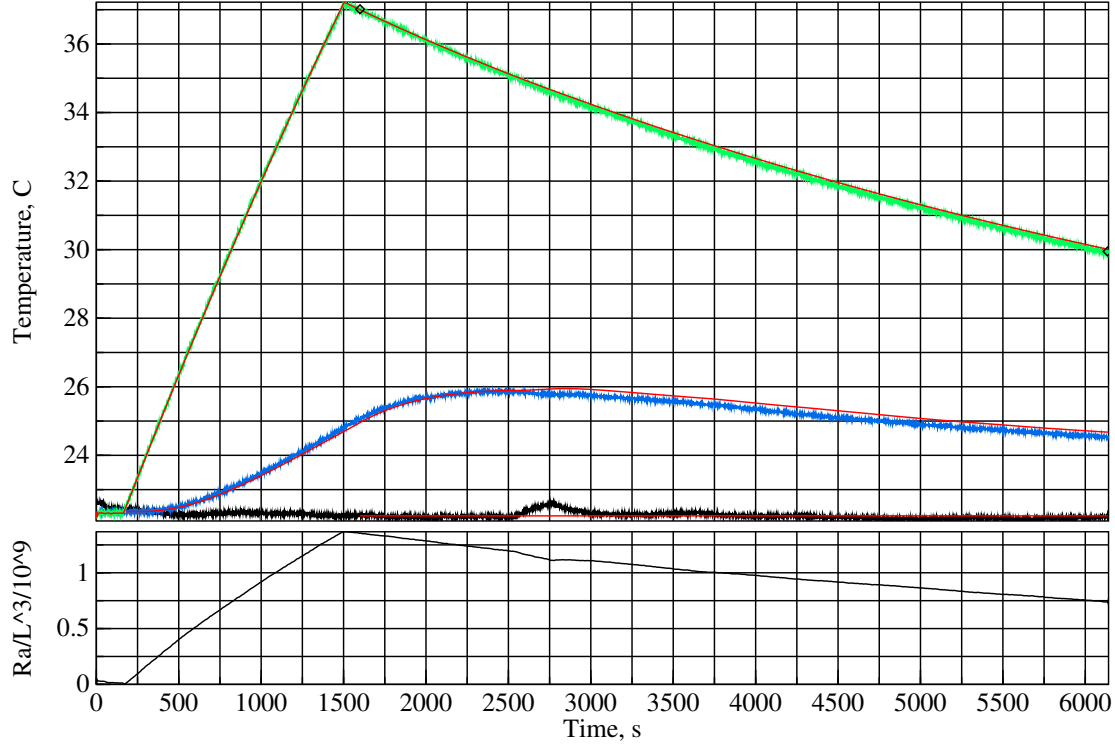


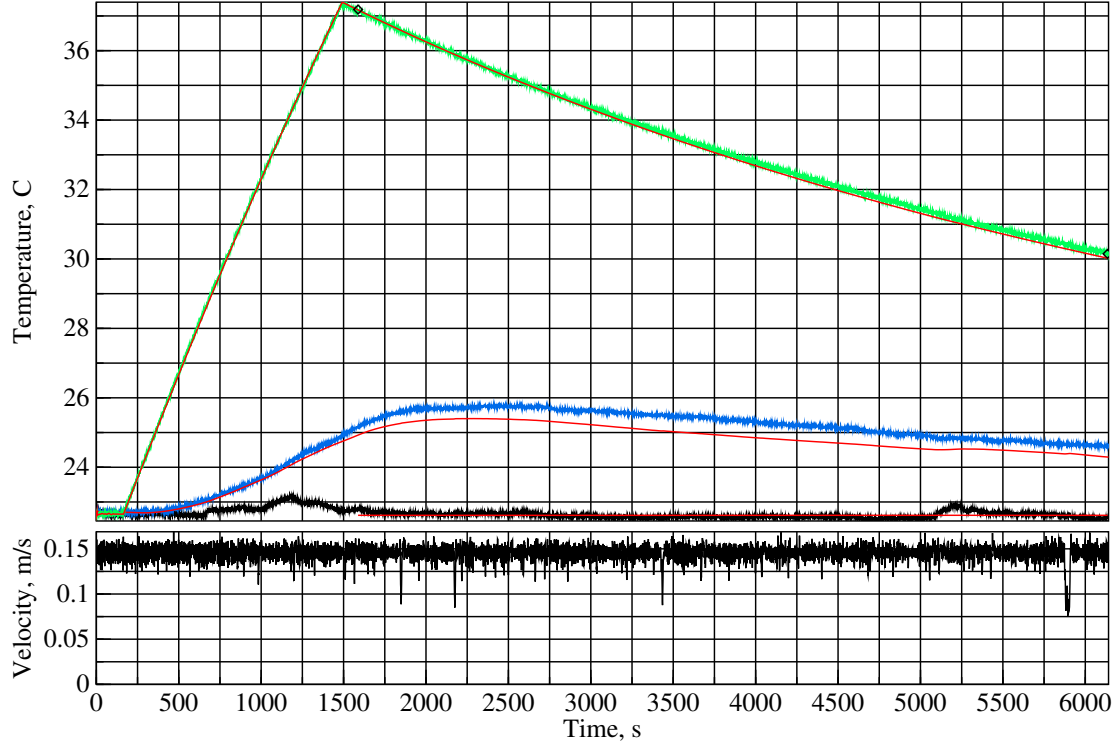
20160814T122505Z – mixed Convection – Roughness=3.00mm; T=22.2+10.7°C; –90.00°  
k=0.0258, Ra/L<sup>3</sup>=1.010x10<sup>9</sup>, h=5.20W/(K.m<sup>2</sup>), U=0.483W/K, Nu=61.5, Pr=0.710



