The new repair technology the spiral heat exchangers

Delia Garleanu1 , GabrielGarleanu 2 *, ClaudiaBorda3, DeliciaArsene4
1 University Politehnica of Bucharest; delia.garleanu@upb.ro
2 University Politehnica of Bucharest; gabriel.garleanu@upb.ro
3 University Politehnica of Bucharest; claudia.borda@upb.ro
4 University Politehnica of Bucharest; delicia.arsene@upb.ro
2* Correspondence:delia.garleanu@upb.ro

Abstract: The paper presents a new technology for repair welding of industrial spiral heat exchangers made of 316L using the WIG process. Are shown defects in service, the old technology of repair and new way to repair with its advantages. By using new technology, decrease repair costs and time spent by 80%. Some defects can be rectified without having to shift the heat exchanger out of installation. Due to the small distance between the coils, approximately 18 to 20 mm and a depth of about 1 m, the current method of repair involves scraping the outside to the inside of the coils to achieve access to the area with defects. The new repair technology involves how punctual intervention using a TIG welding head Micro Torch modified or removal and repair of inner coils and they will be re-welded instead.

Keywords: new repair technology; spiral heat exchangers; flaws; reduce repair costs; WIG (Wolfram-inert-gas welding), Micro TIG Torch welding head

1. Introduction

The paper presents the flaws occurred during operation of the spiral heat exchangers, the current repair method with its disadvantages and propose a new repair technology. The main advantages of the new repair technology are the lower costs ~~of~~ by up to 50%, the possibility of repairing flaws (defects) arranged on turns lower. and on the entire diameter and decreasing the consumption of materials and labour.

The heat exchangers are devices having a thermal transfer function, achieving the heat transfer from one environment to the other. They have an essential role within some systems used on a large scale, among which we can list the vehicles, heating, refrigeration, air-conditioning, distillation systems (in chemical and petrochemical industries), in thermal power plants, central-heating stations and as extensions of thermal machines. After the performance of some surveys, it was acknowledged that more than two thirds of primary energy used in a country passes through minimum two heat exchangers.

The spiral heat exchangers are those exchangers in which the thermal exchange surface is represented by a rolled strip having the form of a spiral. Two parallel channels are thus achieved, one for each fluid, offering a large surface area for thermal transfer, inserted in a lower volume. The channel width is usually comprised between 5 and 20 mm, the intervention for inspection or repair being almost impossible.

Because of its constructive form, the spiral spacing and the high fluid flow rate,namely 2 – 3 m^3/min,the cavitation phenomenon also appears, having major implications on the operation.

2.Processes leading to accelerated erosion of spiral heat exchangers

While using the heat exchanger, various phenomena appear due to the speed of fluid flow, viscosity and microparticles hardness of fluid These flaws have been analysed and the main causes are corrosion, friction, and cavitation.

Erosive corrosion is a local form of corrosion, taking place because of fluid movement along the material surface. Erosive corrosion is generally accelerated when the fluid entering in the exchanger has in its composition air or solid abrasive particles such as sand. The most frequently used methods decrease of this phenomenon is covering with a protection layer.

The parameters influencing the erosive corrosion are the "turbulences", the fluid speed, the quantity of suspension particles and blisters present, partial local pressure, cavitation and piece geometry. Figure 1 presents images with flaws of the spiral heat exchangers caused by these phenomena.

