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Possibilities of Carrying out Quality Control of Solder Joints Using the Burst test in the Practice

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***Abstract* – Nowadays, the human is surrounded by numerous things from small simple parts to sophisticated cars, ships, gigantic constructions. More sophisticated parts are composed of simple parts and there are various joining technologies of materials used either by way of dismountable or mountable joints. One of the possibilities of joining various parts together is soldering. High-quality joint is possible to ensure by carrying out quality control. This article is focused on the issue of carrying out quality control in soldering. The introductory part of the article describes the basic problems of the area of solder connections with consequent characteristic of non-destructive quality control - visual inspection. The second part of the article is focused on description of the Burst test of high-pressure oil cooler that was carried out in the practice. The final part of the article provides global evaluation of this test.**

***Keywords* – Solder joints, Quality control, Burst test.**

1. Introduction

According to the definition of STN 05 00400, the soldering is a method of metallurgical joining of metallic and non-metallic parts or molten soldering, with the soldering surfaces of the base materials not melting but merely wetting the solder used. In most cases, a diffusion and dissolution of the bonded area of the base material in the molten solder also occurs. The soldering diagram is presented in the following figure. [1]

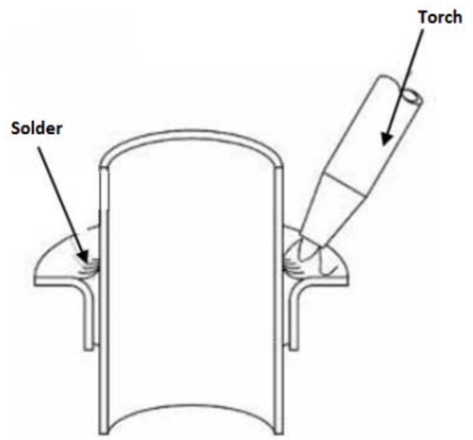

Figure 1. The basic soldering scheme

There are two ways of joining materials by solder: soldering (the temperature of joining materials is lower than 450 °C) and brazing (the joining is carried out by using higher temperature).It is possible to join homogeneous and heterogeneous materials by way of soldering method, not only metallic but also ceramic, materials with different melting temperatures, different expansion and different mechanical properties. [2,3]

The solder joints are specific to high tensile strength, and they are even stronger than solder metals themselves. As with any other technology, this technology of joining materials has several advantages and disadvantages. [4]

The basic advantages of soldering are the following [5]:

- all common metals, glass and ceramics can be joined,
- structural components with large strength differences in walls can be joined,
- soldering temperatures are considerably lower than during welding,

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- solder joints are waterproof and also electrically conductive.

The basic disadvantages of soldering are the following [5]:

- in the case of soft soldering, only small joint strengths are achieved,
- solder joints are corrosive to attack - due to different solder and base material (potential differences),
- due to the low tolerances on joints between materials, a workpiece preparation must be accurate,
- it is necessary to use the protective gas or flux.

2. Quality control of solder joints in the practice – non-destructive test

One of the most commonly used methods of quality control of the solder joints through the non-destructive testing is a visual inspection. By way of this method, it is possible to realize the quick consideration of a join quality. More sophisticated conventional method such as radiography and ultrasound inspection can be used for testing the capillary soldering method. [6,7] Quality of joined special parts (such as ribbed structures) can be verified by the thermal-transfer tests. If the quality control is carried out before an assembly with orientation to the cleanness of the parts it is possible in this way to quickly eliminate serious faults in soldering. In the following table, there are presented several defects and their probable causes.

Table 1. Several defects and their probable causes

Defects	Causes
Broken or non-homogenous joint between surfaces	Temperature was not homogeneous The jointed parts have been shifted during the soldering process
Joint is too soft	Soldering temperature is too low Time at the soldering temperature was too short
Joint is too hard / fragile	The joining material liquefied at low temperature for an extended time
Porous joint	Excretion of gaseous form of additive metal hydrogen
There are gaps in the joint	Insufficient contact of the soldering surfaces The flow of the soldering material was interrupted due to the contamination
An oversized gap in the joint	Absence of flux or inadequate flux density Significant contamination of the soldering surface (oil, dirt, residual oxide)
Falling joining material	Insufficient temperature Insufficient cleanliness Insufficient flux application
The solder joint is under dimensioned	Insufficient value of the joining material (w %) Insufficient temperature of soldering or tenacity at the soldering temperatures (Figure 2.) Vibration in soldering Lack of Flux Insufficient cleanliness Low soldering temperatures or a relatively long service life at soldering temperatures to reduce the joining material
The joint is cracked / open	Insufficient contact between soldering surfaces (non-compliance of the soldering object with the frame – fixation) Incomplete soldering temperature or imperfect brazing process after the soldering
Joining material below expected height	Vibrations during the soldering Non-homogeneous temperature Dirt or absence of flux

In the following figures (Figure 2. and Figure 3.) there are presented examples of possible causes of the defects in the solder joints from the practice – application of visual inspection.

