restart

$$dsys1 := \left\{ \frac{d}{dx} m(x) = \frac{kl\,(Tw - Tlv)}{hlv\,\delta(x)}, \frac{d}{dx} F(x) = \frac{f R\,\mu l\, m(x)}{8\,\rho l\,\delta^2(x)} - \sigma K\, G(x), \frac{d}{dx} u(x) \right.$$

$$= \frac{kl\,(Tw - Tlv)}{\rho l\, hlv\,\delta^2(x)} - \frac{u(x)}{\delta(x)} G(x), \frac{d}{dx} \delta(x) = G(x), \frac{d}{dx} G(x) = K\left(\left(1 + G^2(x)\right)^{\frac{3}{2}} \right), G(0)$$

$$= 0.0005\,, \delta(0) = \left(\frac{(Tv\ A)}{(Tw - Tv)\,\rho v\, hlv} \right)^{\frac{1}{3}}, u(0) = 0, F(0) = -\frac{1.5\,A}{\left(\left(\frac{(Tv\ A)}{(Tw - Tv)\,\rho v\, hlv} \right)^{\frac{1}{3}} \right)^2},$$

$$\left. m(0) = 0 \right\}$$

$$\left\{ F(0) = -\frac{1.5\,A}{\left(\frac{Tv\,A}{(Tw - Tv)\,\rho v\, hlv} \right)^{2/3}}, G(0) = 0.0005, \delta(0) = \left(\frac{Tv\,A}{(Tw - Tv)\,\rho v\, hlv} \right)^{1/3}, \right. \quad \textbf{(1)}$$

$$\frac{d}{dx} F(x) = \frac{1}{8} \frac{f R\,\mu l\, m(x)}{\rho l\,\delta(x)^2} - \sigma K\, G(x), \frac{d}{dx} G(x) = K\left(1 + G(x)^2\right)^{3/2}, \frac{d}{dx} \delta(x)$$

$$= G(x), \frac{d}{dx} m(x) = \frac{kl\,(Tw - Tlv)}{hlv\,\delta(x)}, \frac{d}{dx} u(x) = \frac{kl\,(Tw - Tlv)}{\rho l\, hlv\,\delta(x)^2} - \frac{u(x)\,G(x)}{\delta(x)}, m(0)$$

$$\left. = 0, u(0) = 0 \right\}$$

dsol2 := *dsolve*(*dsys1*, *numeric*, *method* = *rkf45*, *output* = *procedurelist*) :

Warning, The use of global variables in numerical ODE problems is deprecated, and will be removed in a future release. Use the 'parameters' argument instead (see ?dsolve,numeric,parameters)

dsol2(0)

$$\left[x = 0., F(x) = -\frac{1.5\,A}{\left(\frac{Tv\,A}{(Tw - 1.\,Tv)\,\rho v\, hlv} \right)^{2/3}}, G(x) = 0.0005, \delta(x) \right. \quad \textbf{(2)}$$

$$\left. = \left(\frac{Tv\,A}{(Tw - 1.\,Tv)\,\rho v\, hlv} \right)^{1/3}, m(x) = 0., u(x) = 0. \right]$$

$K := 0$

$$0 \quad \textbf{(3)}$$

$\rho l := 999.7$

$$999.7 \tag{4}$$

$hlv := 2513.6820390512\ 10^{3}$

$$2.513682039\ 10^{6} \tag{5}$$

$Tw := 282.98$

$$282.98 \tag{6}$$

$kl := 0.61$

$$0.61 \tag{7}$$

$\mu l := 0.001$

$$0.001 \tag{8}$$

$R := 0$

$$0 \tag{9}$$

$f := 0$

$$0 \tag{10}$$

$\sigma := 0.06$

$Tv := 282.65$

$$282.65 \tag{11}$$

$\rho v := 0.03$

$$0.03 \tag{12}$$

$A := 1.\ 10^{-19}$

$$1.000000000\ 10^{-19} \tag{13}$$

$$Tlv := Tv\left(1 + \frac{\left(\frac{A}{\left(\left(\frac{(\mathrm{Tv}\ \ \mathrm{A})}{(Tw - Tv)\ \rho v\ hlv}\right)^{\frac{1}{3}}\right)^{3}}\right)}{\rho l\ \ hlv}\right)$$

$$282.65 \tag{14}$$

$dsol2(0)$

$$\left[x = 0.,\ F(x) = -\frac{1.5\ A}{\left(\frac{Tv\ A}{(Tw - 1.\ Tv)\ \rho v\ hlv}\right)^{2/3}},\ G(x) = 0.0005,\ \delta(x)\right. \tag{15}$$
$$\left. = \left(\frac{Tv\ A}{(Tw - 1.\ Tv)\ \rho v\ hlv}\right)^{1/3},\ m(x) = 0.,\ u(x) = 0.\right]$$