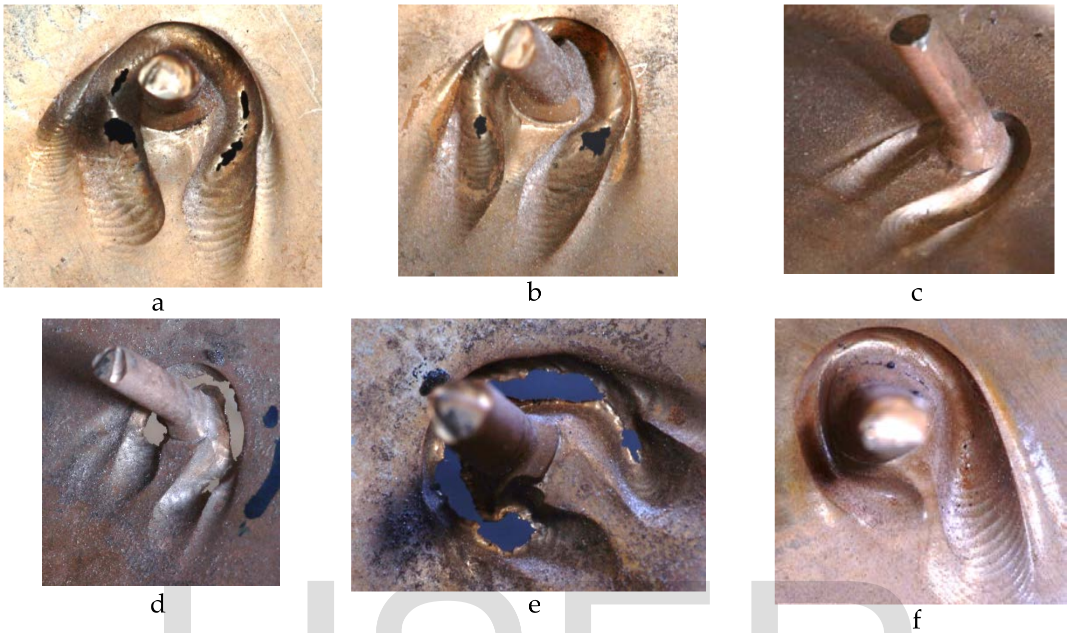

Figure 1. The erosive corrosion models: a- grooves; b- holes; c - hollows horseshoe; d - directional hollow ; e - half-moon cavities; f - waves.

Increased turbulence is directly proportional to fluid velocity increase and higher speeds favour early erosive corrosion. The erosive corrosion model is represented by directional grooves, waves, hollows, holes or horseshoe, star or half-moon cavities. The increased turbulences applied on the inner side of a tube may lead to the rapid growth of erosion rates and finally to leaking.

Cavitation, sometimes also called cavitation corrosion or cavitation erosion, is the dynamic process of formation, development and implosion of bubbles or cavities filled with vapours and gases in a liquid. This process is determined by the decrease of local pressure below some critical values and according to pressure, the cavitation may be vaporous or gaseous.

Among the factors favouring the occurrence and development of cavitation bubbles, we can mention primarily the decrease ~~of~~ in pressure, but also the impurities, microcracks, grooves, and solid bodies. These factors determine the retention of some microscopic volumes of undissolved gas into liquid, so creating the cavitation nuclei or germs. When the pressure reaches critical values as evaporation pressure, the cavitation nuclei or germs primed the evaporation phenomenon and with the release of gases from the fluid and with the surrounding fluid evaporation, the cavitation nuclei develops, forming bubbles or cavities filled with a mixture of dissolved gases and/or fluid vapours.

3.Results

3.1. Curent welding technology of spiral heat exchangers

At present, the repair of heat exchangers is considered a problem as regards the cost, the time and the efficiency. The repair method of spiral heat exchangers is stripping, i.e. the cutting from the external side to the inner side of the spirals of the exchanger until it is reached to the spiral having a flaw or more flaws.

Most of the flaws are usually located on the spirals from the centre of the exchanger, where the peripheral speed increases, greatly because of spiral diameter reduction. The initial spiral has a diameter of approximately 1.1 m, and the final one of 0.3m, which means an increase of almost 3-4 times of the peripheralvelocity flow with major implications on the cavity phenomenon.

Current technology include the following technological steps:

- The identification of affected area or areas;
- Cutting the sheets from outside to inside until the affected area;
- The proper flaws repair by welding;
- The inspection of the repair performed;
- Welding the previously performed cuts;
- Inspection of cut welding;
- Pressure test.

The method is easy in term of repair, but it has several disadvantages:

- stripping the good spirals, which have no flaws, with the possibility to introduce flaws in the welded joint by the subsequent closure welding;

- in most cases, the flaws are found in the spiral/spirals with small diameter, therefore those from the inner side. This means that we will strip more than half of the spirals to reach to the faulty one;

- if the flaws are present in more areas on the entire diameter of a spiral and it is positioned on the inner side of the exchanger, it means that the stripping must be performed more times in different areas, and the repair costs are very high and the repair is not grounded.

