

1. A multi-mode waste-heat recovery device for a pot-furnace cooling water jacket, comprising a pot-furnace cooling water jacket (1), a cooling tower (2), a first water-to-water heat exchanger (3), a second water-to-water heat exchanger (4), a waste-heat power-generation boiler (5), a refrigeration unit (6), a space-heating system (7), a circulating cooling-water pump set (8), and an intelligent control system; wherein the outlet of the pot-furnace cooling water jacket (1) is connected via piping to the hot-side inlet of the first water-to-water heat exchanger (3); the hot-side outlet pipeline of the first water-to-water heat exchanger (3) splits into a first branch and a second branch; the first branch is connected to the inlet of the cooling tower (2); the second branch is connected in parallel—through an intelligent electrically-actuated valve set—to the hot-side inlet of the second water-to-water heat exchanger (4), the inlet of the waste-heat power-generation boiler (5), the inlet of the refrigeration unit (6), and the inlet of the space-heating system (7); the intelligent control system comprises a PLC controller (programmable logic controller), temperature sensors, flow sensors, and a human-machine interface, and is configured to automatically control the open/close state of the intelligent electrically-actuated valve set according to a preset program or manual commands; the hot-side outlet of the second water-to-water heat exchanger (4), the outlet of the waste-heat power-generation boiler (5), the outlet of the refrigeration unit (6), and the outlet of the space-heating system (7) are collected via piping to the cold-side inlet circuit of the first water-to-water heat exchanger (3) and then return to the main return pipeline; the outlet of the cooling tower (2) is connected by piping to the inlet of the circulating cooling-water pump set (8), whose outlet is connected by piping to the inlet of the pot-furnace cooling water jacket (1).

2. The device of claim 1, wherein the intelligent electrically-actuated valve set comprises a plurality of electrically-controlled control valves and electric ball valves respectively provided on the pipelines leading to the second water-to-water heat exchanger (4), the waste-heat power-generation boiler (5), the refrigeration unit (6), and the space-heating system (7), and has remote-control and automatic-regulation capabilities.

3. The device of claim 1, wherein the refrigeration unit is a lithium-bromide absorption chiller.

4. The device of claim 1, wherein the space-heating system comprises radiators.

5. The device of claim 1, wherein the cold-side inlet of the second water-to-water heat exchanger (4) is connected to a municipal water source and its cold-side outlet is connected to points of use for domestic hot water.

6. The device of claim 1, wherein the circulating cooling-water pump set (8) comprises at least two pumps arranged in parallel.

7. A method based on any of claims 1–6 for operating the multi-mode waste-heat recovery device for a pot-furnace cooling water jacket, comprising: delivering high-temperature cooling water generated by the pot-furnace cooling water jacket (1) to the first water-to-water heat exchanger (3); monitoring temperatures at key nodes in real time via temperature sensors; enabling the PLC controller to automatically generate valve-control strategies according to preset seasonal modes and an energy-demand algorithm; automatically switching working modes via the intelligent electrically-actuated valve set so that, according to external energy demands or seasonal changes, one or more target valves directing flow to the waste-heat power-generation boiler (5), the refrigeration unit (6), the space-heating system (7), and the second water-to-water heat exchanger (4) are opened while unused target valves are closed; collecting the cooling water discharged from each device; and finally pumping the mixed cooling water back to the pot-furnace cooling water jacket (1) through the circulating cooling-water pump set (8) to complete the cycle.