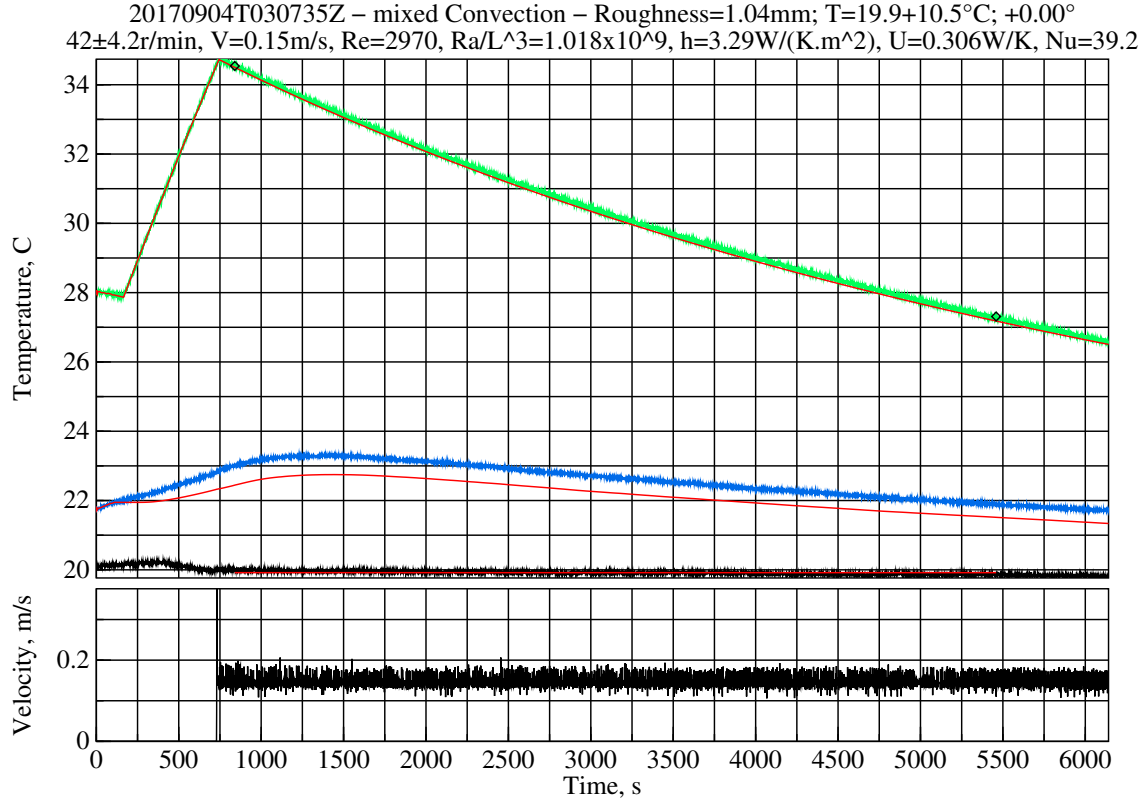


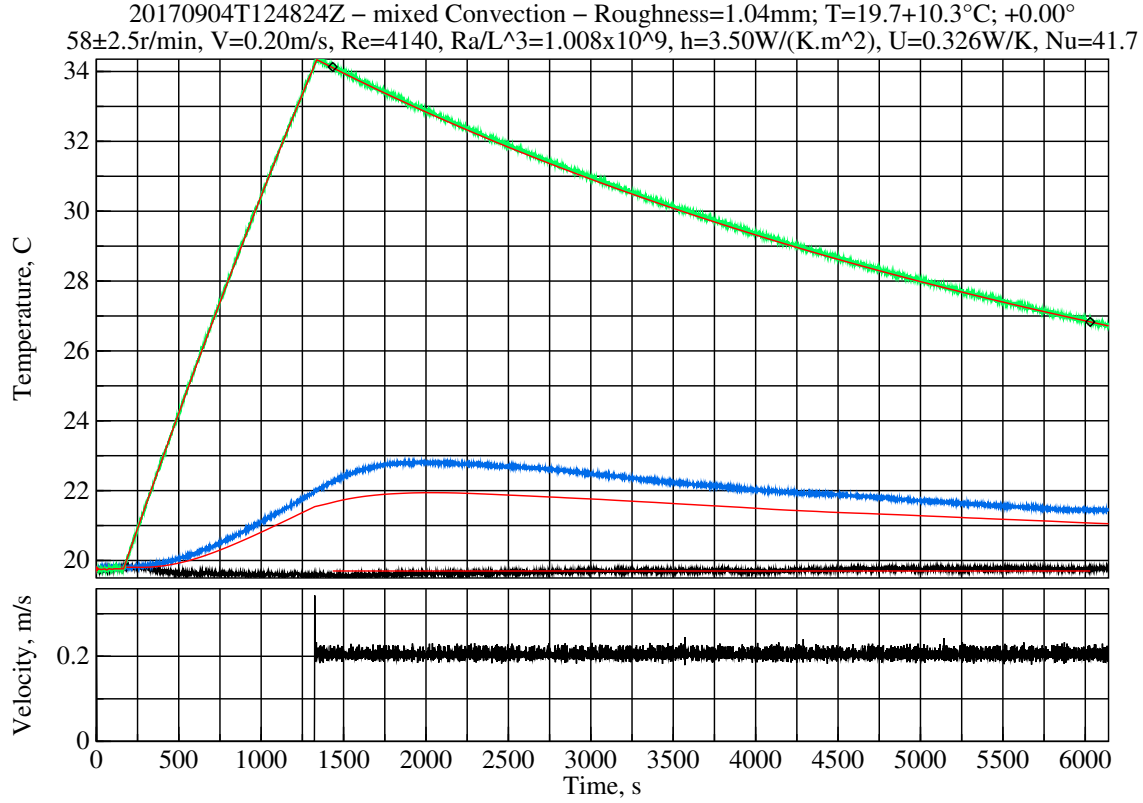
Estimated measurement uncertainties of natural convection at  $\theta = 0.0$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.4K	+22.8%/K	0.10K	2.28%	LM35C differential
$P$	100kPa	+0.0007%/Pa	1.5kPa	1.02%	MPXH6115A6U air pressure
$C_{pt}$	4.24kJ/K	+0.048%/(J/K)	42J/K	2.04%	plate thermal capacity
$C_V$	1.000	−14.1%	0.100	1.41%	vertical reuptake
$L_c$	0.305m	+616%/m	500um	0.31%	characteristic length
$D_{PIR}$	25.4mm	−541%/m	1.0mm	0.54%	insulation thickness
$D_g$	1.00mm	−549%/m	500um	0.27%	air gap
$L_m$	3.57mm	+1185%/m	500um	0.59%	side metal strip width
$k_{PIR}$	22.2 $\frac{mW}{K \cdot m}$	+0.523%/ $\frac{mW}{K \cdot m}$	1.1 $\frac{mW}{K \cdot m}$	0.58%	PIR thermal conductivity
$\epsilon_{XPS}$	0.515	+39.2%	0.010	0.39%	XPS emissivity
$\epsilon_{tp}$	0.890	+46.9%	0.015	0.70%	tape emissivity
$\Omega_{tp}$	0.540	+31.9%	0.020	0.64%	tape coverage
$\epsilon_{rs}$	0.040	+161%	0.010	1.61%	test-surface emissivity
$\epsilon_{wt}$	0.900	+76.9%	0.025	1.92%	wind-tunnel emissivity
				4.58%	combined bias uncertainty