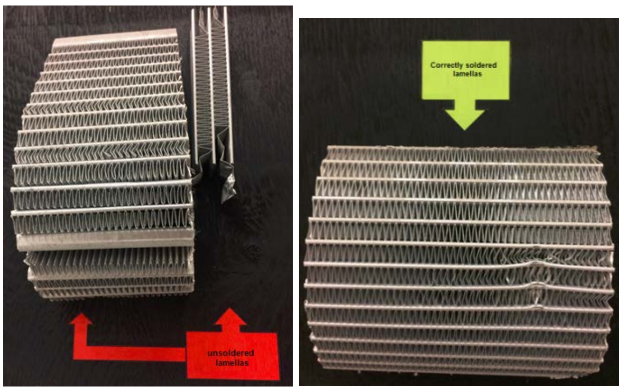

Figure 2. Unachieved soldering tenacity on the lamella section

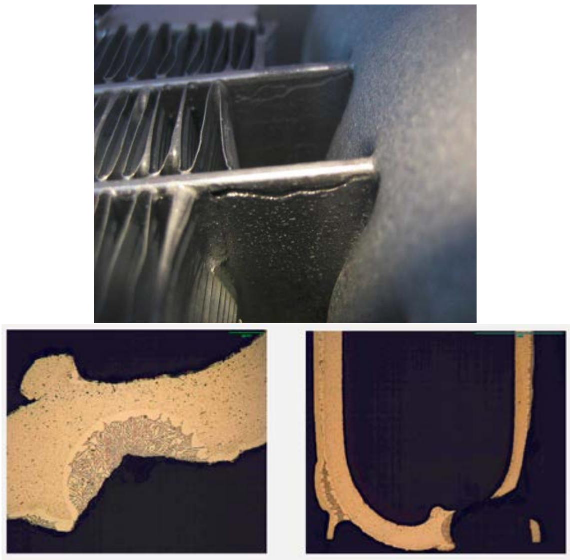

Figure 3. Exceeding temperature / low flux concentration at the edge of the exchanger

3. Quality control of solder joints in the practice – the Burst test

The Burst test can be included in the basic destructive tests of the solder joints. It can be characterized as a solder complex tenacity test. The purpose of this test is to draw a conclusion that the tested product is able to resist the maximum pressure that compels it in the operating conditions of the complex. Elements with a certain error are selected for the tests that could not be used in production or would have to be repaired (too large pieces, pieces with damaged lamellas or sideplate, etc.). Damage must always be assessed - pieces with damage that affect soldering quality (oil-contaminated, etc.) must not be tested. The one of the exceptions is an intentional testing of the impact of such damage on overall strength.

A sampling of testing sample is focused on the high-pressure oil cooler with a high height (140 mm or 160 mm). The reason for sampling is their sensitivity to poor soldering in an operation (there are significant pressure pulses in the oil circuit - in extreme cases up to 150 bar).

Apart from regular tests there are often special requirements for performing the special test where the proper functioning of the soldering is not already verified but the impact of certain factors on a product quality is being investigated (for example cooler soldering up to 2 days after influx, coolers contaminated with oils, the impact of some injuries, etc.). These tests are carried out in addition to the regular production tests and they are processed in a specific way.

Before carrying out the test, it is necessary to do the leak test of the sample. This test is used to verify that the element has been properly welded and that there are no pores causing leakage in the welds - checking the possibility of sample pressure during the Burst test.

