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Code Evaluation for Heat Exchanger of a Research Reactor

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1. Introduction

A heat exchanger is a device for transferring heat from one system to another system for a research reactor. A research reactor use shell-and-tube heat exchanger. For the design of the heat exchanger, ASME Boiler and Pressure Vessel Code was used. In this study, a fixed tubesheet heat exchanger is evaluated by the ASME Code, Part UHX [1]. Because the rules in UHX cover the minimum requirements for design, fabrication, and inspection of shell-and-tube heat exchangers for the research reactor.

2. Methods and Results

2.1 Scope

The target heat exchanger is a fixed tubesheet heat exchanger as shown in Figure 1. Heat exchanger with two stationary tubesheets, each attached to the shell and channel. The heat exchanger contains a bundle of straight tubes connecting both tubesheets [1].

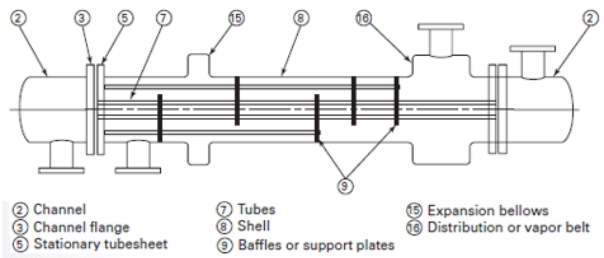

Fig. 1. Fixed tubesheet heat exchanger

The channel component integral with the tubesheet is a cylinder head as shown in Figure 2.

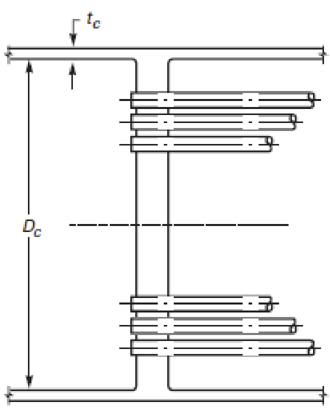

Fig. 2. Cylindrical channel

D_c = inside channel diameter, mm
t_c = channel thickness, mm

For the design of tubesheets for fixed tubesheet heat exchanger, the tubesheet configuration is integral with shell and channel as shown in Figure 3.

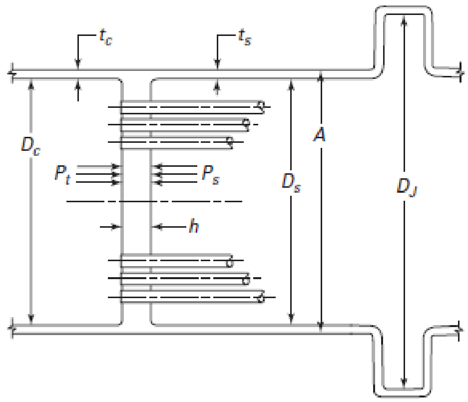

Fig. 3. Tubesheet integral with shell and channel

A = outside diameter of tubesheet, mm
D_J = inside diameter of the expansion joint at its convolution height, mm
D_s = inside shell diameter, mm
h = tubesheet thickness, mm
P_s = shell side internal design pressure, MPa
P_t = tube side internal design pressure, MPa
t_s = shell thickness, mm

2.2 Determination of Effective Dimensions and Ligament Efficiencies

From the geometry as shown in Figure 4 and material properties of the exchanger, it is calculated the required parameters below.

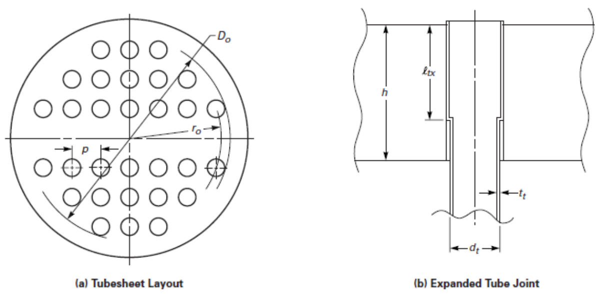

Fig. 4. Tubesheet geometry

D_o = equivalent diameter of outer tube limit circle, mm
d_t = nominal outside diameter of tubes, mm

l_{tx} = expanded length of tube in tubesheet, mm
p = tube pitch, mm
r_o = radius to outermost tube hole center, mm
t_t = nominal tube wall thickness, mm

For geometries where the tubes extend through the tubesheet, it is calculated below (UHX-11.5).

$$D_o = 2r_o + d_t$$

$$\mu = \frac{p - d_t}{p}$$

$$d^* = \text{MAX}\left\{\left[d_t - 2t_t\left(\frac{E_t}{E}\right)\left(\frac{S_t}{S}\right)\rho\right], \left[d_t - 2t_t\right]\right\}$$

$$p^* = \frac{p}{\left(1 - \frac{4\ \text{MIN}\left[(A_L),(4D_o p)\right]}{\pi D_o^2}\right)^{1/2}}$$

$$\mu^* = \frac{p^* - d^*}{p^*}$$

$$h'_g = \text{MAX}\left[(h_g - c_t),(0)\right]$$

2.3 Calculation Procedure

The procedure for the design of tubesheets for a fixed tubesheet heat exchanger is from Step 1 to 11 of UHX-13.5 [1]. Table I shows the calculation and evaluation results.

Table I: Calculation and Evaluation Results

Parameter	Calculation	Allowable	Evaluation
Tubesheet bending stress	26.59 MPa	1.5 S	Acceptable
Tubesheet shear stress	12.24 MPa	0.8 S	Acceptable
Axial tube stress	-4.58 MPa	S_t	Acceptable
Shell total axial stress	61.60 MPa	1.5 S_s	Acceptable
Channel total axial stress	3.97 MPa	1.5 S_c	Acceptable

S = allowable stress for tubesheet material at tubesheet design temperature, MPa
S_c = allowable stress for channel material at design temperature, MPa
S_s = allowable stress for shell material at design temperature, MPa

The calculation procedure is complete and the tube, shell, and channel design is acceptable for the given design conditions.

3. Conclusions

In this study, a specific heat exchanger of a research reactor was evaluated by the ASME Code. From the calculation procedure, the tube, shell, and channel design is acceptable for the given design conditions. Like this procedure, it can be applied and evaluated for other types of heat exchangers for research reactors.

ACKNOWLEDGEMENTS

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REFERENCES

[1] ASME Boiler and Pressure Vessel Code, Section VIII - Division 1, Part UHX, Rules for Shell-and-Tube Heat Exchangers, American Society of Mechanical Engineers, 2007.