APPLICATION OF TRANSIENT ANALYSIS METHODOLOGY TO HEAT EXCHANGER PERFORMANCE MONITORING

I. Rampall — Holtec International, Cherry Hill, New Jersey

A. I. Soler — Holtec International, Cherry Hill, New Jersey

K. P. Singh — Holtec International, Cherry Hill, New Jersey

Benjamin H. Scott
Baltimore Gas and Electric Company
Lusby, Maryland

ABSTRACT

A transient testing technique is developed to evaluate the thermal performance of industrial scale heat exchangers. A

p_s, p_t	Shell, Tube Heat Exchanger Thermal Holdup/Unit Length
T, t	Shell, Tube Temperatures as Functions of Time and Position in the Heat Exchanger

minimize both expected maintenance costs and the original heat exchanger size. Since heat exchangers are not generally sized

with least squares minimization techniques. An important requirement for analyzing transient test data is to have

Figure 1 shows a differential length of a countercurrent heat exchanger with both fluid streams having their appropriate positive direction. An energy balance applied to each stream yields the governing equations given below.

$$\partial T \qquad \partial T \qquad \text{(1)}$$

$$p_t \frac{\partial t}{\partial \tau} = m_t \frac{\partial t}{\partial x} + UA\,(T-t) \qquad (2)$$

In the equations above, T and t are the respective shell and tubeside temperatures, p_s and p_t are the shell and tube thermal

$$t\,(x,\tau) = \bar{t}_{ss}\,(x) + \phi(x,\tau) \qquad (6)$$

temperature transients to be specified by

By virtue of the definition of θ, ϕ as changes from steady state, it is clear that

$$\theta\,(x,0) = \phi\,(x,0) = 0 = \theta_0\,(0) = \phi_L\,(0) \qquad (9)$$

The numerical procedure to solve the foregoing partial differential equations is presented next.

SOLUTION OF THE MODEL EQUATIONS

obtained from Equations (12) and (13) are defined below:

$$R_{\theta}(x,\tau) = p_s \frac{\partial \hat{\theta}}{\partial \tau} + m_s \left(\frac{\partial \bar{\bar{T}}_{ss}}{\partial x} + \frac{\partial \hat{\theta}}{\partial x}\right) + UA\,(\hat{\theta} - \hat{\phi}) + UA\,(\bar{T}_{ss} - \bar{t}_{ss}) \tag{17}$$

DESCRIPTION OF THE TRANSIENT HEAT EXCHANGER

The CCWHX shell and tube flows are also reasonably steady estimate of U_o which minimizes the *total* error is obtained. This optimization process is shown in Figure 5. The individual

Table 1: CCWHX Thermal-Hydraulic Data

Transfer Processes", Journal of Heat Transfer, Vol. 108, pp. 365-369.

