第10卷 第5期 2010年2月
1671－1815(2010)5-1301-03

科 学 技 术 与 工 程
Science Technology and Engineering

Vol. 10 No. 5 Feb. 2010

化工技术

关于浮头法兰厚度计算的一种新方法

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摘 要 通过严格的数学推导,得到了一个满足国家标准 GB 151—1999 要求的浮头法兰厚度计算公式,从而解决了浮头式换热器浮头法兰厚度计算的理论问题,同时也给设计者带来了方便。改变了以往凭经验猜想法兰厚度的现状。

关键词 浮头式 换热器 法兰

中图法分类号 TQ055.81; **文献标志码** A

在浮头式换热器设计当中,浮头法兰厚度计算是很重要的一步。但是在现行的设计规范国家标准 GB 151—1999[1] 及《钢制压力容器》[2] 中,设计者需根据以往经验事先假设一个厚度,然后计算预紧力矩 M_a 和操作力矩 M_p,再取 $M_0 = \left\{M_p M_a \frac{[\sigma]_t}{[\sigma]}\right.$,之后根据 GB 151—1999 的要求进行校核,经过反复试算才能得到合适的厚度。而这种假设,是根据经验估计一个大致范围,然后进行强度校核,若不满足要求增加厚度再校核……,直到满足强度要求为止。因此它完全是经验性的,不具备理论依据。本文利用逆推方法,在理论上对其做深入的探讨,不仅解决了以往凭经验估值的问题. 更重要的是解决了浮头式换热器浮头法兰厚度计算的理论问题. 弥补了国家标准 GB 151 的理论不足。计算结果表明,此方法与按国家设计标准 GB 151 方法凭经验估值相吻合。

1 理论计算方法

首先将操作力矩 M_p 表示为法兰厚度 δ_f 的函数,$M_p = M_p(\delta_f)$,具体表达式为

$$M_p = M_D + M_G + M_T - M_r \tag{1}$$

式(1)中:

$M_D = F_D S_D, M_G = F_G S_G, M_T = F_T S_T, M_r = F_r S_r$[1]。且 $M_r = F_r\left(\frac{\delta_f}{2} - \frac{\delta}{2\cos\beta_l} - l\right)$,将代入(1)式得:

$$M_p = M_D + M_G + M_T - M_r = M_D + M_G + M_T - F_r\left(\frac{\delta_f}{2} - \frac{\delta}{2\cos\beta_l} - l\right) \tag{2}$$

式(2)中:δ 为浮头盖厚度。今取 $M_0 = M_p$,按规定[1]取,$\beta_l = \arcsin\frac{0.5D_{f_i}}{R_i + 0.5\delta}$,

为方便,设 $B = M_D + M_G + M_T, C = \frac{\delta}{2\cos\beta_L} + l$,则有,$M_0 = B - F_r\left(\frac{\delta_f}{2} - C\right)$,

将 M_0 的表达式代入 $J = \frac{M_0}{[\sigma]_f^t D_{f_i}}\left(\frac{D_{f_0} + D_{f_i}}{D_{f_0} - D_{f_i}}\right)$ 中,并令 $A = \frac{1}{[\sigma]_f^t D_{f_i}}\left(\frac{D_{f_0} + D_{f_i}}{D_{f_0} - D_{f_i}}\right)$。

则有,$J = A\,M_0 = A\left[D - F_r\left(\frac{\delta_f}{2} - C\right)\right]$。

按国家标准 GB 151 法兰厚度为:

$$\delta_f = L + \sqrt{L^2 + J^2} \tag{3}$$

2009年11月6日收到 辽宁省教育厅高校科研项目(2004F100)、国家自然科学基金项目(50971068)资助

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式(3)中,$L=\frac{pD_{f_i}\sqrt{4R_i^2-D_{f_i}^2}}{8[\sigma]_f^t(D_{f_0}-D_{f_i})}$,从而$(\delta_f-L)^2=L^2+J^2$,即:$\delta_f^2-2\delta_fL-J=0$,$\delta_f^2-2\delta_fL-A\left[B-F_r\left(\frac{\delta_f}{2}-C\right)\right]=0$,$\delta_f^2+\left(\frac{F_rA}{2}-2L\right)\delta_f-A(B+CF_r)=0$。

