DOI: 10.46793/SBT28.457T

MOBILE DEVICE FOR CHEMICAL CLEANING OF HEAT EXCHANGERS

Tomislav Trišović [1], Branimir Grgur [2], Svetomir Milojević[3], Zaga Trišović [4]

Abstract: Heat exchangers are one of the most frequently used elements in the process industry. Water is usually used as a heating fluid and often is not chemically prepared, i.e. it has bicarbonate, calcium, and magnesium, which make the water temporarily hard and form incrustations on the primary side of the heat exchanger.

The paper shows a device for chemical cleaning of the heat exchanger without disassembling it and when the secondary side of the heat exchanger is actively working. Tests of the device in operation were carried out in the machine plant of the Tonanti Hotel in Vrnjačka Banja from 2021 to 2022, where it showed high reliability and complete independence in operation.

Keywords: heat exchangers, cleaning, descaling, cleaning of heat exchangers, heat pumps, heating and cooling.

Introduction

Cleaning the heat exchanger is often a big problem especially if the scale deposits are such that the specific heat flow through the exchanger is reduced and the pressure drop of the exchanger exceeds 0.5 bar. Then complete disassembly, mechanical and chemical cleaning of each part is necessary, which is an expensive and time-consuming process.

Another way is preventive cleaning of the exchanger after a certain period of operation, using acid-base means with equipment that is very expensive and fully automated. The liquid acid washing and disinfecting agent contains phosphoric and nitric acid, anti-corrosive additives, surfactants and sequestrants, and it is recommended to use it in combination with an alkaline

[1]University of Kragujevac, Faculty of Agronomy, Cara Dušana 34, Čačak, Serbia (trisa@tmf.bg.ac.rs)

[2]University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, 11000 Belgrade, Serbia (BNGrgur@tmf.bg.ac.rs)

[3] University of Priština, Faculty of Technical Sciences, Knjaza Miloša 7, 38220 Kosovska Mitrovica, Serbia (svetomir.milojevic@pr.ac.rs)

[4] The Academy of Applied Technical Studies Belgrade, Katarine Ambrozić 3, 11000 Belgrade, Serbia (ztrisovic@atssb.edu.rs)

agent. The descaling agent is determined based on the chemical analysis of the water entering the heat exchanger. Based on the analysis, the composition of the acidic agent that will most successfully and quickly dissolve scale deposits is tested. When the type of acidic agent is determined, it is necessary to check the sealing of the vessel, ie. exchanger, by measuring the water pressure drop at the inlet and outlet of the heat exchanger. If the exchanger is passable, i.e. acidic medium can pass through the heat exchanger, the inhibited acid solution is dosed. During recirculation, the pH value of the solution is periodically measured. After cleaning, wastewater is neutralized.

Heat exchangers are often the heart of many processes in the food, pharmaceutical and other industries. Their regular maintenance and cleaning is of key importance for proper operation and a long working life.

Results and discussion

We designed and built a mobile device for chemical cleaning of heat exchangers with a simple construction and low cost, which can be used both in small plants and in larger facilities. The device has four components: an electromagnetic pump, a tank, a valve assembly with flexi pipes and a control cabinet. All elements are installed on a mobile platform that can be easily accessed by any exchanger that needs cleaning. Most components are made of plastic resistant to chemical agents. The device must not be in the vicinity of devices that spark or emit heat (grinders, welding devices, furnaces, etc.) during operation. The temperature range in the room where the device is located must be from 5 to 40 °C, air humidity from 20 to 80% and with no condensation. The electromagnetic pump serves to ensure the circulation of the mentioned acid with inhibitors from the tank through the heat exchanger and its return to the tank. Heat exchangers are usually connected via a bypass so that they can be easily disconnected from the main piping and serviced (Figure 1).