Estimated measurement uncertainties of natural convection at  $\theta = -90.0$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.7K	+15.2%/K	0.10K	1.52%	LM35C differential
$P$	100kPa	+0.0005%/Pa	1.5kPa	0.78%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.029%/(J/K)	47J/K	1.37%	plate thermal capacity
$C_S$	1.000	–38.7%	0.050	1.94%	side reuptake
$C_B$	1.000	–10.6%	0.100	1.06%	back reuptake
$L_c$	0.305m	+421%/m	500um	0.21%	characteristic length
$L_m$	3.57mm	+828%/m	500um	0.41%	side metal strip width
$\epsilon_{XPS}$	0.515	+25.1%	0.010	0.25%	XPS emissivity
$\epsilon_{tp}$	0.890	+30.3%	0.015	0.45%	tape emissivity
$\Omega_{tp}$	0.540	+20.5%	0.020	0.41%	tape coverage
$\epsilon_{rs}$	0.040	+109%	0.010	1.09%	test-surface emissivity
$\epsilon_{wt}$	0.900	+49.2%	0.025	1.23%	wind-tunnel emissivity
				3.61%	combined bias uncertainty

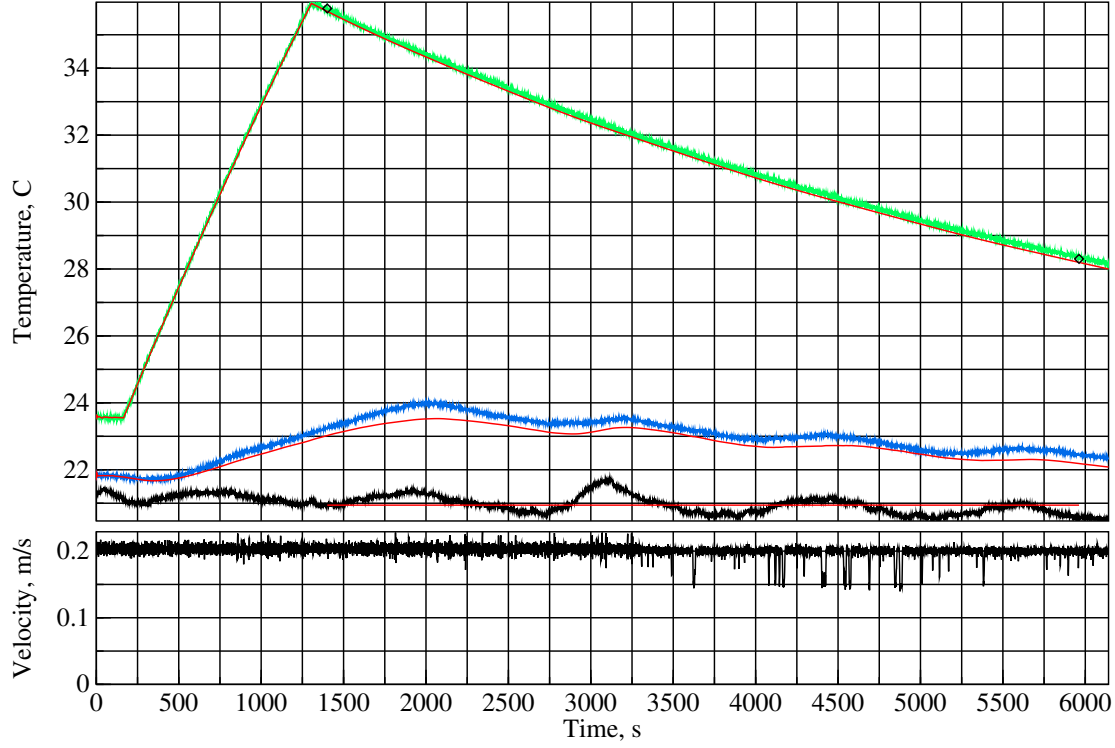
20160813T235139Z – mixed Convection – Roughness=3.00mm; T=22.6+10.6°C; -90.00°  
40±2.5r/min, V=0.14m/s, Re=2880, Ra/L^3=0.993x10^9, h=5.14W/(K.m^2), U=0.478W/K, Nu=60.7



Estimated measurement uncertainties, bi-level 3mm roughness at  $Re = 2880$ .