Estimated measurement uncertainties, bi-level 1mm roughness at  $Re = 2970$ .

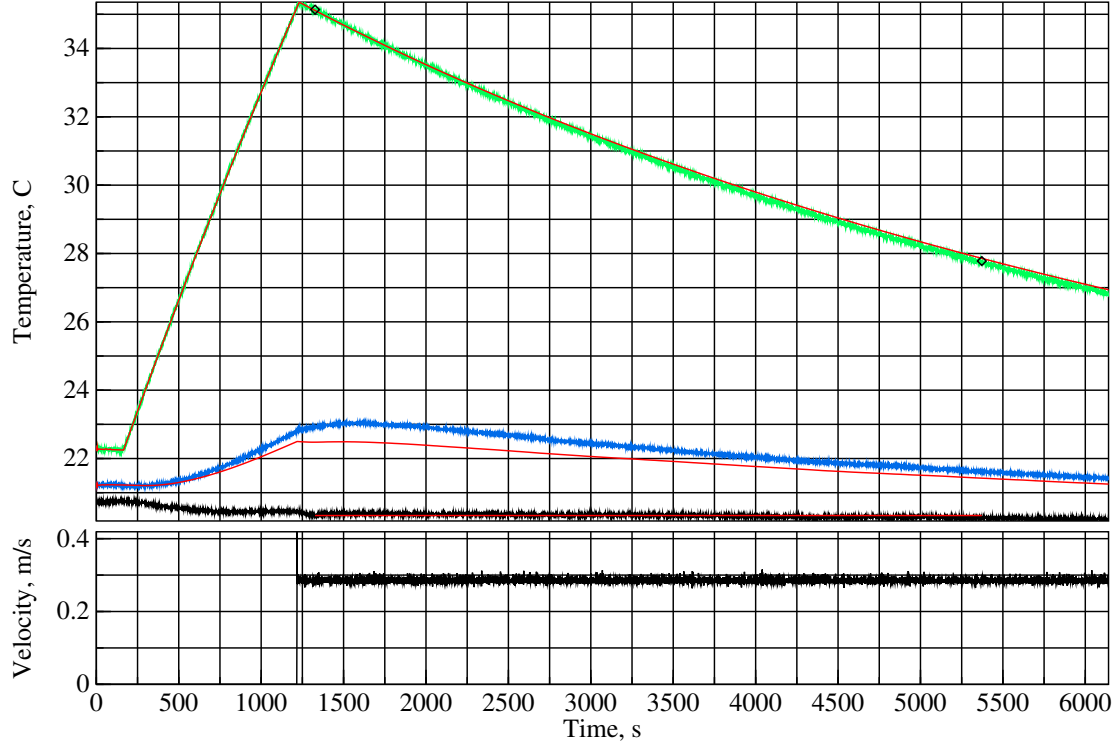
Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.5K	+22.4%/K	0.10K	2.24%	LM35C differential
$P$	100kPa	+0.0007%/Pa	1.5kPa	1.07%	MPXH6115A6U air pressure
$C_{pt}$	4.24kJ/K	+0.048%/(J/K)	42J/K	2.03%	plate thermal capacity
$C_V$	1.000	−13.9%	0.100	1.39%	vertical reuptake
$L_c$	0.305m	+605%/m	500um	0.30%	characteristic length
$D_{PIR}$	25.4mm	−532%/m	1.0mm	0.53%	insulation thickness
$D_g$	1.00mm	−539%/m	500um	0.27%	air gap
$L_m$	3.57mm	+1245%/m	500um	0.62%	side metal strip width
$k_{PIR}$	22.2 $\frac{mW}{K \cdot m}$	+0.522%/ $\frac{mW}{K \cdot m}$	1.1 $\frac{mW}{K \cdot m}$	0.58%	PIR thermal conductivity
$\epsilon_{XPS}$	0.515	+38.4%	0.010	0.38%	XPS emissivity
$\epsilon_{tp}$	0.890	+46.0%	0.015	0.69%	tape emissivity
$\Omega_{tp}$	0.540	+31.3%	0.020	0.63%	tape coverage
$\epsilon_{rs}$	0.040	+158%	0.010	1.58%	test-surface emissivity
$\epsilon_{wt}$	0.900	+75.3%	0.025	1.88%	wind-tunnel emissivity
				4.53%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	41.7r/min	+0.178%/(r/min)	4.2r/min	0.74%	fan rotation rate
				4.76%	RSS combined uncertainty



Estimated measurement uncertainties, bi-level 1mm roughness at  $Re = 4140$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.3K	+22.4%/K	0.10K	2.24%	LM35C differential
$P$	100kPa	+0.0008%/Pa	1.5kPa	1.13%	MPXH6115A6U air pressure
$C_{pt}$	4.24kJ/K	+0.047%/(J/K)	42J/K	2.01%	plate thermal capacity
$C_V$	1.000	−13.5%	0.100	1.35%	vertical reuptake
$L_c$	0.305m	+596%/m	500um	0.30%	characteristic length
$D_{PIR}$	25.4mm	−562%/m	1.0mm	0.56%	insulation thickness
$D_g$	1.00mm	−570%/m	500um	0.29%	air gap
$L_m$	3.57mm	+1267%/m	500um	0.63%	side metal strip width
$k_{PIR}$	22.2 $\frac{mW}{K \cdot m}$	+0.555%/ $\frac{mW}{K \cdot m}$	1.1 $\frac{mW}{K \cdot m}$	0.62%	PIR thermal conductivity
$\epsilon_{XPS}$	0.515	+37.2%	0.010	0.37%	XPS emissivity
$\epsilon_{tp}$	0.890	+44.6%	0.015	0.67%	tape emissivity
$\Omega_{tp}$	0.540	+30.3%	0.020	0.61%	tape coverage
$\epsilon_{rs}$	0.040	+154%	0.010	1.54%	test-surface emissivity
$\epsilon_{wt}$	0.900	+72.8%	0.025	1.82%	wind-tunnel emissivity
				4.49%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	57.8r/min	+0.285%/(r/min)	2.5r/min	0.71%	fan rotation rate
				4.71%	RSS combined uncertainty

