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# ALTERNATIVE SOLUTION FOR CONSUMPTION HOT WATER RECIRCULATION FOR THE CIVIL BUILDINGS

BY
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The sanitary comfort and the effective cost of maintenance in the civil buildings (block of flats) are badly affected by the absence of the consumption hot water recirculation.

From the technical point of view, the classical solution imposes the doubling of the transport and distribution pipes on the entire route, between the source and the consumption points.

The materialization of the solution requires important financial investment, discouraging most of the time and the postponement of the problem solving with important consequences.

This paper proposes an alternative technical solution which limits to a minimum the intervention, only in the interior hot water distribution system.

## 1. General Scheme

For the maintaining of the water consumption temperature at acceptable values is assured the compensation of the heat losses from the interior installation through the recirculation, with a local heat source placed in the basement.

The heat source is scheduled with accumulator whose storage capacity compensates the cold water volume from the exterior distribution system, to the first utilization.

For the elimination of the recirculation pipes on the column root, these ones are connected to the superior part, two by two, and on the basis one to the distribution pipe and the other one to the circulation pipe, corresponding to Fig. 1.

In the distribution modulus the water circulates ascending through a column and descending through another column.

The alimentation is made from the exterior distribution network through the hot water accumulator.

For the heating of the recirculation water it is used a bienergy boiler supplied in the winter regime by the thermal agent from the heating installation, and in the summer regime, with electrical energy.

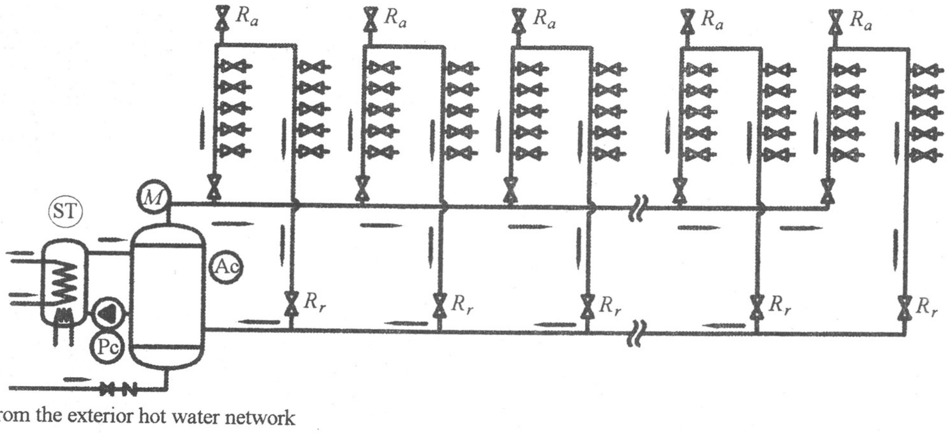


Fig. 1.– Distribution system schema; Ac – accumulator, Pc – circulating pump, ST – bienergy boiler.

The circulating pump is working continuously or can be automatized, in function of the water temperature from the distribution system.

The efficiency of the installation is conditioned by the correct dimensioning of the components elements.

## 2. Thermal Source

The thermal power of the local heat source must compensate the heat losses corresponding to the interior installation – the distribution system and the hot water boiler/mantle storage.

The heat losses from the distribution system are determined with relation

$$Q_S = Q_{ac,d} + Q_{ac,s}, \quad \text{[kWh]} \tag{1}$$

where

$$Q_{ac,d} = \frac{\Delta\theta}{1,000} \sum U_i L_i, \quad \text{[kWh]}, \tag{2}$$

$\Delta\theta = \theta_{\text{mac}} - \theta_{\text{amb}}$ – temperature difference between the average distribution temperature and the ambient medium one; $U_i$ – specific loss on unit length coefficient, [W/m.K]; $L_i$ – length of the pipe section, [m].