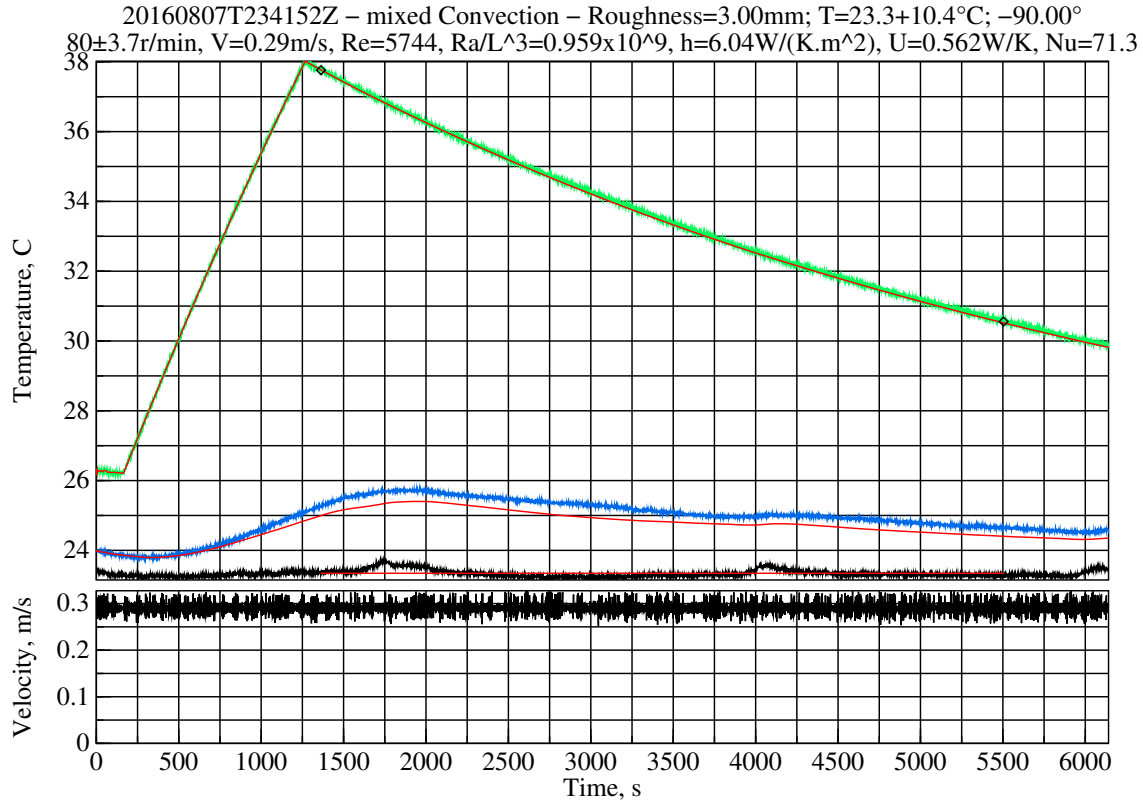
Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.6K	+15.0%/K	0.10K	1.50%	LM35C differential
$P$	101kPa	+0.0006%/Pa	1.5kPa	0.86%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.029%/(J/K)	47J/K	1.35%	plate thermal capacity
$\eta$	0.409	+28.1%	0.014	0.40%	anemometer calibration
$C_S$	1.000	-36.5%	0.050	1.83%	side reuptake
$C_B$	1.000	-11.2%	0.100	1.12%	back reuptake
$L_c$	0.305m	+401%/m	500um	0.20%	characteristic length
$L_m$	3.57mm	+843%/m	500um	0.42%	side metal strip width
$\epsilon_{XPS}$	0.515	+23.8%	0.010	0.24%	XPS emissivity
$\epsilon_{tp}$	0.890	+28.8%	0.015	0.43%	tape emissivity
$\Omega_{tp}$	0.540	+19.4%	0.020	0.39%	tape coverage
$\epsilon_{rs}$	0.040	+104%	0.010	1.04%	test-surface emissivity
$\epsilon_{wt}$	0.900	+46.7%	0.025	1.17%	wind-tunnel emissivity
				3.56%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	39.9r/min	+0.288%/(r/min)	2.5r/min	0.73%	fan rotation rate
				3.85%	RSS combined uncertainty

20160814T171610Z – mixed Convection – Roughness=3.00mm; T=20.9+10.6°C; -90.00°  
55±2.9r/min, V=0.20m/s, Re=4009, Ra/L^3=1.016x10^9, h=5.47W/(K.m^2), U=0.509W/K, Nu=64.9



Estimated measurement uncertainties, bi-level 3mm roughness at  $Re = 4008$ .

