

# LIST OF FIGURES

Figure 1.1	Helical coil with secondary flow	4
Figure 3.1	Schematic diagram of experimental facility	36
Figure 3.2	Photograph of experimental setup	36
Figure 3.3	Test section showing of helical coils	37
Figure 3.4	Sketch diagram of helical coil	37
Figure 3.5	Helical coil with insulation	38
Figure 3.6	Peristaltic pump	39
Figure 3.7	DC power supply unit	40
Figure 3.8	Digital manometer	40
Figure 3.9	Data acquisition system	41
Figure 3.10	Pump speed (rpm) vs. flowrate	44
Figure 4.1	Pressure drop vs. velocity in a straight micro-diameter tube of 720 $\mu m$ for all three fluids	49
Figure 4.2	Pressure drop vs. velocity in a straight micro-diameter tube of 850 $\mu m$ for all three fluids	50
Figure 4.3	Pressure drop vs. velocity in a straight micro-diameter tube of 1000 $\mu m$ for all three fluids	50
Figure 4.4	Pressure drop vs. velocity in a helical coil of inner tube diameter 720 $\mu m$ for all three fluids	51
Figure 4.5	Pressure drop vs. velocity in a helical coil of inner tube diameter 850 $\mu m$ for all three fluids	52
Figure 4.6	Pressure drop vs. velocity in a helical coil of inner tube diameter 1000 $\mu m$ for all three fluids	52
Figure 4.7	Variation of friction factor with Reynolds number in straight micro-diameter tube and helical coil of tube diameter 720 $\mu m$ for all three working fluids	53
Figure 4.8	Variation of friction factor with Reynolds number in straight micro-diameter tube and helical coil of tube diameter 850 $\mu m$ for all three working fluids	54

Figure 4.9	Variation of friction factor with Reynolds number in straight micro-diameter tube and helical coil of tube diameter 1000 $\mu m$ for all three working fluids	54
Figure 4.10	Present and Cioncolini and Santini's (2006) experimental friction factor data in helical coil of curvature ratio 0.012	55
Figure 4.11	Variation of friction factor with Dean number in a helical coil of curvature ratio 0.012	56
Figure 4.12	Variation of friction factor with Dean number in a helical coil of curvature ratio 0.014	57
Figure 4.13	Variation of friction factor with Dean number in a helical coil of curvature ratio 0.017	57
Figure 4.14	Comparison of experimental friction factor ratio ( $f_c/f_s$ ) with those predicted from present correlation	58
Figure 4.15	Comparison of experimental friction factor ratio ( $f_c/f_s$ ) with values predicted from correlations of Mishra and Gupta (1979) and Ito (1969)	59
Figure 4.16	Comparison of experimental friction factor ratio ( $f_c/f_s$ ) with values predicted from correlations of White (1929) and Mori and Nakayama (1967)	60
Figure 4.17	Comparison between Cioncolini and Santini's (2006) experimental values of $f_c/f_s$ and values predicted from present correlation	61
Figure 4.18	Comparison between Cioncolini and Santini's (2006) experimental values of $f_c/f_s$ and values predicted from correlations of Mishra and Gupta (1979) and Ito (1969)	62
Figure 4.19	Comparison between Cioncolini and Santini's (2006) experimental values of $f_c/f_s$ and values predicted from correlations of White (1934) and Mori and Nakayama (1967)	62
Figure 4.20	Comparison of experimental friction factor ratio ( $f_c/f_s$ ) (both present Cioncolini and Santini's (2006)) and with those predicted from the generalized correlation	64

Figure 4.21	Average heat transfer coefficient vs. velocity in a helical coil for all three fluids	65
Figure 4.22	Variation of average wall temperature with velocity in a helical coil	66
Figure 4.23	Variation of bulk fluid temperature with velocity in a helical coil	67
Figure 4.24	Nusselt number in a helical coil of curvature ratio 0.012 for three working fluids	67
Figure 4.25	Nu vs. Re plot: Present and Kahani et al.'s (2013) experimental Nusselt number in helical coils	68
Figure 4.26	Variation of Nusselt number with Dean number in a helical coil of curvature ratio 0.012	69
Figure 4.27	Predicted Nusselt number from present correlation vs. experimentally obtained Nusselt number	70
Figure 4.28	Comparison of experimental Nusselt number with value predicted from correlations of Kalb and Seider (1974) and Dravid et al. (1971)	71
Figure 4.29	Comparison between Kahani et al.'s (2013) experimental results with values predicted from the present correlation	72
Figure 4.30	Comparison between Kahani et al.'s (2013) experimental results with values predicted from Kalb and Seider's (1974) and Dravid et al.'s (1971) correlations	73
Figure 4.31	Comparison of experimental Nusselt number (both present and Kahani et al. (2013)) with those predicted from the generalized correlation	74
Figure A.1	Density of water vs. temperature	88
Figure A.2	Specific heat capacity of water vs. temperature	88
Figure A.3	Viscosity of water vs. temperature	90
Figure A.4	Density of methanol vs. temperature	92
Figure A.5	Viscosity of methanol vs. temperature	92
Figure A.6	Density of acetone vs. temperature	94
Figure A.7	Viscosity of acetone vs. temperature	94
Figure A.8	Thermal conductivity of water vs. temperature	99

Figure A.9	Specific heat capacity of methanol vs. temperature	100
Figure A.10	Thermal conductivity of methanol vs. temperature	101
Figure A.11	Specific heat capacity of acetone vs. temperature	102
Figure A.12	Thermal conductivity of acetone vs. temperature	103
Figure B.1	Friction factor for helical coil to that for straight tube ( $f_c / f_s$ ) in case of laminar flow as a function of De number	105
Figure B.2	( $f_c / f_s - 1$ ) vs. De	108
Figure B.3	$Nu / Pr^{0.75}$ vs. De	109
Figure B.4	$Nu / Pr^{0.89}$ vs. De	111