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IMPROVING THE TECHNOLOGICAL WELDING PROCESS IN THE CONDITIONS OF SUSTAINABLE DEVELOPMENT

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Rezumat. *În condiţiile actuale ale cerinţelor dezvoltării sustenabile, este importanta evaluarea activităţilor companiilor din industrie. Această evaluare este importantă din perspectiva îmbunătății impactului organizatiilor asupra mediului înconjurător. Primul pas spre îmbunătățirea amprentei organizaționale asupra mediului înconjurător este înlocuirea procesului de îmbinare lipire flacăra* cu lipirea cu laser deoarece cantitatea de *emisii generată de* CO_2 este minimă, *în comparație cu lipirea cu flacăra unde cantitatea de emisii de* CO_2 *este mult mai mare. Sunt prezentate o serie de implicaţii teoretice care stau la baza prezentării unui studiu de caz care a fost realizat într*-o *companiei din industria automotive. În final sunt prezentate o serie de activităţi de management care contribuie la îmbunătățirea amprentei organizaționale de* CO_2.

Abstract. *In the current conditions of sustainable development requirements, it is important to evaluate the activities of companies in the industry. This assessment is important from the perspective of improving the impact of organizations on the environment. The first step towards improving the organizational footprint on the environment is to replace the process of joining flame bonding with laser bonding because the amount of* CO_2 *emissions generated is minimal, compared to flame bonding where the amount of* CO_2 *emissions is much higher. A series of theoretical implications are presented that underlie the presentation of a case study that was conducted in a company in the automotive industry. Finally, a series of management activities are presented that contribute to the improvement of the organizational footprint of* CO_2.

Keywords: organizational process, sustainable development, CO_2 footprint, environment, soldering process, process improvement.

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1. Introduction

Companies invest resources for the development of technological processes in accordance with the current requirements of the business environment and with the requirements of customers. In terms of soldering processes, many companies in the automotive industry are replacing the old flame soldering process with the laser welding process [1]. Activities to improve the technological process of

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soldering automatically involve a reduction of costs in the business environment, this being a very important point for the company [2]. It is found that the laser soldering process brings both a minimization of costs and a total reduction of carbon dioxide [1].

This type of welding is done with the help of a high energy laser beam to melt the material in the joint area between the two parts. Laser bonding has been used for some time in the steel industry, and with the help of new generations of laser sources, this process is also compatible to process aluminium. Beam switches and power dividers allow the operation of up to four working cells with a single laser source, unproductive times being reduced and laser use will increase [3].

The paper is structured in two important directions. The first direction of research is the qualitative evaluation of the literature to identify the advantages, benefits and other aspects of the laser bonding process in the context of sustainable development and the reduction of the amount generated by CO_2. The second direction is to evaluate a laser soldering process within a major company and to propose a series of improvements following the identified defects. At the end of the paper a series of conclusions are presented.

2. Aspects of replacing the technological process of flame soldering with the laser soldering process

The flame bonding process generates a considerable amount of CO_2, which in the current conditions of sustainability is a major minus [3]. In this sense, the following are a series of directions regarding the improvement of the soldering process within the enterprises. If we evaluate laser welding compared to traditional welding, there are a number of advantages [3-7] such as:

- the tools will not be worn, the processing is done without contact
- various materials and different thicknesses of materials can be welded
- conversion to automatic operation is easy
- welding speed is higher compared to flame soldering or other conventional soldering
- high quality of the welding seam, which reduces the need to redo the steps
- low influence of thermal materials
- power supply adjustable
- safe operation taking into account different working conditions
- the use of this type of welding presents the possibility of customizing the requirements

- simultaneous operation at different machines or at different welding points
- optimized nozzle geometries to provide the best application results
- possibility of quality monitoring, documentation of process data and other information.

The benefits of laser soldering [4-8] are numerous, and among them are: in terms of quality the benefit is the stability of the process; in terms of processing time, the process is highly automated; from the point of view of the material, 3 mm will be exempted from each welded tube.

Within this process, a series of risks can appear. These include: the risk of "overkill" means using a very modern technology but complex solutions for very simple applications; risk control by step-by-step communication with the supplier; market research risks to identify all existing solutions; "No future" risk means the development of the project without covering the trends of the air conditioning system; the risk of "laser misuse" means that the laser source is not used at full capacity [7].

From the perspective of risk control, the following activities can be adopted: control, consultation with specialists within the company, identification of the trend on the air conditioning piping market, transparent communication to the supplier; performing the complete calculation of the process for the best design of the laser welding cell [6]. From the perspective of the aluminum properties used in the soldering process, there are a number of approaches in the literature [3-7].

The porosity of hydrogen can be avoided by using a suitable shielding gas during soldering, so that the aluminum will be kept clean and dry and temperature fluctuations leading to condensation will be avoided [6]. Welding of the porosity may occur due to the presence of moisture or contaminants given that the surface of the aluminum oxide is porous. This is especially true for magnesium-containing alloys, as magnesium aluminum oxide is easily hydrated. In most cases, alcohol is used to clean the parts. The addition of manganese to aluminum somewhat increases its strength and improves the response to hardening efforts, while greatly reducing corrosion resistance. All these alloys are weldable and are not prone to hot cracking [5-8].