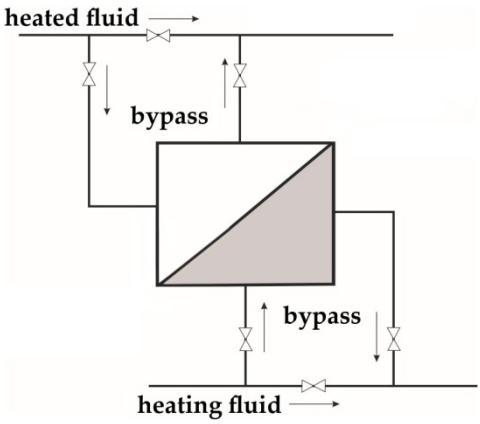

Figure 1. Block diagram of the connection of the heat exchanger

The heating fluid is of a higher temperature and it passes through the primary chamber of the heat exchanger, while the heated fluid is of a lower temperature and passes through the secondary part of the heat exchanger. When the primary or secondary bypass valves are closed, the heat exchanger can be serviced or dismantled. If thermal mineral water of high temperature is passed through the primary of the heat exchanger, it is possible to create scale deposits that reduce the efficiency of the heat exchanger or further scale deposition by completely closing the water passage on the primary side of the heat exchanger. In this way, the exchanger would reduce its heat flow (J/s = W) from its maximum (when completely clean) to practically zero (when, due to scale, the primary or secondary side of the heat exchanger is completely impassable).

The device for chemical cleaning of the heat exchanger (Figure 2) serves for occasional cleaning of the primary or secondary side of the heat exchanger, without dismantling it from the network. The cleaning process takes about an hour. After isolation from the mains by closing the bay pass valve, cocktail of acids is injected into the primary or secondary side using an electromagneten pump. The pump pushes the acid that flows through the exchanger and thus dissolves the incrustations that have formed during its operation. After the process is completed, the acid is returned to the tank and the exchanger is rinsed with running water. After that, the bay pass valves are opened and the exchanger is operational again.

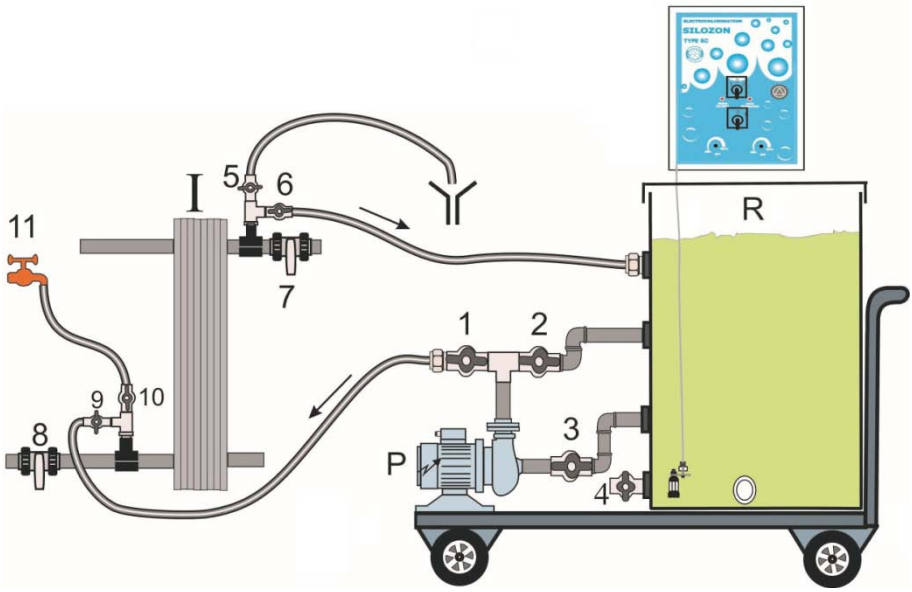

Figure 2. Device for chemical cleaning of heat exchangers

Technical data

The basic characteristics of the device are:
- Operating temperature: 10 - 38 °C;
- Operating voltage: 220 V AC;
- Capacity: 30 l/min;
- Power: 800 W;
- Maximum pressure: 1 bar.

Device installation requirements:
- Socket 220 V, 50 Hz, 1 kW;
- Connection ½", P = 0.5 - 3 bar;
- Connection to the sewage network min. Ø 50;
- Possibly a device that ensures the temperature in the room between 5 and 20 °C if the temperature in the room is lower than 5 or higher than 20 °C and the humidity is such that it does not reach the dew point so that the operational life of the electric components is longer;
- Given that there are large chemical vapors in the engine room, it is necessary to ensure air circulation through the engine room in order to ensure a longer life for all energy and electrical components and pumps;

• Lighting min bulbs 100 W;
• Ventilation drain Ø 70 for removing hydrogen and carbon dioxide without negative drops through the ventilation line;
• A dry room of 3 m² where the device is installed and at least 2 m² manupulative space around the device;
• That there is no condensation in the room for accommodation and operation of the device.

