Claims

We claim that:

1. Method for operating a circulation system (10) having a cooling device (12, 14) with an input port (12a, 14a) and an output port (12b, 14b) for the cooling of water and having a pipeline system with multiple branches comprising one or more partial sections with given thermal coupling to the surroundings and being connected by means of nodes, wherein one or more of the lines of the pipeline system are configured as a flow pipe (4, 5, 6), at least one as a single supply line (7) connected to a tapping point (9), and at least one line configured as a circulation conduit (10a) connected to the flow pipe or pipes (4, 5, 6),

   with the steps

   - setting a water temperature at the output port (12b, 14b) to a value (T_a) by means of the cooling device (12, 14)

   - setting a volume flow at the input port (12a) to a value (V_z)

   characterized by the following steps

   - determining, in particular calculating, a temperature change of the water between the initial region and the end region according to a model of the axial temperature change for the first partial section connected to the output port (12b, 14b), starting from a temperature start value (T_{MA}*) that is less than a target temperature ($T_{soll)}$ and a volume flow start value (V_z*),

   - determining, in particular calculating, a temperature change of the water between the initial region and the end region for each further given partial section according to the model of the axial temperature change, under the boundary condition that the water temperature in the initial region of the given partial section is equal to the water temperature in the end region of the partial section to which the given partial section is connected, and

   - selecting the value (T_a) of the water temperature and the value (V_z) of the volume flow at the output port (12b, 14b) such that,the water temperature in the end region of each partial section ($T_{ME)}$and the water temperature at the input port

(12a, 14b) (T_b), each is less than a target temperature (T_{soll}) with $T_{soll} - T_b < \theta$, where $\theta > 0$ is a given value.

2. The method according to claim 1, characterized in that the values T_a and V_z are determined in an iterative approximation procedure, wherein the temperature change of the water between the initial region and the end region is calculated starting from a temperature start value (T_{MA}*) that is less than a target water temperature (T_{soll}) and a volume flow start value (V_z*) for the first partial section connected to the output port (12b, 14b) for each further given partial section under the boundary condition that the water temperature in the initial region of the given partial section is equal to the water temperature in the end region of the partial section to which the given partial section is connected.

3. The method according to claim 1 or 2, characterized in that the partial sections are designed uniformly in regard to their thermal coupling to the surroundings along the length between their initial region and their end region.

4. The method according to claim 3, characterized in that the water temperature T_{ME} in the end region of at least one partial section with length L is determined by means of the formula

$$T_{ME} = (T_{MA} - T_{Luft}) * e^{-\varepsilon * L} + T_{Luft}$$

$$\varepsilon = \frac{k_R}{m_M * c_{pm}} = \frac{k_R}{V_M * \rho_M * c_{pm}}$$

where

L = the length of the uniform partial section (T_{S1}) (m)
T_{MA} = the water temperature in the initial region (°C)
T_{ME} = the water temperature in the end region (°C)
T_{Luft} = the temperature of the ambient air(°C)
k_R = the heat transfer coefficient of the pipeline (W/(m*K))
m_M = the mass flow of the water in the partial section (kg/ s)
c_{pm} = the spec. heat capacity of the water (J/(kg*K)
V_M = the volume flow of the water in the partial section (m^3/s)
ρ_M = the density of the water (kg/m^3)

5. The method according to claim 4, characterized in that the heat transfer coefficient of the partial sections is determined by the formula

$$\frac{1}{k_R} = \frac{1}{d_i * \alpha_i * \pi} + \frac{1}{\Lambda_R} + \frac{1}{d_a * \alpha_a * \pi}$$

where

$1/k_R$ = the heat transmission resistance of the pipeline (m * K/W)
αi = the inward heat transfer coefficient (W/(m² * K))
$1/\Lambda R$ = the thermal resistance (m * K/W)
α_a = the outward heat transfer coefficient (W/(m² * K))
d_a = the outer diameter (m)
d_i = the inner diameter (m)

and

$$\frac{1}{\Lambda_R} = \frac{1}{2*\pi} * \left(\frac{1}{\lambda_i} * ln\frac{d_{aR}}{d_{iR}} + \frac{1}{\lambda_D} * ln\frac{d_{aD}}{d_{iD}}\right)$$

6. The method according to one of the preceding claims, characterized in that a circulation pump (10b) is integrated in the circulation system (10).

7. The method according to one of the preceding claims, characterized in that the cooling device (12, 14) is used to cool the circulating water by transferring thermal energy from the circulating water to another material flow, preferably by means of a heat transfer agent.

8. The method according to claim 7, characterized in that the cooling device (12, 14) is thermally coupled to a cold generator, preferably a heat pump, a water chiller or a cold supply network.