令:$I=\frac{F_rA}{2}-2L$,$K=A(B+CF_r)$,则得到一个一元二次方程:

$$\delta_f^2+I\delta_f-K=0 \tag{4}$$

解之,得到

$$\delta=\frac{-I\pm\sqrt{I^2-4K}}{2} \tag{5}$$

式(5)就是钩圈式浮头法兰的厚度 δ_f 的理论求解公式。

2 算例

例:设计一个材料为 16 M_n,$[\delta]=150$ MPa,$[\delta]^t=135$ MPa,参数为 $D_{f_i}=758$ mm,$R_i=600$ mm,$\delta=20$ mm,$P=2.5$ MPa,$D_b=830$ mm,$D_g=776$ mm 的换热器。

解:

$\beta_l=\arcsin\frac{0.5D_{f_i}}{R_i+0.5\delta}=\arcsin\frac{0.5\times758}{600+10}=38.4°$,$F_D=0.785D_{f_i}P=0.785\times785^2\times2.5=1\ 127\ 581.85N$,$S_D=\frac{1}{2}(D_b-D_{f_i})=36$ mm,$M_D=F_DS_D=40\ 592\ 946.6$ N·mm $=405\ 930$ N·m,$F_G=F_p=213\ 206$ N,$S_G=\frac{1}{2}(D_b-D_G)=\frac{1}{2}(830-776)=27$ mm,$M_G=5\ 757$ N·m,$F_T=F-F_D=54\ 188.55$ N,$S_T=\frac{1}{2}(S_D+S_G)=\frac{1}{2}(36+27)=31.5$,$M_T=F_TS_T=1\ 707$ N·m。从而 $A=\frac{1}{[\sigma]_f^tD_{f_i}}\left(\frac{D_{f_0}+D_{f_i}}{D_{f_0}-D_{f_i}}\right)=1.31\times10^{-4}$,$B=M_D+M_G+M_T=48\ 056\ 447.925$,$C=\frac{\delta}{2\cos\beta_L}+L=21.47$,$F_r=F_D\mathrm{C}\tan\beta_l=1\ 422\ 654$ N,$L=\frac{PD_{f_i}\sqrt{4R_I^2-D_{f_i}^2}}{8[\sigma]_f^t(D_{f_0}-D_{f_i})}=13.38$,$I=66.57$,$K=10\ 312$,

则有 $\delta_f^2+66.57\delta_f-10\ 312=0$,解得:

$$\delta_f=\frac{-66.57\pm\sqrt{66.57^2+4\times10\ 312}}{2}=$$

$$\frac{-66.57\pm213.73}{2}=\begin{cases}73.53\text{ mm}\\-140.15(\text{舍去})\text{mm}\end{cases}。$$

而按国家设计标准 GB 151 凭经验经多次试算,得出的法兰厚度 $\delta_f=74$ mm。与按本文理论公式的计算结果是相吻合的。从而可以看出本文推导的理论公式不仅具有理论的完备性,而且与国标 GB 151 强制要求完全符合。

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A New Method for Calculating the Thickness of Floating Head Flanges

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[**Abstract**] The floating head flange thickness formula was obtained, which satisfy the national standards GB 151—1999 request, through the strict mathematical deduction. Thus the theory problem of floating head type heat interchanger floating head flange thickness' computation has been solved, which has also brought convenience to the designer simultaneously. It has changed the situation that depends on the experience to suspect the flange thickness.

[**Key words**] floating head type exchanger flanges

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A Case Study Assessment on the Energy Consumption of Special Mid-rise Residential Buildings (Mashad-Iran)

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[**Abstract**] Especial type of mid-rise residential buildings has been built in Mashad (a big city inIran) during last two decades, which have vast eastern and western walls in contact with free air. These walls are the main factor of wasting energy in these apartments because these walls are vast (high amount of energy flux) and have conventional construction method (poor thermal properties). The energy consumption in an assumed building in the Mashad with different conditions for western and eastern walls was simulated by DeST-h. The results showed that despite of southern walls, existence of neighborhood in the eastern and western walls can decline the amount of consumed energy for heating and cooling about 37% and 15%, respectively. In addition, the results of simulations showed that the share of eastern and western walls on energy consumption is about 33% of total annual energy consumption in the assumed building. Then, the influences of the position of different rooms in one floor on the energy consumption and the amount of energy consumption in different floors are evaluated. These evaluations show that the designer should have especial attention to the position of a room in the building and its stories.

[**Key words**] hollow clay block neighborhood energy consumption Mashad