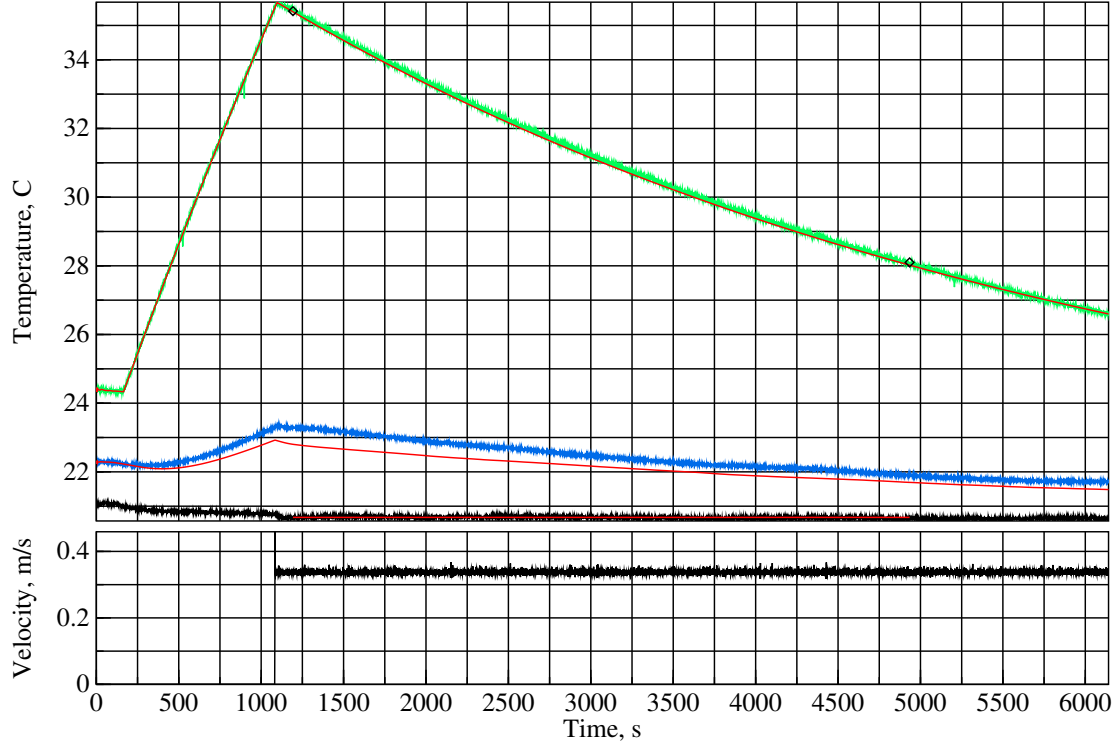
20170904T231856Z – mixed Convection – Roughness=1.04mm; T=20.3+10.7°C; +0.00°  
81±1.9r/min, V=0.29m/s, Re=5738, Ra/L^3=1.028x10^9, h=4.17W/(K.m^2), U=0.387W/K, Nu=49.5



Estimated measurement uncertainties, bi-level 1mm roughness at  $Re = 5738$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.7K	+18.6%/K	0.10K	1.86%	LM35C differential
$P$	100kPa	+0.0013%/Pa	1.5kPa	1.88%	MPXH6115A6U air pressure
$C_{pt}$	4.24kJ/K	+0.045%/(J/K)	42J/K	1.91%	plate thermal capacity
$\eta$	0.400	+297%	0.004	1.19%	anemometer calibration
$C_V$	1.000	−12.0%	0.100	1.20%	vertical reuptake
$L_c$	0.305m	+755%/m	500um	0.38%	characteristic length
$\varsigma$	2.00mm	−11498%/m	100um	1.15%	post height
$D_{PIR}$	25.4mm	−533%/m	1.0mm	0.53%	insulation thickness
$D_g$	1.00mm	−540%/m	500um	0.27%	air gap
$L_m$	3.57mm	+1261%/m	500um	0.63%	side metal strip width
$k_{PIR}$	22.2 $\frac{mW}{K \cdot m}$	+0.534%/ $\frac{mW}{K \cdot m}$	1.1 $\frac{mW}{K \cdot m}$	0.59%	PIR thermal conductivity
$\epsilon_{XPS}$	0.515	+33.0%	0.010	0.33%	XPS emissivity
$\epsilon_{tp}$	0.890	+39.6%	0.015	0.59%	tape emissivity
$\Omega_{tp}$	0.540	+26.9%	0.020	0.54%	tape coverage
$\epsilon_{rs}$	0.040	+137%	0.010	1.37%	test-surface emissivity
$\epsilon_{wt}$	0.900	+64.5%	0.025	1.61%	wind-tunnel emissivity
$\theta$	50.0m°	+2.13%/°	0.50°	1.07%	plate angle
				4.75%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	80.6r/min	+1.47%/(r/min)	1.9r/min	2.81%	fan rotation rate
				7.36%	RSS combined uncertainty