Mikhlin, S.G., "Variational Methods in Mathematical

Temperature Variation and Longitudinal Core Conduction",

APPENDIX

$$I_4(n,m) = \int_0^L \cos \frac{n\pi x}{2L} \sin \frac{n\pi x}{2L} \, dx$$

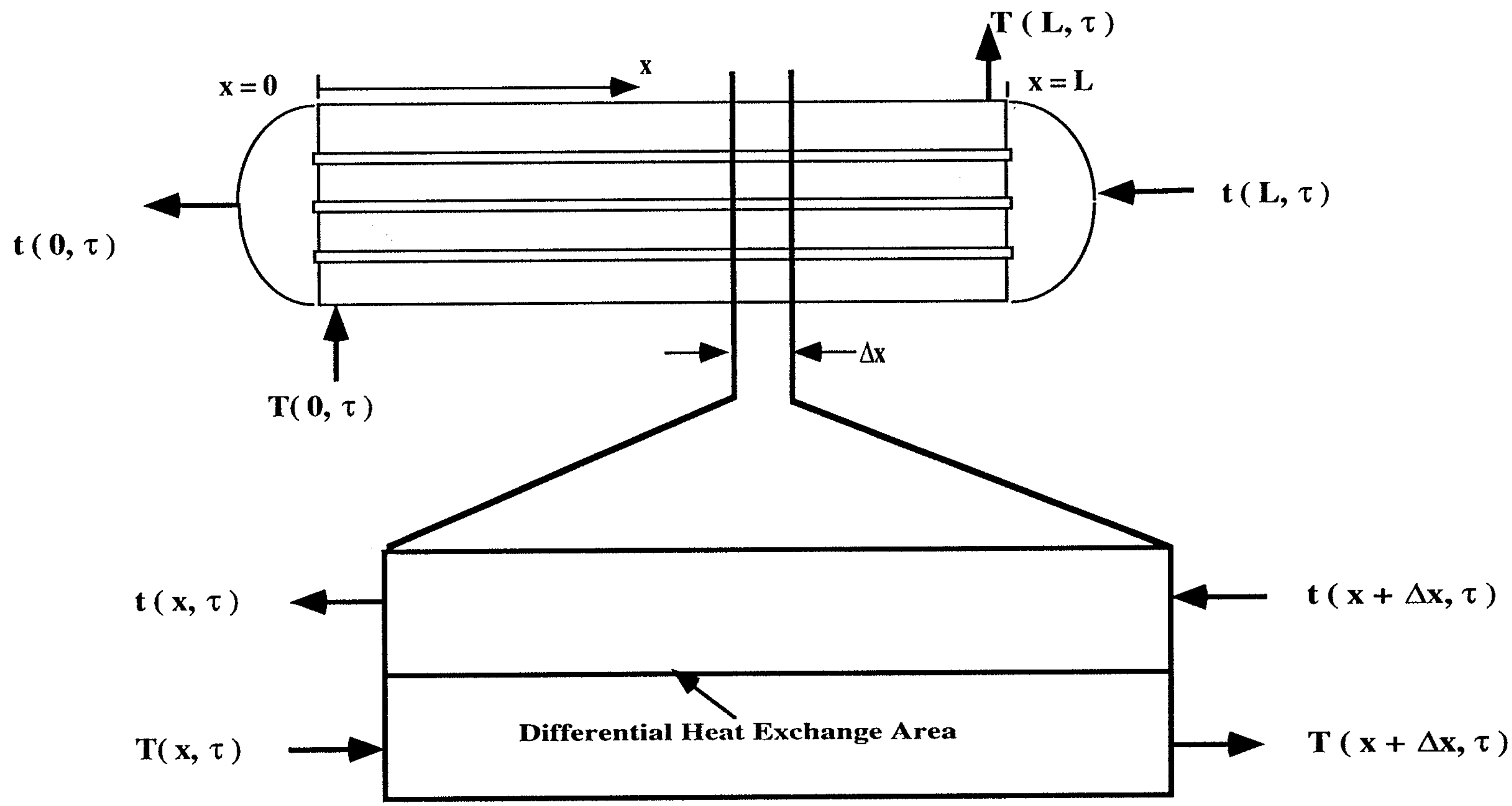
$$[\cos (m-n)\pi x/2L \ldots \cos (m+n)\pi x/2L]^L \quad \text{(A.8)}$$

(A.16)

$$J_p(m) = \int_0^L K_T(x) \sin \frac{n\pi}{2}\left(1 - \frac{x}{L}\right) dx \tag{A.17}$$

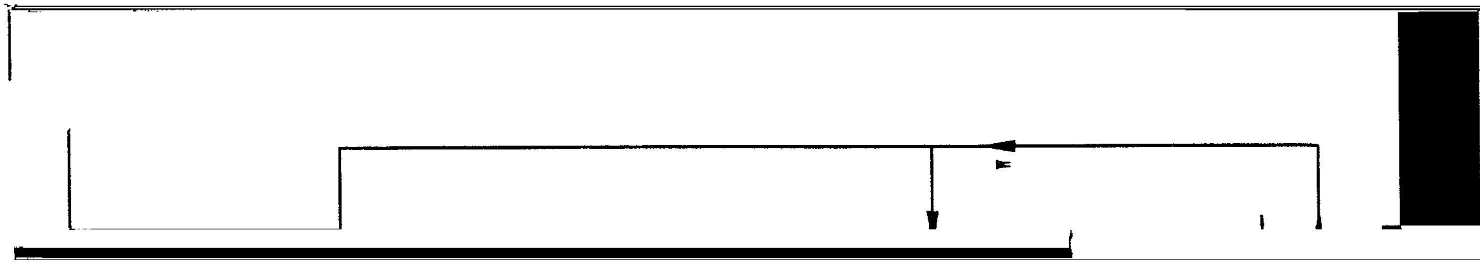
This completes the definition of all Galerkin coefficients required to solve the coupled set of ordinary differential equations for time dependent shell and tube temperature profiles.