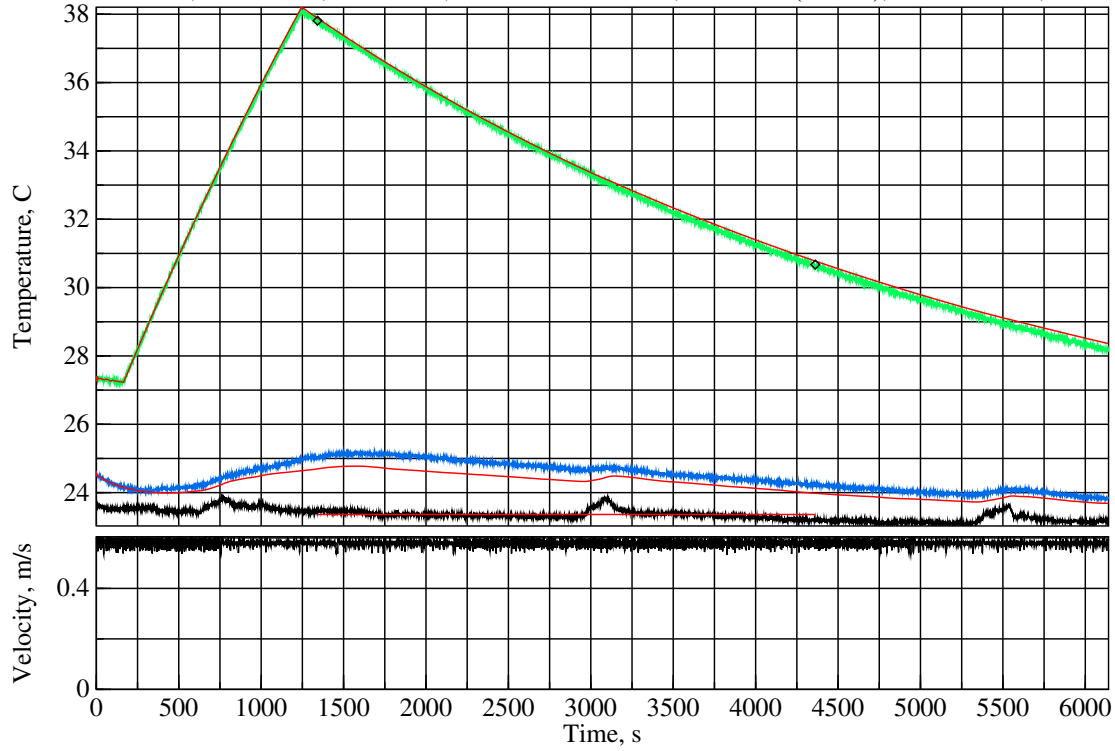
Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.6K	+14.6%/K	0.10K	1.46%	LM35C differential
$P$	100kPa	+0.0006%/Pa	1.5kPa	0.92%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.028%/(J/K)	47J/K	1.33%	plate thermal capacity
$\eta$	0.409	+48.2%	0.014	0.69%	anemometer calibration
$C_S$	1.000	-34.8%	0.050	1.74%	side reuptake
$C_B$	1.000	-11.1%	0.100	1.11%	back reuptake
$L_m$	3.57mm	+818%/m	500um	0.41%	side metal strip width
$\epsilon_{XPS}$	0.515	+22.2%	0.010	0.22%	XPS emissivity
$\epsilon_{tp}$	0.890	+26.8%	0.015	0.40%	tape emissivity
$\Omega_{tp}$	0.540	+18.1%	0.020	0.36%	tape coverage
$\epsilon_{rs}$	0.040	+97.1%	0.010	0.97%	test-surface emissivity
$\epsilon_{wt}$	0.900	+43.5%	0.025	1.09%	wind-tunnel emissivity
				3.49%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	55.1r/min	+0.358%/(r/min)	2.9r/min	1.02%	fan rotation rate
				4.05%	RSS combined uncertainty



Estimated measurement uncertainties, bi-level 3mm roughness at  $Re = 5744$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.4K	+14.4%/K	0.10K	1.44%	LM35C differential
$P$	100kPa	+0.0007%/Pa	1.5kPa	1.02%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.028%/(J/K)	47J/K	1.31%	plate thermal capacity
$\eta$	0.409	+83.3%	0.014	1.19%	anemometer calibration
$C_S$	1.000	-31.7%	0.050	1.58%	side reuptake
$C_B$	1.000	-10.6%	0.100	1.06%	back reuptake
$\varsigma$	6.00mm	+2405%/m	100um	0.24%	post height
$L_m$	3.57mm	+802%/m	500um	0.40%	side metal strip width
$\epsilon_{XPS}$	0.515	+20.8%	0.010	0.21%	XPS emissivity
$\epsilon_{tp}$	0.890	+25.2%	0.015	0.38%	tape emissivity
$\Omega_{tp}$	0.540	+17.0%	0.020	0.34%	tape coverage
$\epsilon_{rs}$	0.040	+90.9%	0.010	0.91%	test-surface emissivity
$\epsilon_{wt}$	0.900	+40.9%	0.025	1.02%	wind-tunnel emissivity
				3.51%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	80.1r/min	+0.426%/(r/min)	3.7r/min	1.56%	fan rotation rate
				4.70%	RSS combined uncertainty