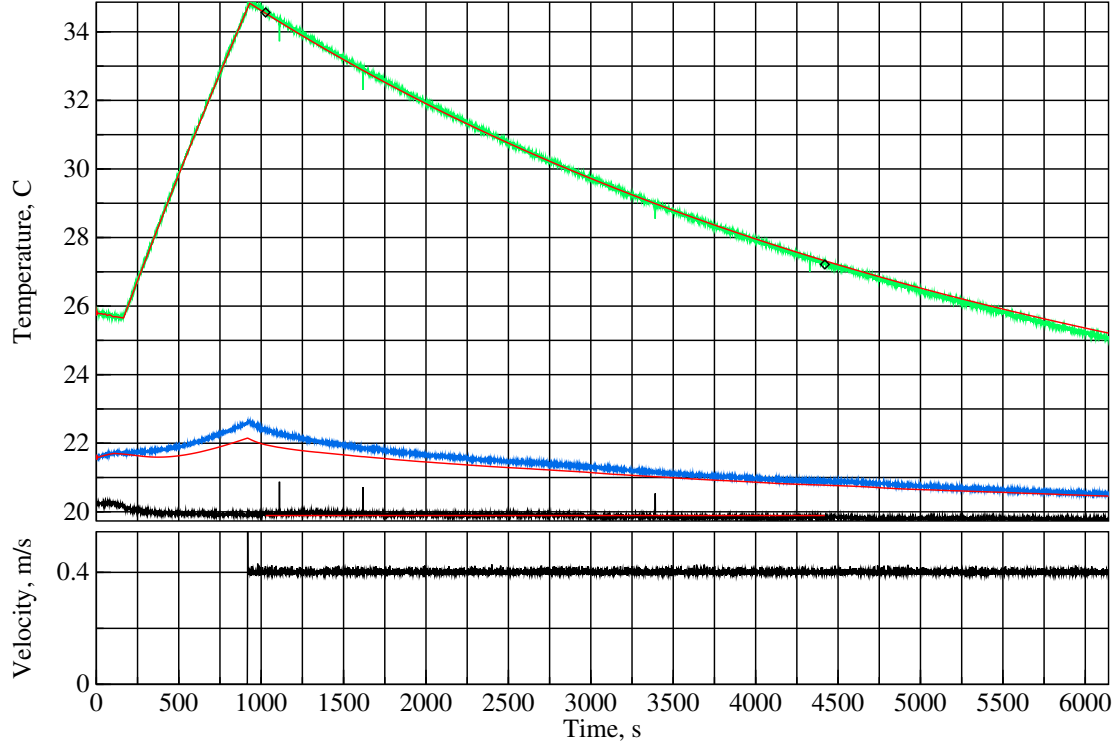
20170905T211144Z – mixed Convection – Roughness=1.04mm; T=20.7+10.6°C; +0.00°  
95±1.7r/min, V=0.34m/s, Re=6754, Ra/L^3=1.015x10^9, h=4.79W/(K.m^2), U=0.445W/K, Nu=56.9



Estimated measurement uncertainties, bi-level 1mm roughness at  $Re = 6753$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.6K	+18.4%/K	0.10K	1.84%	LM35C differential
$P$	100.0kPa	+0.0010%/Pa	1.5kPa	1.48%	MPXH6115A6U air pressure
$C_{pt}$	4.24kJ/K	+0.042%/(J/K)	42J/K	1.76%	plate thermal capacity
$\eta$	0.400	+156%	0.004	0.62%	anemometer calibration
$C_V$	1.000	−9.82%	0.100	0.98%	vertical reuptake
$L_c$	0.305m	+560%/m	500um	0.28%	characteristic length
$L_T$	8.34mm	+3120%/m	100um	0.31%	post length
$\varsigma$	2.00mm	−8295%/m	100um	0.83%	post height
$D_{PIR}$	25.4mm	−449%/m	1.0mm	0.45%	insulation thickness
$D_g$	1.00mm	−455%/m	500um	0.23%	air gap
$L_m$	3.57mm	+1127%/m	500um	0.56%	side metal strip width
$k_{PIR}$	22.2 $\frac{mW}{K \cdot m}$	+0.454%/ $\frac{mW}{K \cdot m}$	1.1 $\frac{mW}{K \cdot m}$	0.50%	PIR thermal conductivity
$\epsilon_{XPS}$	0.515	+26.9%	0.010	0.27%	XPS emissivity
$\epsilon_{tp}$	0.890	+32.3%	0.015	0.49%	tape emissivity
$\Omega_{tp}$	0.540	+22.0%	0.020	0.44%	tape coverage
$\epsilon_{rs}$	0.040	+113%	0.010	1.13%	test-surface emissivity
$\epsilon_{wt}$	0.900	+52.6%	0.025	1.32%	wind-tunnel emissivity
				3.91%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	95.3r/min	+0.655%/(r/min)	1.7r/min	1.11%	fan rotation rate
				4.50%	RSS combined uncertainty

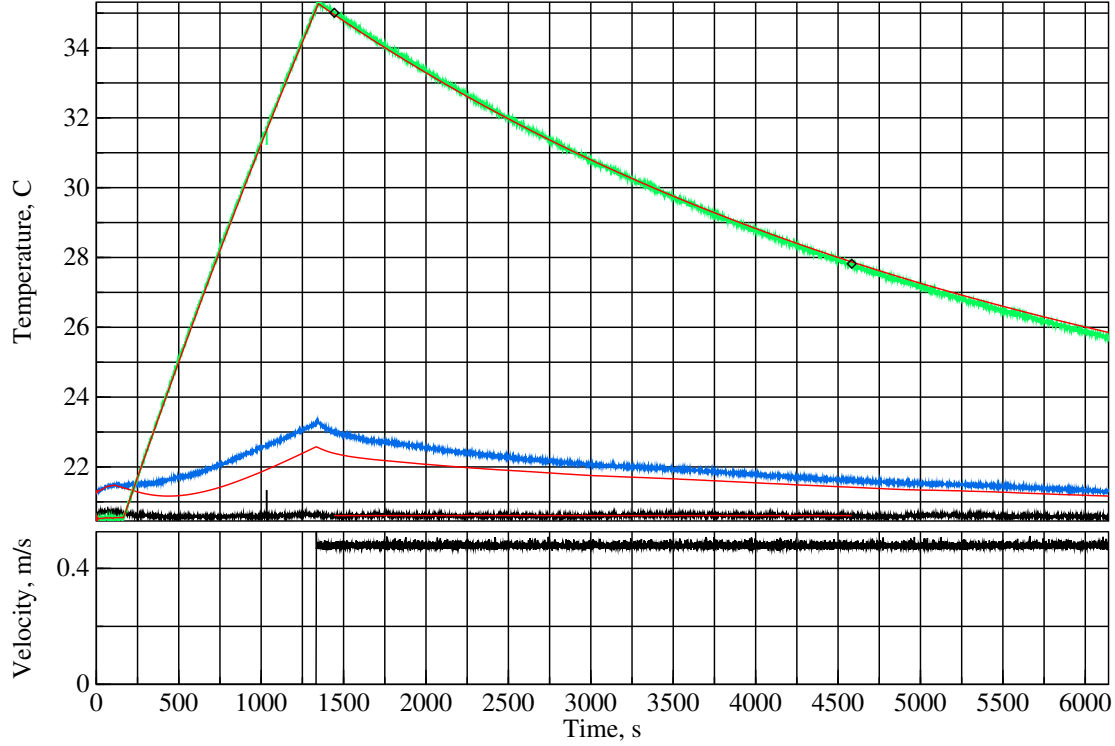
20170904T144811Z – mixed Convection – Roughness=1.04mm; T=19.9+10.6°C; +0.00°  
113±1.9r/min, V=0.40m/s, Re=8095, Ra/L^3=1.033x10^9, h=5.59W/(K.m^2), U=0.520W/K, Nu=66.5