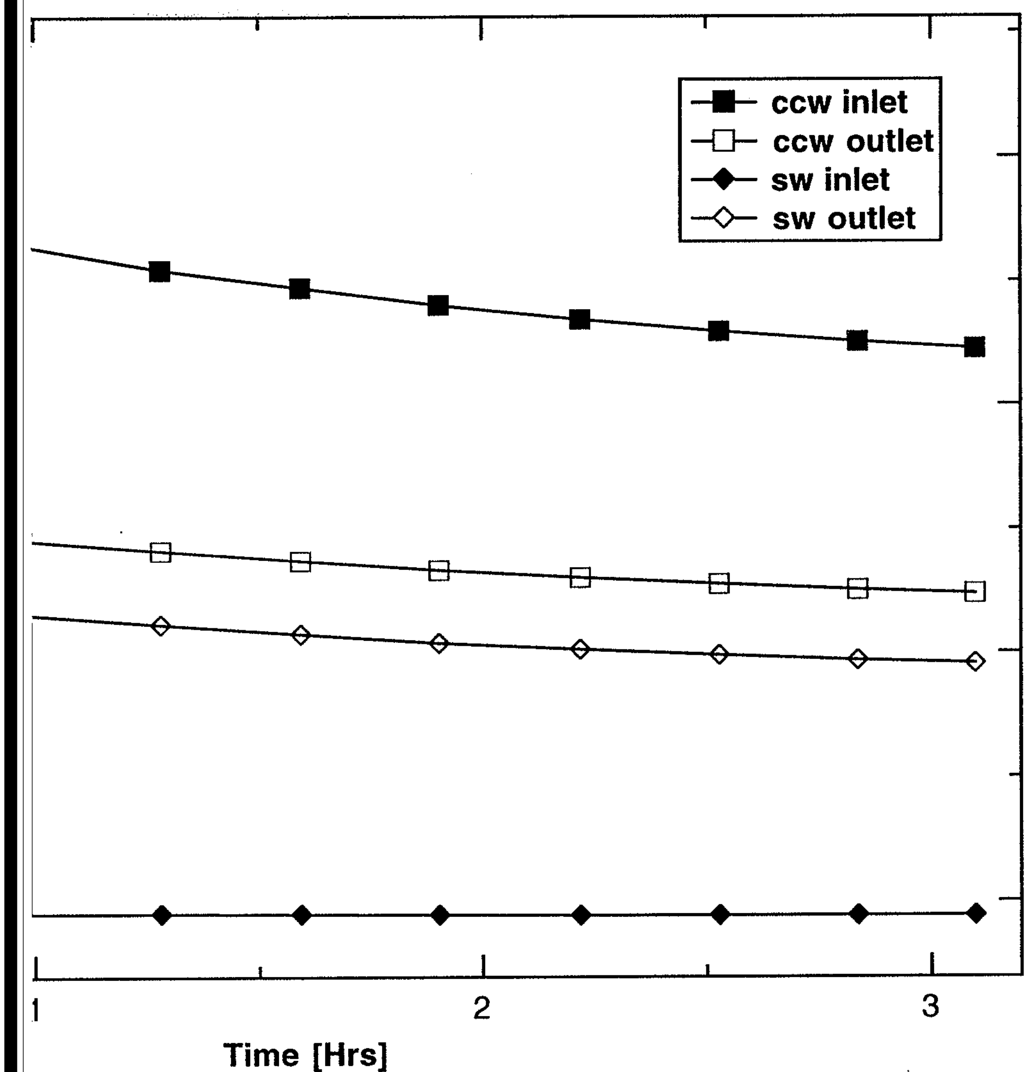
(a) Typical Countercurrent Shell & Tube Heat Exchanger



(b) Idealized Model of a Differential Element

Figure 1: Schematic Outline of the Countercurrent Transient Heat Exchange Process