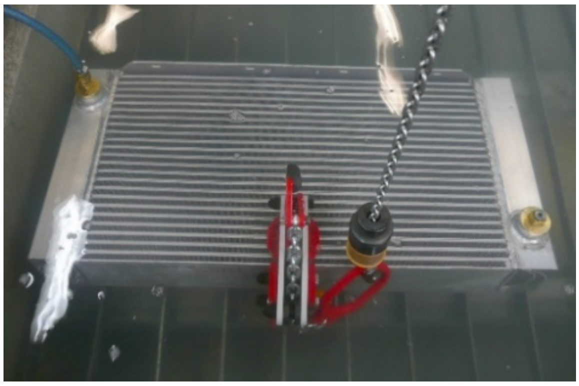

Figure 4. Pressurization of cooler

Figure 5. Test station (left) and cooler connection (right)

The Hydac software gradually increases the air pressure that is delivered to the pneumatic-hydraulic pump. The water pressure in the cooler will increase to the point at which the weakest element on the cooler breaks.

After breaking the weakest element on the cooler, the air intake to the pump is closed (water is stopped in the cooler) to check if the pressure in the cooler (Hydac display) is fully released. Subsequently, the cooler from the test station is disconnected and the necessary data are recorded.

In some cases, it is necessary to document the leakage of the water from the pressurized cooler (especially if the cooler does not tear, but only to create a crack through which water leaks - most often when the tube is pulled out or the weld breaks partially). In this case, the water is not pumped into the cooler immediately after the crack is formed, but the leak itself is first documented.

4. Results of the Burst test

After the carried out Burst test, all of the required data were documented. Through the air flow, all the contact surfaces of the radiator were dried and the production order number of the element + the maximum pressure reached in the cooler was re-written.

After the test is complete, it is also necessary to dry and mark the tear on the cooler and its surrounding. Also the locations on the cooler to be cut for breaking test and acid welding test can be marked.

From the carried out test, the following data were documented:

- Water leakage from the cooler through the rift

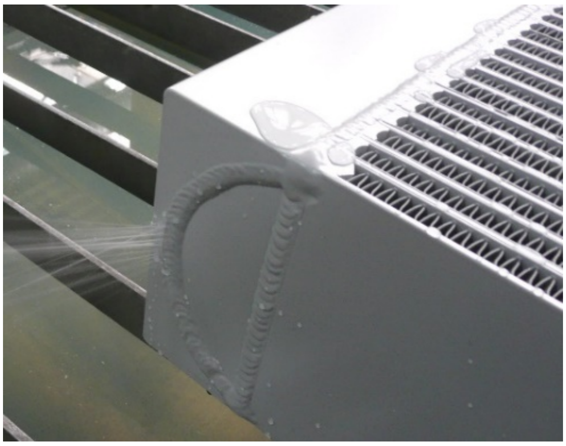

Figure 6. Water leakage from the cooler after the carrying out the Burst test

- Maximum pressure achieved in the cooler – record from the Hydac scanner

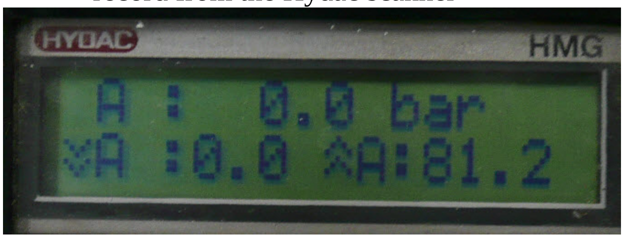

Figure 7. Maximum pressure in the cooler

- Marker of the weakest position in the cooler – the weakest position, production order and maximum pressure were marked

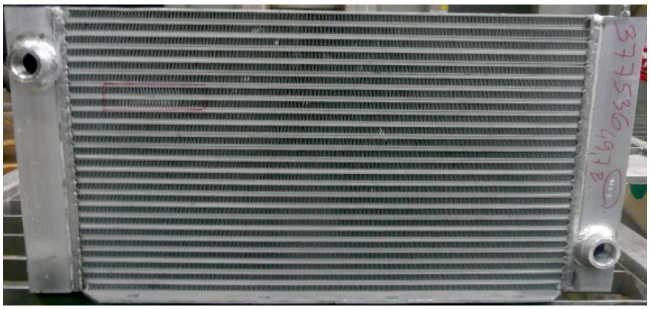

Figure 8. Marker of the weakest position in the cooler

- Stamping of the production batch of element - it is also necessary to document the production batch number of the element for subsequent data completion. In addition to this number, it is also necessary to take out additional symbols, which must also be visible.

Figure 9. Stamping of the production batch of element

- Shape of the pressure curve during the Burst test – in the following figure is presented the shape of the pressure curve that clearly determines the pressure value at which the cooler has occurred.

