Study of Calculation Methods of Heat Transmission of Heat Meters

Li Fang

(Heat Division, National Institute of Metrology of China,No 18 Bei San Huan Dong Lu, Bei jing ,China,100013)

Abstract This paper describes the researches of the calculation method of heat transmission of heat meters: Enthalpies difference method and heat coefficient method are the same in nature, each method can be chosen at different conditions. While consulting the heat coefficient table, the flow measuring position corresponding to the heat coefficient should be consistent with the installation position of the flow sensor, otherwise correction should be carried out to avoid the errors.

Keywords: Heat meter, Heat transmission calculation, Heat coefficient

Foreword

At present, large numbers of heat meters are used in new buildings. But there are still some problems exist in the calculation of heat transmission: which calculation method is more exact and should be used first, and how to avoid some errors.

More study should be made to ensure the exactness of heat transmission calculation.

1. Working principle for heat meters

Install the temperature sensor pair at the flow and return of the heat-exchange circuit, and install the flow sensor at either the flow or the return of the circuit. The temperature sensor pair gives out the flow and return temperature signals, and the flow sensor gives out the flow signal. After collecting the temperature and flow signals and calculating, the calculator can display the heat exhausted by the heat-conveying liquid from the flow to the return of the circuit.

2. Heat transmission formula

There exist two types of formula for heat transmission:

$$Q = \int_0^t q_m \cdot (h_f - h_r) \cdot dt \qquad (1)$$

where Q is the quantity of heat given up, kJ; q_m is the mass flow rate of the heat-conveying liquid passing through the heat meter, kg/s; h_f and h_r are the specific enthalpies of the heat-conveying liquid at the flow and return temperatures of the heat-exchange circuit, kJ/kg; t is time, s.

$$Q = \int_0^V k \cdot \Delta\theta \cdot dV \qquad (2)$$

where Q is the quantity of heat given up, J or kW·h; V is the volume of liquid passed, m^3; $\Delta\theta$ is the temperature difference between the flow and return of the heat exchange circuit, °C; k called the heat coefficient, is a function of the properties of the heat-conveying liquid at the relevant temperatures and pressure, J/(m^3·°C) or kW·h/(m^3·°C).

Usually, the two calculation methods are called enthalpies difference method and heat coefficient method.

2.1 Difference between the two calculation methods

According to EN 1434 " Heat Meters", the heat coefficient k can be obtained from

$$k = \frac{1}{v} \cdot \frac{h_f - h_r}{\theta_f - \theta_r} \qquad (3)$$

where v is the specific volume, m^3/Kg.

$$v = \frac{R \cdot \theta \cdot \gamma_\pi}{P_*} \quad (4)$$

where $R = 461.526 \quad J/(kg.K)$;

$\theta = \theta_f$ (while the volume is measured at

the flow position) or θ_r (while the volume is

measured at the return position);

$$\gamma_\pi = \sum_{i=1}^{34} -n_i I_i (7.1 - \pi)^{I_i - 1} (\tau - 1.222)^{J_i} \quad (5)$$

where n_i, I_i, J_i are constants;

$\pi = P / P_*$

where $P_* = 16.53 MPa$

$\tau = \theta_* / \theta$

where $\theta_* = 1386K$

It is clear that the heat coefficient k is calculated from the difference between the specific enthalpies. So the two calculation methods are the same in nature.

Following are some examples to show the calculation difference between the two calculation methods.

(1) flow temperature is 80 ℃, return temperature is 50 ℃, pressure is 0.6 MPa, mass flow rate is 6 kg/h, the heat transmission during 1 hour is:

by the enthalpies difference method

$Q_1 = 753.6$ kJ

by the heat coefficient method.

$Q_2 = 0.2093$ kWh $= 753.4$ kJ

The calculation difference between the two method is $\triangle = 0.03\%$

(2) flow temperature is 95 ℃, return temperature is 45 ℃, pressure is 0.6 MPa, mass flow rate is 10 kg/h, the heat transmission during 1 hour is:

by the enthalpies difference method

$Q_1 = 2095.3$ kJ

by the heat coefficient method.

$Q_2 = 0.58209$ kWh $= 2095.5$ kJ

The calculation difference between the two methods is $\triangle = 0.01\%$

For the class 1 heat meters, the maximum permissible errors is

$$E = \pm \left(2 + 4 \frac{\Delta\theta_{min}}{\Delta\theta} + 0.01 \frac{q_p}{q} \right) \%$$

The calculation difference between the two calculation methods is far less than the maximum permissible of heat meters, so it can be ignored completely.

2.2 Choose the proper calculation method

The enthalpies difference method and the heat coefficient method are the same in nature, but different method should be chosen first at different condition.

(1) In order to calculate conveniently, enthalpies difference method should be used while the flow sensor gives out the signal of mass flow rate, but heat coefficient method should be used while the flow sensor gives out the signal of volume flow rate.

(2) Compared to the enthalpy and density table, the heat coefficient table has huge data, so lots of publication can not provide the users a full scale heat coefficient table. Thus many manufacturers calculate the heat transmission by using the enthalpies difference method. For example, the following formula is used by some manufactures.

$$Q = \int_{V_1}^{V_2} \rho \cdot \Delta h dV \quad (6)$$

where, ρ is the density of the fluid, kg/m^3.

2.3 Attention should be paid to the measuring position of the flow while using the heat

coefficient method

When the heat transmission is calculated by the heat coefficient method, we should know that the heat coefficient is corresponding to the flow position or the return position. If it is different from the actual flow measuring position, the flow must be corrected.

According to the mass constant law

$$V_f \cdot \rho_f = V_r \cdot \rho_r \qquad (7)$$

where V_f is the flow measured at the flow position, m^3; V_r is the flow measured at the return position, m^3; ρ_f is the density of the fluid at the flow position, Kg/m^3; ρ_r is the density of the fluid at the return position, Kg/m^3.

So we can get

$$Q = \int_0^{t'} (k_f \cdot \frac{\rho_r}{\rho_f}) \cdot (\theta_f - \theta_r) dV_r \qquad (8)$$

$$Q = \int_0^{t'} (k_r \cdot \frac{\rho_f}{\rho_r}) \cdot (\theta_f - \theta_r) dV_f \qquad (9)$$

where k_f is the heat coefficient while the flow is measured at the flow position, $J/m^3 \cdot ^\circ C$ or $kWh/m^3 \cdot ^\circ C$; k_r is the heat coefficient while the flow is measured at the return position, $J/m^3 \cdot ^\circ C$ or $kWh/m^3 \cdot ^\circ C$.

Errors will occur if the flow measuring position corresponding to the heat coefficient is different from the actual flow measuring position. If the actual flow measuring position is the flow position, while the position corresponding to the heat coefficient is the return position, the error is

$$\Delta = (\frac{\rho_r}{\rho_f} - 1) \times 100\%$$

While the flow temperature is 90℃, the return temperature is 20℃,

$$\Delta = (\frac{\rho_r}{\rho_f} - 1) \times 100\% = (998.44 / 965.54 - 1) \times 100\% =$$

This error can not be ignored.

3. Conclusion

(1) Enthalpies difference method and heat coefficient method are the same in nature. Each method can be chosen at different conditions.

(2) While consulting the heat coefficient table, the flow measuring position corresponding to the heat coefficient should be consistent with the installation position of the flow sensor, otherwise correction should be carried out to avoid the errors.

Reference

[1] EN 1434 Heat Meters
[2] JJG 225-2001 Heat Meters Verification Regulation