Commissioning

The device must be connected using a properly installed socket-outlet with a protected contact. When the electric plug of the device is installed in the AC outlet, the green LED will light up, indicating the presence of AC voltage at the input of the device. The tank is filled with acids from buckets of 10 or 20 l, and then tap water is added in the same amount as the acid was added. The amount of solution in the tank must be at least 10% greater than the volume of the primary or secondary side of the heat exchanger into which the solution is introduced.

Sequence of operations for device startup

First phase:
1. Connecting the valve assembly to the exchanger pipe;
2. Closing all valves;
3. Filling the vessel R with two primary volumes of the exchanger;
4. Opening the main valve on the pipeline;
5. Closing the bypass piping of the exchanger;

Second phase:
6. Opening valves 9, 5, 1, 2, 3;
7. Turning on the pump P;
8. Pouring one volume of primer into the bucket, turning off the pump;
9. Opening valve 6 and closing valve 5;
10. Turning on the pump P;

Third phase:
11. After 20 minutes, the pump is switched off;

12. Closing valve 9, opening valve 10 and faucet 11;
13. Filling the tank R to the initial volume, closing the tap 11;
14. Closing valve 6, opening valve 5 and faucet 11;
15. After 10 minutes, the tap is 11 closed;
16. Removing connections from valves 5, 6, 9, 10;
17. Armor penetration and opening of valves 7 and 8.

After use, the acid should be emptied from the tank and stored in canisters with caps that have a rubber seal.

Conclusion

The prototype of the device for chemical cleaning of heat exchangers was installed in the Tonanti Hotel in Vrnjačka Banja in the machine room where plate heat exchangers with power from 40 to 800 kW are located. All heat exchangers are plate type and are used to heat water in swimming pools and for central heating in rooms and common areas with the help of heat pumps. The heating fluid on the primary side of the heat exchanger is thermomineral water from arterial wells located near the hotel. Such water has high electrical conductivity, and is therefore rich in minerals - bicarbonates of calcium, iron and magnesium. The primary side of the 200 kW exchanger is heavily loaded with incrustations of calcium, magnesium carbonate, and iron hydroxide. After a few months of operation of the heat exchanger, a larger pressure drop was observed on the primary side of the exchanger when the cleaning process was initiated. In one hour and twenty minutes, the primary side was completely cleaned and the exchanger was then put back into operation. In a period of 18 months, the cleaning process was carried out several times, so that the device fully met expectations and proved its performance in exploitation on a real system - the machine plant of the Tonanti Hotel in Vrnjačka Banja.

Acknowledgement

This article/publication is based upon work from COST Action CA21112 - Offshore freshened groundwater: An unconventional water resource in coastal regions? (OFF-SOURCE), supported by COST (European Cooperation in Science and Technology).

References

Angelovski M., Čađenović Milovanović J. (2012). Kvalitet procesa proizvodnje demineralizovane vode. 39. Nacionalna konferencija o kvalitetu sa međunarodnim učešćem ISBN: 978-86-86663-83-2

Cibulić V., Veljković N., Stamenković L., Staletović N. (2015). Procena i upravljanje rizikom u sistemima za snabdevanje vodom za piće. Vodoprivreda ISSN 0350-0519. Vol. 47 No. 273-275: 119-130.

Vlada Republike Srbije (2012). Nacionalna strategija održivog korišćenja prirodnih resursa i dobara. "Službeni glasnik RS" broj 33/2012

Republički zavod za statistiku (2021). Snabdevanje pitkom vodom i otpadne vode iz naselja. https://publikacije.stat.gov.rs/G2022/HtmlL/G20221129.html

Pravilnik o nacionalnoj listi indikatora zaštite životne sredine (2011). „Službeni glasnik RS" broj 37/2011

Zakon o sanitarnom nadzoru (2004). "Službeni glasnik RS" broj 125/04