In the images below,figure 2, one can notice such a case where the flaws were present on the entire width of the spirals toward the centre of the exchanger and on the entire diameter.

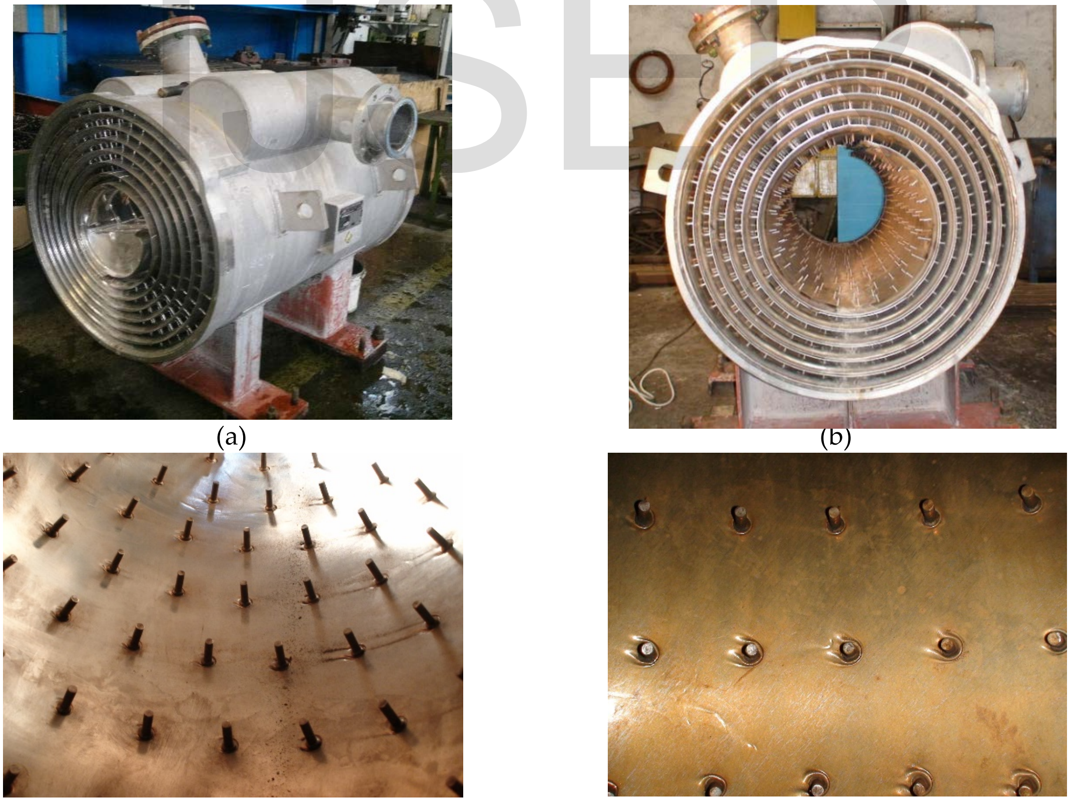

Figure 2: Usually flaws of spiral heat exchangers: a - overview; b - core removal; c -erosive corrosion of welded spacers ; d - detail erosive corrosion flaws.

The repair would have meant the stripping and re-welding in different areas on the entire diameter of the exchanger, with major implications on the stresses and huge residual deformations, high costs related to materials and labour.

In such cases, the exchanger is fully compromised and it must be replaced. Unfortunately, such situations can be found in most cases, the flaws being disposed on the entire spiral diameter, and the current technology is not capable to solve such situations.

3.2. New repair technology of spiral heat exchangers

In this case, a new repair method was applied for the exchanger, i.e. the intervention from the interior toward the exterior, namely the removal of the nucleus and spirals from the centre towards the exterior.

The new technology consisted in following steps:

- the flaw areas were identified;
- the nucleus and the first spirals from the centre were cut using a manual plasma;
- the spirals were removed to the exterior and examined on both sides;
- each spiral was repaired by welding and then inspected non-destructively using the penetrating fluid method;
- the spiral left on the exchanger body was repaired and inspected;
- the spirals were inserted and re-welded one by one, recovering thus the technological routes for cooling;
- a non-destructive inspection was performed after each welding
- spiral edges were charged by welding. Because of deformations, the spiral length was changed in the sense that it was shortened by approximately 2 – 3 mm.
- to ensure the tightness, the surface was processed on the lathe on the ends of each spiral
- the installation and execution of a hydraulic test of 8 bars.

