Dinesh Ramachandran
Department of Mechanical Engineering
University of Texas at San Antonio

Instructor: Dr. Randall D. Manteufel

Abstract

Exercise problem 11.5 from the textbook Fundamentals of Heat and Mass Transfer (Seventh Edition) was solved and an uncertainty analysis was obtained for the changes in outputs with relative uncertainties in inputs using sequential perturbation method in MS-Excel.

Introduction

A concentric tube heat exchanger problem with water flowing across the inner tube and air across the outer tube. A uniform uncertainty of 10% was made for most of the inputs and was propagated to obtain uncertainties in output. It was observed that even a small uncertainty in negligible quantities bring about a drastic change in outputs.

Inputs	Value	Units	Uncertainty
1: Do	60	mm	+/- __10__%
2: D2	30	mm	+/- __10__%
3: D1	24	mm	+/- __10__%
4: Ta_avg	800	K	+/- __10__%
5: Tw_avg	300	K	+/- __10__%
6: mdot_w	0.161	kg/s	+/- __10__%
7: t	3	mm	+/- __10__%
8: k_carbonsteel	50	W/mK	+/- __10__%
9: h_air	100	W/m^2K	+/- __10__%
10: k_water@300K	0.613	W/mK	+/- __10__%
11: Pr_water@300K	5.83	( )	+/- __10__%
12: mu_water @300K	8.55*10^-4	Ns/m^2	+/- __10__%
13: mu_air @ 800K	369.8*10^-7	Ns/m^2	+/- __10__%
14: k_air @ 800 K	0.573	W/mK	+/- __10__%
15: Pr_air@800K	0.709	( )	+/- __10__%
16: Coeff in Nusselt correlation?	0.023	( )	+/- __2__%
17: Exponent in Nusselt correlation?	0.8	( )	+/- __1__%

Calculations

1. Re_water = 9994.91 +/- 16 %
   (input: mdot_w (Kg/s) contributes 38 % of uncertainty in response)
   (input: Di,1 (m) contributes 31 % of uncertainty in response)
   (input: mu_water (Ns/m^2) contributes 31 % of uncertainty in response)

2. Nu_water = 73.76 +/- 16 %
(input: mdot_w (Kg/s) contributes 25 % of uncertainty in response)
(input: exponent in Nu correlation contributes 24 % of uncertainty in response)
(input: mu_water (Ns/m^2) contributes 22 % of uncertainty in response)
(input: Di,1 (m) contributes 22 % of uncertainty in response)

3. Overall_eff_fin_strut = 0.93 +/- 4 %
(input: Do (m) contributes 73 % of uncertainty in response)
(input: Di,2 (m) contributes 19 % of uncertainty in response)
(input: h air (W/m^2K) contributes 3 % of uncertainty in response)

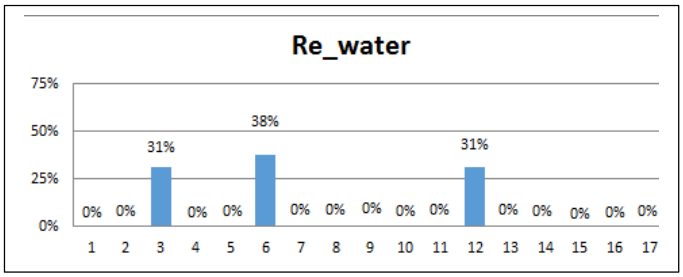
4. Thermal_Resistance_Wall = 0.00071 (K/W) +/- 61 %
(input: Di,2 (m) contributes 49 % of uncertainty in response)
(input: Di,1 (m) contributes 49 % of uncertainty in response)
(input: k_steel (W/mC) contributes 2 % of uncertainty in response)

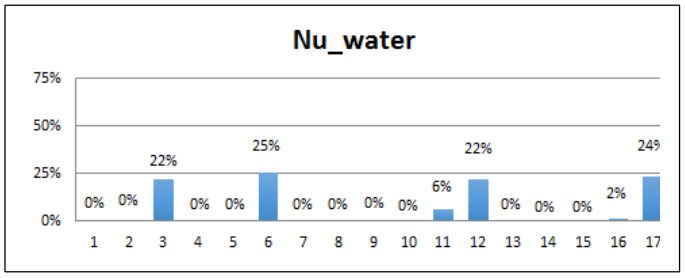
5. UA_{water} = 23.59 (W/K) +/- 13 %
(input: Do (m) contributes 55 % of uncertainty in response)
(input: h air (W/m^2K) contributes 34 % of uncertainty in response)
(input: Di,2 (m) contributes 7 % of uncertainty in response)