Estimated measurement uncertainties, bi-level 1mm roughness at  $Re = 8096$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.6K	+17.4%/K	0.10K	1.74%	LM35C differential
$P$	100kPa	+0.0010%/Pa	1.5kPa	1.53%	MPXH6115A6U air pressure
$C_{pt}$	4.24kJ/K	+0.040%/(J/K)	42J/K	1.68%	plate thermal capacity
$\eta$	0.400	+180%	0.004	0.72%	anemometer calibration
$C_V$	1.000	-8.75%	0.100	0.87%	vertical reuptake
$L_c$	0.305m	+529%/m	500um	0.26%	characteristic length
$L_T$	8.34mm	+4398%/m	100um	0.44%	post length
$\varsigma$	2.00mm	-11174%/m	100um	1.12%	post height
$D_{PIR}$	25.4mm	-411%/m	1.0mm	0.41%	insulation thickness
$D_g$	1.00mm	-417%/m	500um	0.21%	air gap
$L_m$	3.57mm	+1047%/m	500um	0.52%	side metal strip width
$k_{PIR}$	22.2 $\frac{mW}{K \cdot m}$	+0.417%/ $\frac{mW}{K \cdot m}$	1.1 $\frac{mW}{K \cdot m}$	0.46%	PIR thermal conductivity
$\epsilon_{XPS}$	0.515	+23.7%	0.010	0.24%	XPS emissivity
$\epsilon_{tp}$	0.890	+28.4%	0.015	0.43%	tape emissivity
$\Omega_{tp}$	0.540	+19.3%	0.020	0.39%	tape coverage
$\epsilon_{rs}$	0.040	+99.4%	0.010	0.99%	test-surface emissivity
$\epsilon_{wt}$	0.900	+46.2%	0.025	1.15%	wind-tunnel emissivity
				3.80%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	113r/min	+0.635%/(r/min)	1.9r/min	1.21%	fan rotation rate
				4.51%	RSS combined uncertainty

20170908T005847Z – mixed Convection – Roughness=1.04mm; T=20.6+10.4°C; +0.00°  
135±2.3r/min, V=0.48m/s, Re=9639, Ra/L^3=1.005x10^9, h=6.49W/(K.m^2), U=0.604W/K, Nu=77.2

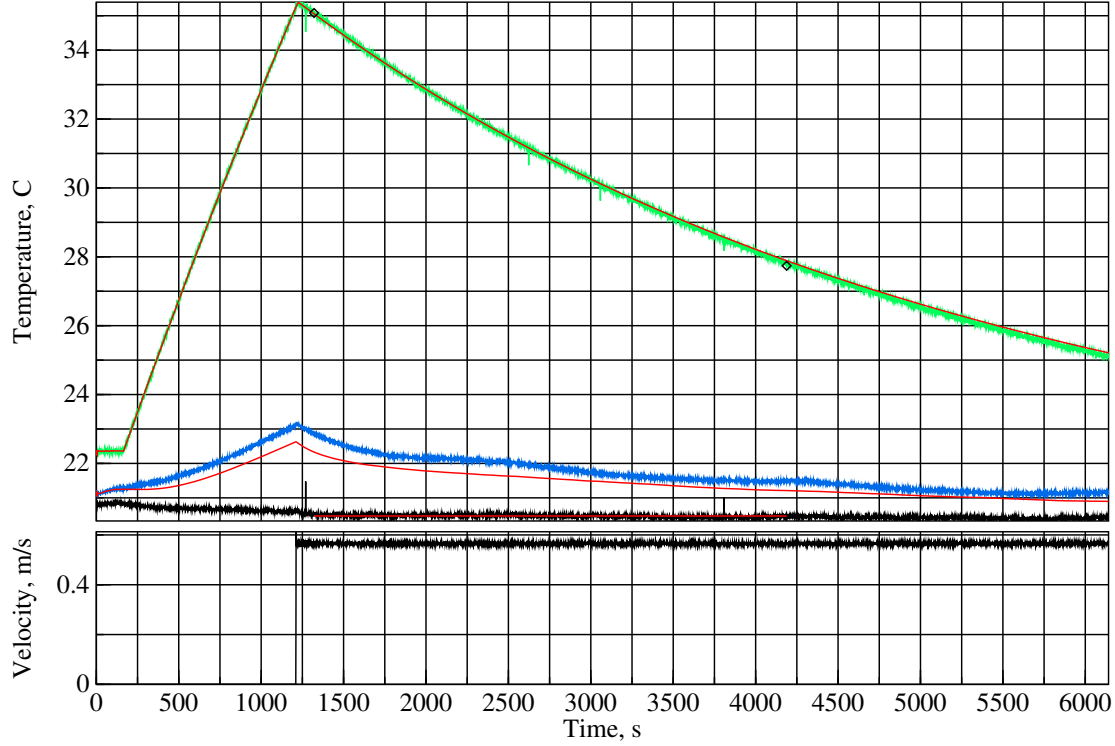


Estimated measurement uncertainties, bi-level 1mm roughness at  $Re = 9640$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.4K	+16.8%/K	0.10K	1.68%	LM35C differential
$P$	101kPa	+0.0010%/Pa	1.5kPa	1.56%	MPXH6115A6U air pressure
$C_{pt}$	4.24kJ/K	+0.038%/(J/K)	42J/K	1.60%	plate thermal capacity
$\eta$	0.400	+200%	0.004	0.80%	anemometer calibration
$C_V$	1.000	-7.67%	0.100	0.77%	vertical reuptake
$L_c$	0.305m	+484%/m	500um	0.24%	characteristic length
$L_T$	8.34mm	+5565%/m	100um	0.56%	post length
$\varsigma$	2.00mm	-12582%/m	100um	1.26%	post height
$D_{PIR}$	25.4mm	-372%/m	1.0mm	0.37%	insulation thickness
$L_m$	3.57mm	+976%/m	500um	0.49%	side metal strip width
$k_{PIR}$	22.2 $\frac{mW}{K \cdot m}$	+0.378%/ $\frac{mW}{K \cdot m}$	1.1 $\frac{mW}{K \cdot m}$	0.42%	PIR thermal conductivity
$\epsilon_{XPS}$	0.515	+20.9%	0.010	0.21%	XPS emissivity
$\epsilon_{tp}$	0.890	+25.1%	0.015	0.38%	tape emissivity
$\Omega_{tp}$	0.540	+17.1%	0.020	0.34%	tape coverage
$\epsilon_{rs}$	0.040	+87.9%	0.010	0.88%	test-surface emissivity
$\epsilon_{wt}$	0.900	+40.8%	0.025	1.02%	wind-tunnel emissivity
				3.71%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	135r/min	+0.590%/(r/min)	2.3r/min	1.33%	fan rotation rate
				4.57%	RSS combined uncertainty