Laser bonding uses the energy of a laser beam produced by a source and managed by automation to melt the two materials locally [7].

3. Evaluation of laser soldering at a company in the automotive industry

The evaluation of the laser soldering was performed at an automotive company. The old flame bonding process is performed by simultaneously heating both sides to be joined together with a filling alloy and a chemical component with the role of breaking the aluminum oxide layer. That filling material has a melting point 40 degrees lower than the temperatures of the base materials of the two components to be joined.

The first series of tests were held in Hamburg, at one of the company's work points when the following were registered:

- the tubes with a diameter of 10 and 18 mm were welded to different connectors;
- the external appearance of the weld was very good, there were no pores inside the weld and all parts of the tube had a 100% green result in the helium test.
- in the stress test of the efficiency, the parts presented a specific breaking area, being exposed a weakness regarding the overlap of the welding seam.

Two possible reasons that have been identified for this deficiency, which are the following:

- the fixing bodies on which the connectors were mounted
- overheating of the material in the overlap of the seam which led to a fragile structure

The results of the first test were carefully analyzed and in the second set of tests 200 tube connectors were welded, under 10 sets of parameters. Following the second test, the following results are found:

- the parts made in the second attempt showed better results in the yield strength test, this fact emphasizing the importance of the parameters and devices used in the process.
- after the helium test which came out 100% in order, and after the yield strength test, the parts are prepared for the pressure impulse test, the vibration test and the salinity test.

Also, laser welding is a technological process that uses the concentrated energy of a laser beam to melt the contact area between the two parts to be joined. After cooling this molten area, the two parts are joined, see Figure 1.

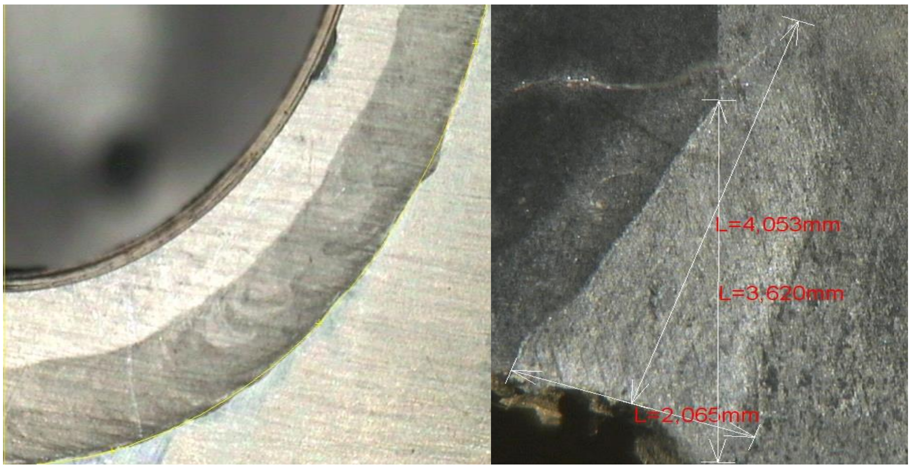

Fig. 1. The technological process of laser soldering

The tests performed for this new soldering process are performed following the test specifications available for car air conditioning lines, regarding the standard TL 82316. As a result, the following are performed: leakage test in the helium chamber, various stress tests to observe how the welded part reacts, the possible ruptures and the place where they break, salinity specific tests and air condition specific tests.

Leak tests are performed as follows: test environment: helium (it is tested under water and then the product is placed in a standard drain machine), pressure test: the test is performed at 40 Bar and the test time under pressure is for 20 seconds.

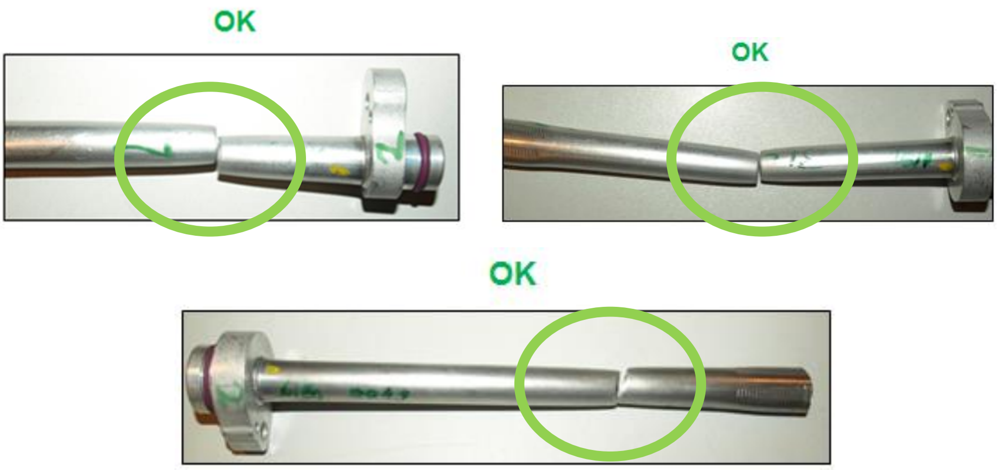

Fig. 2. Breaking points

In Figure 2 it can be seen that the breaking points of each tested part are due to the tube. Hence the fact that the soldering was performed successfully, not being the main cause in breaking the tube.