9. The method according to one of claims 6 to 8, characterized by

- determining a consumer characteristic of a circulation pump (10b) in dependence on a delivered volume flow of the circulation pump (10b)

- determining a consumer characteristic of the cooling device (12, 14) in dependence on a water temperature at the output port (12b, 14b)

- setting a volume flow (V_z) and a water temperature (T_a) at the output port (12b, 14b) such that the power consumption of the circulation pump (10b) and the cooling device (12, 14) takes on a relative or absolute minimum value.

10. The method according to one of the preceding claims, characterized in that a value of 20° C +/- 5° C is chosen for the target temperature (T_{soll}) and a value of 15° C +/-5° C is chosen for the water temperature (T_a) at the output port (12b, 14b).

11. A circulation system having a cooling device (12, 14) with an input port (12a, 14a) and an output port (12b, 14b) for the cooling of water and having a pipeline system with multiple branches comprising one or more partial sections with given thermal coupling to the surroundings and being connected by means of nodes,

- wherein, for a given apportionment of the volume flows emerging from the nodes, a mixed water temperature is determinable from the volume flows emerging from the nodes in dependence on the volume flows entering the nodes,

- wherein one or more of the lines of the pipeline system are configured as a flow pipe (4, 5, 6), at least one as a single supply line (7) connected to a tapping point (9), and at least one line configured as a circulation conduit (10a) connected to the flow pipe or pipes (4, 5, 6),

having

- means of setting the water temperature at the output port (12b, 14b) to a value (T_a) by means of the cooling device (12, 14)

- means of setting a stationary volume flow of circulating water at the input port (12a, 14a) to a value (V_z)

characterized by

- device means for determining a temperature change of the water between the initial region and the end region of each partial section under the boundary

condition that the water temperature in the end region of a given partial section is chosen equal to the water temperature in the initial region of the partial section connected to the given partial section in the flow direction of the circulating water and

- device means for selecting the value (T_a) of the water temperature and the value (V_z) of the volume flow at the output port (12b, 14b) such that, the water temperature in the end region of each partial section (T_{ME}) and the water temperature at the input port (12a, 14b) (T_b), each is less than a target temperature (T_{soll}) with $T_{soll} - T_b < \theta$, where $\theta > 0$ is a given value.

12. The circulation system according to claim 11, characterized in that device means are provided for determining the values T_a and V_z in an iterative approximation procedure, wherein the water temperature T_{ME} is calculated for each given partial section in its end region, starting from a temperature start value T_{MA}* that is less than the target temperature (T_{soll}) and a volume flow start value (V_z*) for the first partial section connected to the output port (12b), wherein the water temperature T_{MA}^* in the initial region of the next attached partial section is chosen equal to the water temperature T_{ME} in the end region of the given partial section.

13. The circulation system according to claims 11 to 13, characterized in that the partial sections are designed uniformly in regard to their thermal coupling to the surroundings along the length between their initial region and their end region.

14. The circulation system according to claims 11 to 13, characterized in that a circulation pump (7) is integrated in the circulation system (10).

15. The circulation system according to one of the preceding claims, characterized in that at least one flow pipe (4, 5, 6) is connected to at least one loop line (8).

16. The circulation system according to one of the preceding claims, characterized in that at least one line of the circulation conduit (10a) departs from the at least one flow pipe (4, 5, 6).

17. The circulation system according to one of the preceding claims, characterized in that at least one line of the at least one circulation conduit (10a) departs from the at least one loop line (8).

18. The circulation system according to one of the preceding claims, characterized in that the at least one flow pipe (4, 5, 6) comprises at least one riser line (5) and/or a building floor line (6).

19. The circulation system according to one of the preceding claims, characterized in that the at least one flow pipe (4, 5, 6) comprises a collective feed line (4), which is connected by a junction (1) to a water supply network.

20. The circulation system according to claim 19, characterized in that the junction (1) is connected to at least one connection line (2) and/or at least one consumer line (3).

21. The circulation system according to one of the preceding claims, characterized in that at least one static or dynamic flow divider (8a) is arranged in the at least one flow pipe (4, 5, 6) and/or the at least one loop line (8).

22. The circulation system according to one of the preceding claims, characterized in that the cooling device (12, 14) is used to transfer thermal energy from the circulating water to another material flow, preferably by means of a heat transfer agent.

23. The circulation system according to claim 22, characterized in that the cooling device (12, 14) is thermally coupled to a cold generator, preferably a heat pump, a water chiller or a cold supply network.

24. The circulation system according to claim 23, characterized in that at least one partial section of the pipeline system is designed as an outer circulation conduit.

25. The circulation system according to claim 24, characterized in that at least one partial section is designed as an inliner circulation conduit.

26. The circulation system according to one of claims 11 to 25, characterized in that the cooling device (12) is connected by its output port (12b) to a flow pipe (4a) and by its input port (12a) to a vertical circulation conduit.

27. The circulation system according to one of claims 11 to 26, characterized in that the cooling device (14) is integrated in a riser line (5) and/or a building floor line (6).