$dsol2(0.000005)$

$$[x = 0.000005,\ F(x) = -0.0000137791456327161,\ G(x) = 0.0005000000000000000,\ \delta(x) \tag{16}$$
$$= 1.06836072442695\ 10^{-7},\ m(x) = 0.00000379242610721238,\ u(x)$$
$$= 0.03550829217384 01]$$

for i **from** 0 **to** $100.0\cdot 10^{-5}$ **by** $100\cdot 10^{-6}$ **do**
$dsol2(i)$;
end do

$$[x = 0.,\ F(x) = -0.0000137791456327161,\ G(x) = 0.0005,\ \delta(x) = 1.04336072442695\ 10^{-7},\ m(x) = 0.,\ u(x) = 0.]$$

$$[x = 0.000100000000000000,\ F(x) = -0.0000137791456327161,\ G(x) = 0.000500000000000000,\ \delta(x) = 1.54336072442695\ 10^{-7},\ m(x) = 0.0000627064530154883,\ u(x) = 0.406420043088061]$$

$$[x = 0.000200000000000000,\ F(x) = -0.0000137791456327161,\ G(x) = 0.000500000000000000,\ \delta(x) = 2.04336072442695\ 10^{-7},\ m(x) = 0.000107653692275882,\ u(x) = 0.527004383778885]$$

$$[x = 0.000300000000000000,\ F(x) = -0.0000137791456327161,\ G(x) = 0.000500000000000000,\ \delta(x) = 2.54336072442695\ 10^{-7},\ m(x) = 0.000142711943053275,\ u(x) = 0.561284006084702]$$

$$[x = 0.000400000000000000,\ F(x) = -0.0000137791456327161,\ G(x) = 0.000500000000000000,\ \delta(x) = 3.04336072442695\ 10^{-7},\ m(x) = 0.000171457452373531,\ u(x) = 0.563551011764810]$$

$$[x = 0.000500000000000000,\ F(x) = -0.0000137791456327161,\ G(x) = 0.000500000000000000,\ \delta(x) = 3.54336072442695\ 10^{-7},\ m(x) = 0.000195820441790271,\ u(x) = 0.552806349964308]$$

$$[x = 0.000600000000000000,\ F(x) = -0.0000137791456327161,\ G(x) = 0.000500000000000000,\ \delta(x) = 4.04336072442695\ 10^{-7},\ m(x) = 0.000216962105988431,\ u(x) = 0.536749580889446]$$

$$[x = 0.000700000000000000,\ F(x) = -0.0000137791456327161,\ G(x) = 0.000500000000000000,\ \delta(x) = 4.54336072442695\ 10^{-7},\ m(x) = 0.000235635686927672,\ u(x) = 0.518793049215732]$$

$$[x = 0.000800000000000000,\ F(x) = -0.0000137791456327161,\ G(x) = 0.000500000000000000,\ \delta(x) = 5.04336072442695\ 10^{-7},\ m(x) = 0.000252357667121215,\ u(x) = 0.500526167585693]$$

$$[x = 0.000900000000000000,\ F(x) = -0.0000137791456327161,\ G(x) = 0.000500000000000000,\ \delta(x) = 5.54336072442695\ 10^{-7},\ m(x) = 0.000267497653756295,\ u(x) = 0.482699866292960]$$

$$[x = 0.00100000000000000,\ F(x) = -0.0000137791456327161,\ G(x) = 0.000500000000000000,\ \delta(x) = 6.04336072442695\ 10^{-7},\ m(x) = 0.000281329252237854,\ u(x) = 0.465657598307485] \qquad \textbf{(17)}$$