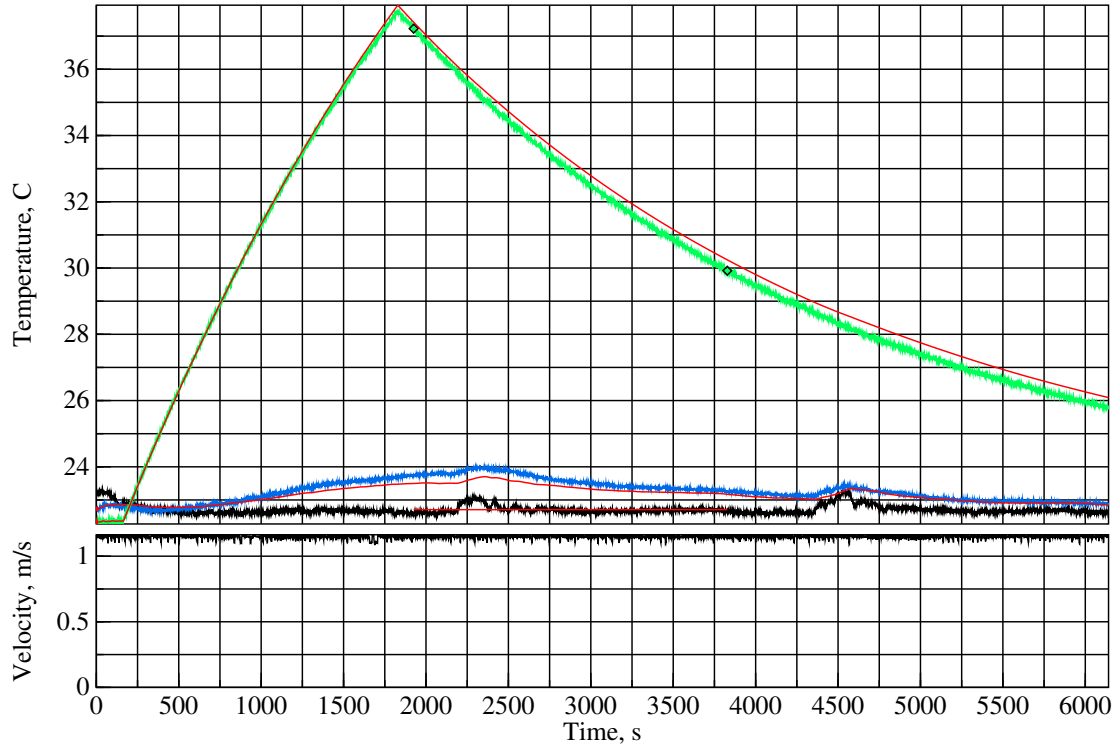
20160808T022413Z – mixed Convection – Roughness=3.00mm; T=23.4+10.5°C; –90.00°  
160±3.4r/min, V=0.58m/s, Re=11470, Ra/L^3=0.970x10^9, h=9.02W/(K.m^2), U=0.839W/K, Nu=106.4



Estimated measurement uncertainties, bi-level 3mm roughness at  $Re = 11470$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.5K	+12.6%/K	0.10K	1.26%	LM35C differential
$P$	101kPa	+0.0008%/Pa	1.5kPa	1.25%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.026%/(J/K)	47J/K	1.22%	plate thermal capacity
$\eta$	0.409	+164%	0.014	2.34%	anemometer calibration
$C_S$	1.000	–22.4%	0.050	1.12%	side reuptake
$C_B$	1.000	–7.89%	0.100	0.79%	back reuptake
$\varsigma$	6.00mm	+4773%/m	100um	0.48%	post height
$L_m$	3.57mm	+659%/m	500um	0.33%	side metal strip width
$\epsilon_{tp}$	0.890	+17.7%	0.015	0.27%	tape emissivity
$\Omega_{tp}$	0.540	+12.0%	0.020	0.24%	tape coverage
$\epsilon_{rs}$	0.040	+64.3%	0.010	0.64%	test-surface emissivity
$\epsilon_{wt}$	0.900	+28.8%	0.025	0.72%	wind-tunnel emissivity
				3.68%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	160r/min	+0.419%/(r/min)	3.4r/min	1.43%	fan rotation rate
				4.65%	RSS combined uncertainty