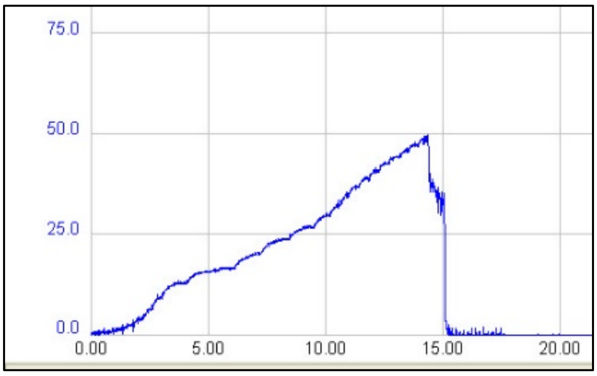

Figure 10. Shape of the pressure curve

- Marking the damages in the cooler – after the test is done, it is also necessary to document the anomalies - damages caused to the cooler.

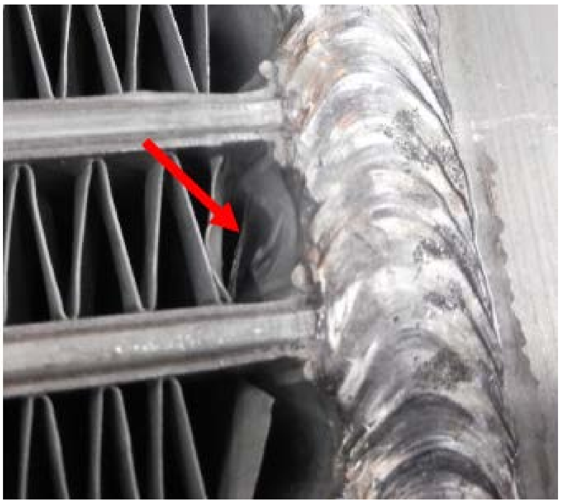

Figure 11. Damage of the cooler

- The Burst test was carried out in several batches. The example of the results is presented in the following figure.

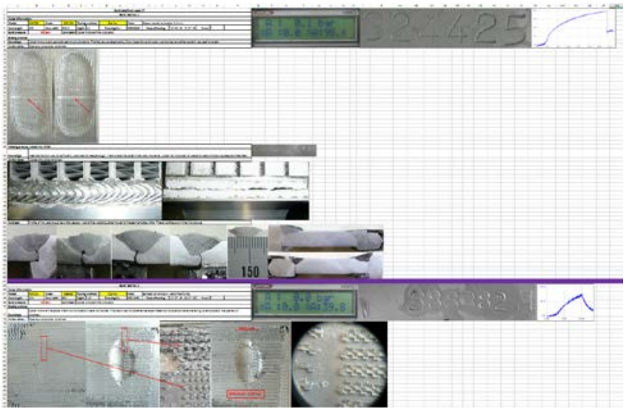

Figure 12. Results of the Burst test

For the need to investigate the soldering failure points, it is necessary to cut the test units further. From the test units, the following sections were cut out:

- the weakest place on the elements (depends on the design and parameters of the cooler)
- fracture test sample (one standard, if necessary more); for the sample it is necessary to ensure a cutting width of at least 5 tubing

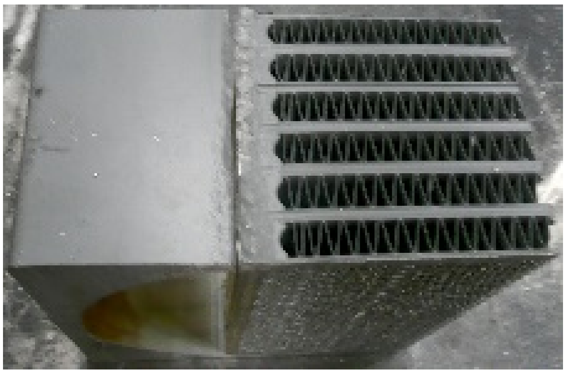

Figure 13. Fracture test sample

- Sample for the acidic test (one standard, if necessary even more), the cut is realized through two adjacent tubes

Figure 14. Sample for the acidic test

5. Conclusion

The purpose of the Burst test or the test of the soldering complex's durability test, results in a conclusion that the product can withstand the maximum pressure that is compelled by the operating conditions. On the basis of the experiments, it was found that the two samples were damaged at 39.8 bar and 50.0 bar. Due to the condition that the cooler has a minimum value of 80 bar for a few seconds, these two samples have been identified as unsatisfactory. Other products can be considered approved because they have been able to maintain the prescribed pressure.

Acknowledgements

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