The amount of dissipated heat through the boiler mantle is calculated with relation

$$Q_{ac,s} = \frac{0.001 S_{\text{lat}}}{0.10 + \dfrac{\delta_m}{\lambda_m} + \dfrac{\delta_{\text{iz}}}{\lambda_{\text{iz}}}} (\theta_{acb} - \theta_{\text{amb}}) \tag{3}$$

where $S_{\text{lat}}$ is the lateral surface of the boiler, [m$^2$]; $\delta_m$, $\delta_{\text{iz}}$ – the thickness of the boiler's wall and of the insulation, [m]; $\lambda_m$, $\lambda_{\text{iz}}$ – thermal conductivity of the steel and insulation, [W/m.K]; $\theta_{acb}$ – average temperature of the water in the boiler, [K]; $\theta_{\text{amb}}$ – ambient medium temperature, [K].

The specific loss coefficient, $U_i$, is determined as function of the pipes diameter, material type and insulation degree, with the relation

$$U_i = \frac{\pi}{\dfrac{1}{\alpha_c D_{ec}} + \sum \dfrac{1}{2\lambda_j} \ln\left(\dfrac{D_e}{D_i}\right)_j}, \quad [\text{W/m.K}], \tag{4}$$

where: $\alpha_c = 8$ W/m$^2$.K is the coefficient of the convective heat transfer; $D_{ec}$ – the exterior diameter of the pipe including the insulation, [m]; $(D_e/D_i)_j$ – the ratio between the exterior and interior diameter; $\lambda_j$ – thermal conductivity of the successive layer, [W/m.K].

## 3. Stocking Capacity of the Source

Is determined as function of the exterior distribution network, so that the hot water quantity from the accumulator be able to compensate the cold water volume taken from the network at first use.

The storage volume is adopted depending to the network total size or, if necessary, with a fraction proportional to the number of user/$N_b$ block deserved by it

$$W_{ac} = 0.785p \sum_i L_i D_i^2, \quad [\text{m}^3], \tag{5}$$

where: $p=1$ for the reduced networks, $p=1/N_b$ for the extended networks.

## 4. Circulating Pump

Circulation of the water in the interior installation is assured in continuous state, using a pump with a flow equal to the circulating flow,

$$Q_p = D_s, \quad [\text{m}^3/\text{h}], \tag{6}$$

and a pumping height equal with the total charge loss corresponding to this flow,

$$H_p = H_r, \quad [\text{m}]. \tag{7}$$

The volumetric hot water flow is calculated in function of the total thermal power, $Q_S$, the temperature deviation $\delta T = 10°$C, with relation

$$D_S = \frac{Q_S}{1.164\delta T}, \quad [\text{m}^3/\text{h}]. \tag{8}$$

## 5. Ciculating Pipe

In order to assure a uniform temperature in the whole installation the vehiculated hot water volume is distributed equally between the $n$ coupled distribution columns, resulting the circulating unitary flow

$$d = \frac{D_S}{n}, \quad [\mathrm{m}^3/\mathrm{h}]. \tag{9}$$

The constant maintenance of these flows improves the distribution network balancing it by the corresponding adjustment of the circulating pipe and the regulation cock.

Applying the energy conservation law,

$$\sum_{j=1}^{n} (M_i d_i^2)_j = H_r, \tag{10}$$

to the binary network rings equivalent to the modified interior distribution system (Fig. 2) it results the algebraic system

$$\left\{\begin{array}{l} M_n(nd)^2 + m_n d^2 + Mr_n(nd)^2 = H_r, \\ M_n(nd)^2 + M_{n-1}[(n-1)d]^2 + m_{n-1}d^2 + Mr_n(nd)^2 + Mr_{n-1}[(n-1)d]^2 = H_r, \\ M_n(nd)^2 + M_{n-1}[(n-1)d]^2 + M_{n-2}[(n-2)d]^2 + m_{n-2}d^2 + \\ \quad + Mr_n(nd)^2 + Mr_{n-1}[(n-1)d]^2 + Mr_{n-2}[(n-2)d]^2 = H_r, \\ \vdots \\ M_n(nd)^2 + M_{n-1}[(n-1)d]^2 + M_{n-2}[(n-2)d]^2 + \ldots + M_2(2d)^2 + m_2 d^2 + \\ \quad + Mr_n(nd)^2 + Mr_{n-1}[(n-1)d]^2 + Mr_{n-2}[(n-2)d]^2 + \ldots + Mr_2(2d)^2 = H_r, \\ M_n(nd)^2 + M_{n-1}[(n-1)d]^2 + M_{n-2}[(n-2)d]^2 + \ldots + M_2(2d)^2 + M_1 d^2 + \\ \quad + m_1 d^2 + Mr_n(nd)^2 + Mr_{n-1}[(n-1)d]^2 + Mr_{n-2}[(n-2)d]^2 + \ldots \\ \quad \ldots + Mr_2(2d)^2 + Mr_1 d^2 = H_r, \end{array}\right. \tag{11}$$