In order to achieve a reliable welding process of the tube where the valve body is found, with ideal quality results, the tube was pressed to obtain a 2D plan in which they are to be welded.

Figure 3 is made before laser welding, and in Figure 4 it can be seen that the deformation of the tube was done correctly after welding.

Fig. 3. The tube before welding

Fig. 4. The tube after welding

After all the tests, the results were successful and the quality of the products was closely related to the geometry and appearance of the joint. Based on these requirements, a unique series production installation has been established together with the suppliers, which is the only one of its kind in the entire air conditioning segment.

4. Proposals to improve the soldering process

Evaluating the gluing process on certain parts, various leaks were identified. A leak in the weld was identified as shown in Figure 5.

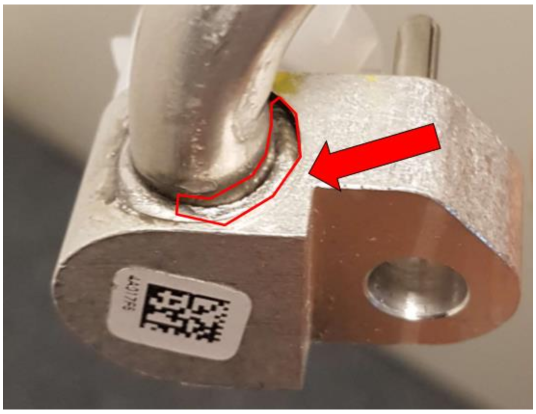

Fig. 5. Leakage identified at the glued point

The steps followed to identify this case were: information for the client, pipe identification, visual inspection of the pipe, tightness test and identification of causes through brainstorming meetings.

The claimed KM pipes are AC.0010.0830.0100T (according to the helium label). The helium label confirms that the pipe was tightened before delivery.

Fig. 6. The identified pipe

The visual inspection of the pipeline was performed. The gap between the nozzle and the pipe is filled with solder material. The leak was identified in the solder seam as seen in Figure 7.

Fig. 7. The drain point

The tightness test was performed. To test the tightness of the pipe, the pipe was tested in a helium chamber. It was found that the piping had leaks, see Figure 8.

Fig. 8. Identification of the leakage point

It was found that during the helium test the pipe had leaks. The pipe was leaking due to the fact that the soldering was not done correctly.

A microscopic analysis was performed. The connecting piece was examined near the sand leak, and part was cut and analyzed under a microscope; it was observed that the distance between the nozzle and the pipe is filled with soldering material; the upper area lacked the soldering material. As such, this is due to the fact that the connecting piece has not been heated evenly.

The causes of the occurrence were also evaluated. The solder seam is missing between the connecting piece and the pipe, this is partly due to the setting of the machine. While the machine is adjusted, the flames are adjusted until the connecting piece and the pipe heat up immediately so that the soldering ring melts and the space between the pipe and the connecting piece can be completely filled. Due to the fact that temperature monitoring at the melting point is not possible, several parts are used until the correct setting of the machine is reached.

The setting instructions have been made in more detail to accommodate the adjustments made, to facilitate the configuration of the machine and to reduce the parts used to adjust the machine. The following were evaluated: the distance between the flame and the connecting piece and the positioning of the burners, see Figure 9.

Fig. 9. The current situation

The new working instructions included:

- The distance between the flame and the connecting piece is precisely defined;
- The position of the flame in relation to the connecting piece is presented more explicitly.

Fig. 10. The improved situation

As an estimate after the above analysis, this type of error is an incomplete solder (the solder layer is too thin) which can open in certain situations (for example in a product handling situation, the part can come off cause of this incomplete soldering).

Conclusions

This air conditioning production company, ready to deliver suction lines with laser welded valve bodies, has taken a precaution in developing and industrializing the process. As such, the series production offers the same quality aspect as those from the laboratory tests that are approved.

This paper identified that the flame welding process is one that generates too much CO_2, so in the current environmental conditions, new solutions must be identified that reduce the negative impact of businesses on the environment. The analyzed case study contributed to the improvement of the conditions in the welding process and proposed the two improvements that the company currently uses: precisely defining the distance between the flame and the connecting piece and explaining the position of the flame in relation to the connecting piece.

As a limitation of the case study presented, it was not possible to determine an indication of a fundamentally incorrect execution of the soldering process or of a dimensional deviation of the parts to be joined.

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