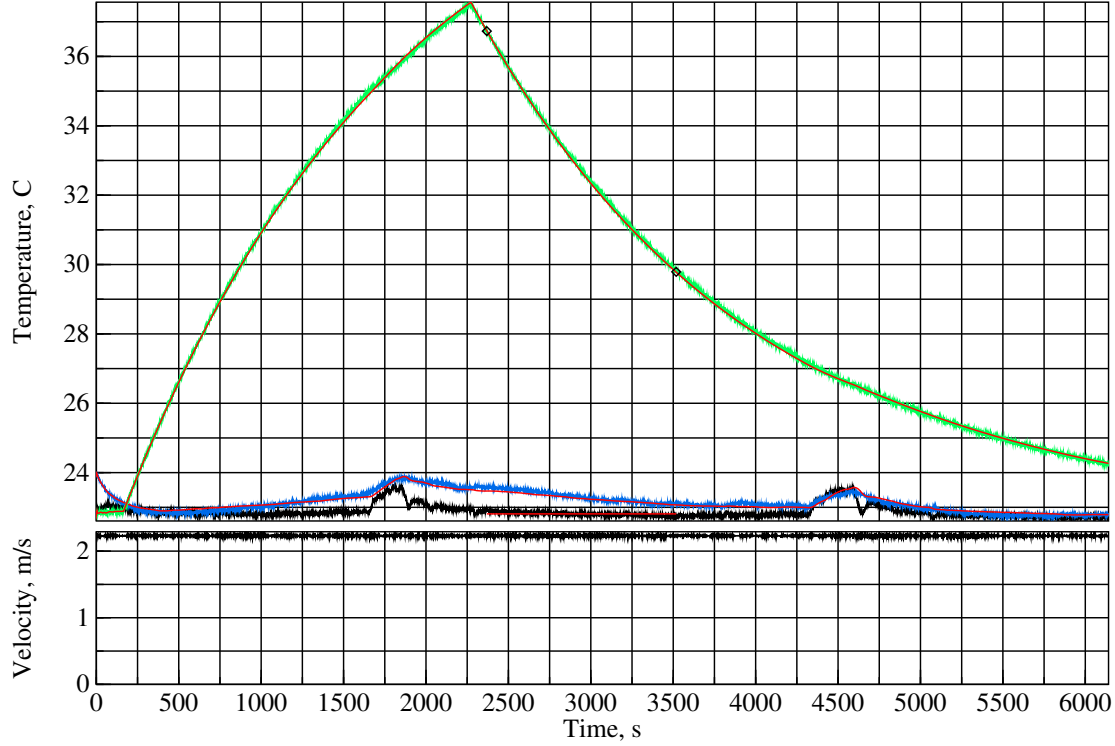
20160808T224235Z – mixed Convection – Roughness=3.00mm; T=22.7+10.4°C; –90.00°  
320±2.4r/min, V=1.1m/s, Re=22910, Ra/L^3=0.984x10^9, h=16.0W/(K.m^2), U=1.48W/K, Nu=188.6



Estimated measurement uncertainties, bi-level 3mm roughness at  $Re = 22910$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.4K	+11.3%/K	0.10K	1.13%	LM35C differential
$P$	101kPa	+0.0009%/Pa	1.5kPa	1.40%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.024%/(J/K)	47J/K	1.13%	plate thermal capacity
$\eta$	0.409	+213%	0.014	3.05%	anemometer calibration
$C_S$	1.000	–13.0%	0.050	0.65%	side reuptake
$C_B$	1.000	–4.74%	0.100	0.47%	back reuptake
$\varsigma$	6.00mm	+6413%/m	100um	0.64%	post height
$L_m$	3.57mm	+485%/m	500um	0.24%	side metal strip width
$\epsilon_{rs}$	0.040	+36.9%	0.010	0.37%	test-surface emissivity
$\epsilon_{wt}$	0.900	+16.5%	0.025	0.41%	wind-tunnel emissivity
				3.92%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	320r/min	+0.273%/(r/min)	2.4r/min	0.66%	fan rotation rate
				4.13%	RSS combined uncertainty

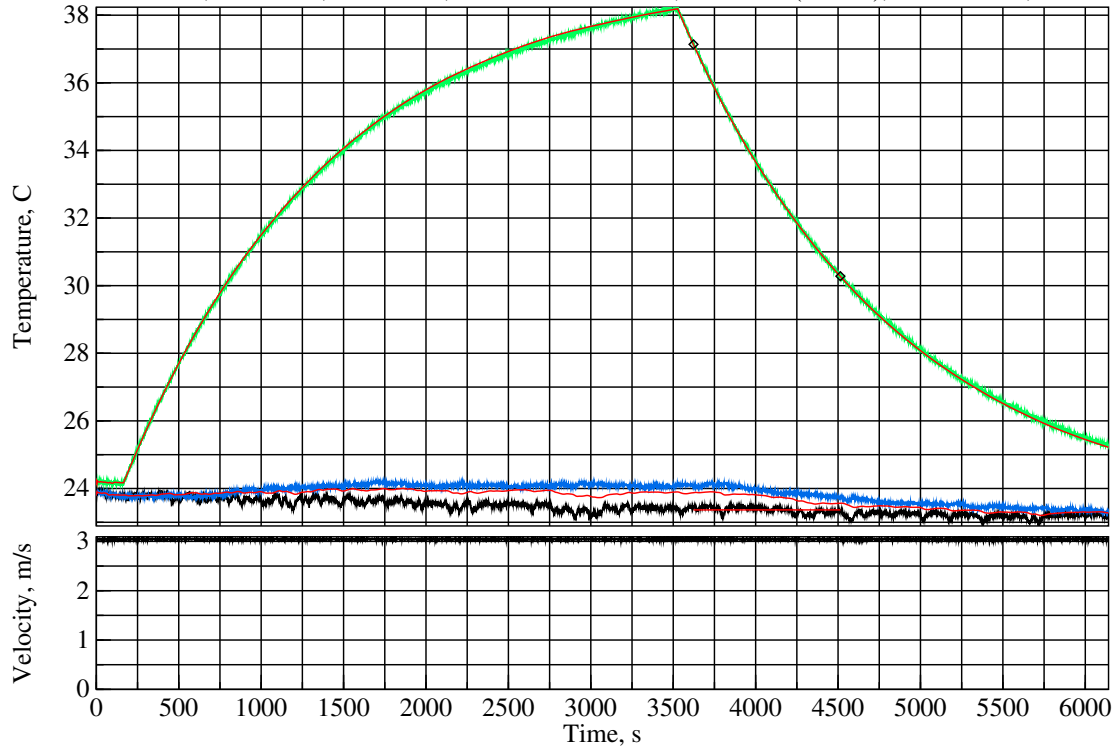
20160811T002147Z – mixed Convection – Roughness=3.00mm; T=22.8+10.1°C; –90.00°  
640±4.8r/min, V=2.2m/s, Re=44534, Ra/L^3=0.955x10^9, h=27.5W/(K.m^2), U=2.56W/K, Nu=325.4



