{incomp}} = 1.312\sqrt{\rho_\infty \mu_\infty U_e^2 \left(\frac{dU_e}{dx}\right)}$$

$$q_w = 0.736 P_r^{-0.6} (\rho_e \mu_e K)^{\frac{1}{2}} \left(\frac{\rho_w \mu_w}{\rho_e \mu_e}\right)^{0.1} (H_e - h_w)$$

$$\frac{KD}{V_\infty} = \sqrt{8\frac{\rho_\infty}{\rho_e}}$$

$$\frac{\rho_\infty}{\rho_e} = \frac{(\gamma+1)M_\infty^2}{(\gamma+1)M_\infty^2 + 2}\left[1 + \frac{\frac{\gamma+1}{2}\left((\gamma-1)M_\infty^2 + 2\right)}{2\gamma M_\infty^2 - \gamma + 1}\right]^{\frac{1}{\gamma-1}}$$

Metodo approssimato

$$\tau_{w_{comp}} = c\sqrt{\rho^* \mu^* U_e(x)^2 \left(\frac{dU_e}{dx}\right)}$$

$$q_w(x) = -\frac{c\sqrt{\rho^*\mu^*\left(\frac{dU_e}{dx}\right)}}{A} C_p(T_0 - T_w)$$

$$q_w(0) = -\frac{c\sqrt{\rho^*\mu^* K}}{P_r^{0.6}} C_p(T_0 - T_w)$$

Formula di Roming

$$q_w(0) = 0.0145 M_\infty^{3.1}\sqrt{\frac{P_\infty}{R}}$$ risultato in $\frac{BTU}{ft^2 s}$

$$q_w(0) = 164.6724 M_\infty^{3.1}\sqrt{\frac{P_\infty}{R}}$$