The images below,Figure 3, present a new repair technology of a spiral heat exchanger. Suggestive images are presented, with the above-mentioned phases. The use of the new technology made possible to repair this type of flaw-multiple flaws disposed on the entire diameter of the spiral and located in the centre of the exchanger.

4.Conclusions

The new technology proposed in this paper makes it possible to repair multiple defects arranged on the entire diameter of the central spiral of the heat exchanger.

It has applied a new method of repairing for the exchanger ie from inside to outside intervention, namely the removal of the nucleus and spirals from the centre to the outside and repair flows, avoiding stripping of the large diameter spirals and substantially reducing repair costs.

This new repair technology presents several advantages:

- the exchangers with flaws on the first inner spirals can be repaired without stripping;
- the possibility exchangers repair which presents flaws on the first spirals of the interior without requiring stripping operation;
- the spirals with large diameters having no flaws are not affected,
- reduce welding operations and consequently reducing the numbers of possible flaws, reducing residual stresses and deformations;
- repair or replace usedthe spiral, depending on rate of use found;
- the possibility of repairing all the flaws, regardless of their position on the the spiral surface.

ISSN 2229-5518

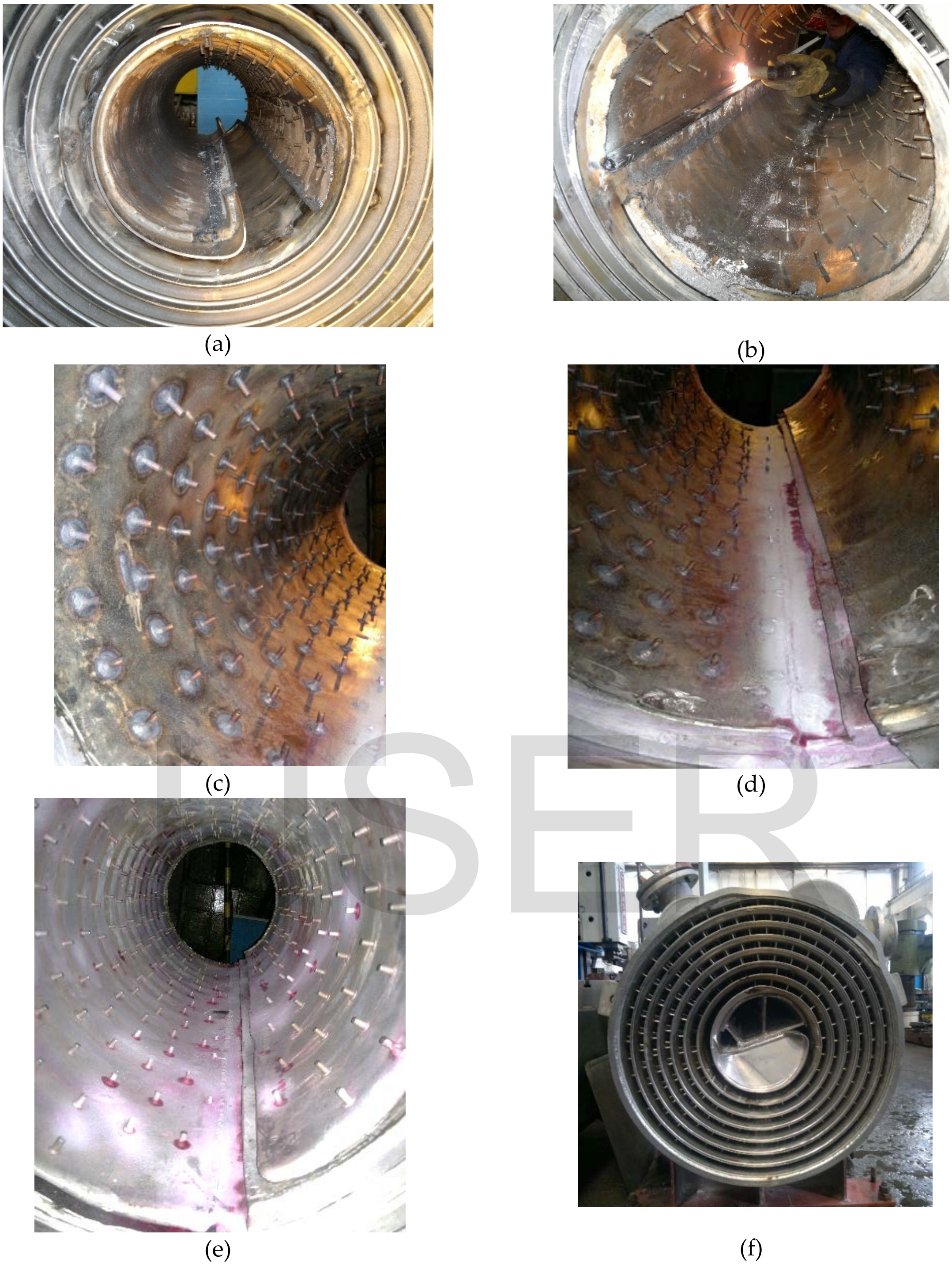

Figure 3: New repair technology of a spiral heat exchanger: a -removing the nucleus; b - elimination of spirals flawsby plasma cutting; c - repair flows by welding; d - penetrant testing along generators; e - local penetrant testing; f - spiral heat exchanger repair.

The new repair method proposed reduce welding operations required, reduce residual stresses and deformations that may occur and lead to a decrease in materials and labor costs by about 40%.

References

1. Kuppan Thulukkanam, Heat exchanger Design Handbook, CRC Press, Taylor&Francis Group, USA, 2013;