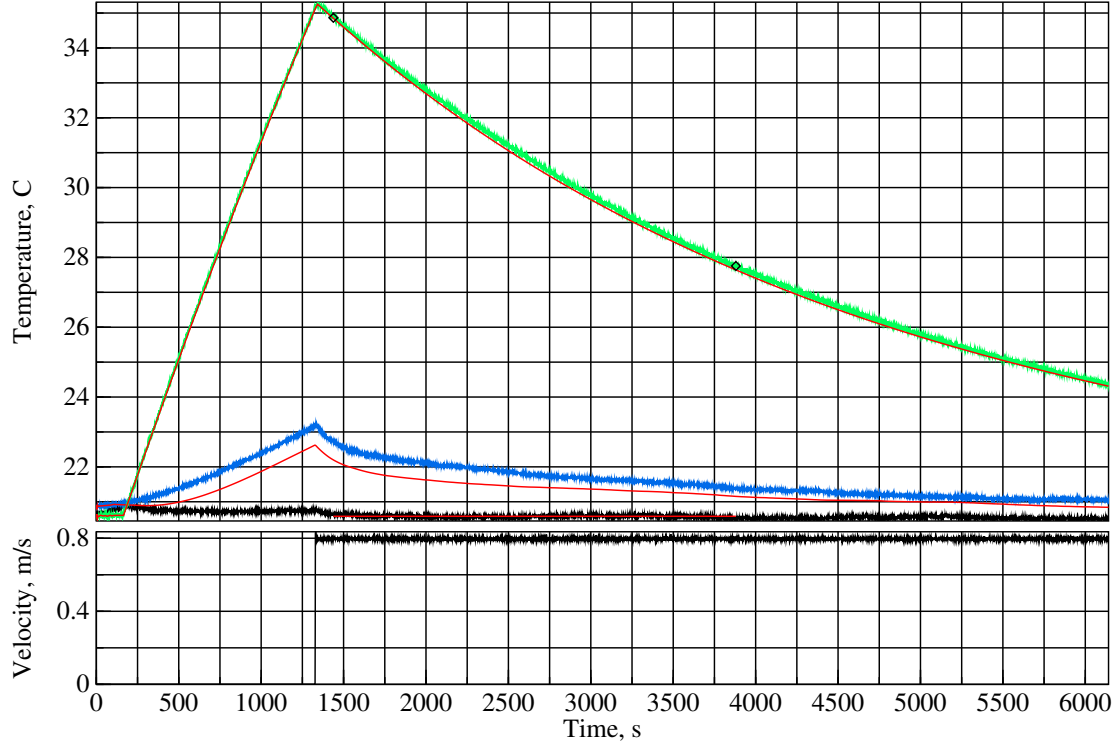
20170905T191045Z – mixed Convection – Roughness=1.04mm; T=20.5+10.5°C; +0.00°  
160±0.9r/min, V=0.57m/s, Re=11324, Ra/L^3=1.009x10^9, h=7.18W/(K.m^2), U=0.668W/K, Nu=85.3



Estimated measurement uncertainties, bi-level 1mm roughness at  $Re = 11324$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.5K	+15.6%/K	0.10K	1.56%	LM35C differential
$P$	99.9kPa	+0.0010%/Pa	1.5kPa	1.56%	MPXH6115A6U air pressure
$C_{pt}$	4.24kJ/K	+0.036%/(J/K)	42J/K	1.53%	plate thermal capacity
$\eta$	0.400	+210%	0.004	0.84%	anemometer calibration
$C_V$	1.000	−6.74%	0.100	0.67%	vertical reuptake
$L_c$	0.305m	+431%/m	500um	0.22%	characteristic length
$L_T$	8.34mm	+6447%/m	100um	0.64%	post length
$\varsigma$	2.00mm	−12537%/m	100um	1.25%	post height
$D_{PIR}$	25.4mm	−334%/m	1.0mm	0.33%	insulation thickness
$L_m$	3.57mm	+905%/m	500um	0.45%	side metal strip width
$k_{PIR}$	22.2 $\frac{mW}{K \cdot m}$	+0.341%/ $\frac{mW}{K \cdot m}$	1.1 $\frac{mW}{K \cdot m}$	0.38%	PIR thermal conductivity
$\epsilon_{tp}$	0.890	+22.1%	0.015	0.33%	tape emissivity
$\Omega_{tp}$	0.540	+15.0%	0.020	0.30%	tape coverage
$\epsilon_{rs}$	0.040	+77.3%	0.010	0.77%	test-surface emissivity
$\epsilon_{wt}$	0.900	+35.8%	0.025	0.90%	wind-tunnel emissivity
				3.55%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	160r/min	+0.524%/(r/min)	0.90r/min	0.47%	fan rotation rate
				3.67%	RSS combined uncertainty