Estimated measurement uncertainties, bi-level 3mm roughness at  $Re = 44536$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.1K	+10.9%/K	0.10K	1.09%	LM35C differential
$P$	101kPa	+0.0009%/Pa	1.5kPa	1.35%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.023%/(J/K)	47J/K	1.08%	plate thermal capacity
$\eta$	0.409	+202%	0.014	2.90%	anemometer calibration
$C_S$	1.000	–7.06%	0.050	0.35%	side reuptake
$C_B$	1.000	–2.65%	0.100	0.26%	back reuptake
$\varsigma$	6.00mm	+8855%/m	100um	0.89%	post height
$\epsilon_{rs}$	0.040	+20.2%	0.010	0.20%	test-surface emissivity
$\epsilon_{wt}$	0.900	+8.93%	0.025	0.22%	wind-tunnel emissivity
				3.71%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	640r/min	+0.130%/(r/min)	4.8r/min	0.62%	fan rotation rate
				3.91%	RSS combined uncertainty

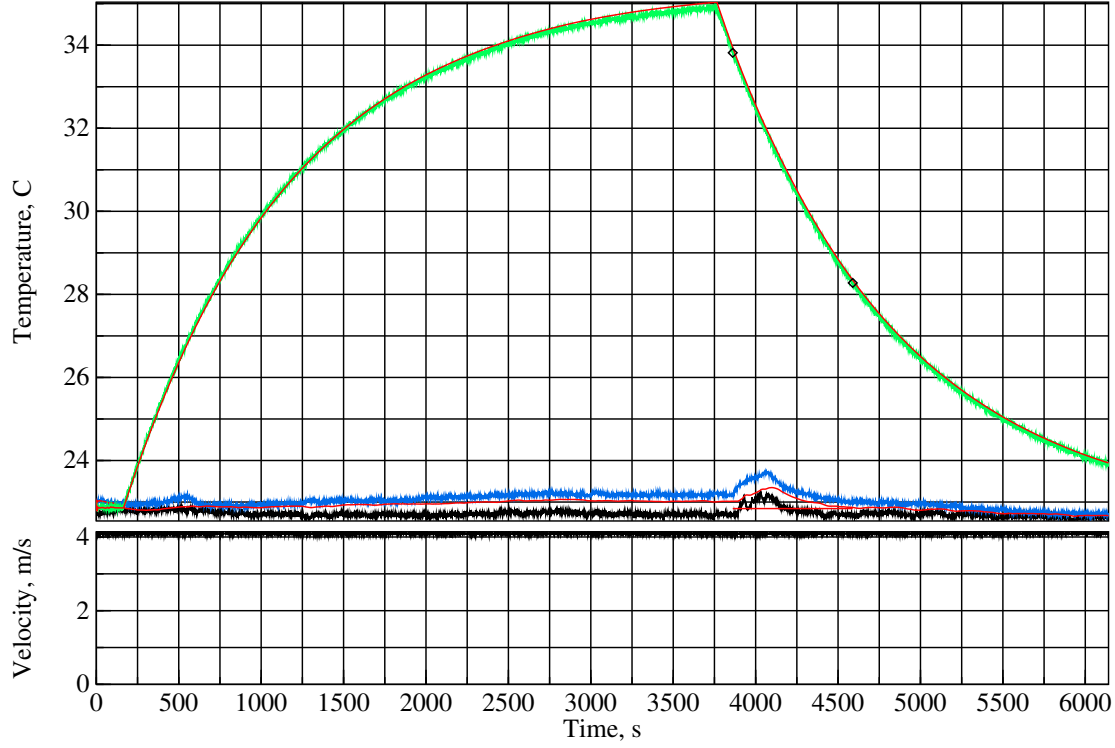
20160828T040504Z – mixed Convection – Roughness=3.00mm; T=23.4+10.0°C; -90.00°  
 905±4.1r/min, V=3.0m/s, Re=60874, Ra/L^3=0.944x10^9, h=36.4W/(K.m^2), U=3.38W/K, Nu=428.8



Estimated measurement uncertainties, bi-level 3mm roughness at  $Re = 60875$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	9.97K	+10.8%/K	0.10K	1.08%	LM35C differential
$P$	102kPa	+0.0008%/Pa	1.5kPa	1.22%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.023%/(J/K)	47J/K	1.06%	plate thermal capacity
$\eta$	0.409	+171%	0.014	2.46%	anemometer calibration
$C_S$	1.000	-5.39%	0.050	0.27%	side reuptake
$C_B$	1.000	-2.04%	0.100	0.20%	back reuptake
$\varsigma$	6.00mm	+11227%/m	100um	1.12%	post height
				3.37%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	905r/min	+0.079%/(r/min)	4.1r/min	0.33%	fan rotation rate
				3.43%	RSS combined uncertainty