2. G. Solomon, Curs de Inginer Sudor Internațional/European IWE/EWE, Cap. 2.16 Oțeluri înalt aliate (inoxidabile), ASR, 2012;
3. Micloși V., ș.a., Bazele proceselor de sudare, Editura Didactică și Pedagogică, București, 1984;
4. G. Gârleanu, Informatizarea si optimizarea proceselor tehnologice Bucuresti 2007, G. Gârleanu, Curs de Proiectarea Constructiilor Sudate – notite de curs 2014
5. G. Gârleanu, Proiectarea Constructiilor Sudate – Note de curs pentru uzul studentilor, 2014
6. Welding handbook, vol.2, 8-th Edition, Welding Processes, American Welding Society, Miami, 1991;
7. G. Zgură, D. Răileanu, L. Scorobetiu, Tehnologia sudării prin topire, Editura didactică și pedagogică, București, 1983;
8. D. Dehelean, Sudarea prin topire, Editura Sudură, Timișoara, 1997;
9. D. Dehelean, Curs de Inginer Sudor Internațional/European IWE/EWE, Cap. 1.7 Sudarea WIG, ASR, 2012;
10. Roșca Radu, Elemente de mecanica fluidelor și acționări hidraulice, Editura ”Ion Ionescu de la Brad”, Iași, 2015;
11. Iulian Florescu, Mecanica fluidelor – Note de curs pentru uzul studenților, Editura Alma Mater, Bacău, 2007;
12. Forchhammer, P., Results of damage research on corrosion failures in heat exchangers, Heat Transfer Eng., 1984;
13. Syrett, B. C. and Coit, R. L., Causes and prevention of power plant condenser tube failures, 1983;
14. Luchian, Cornelia; Nitoi, Dan Florin; Dumitrache, Florea; Borda, Claudia; Experimental and Theoretical Researches Regarding Ultrasonic Welding Process Optimization of the Polymeric Matrix Composite Materials. MATERIALE PLASTICE, 46 (3), pp. 327-335, 2009. ISSN0025-5289
15. Arsene Delicia, Popovici Victor, Borda Claudia, Marinela Marinescu, Angela Mincă, Larisa Buţu *"Morphological fields and there influence on the technological forms"*,the 12th International Conference of Nonconventional Technologies – ICNcT 2005, November 3-4, 2005, Bucharest, Romania.
16. www.slideshare.net/assalihi/heat-transfer-heat-exchangers Heat Transfer and Heat Exchangers;
17. www.fronius.com, Focus on welding;
18. www.termo.utcluj.ro, Lucrarea 5, Studiul fenomenului de cavitație;