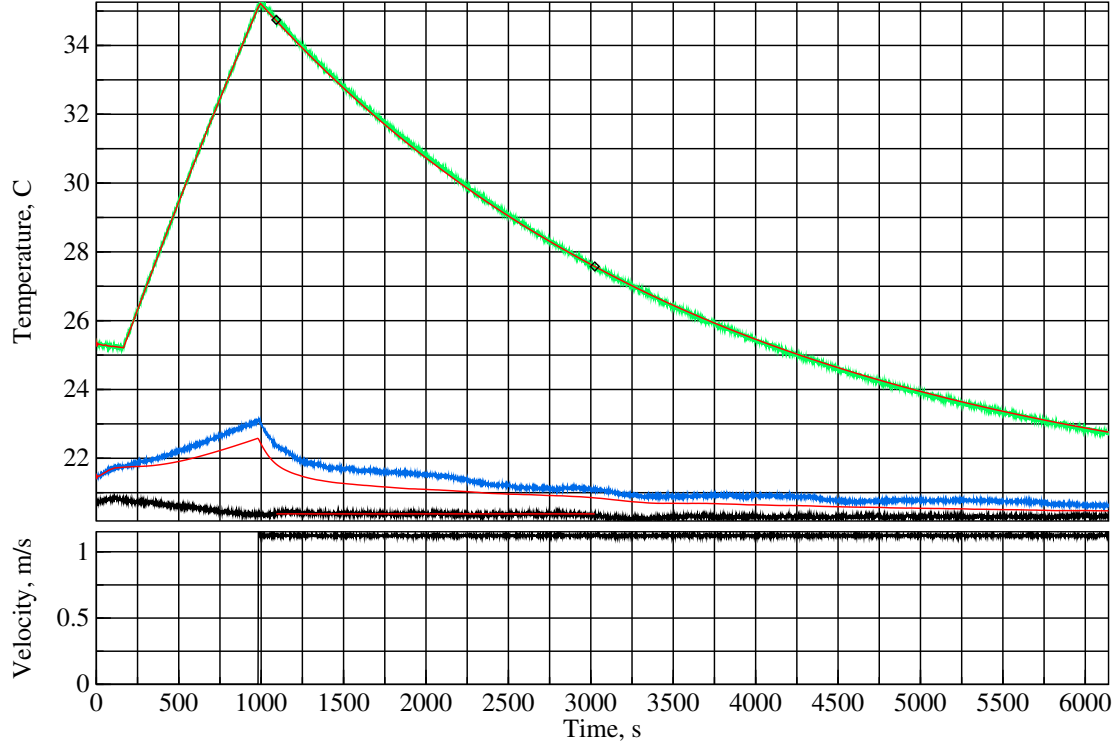
20170906T231528Z – mixed Convection – Roughness=1.04mm; T=20.6+10.3°C; +0.00°  
226±1.3r/min, V=0.80m/s, Re=16037, Ra/L^3=1.000x10^9, h=9.01W/(K.m^2), U=0.838W/K, Nu=107.1



Estimated measurement uncertainties, bi-level 1mm roughness at  $Re = 16038$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.3K	+14.3%/K	0.10K	1.43%	LM35C differential
$P$	101kPa	+0.0010%/Pa	1.5kPa	1.48%	MPXH6115A6U air pressure
$C_{pt}$	4.24kJ/K	+0.033%/(J/K)	42J/K	1.40%	plate thermal capacity
$\eta$	0.400	+217%	0.004	0.87%	anemometer calibration
$C_V$	1.000	−5.01%	0.100	0.50%	vertical reuptake
$L_T$	8.34mm	+7807%/m	100um	0.78%	post length
$\varsigma$	2.00mm	−10255%/m	100um	1.03%	post height
$D_{PIR}$	25.4mm	−259%/m	1.0mm	0.26%	insulation thickness
$L_m$	3.57mm	+768%/m	500um	0.38%	side metal strip width
$k_{PIR}$	22.2 $\frac{mW}{K \cdot m}$	+0.266%/ $\frac{mW}{K \cdot m}$	1.1 $\frac{mW}{K \cdot m}$	0.29%	PIR thermal conductivity
$\epsilon_{tp}$	0.890	+16.4%	0.015	0.25%	tape emissivity
$\Omega_{tp}$	0.540	+11.1%	0.020	0.22%	tape coverage
$\epsilon_{rs}$	0.040	+57.5%	0.010	0.58%	test-surface emissivity
$\epsilon_{wt}$	0.900	+26.5%	0.025	0.66%	wind-tunnel emissivity
				3.18%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	226r/min	+0.384%/(r/min)	1.3r/min	0.49%	fan rotation rate
				3.33%	RSS combined uncertainty

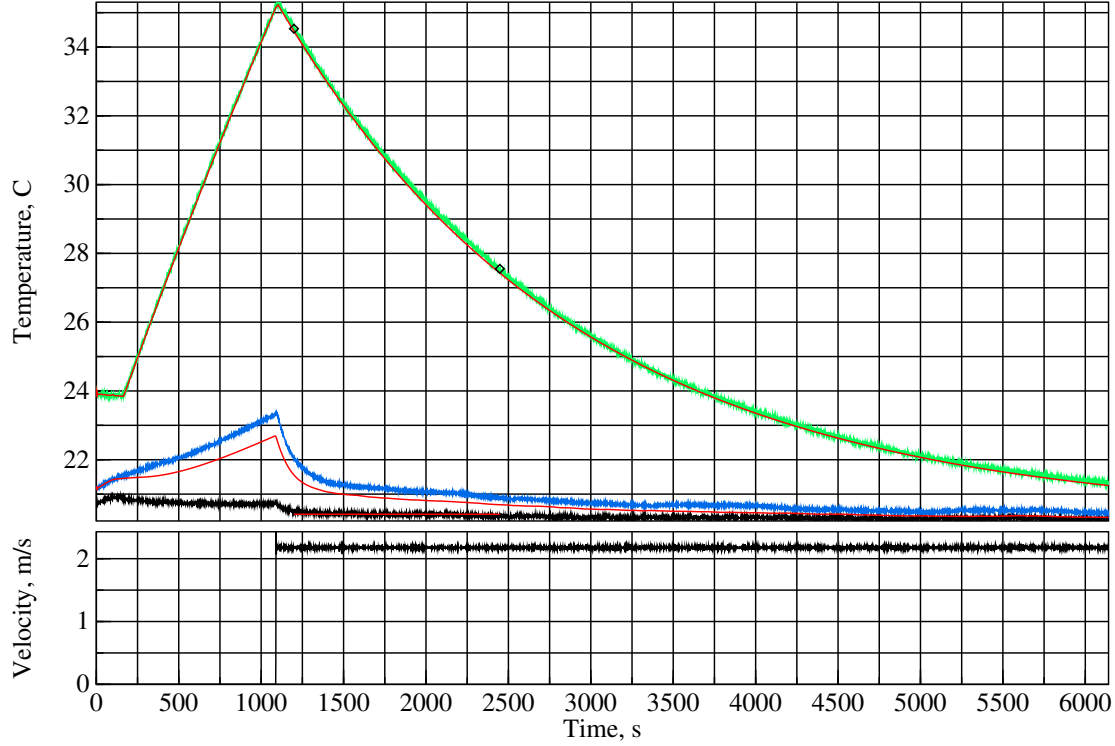
20170906T021026Z – mixed Convection – Roughness=1.04mm; T=20.4+10.4°C; +0.00°  
320±1.0r/min, V=1.1m/s, Re=22554, Ra/L^3=1.003x10^9, h=12.3W/(K.m^2), U=1.15W/K, Nu=146.4