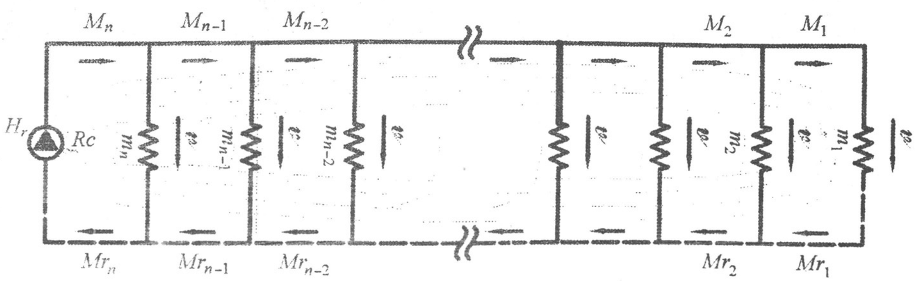


Fig. 2.- Equivalent binary network scheme.

where: $H_r$ is the total charge loss in interior distribution insulation, corresponding to the circulating flow, $D_S$; $m_i$ – hydraulic modulus corresponding to the coupling $i$; $M_i$ – hydraulic modulus corresponding to the section $i$ belonging to the ongoing pipe; $Mr_i$ – hydraulic modulus corresponding to the section $i$ on the circulating pipe.

The resulting system contains $n$ equations with $n+1$ unknowns and the hydraulic modulus $Mr_1$–$Mr_n$, which corresponds to the $n$ sections of the circulating pipes and the system charge loss, $H_r$, corresponding to the circulating flow, respectively.

For the solving of this system it is required the total hydraulic resistance value, $Mr_n$, for the section adjacent to the circulating pump.

The solutions of system (11), are of the form

$$H_r = \left[nMr_n + (m+M)_n\right]d^2 \tag{12}$$

and

$$Mr_i = \frac{1}{i}\left[\frac{H_r}{d^2} + m_{n-1} - (m+M)_i\right], \tag{13}$$

where: $n$ is the total number of the regulated distribution modulus by coupling the columns; $i$ – current number of the section in the network equivalent scheme.

Depending on the geometric and hydraulic configuration of the pipe, from the explicit expression of the hydraulic modulus

$$Mr_i = 0.0827q_i^2\left(\frac{\lambda L}{D^5} + \frac{\sum\xi}{D^4}\right), \tag{14}$$

the diameters and local resistances necessary for the circulating pipe are obtained.

## 6. Conclusions

The proposed solution concerning the consumption of hot water may be applied for the new buildings and for the modernization of the installations from the existent blocks of flats.

The achievement of the solution implies a small amount of interventions in the initial installation, respectively coupling the columns in the superior part, doubling the interior distribution with a circulating pipe and assembling the pump and equipment for the local heat source of the circulating water.

Comparing with the classic solution the advantages of the proposed one consist in a smaller investmet effort.

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# SOLUŢIE ALTERNATIVĂ PENTRU RECIRCULAREA APEI CALDE DE CONSUM ÎN CONSTRUCŢII

(Rezumat)

Confortul sanitar şi costul întreţinerii în locuinţe de tip colectiv (blocurile de locuinţe) sunt afectate în mod negativ de lipsa instalaţiilor de recirculare a apei calde de consum.

Din punct de vedere tehnic, soluţia clasică impune dublarea conductelor de transport şi distribuţie pe tot traseul, între sursă şi punctele de consum.

Materializarea acestei soluţii presupune investiţii financiare importante, de multe ori descurajante, care amână rezolvarea problemei, cu consecinţe agravante.

Se propune o soluţie tehnică alternativă, care limitează intervenţiile la un minim necesar şi numai în instalaţia interioară de alimentare cu apă caldă.