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Design and performance evaluation of heat exchangers: The effectiveness – N_{TU} method

Part 5: Analytical techniques

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THE PREPARATION OF THIS DATA ITEM

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This Data Item is one of a group that supersedes Data Items developed for ESDU under contract by

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who undertook the technical work involved in the assessment of the available information and the construction and subsequent development of the original Data Items.

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DESIGN AND PERFORMANCE EVALUATION OF HEAT EXCHANGERS: THE EFFECTIVENESS – N_{TU} METHOD

PART 5: ANALYTICAL TECHNIQUES

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DESIGN AND PERFORMANCE EVALUATION OF HEAT EXCHANGERS: THE EFFECTIVENESS – N_{TU} METHOD

PART 5: ANALYTICAL TECHNIQUES

1. NOTATION AND UNITS

Two sets of self-consistent units are given.

		Units	
		SI	British
A	effective surface area of heat exchanger	m^2	ft^2
C^*	thermal capacity ratio, defined in Section 4.2.3 of Part 1	—	—
c_p	specific heat capacity	J/kg K	Btu/lb °F
E	thermal effectiveness, defined in Section 4.2.1 of Part 1	—	—
K	parameter defined by Equation (3.13)	—	—
L	tube length	m	ft
M	number of tube rows per pass	—	—
$\dot{M}$	mass flow rate	kg/s	lb/h
N	number of elements into which tube length is divided	—	—
N_{TU}	number of heat transfer units, defined in Section 4.2.2 of Part 1	—	—
n	number of elements in calculation	—	—
P	number of tubeside passes	—	—
$\dot{Q}$	rate of heat transfer between streams (heat load)	W	Btu/h
$\dot{q}$	rate of heat transfer between streams over small element	W	Btu/h
T	stream temperature	K	°F
U	overall heat transfer coefficient	W/m ² K	Btu/h ft ² °F
X	parameter defined by Equation (3.14)	—	—
$\delta x, \delta y$	define element of tube	m	ft
<i>Subscripts</i>			
a	refers to single exchanger		

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<i>j</i>	refers to element in array
<i>k</i>	refers to element in array
<i>in</i>	value of parameter at inlet to heat exchanger
<i>out</i>	value of parameter at outlet from heat exchanger
larger	larger value of parameter in streams
smaller	smaller value of parameter in streams
1	refers to stream number 1 or location 1
2	refers to stream number 2 or location 2
1, <i>i</i>	refers to inlet to element of tube (stream 1)
1, <i>o</i>	refers to outlet from element of tube (stream 1)

2. PURPOSE AND SCOPE

This is the fifth of a group of Data Items on the effectiveness (E) - number of heat transfer units (N_{TU}) method for the thermal analysis of two-stream heat exchangers.

Aspects of the method presented in the Data Items in the group are as follows.

Data Item Number	Title	Description
98003	Part 1. Introduction	Description and overview of the $E-N_{TU}$ method.
98004	Part 2. Performance comparisons and selection of configurations presented in Part 3	Comparative performance and performance limitations of particular heat exchanger configurations.
98005	Part 3. Graphical and analytical data	Data required to use the method. The range of heat exchangers covered includes pure counter-current, pure co-current, crossflow, shell-and-tube and plate heat exchanger configurations.
98006	Part 4. Case studies	Case studies, incorporating all elements of the method presented.
98007	Part 5. Analytical techniques	Numerical and algebraic techniques for relating heat transfer effectiveness, E , to the number of heat transfer units, N_{TU} .

Analytical relationships are provided in Part 3 for some of the heat exchanger configurations for which graphical data are presented. Numerical modelling techniques were used to generate the $E - N_{TU}$ data for those configurations for which analytical relationships were not available. These techniques are described in this Item for the following exchanger configurations:

- crossflow configurations with unmixed/unmixed flow (see Section 3.1),
- crossflow configurations with finite number of tube rows (see Section 3.2),
- shell-and-tube configurations with finite number of baffles (see Section 3.3),
- plate-type configurations (see Section 3.4).