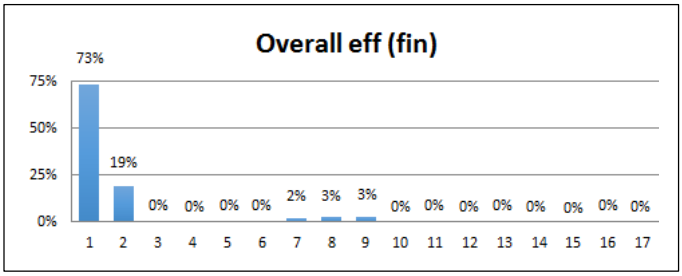
6. q/L = 11796.89 (W/m) +/- 21 %
(input: Ta_avg (K) contributes 56 % of uncertainty in response)
(input: Do (m) contributes 20 % of uncertainty in response)
(input: h air (W/m^2K) contributes 12 % of uncertainty in response)

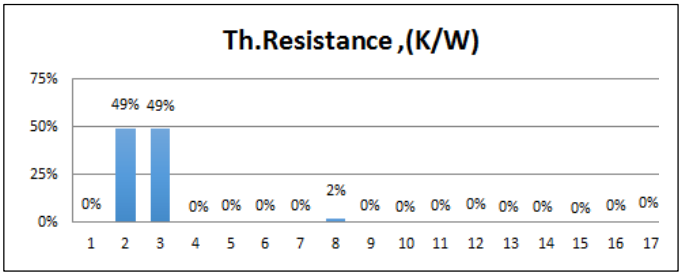
7. gas mass flowrate = 0.04879 (Kg/s) +/- 42 %
(input: Do (m) contributes 66 % of uncertainty in response)
(input: h air (W/m^2K) contributes 9 % of uncertainty in response)
(input: k_air (W/mK) contributes 7 % of uncertainty in response)

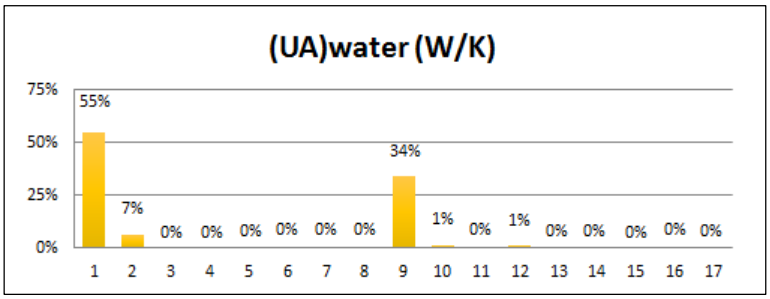
Graphs

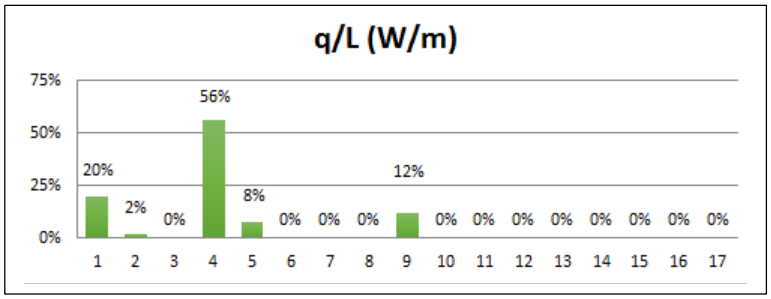


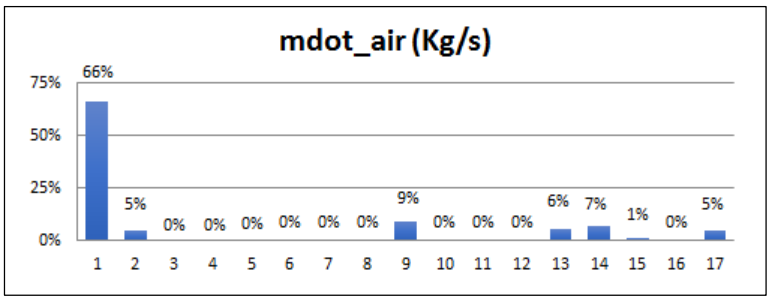












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