Estimated measurement uncertainties, bi-level 1mm roughness at  $Re = 22552$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.4K	+13.0%/K	0.10K	1.30%	LM35C differential
$P$	100kPa	+0.0009%/Pa	1.5kPa	1.39%	MPXH6115A6U air pressure
$C_{pt}$	4.24kJ/K	+0.031%/(J/K)	42J/K	1.30%	plate thermal capacity
$\eta$	0.400	+212%	0.004	0.85%	anemometer calibration
$C_V$	1.000	-3.74%	0.100	0.37%	vertical reuptake
$L_T$	8.34mm	+8534%/m	100um	0.85%	post length
$\varsigma$	2.00mm	-7320%/m	100um	0.73%	post height
$L_m$	3.57mm	+665%/m	500um	0.33%	side metal strip width
$k_{PIR}$	22.2 $\frac{mW}{K \cdot m}$	+0.206%/ $\frac{mW}{K \cdot m}$	1.1 $\frac{mW}{K \cdot m}$	0.23%	PIR thermal conductivity
$\epsilon_{rs}$	0.040	+42.9%	0.010	0.43%	test-surface emissivity
$\epsilon_{wt}$	0.900	+19.7%	0.025	0.49%	wind-tunnel emissivity
				2.87%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	320r/min	+0.265%/(r/min)	1.0r/min	0.28%	fan rotation rate
				2.92%	RSS combined uncertainty

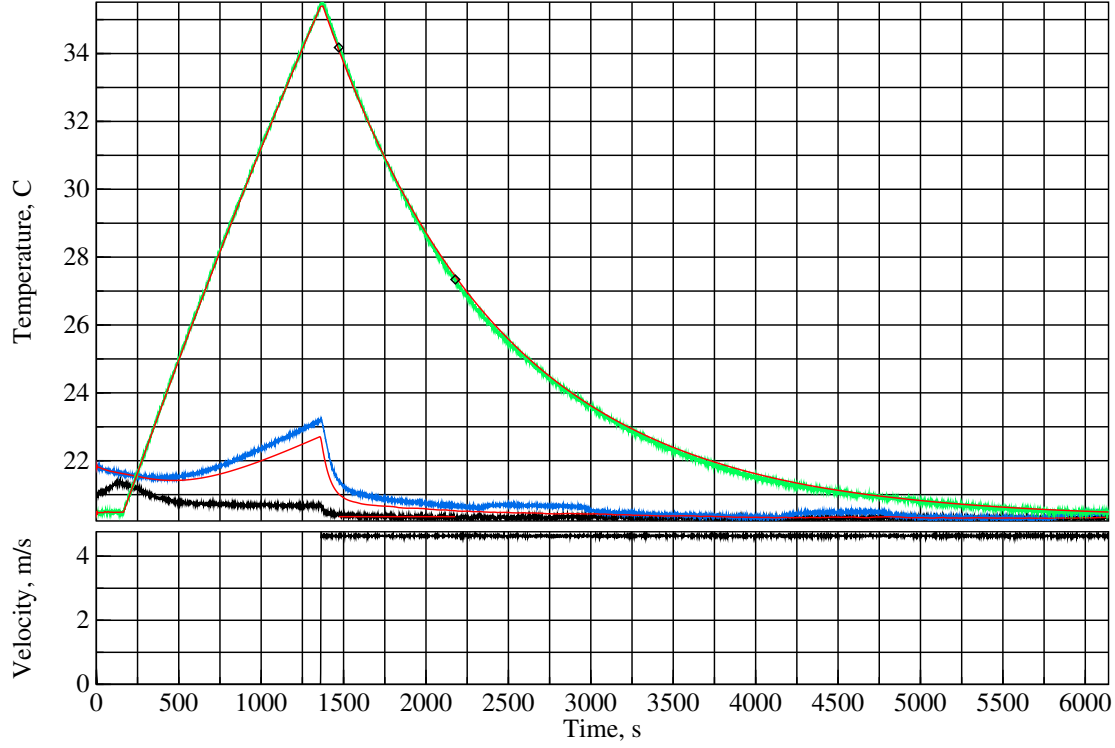
20170907T010459Z – mixed Convection – Roughness=1.04mm; T=20.4+10.2°C; +0.00°  
640±4.1r/min, V=2.2m/s, Re=43897, Ra/L^3=0.994x10^9, h=20.9W/(K.m^2), U=1.94W/K, Nu=248.5



Estimated measurement uncertainties, bi-level 1mm roughness at  $Re = 43897$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.2K	+11.8%/K	0.10K	1.18%	LM35C differential
$P$	101kPa	+0.0008%/Pa	1.5kPa	1.26%	MPXH6115A6U air pressure
$C_{pt}$	4.24kJ/K	+0.028%/(J/K)	42J/K	1.18%	plate thermal capacity
$\eta$	0.400	+189%	0.004	0.76%	anemometer calibration
$C_V$	1.000	-2.15%	0.100	0.21%	vertical reuptake
$L_T$	8.34mm	+9118%/m	100um	0.91%	post length
$\varsigma$	2.00mm	-2945%/m	100um	0.29%	post height
$L_m$	3.57mm	+543%/m	500um	0.27%	side metal strip width
$\epsilon_{rs}$	0.040	+24.7%	0.010	0.25%	test-surface emissivity
$\epsilon_{wt}$	0.900	+11.2%	0.025	0.28%	wind-tunnel emissivity
				2.50%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	640r/min	+0.118%/(r/min)	4.1r/min	0.48%	fan rotation rate
				2.68%	RSS combined uncertainty

20170907T230723Z – mixed Convection – Roughness=1.04mm; T=20.4+10.0°C; +0.00°  
1500±3.3r/min, V=4.6m/s, Re=93318, Ra/L^3=0.972x10^9, h=39.8W/(K.m^2), U=3.70W/K, Nu=473.7



Estimated measurement uncertainties, bi-level 1mm roughness at  $Re = 93318$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.0K	+11.2%/K	0.10K	1.12%	LM35C differential
$P$	100kPa	+0.0008%/Pa	1.5kPa	1.19%	MPXH6115A6U air pressure
$C_{pt}$	4.24kJ/K	+0.026%/(J/K)	42J/K	1.10%	plate thermal capacity
$\eta$	0.400	+127%	0.004	0.51%	anemometer calibration
$u_u$	7.755	+3.63%	0.100	0.36%	diffuser airflow upper bound
$L_T$	8.34mm	+9329%/m	100um	0.93%	post length
$L_m$	3.57mm	+483%/m	500um	0.24%	side metal strip width
				2.31%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	1.50kr/min	+0.056%/(r/min)	3.3r/min	0.18%	fan rotation rate
				2.34%	RSS combined uncertainty