HX Inlet/Outlet Temperature Transients

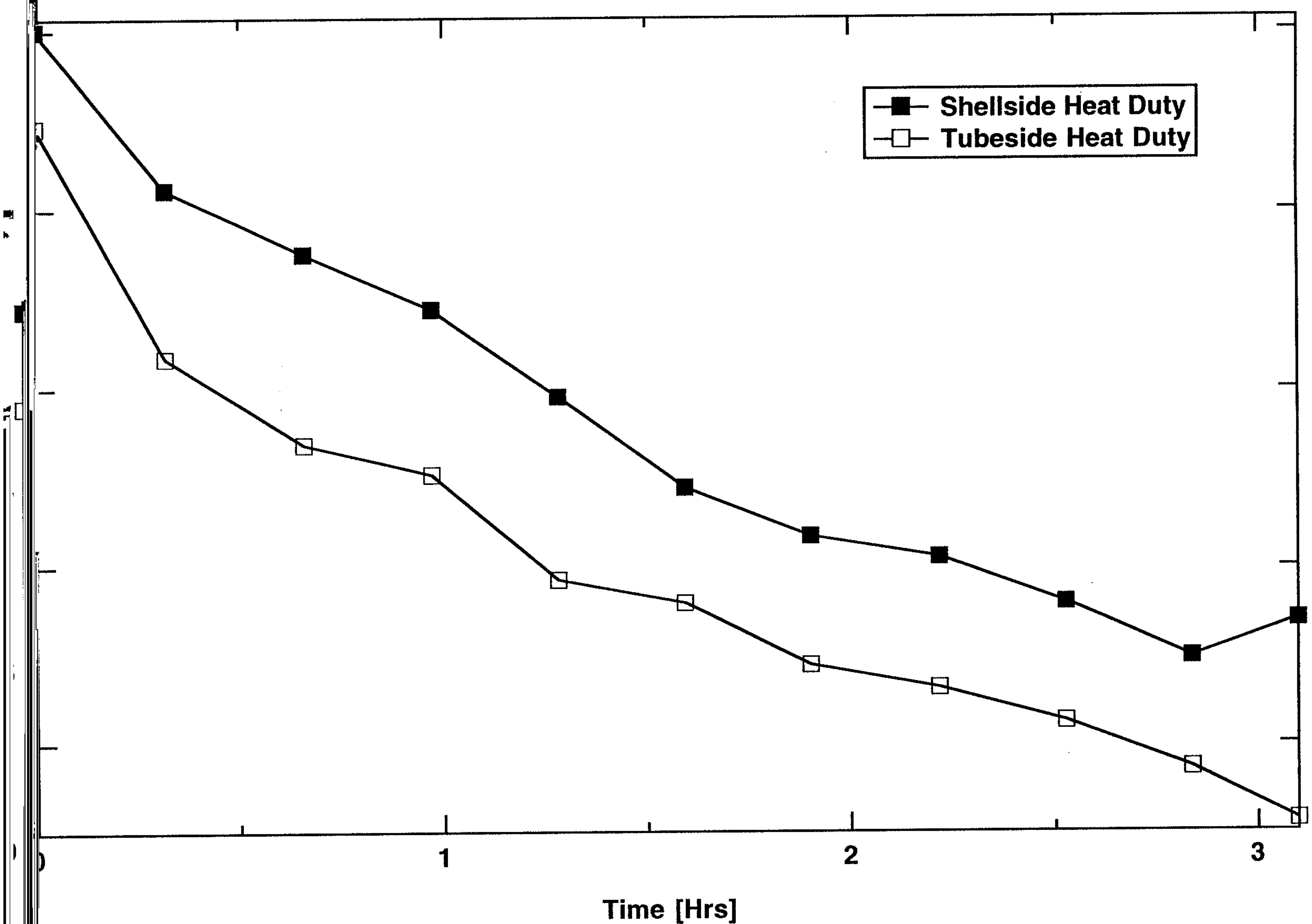
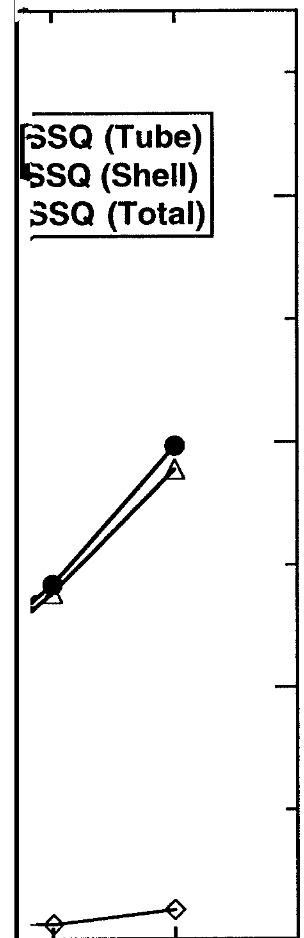


Figure 4: Transient Shell & Tubeside Heat Duty Profiles


SSQ (Tube)
SSQ (Shell)
SSQ (Total)

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