$\delta n := 0.00000509363100481461$

$$0.00000509363100481461 \quad (18)$$

$Fn := -0.0000171100741184493$

$$-0.0000171100741184493 \quad (19)$$

$mn := 0.00000969811837599714$

$$0.00000969811837599714 \quad (20)$$

$un := 0.00190453207045465$

$$0.00190453207045465 \quad (21)$$

$$Ct := \frac{\mu l \cdot kl}{hlv \cdot \rho l \cdot \delta n}$$

$$4.765651940\ 10^{-8} \quad (22)$$

$$Kn := \left(\frac{1}{\sigma \cdot \left(\delta n + \frac{Ct \cdot Tv}{hlv \cdot \rho v} \right)} \right) \cdot \left(-Fn - \left(1.5 \cdot \delta n + \frac{Ct \cdot Tv}{hlv \cdot \rho v} \right) \frac{A}{(\delta n)^3} + \frac{1}{2} (mn \cdot un + Ct \cdot (Tw - Tv)) \right)$$

$$56.02025566 \quad (23)$$

$$et := \frac{\sigma \cdot Kn + \frac{A}{(\delta n)^3}}{\rho l \cdot hlv}$$

$$1.337870451\ 10^{-9} \quad (24)$$

$$et := \frac{\sigma \cdot Kn + \frac{A}{(\delta n)^3}}{\rho v \cdot hlv}$$

$$0.00004458230300 \quad (25)$$

$$Tlvn := Tv \left(1 + \frac{\sigma \cdot Kn + \frac{A}{(\delta n)^3}}{\rho v \cdot hlv} \right)$$

$$282.6626011 \quad (26)$$

$$Tlvn1 := Tv \left(1 + \frac{\sigma \cdot Kn + \frac{A}{(\delta n)^3}}{\rho l \cdot hlv} \right)$$

$$282.6500003 \quad (27)$$

$$q'' := \frac{kl\ (Tw - Tlvn1)}{\delta n}$$

$$39519.90570 \quad (28)$$

$$h := \frac{q''}{(Tw - Tlvn1)}$$

$$1.197573989\ 10^{5} \quad (29)$$

$$p := 6.35\ 10^{-4}$$

$$0.0006350000000 \quad (30)$$

$$Q1 := q''\,p$$

$$25.09514012 \quad (31)$$

$$\phi 0 := 0.5235$$

$$0.5235 \quad (32)$$

$$Di := 0.016$$

$$0.016 \quad (33)$$

$$Q := \int_{\phi 0}^{\pi} 2\ q''p\ Di\ \mathrm{d}\phi$$

$$2.102444864 \quad (34)$$

$$W := 1\ 10^{-4}$$

$$\frac{1}{10000} \quad (35)$$

$$H := 1.473\ 10^{-3}$$

$$0.001473000000 \quad (36)$$

$$Atcs := W + 2\,H$$

$$0.003046000000 \quad (37)$$

$$At := \int_{\phi 0}^{\pi} Atcs\ \mathrm{d}\phi$$

$$0.007974710223 \quad (38)$$

$$h := \frac{Q}{\mathrm{At}\ (Tw - Tlvn1)}$$

$$798.9068763 \quad (39)$$

$$C1 := 0.48$$

$$0.48 \quad (40)$$

$$C2 := 0.25$$

$$0.25 \quad (41)$$

$$g := 9.81$$

$$9.81 \quad (42)$$

$$Tf := 278$$

$$278 \quad (43)$$

$$Tm := \frac{(Tw + Tf)}{2}$$

$$280.4900000 \quad (44)$$

$$\eta := \frac{1}{Tm}$$

$$0.003565189490 \quad (45)$$

$\upsilon := 1\ 10^{-6}$

$$\frac{1}{1000000} \quad (46)$$

$\Delta T := Tw - Tf$

$$4.98 \quad (47)$$

$l := 0.01905$

$$0.01905 \quad (48)$$

$$Gr := \frac{g\,\eta\,\Delta T\,l^3}{\upsilon^2}$$

$$1.204109292\ 10^6 \quad (49)$$

$Pr := 8$

$$8 \quad (50)$$

$\mathrm{Nu} := C1\ (Gr\,Pr)^{C2}$

$$26.74115807 \quad (51)$$

$$hnc := \frac{\mathrm{Nu}\,kl}{l}$$

$$856.2785522 \quad (52)$$