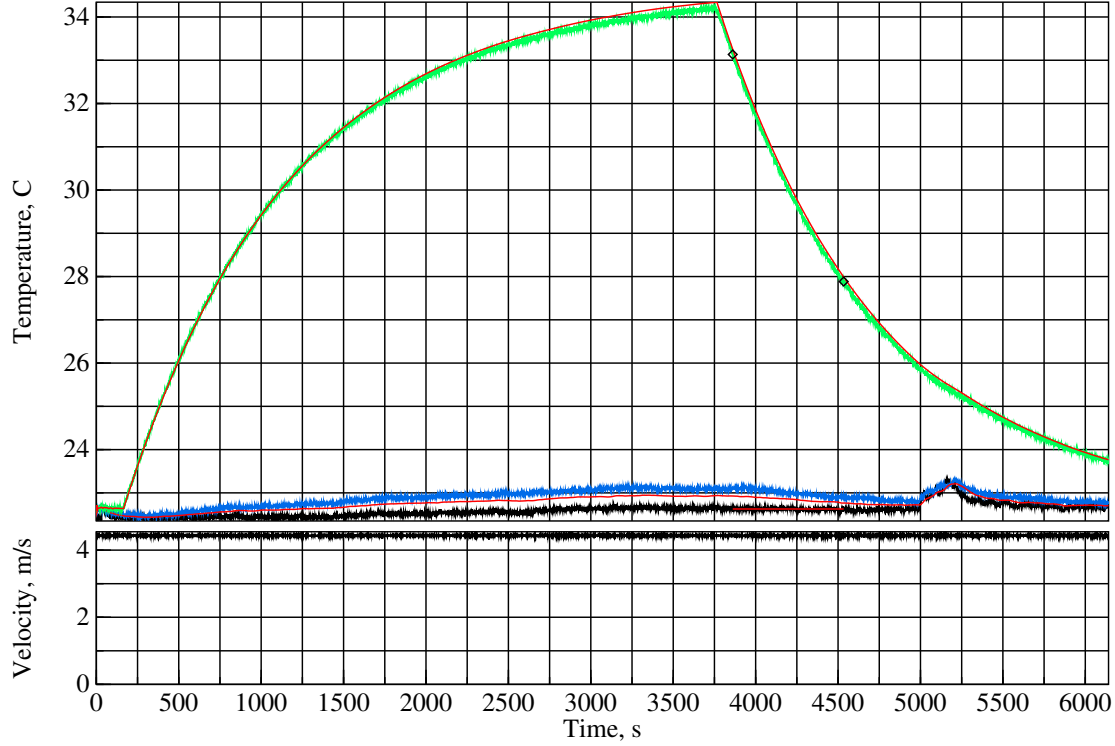
20160828T141201Z – mixed Convection – Roughness=3.00mm; T=22.8+07.9°C; -90.00°  
1280±5.3r/min, V=4.1m/s, Re=82189, Ra/L^3=0.767x10^9, h=45.7W/(K.m^2), U=4.25W/K, Nu=539.7



Estimated measurement uncertainties, bi-level 3mm roughness at  $Re = 82184$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	7.91K	+13.4%/K	0.10K	1.34%	LM35C differential
$P$	102kPa	+0.0008%/Pa	1.5kPa	1.13%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.022%/(J/K)	47J/K	1.05%	plate thermal capacity
$\eta$	0.409	+137%	0.014	1.96%	anemometer calibration
$u_u$	7.943	+2.55%	0.100	0.26%	diffuser airflow upper bound
$C_S$	1.000	-4.07%	0.050	0.20%	side reuptake
$\varsigma$	6.00mm	+12380%/m	100um	1.24%	post height
				3.13%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	1.28kr/min	+0.052%/(r/min)	5.3r/min	0.27%	fan rotation rate
				3.18%	RSS combined uncertainty

20160828T231631Z – mixed Convection – Roughness=3.00mm; T=22.6+07.6°C; -90.00°  
1400±7.3r/min, V=4.4m/s, Re=88764, Ra/L^3=0.731x10^9, h=49.0W/(K.m^2), U=4.56W/K, Nu=578.9



Estimated measurement uncertainties, bi-level 3mm roughness at  $Re = 88775$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	7.57K	+13.9%/K	0.10K	1.39%	LM35C differential
$P$	101kPa	+0.0007%/Pa	1.5kPa	1.12%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.022%/(J/K)	47J/K	1.05%	plate thermal capacity
$\eta$	0.409	+127%	0.014	1.82%	anemometer calibration
$u_u$	7.943	+2.96%	0.100	0.30%	diffuser airflow upper bound
$\varsigma$	6.00mm	+12388%/m	100um	1.24%	post height
				3.07%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	1.40kr/min	+0.050%/(r/min)	7.3r/min	0.37%	fan rotation rate
				3.15%	RSS combined uncertainty