

THE MODELING OF THE ULTRASONIC WELDING PROCESS OF THE AIRBAG'S SEALING ELEMENTS

Elena Stela Muncut [1], Aurelia Tanasoiu[2] and Valentin Muller[3]
[1] A University "Aurel Vlaicu" of Arad, B-dul Revoluţiei Nr. 77, 310130, România. P. O. BOX 2/158 AR, muncutstela@yahoo.com
[2] A University "Aurel Vlaicu" of Arad, B-dul Revoluţiei Nr. 77, România. P. O. BOX 2/158 AR, aurelia.tanasoiu@gmail.com
[31] A University "Aurel Vlaicu" of Arad, B-dul Revoluţiei Nr. 77, România. P. O. BOX 2/158 AR, valentinmuller7@yahoo.com

ABSTRACT: The paper presents the design of ultrasonic welding equipment that replaces two equipment with heater elements. The purpose of making the equipment besides increasing productivity is the significant increase in quality. The equipment was designed using industrial electronic components available on the market and aluminum profiles. The new part is the clamping device of the piece and the sonotrode control program. Finally, two welded pieces are presented comparing the two methods and the obtained parameters after the optimization. Developing the equipment and the quality of the sonotrode is very important. This is the key element of the equipment.

KEYWORDS: ultrasound, dissimilar materials, welding parameters, aluminum profiles

1. INTRODUCTION

The aim of the work is to present a study of the design and modeling of ultrasonic welding installations in SOLIDWORK destined to replace two welding installations with heating elements used for the airbag sealing. The joint is done between two dissimilar materials steel and polyethylene.

The ultrasonic welding is carried out in the solid state, which gives a number of advantages as compared with conventional welding methods such as low residual stress, an increased tensile strength of the joint, and lack of deformation. Also, results lack of porosity and cracks due to melting [1].

The ultrasounds are sound vibrations with frequencies higher than 20.000 Hz. In the moment of impact of the ultrasound with the material the ultrasonic energy is absorbed and creates a localized heating resulting a temperature higher than the recrystallization temperature. At the same time, there is a growth of deformability and ease the process of plastic deformation of the material, and the destruction and removal of oxide layers, removing gas from the material's surface [2].

As a result of viscous flow, of volume self-diffusion and of surface tension a redistribution of solid material in the contact area are produced and, as effect, a welded joint result, [3].

The ultrasonic welding is performed without filler. With this process, you can perform the following types of welded joints: butt welds and overlap weld in points or in line, [4-6].

1.1 Presentation of the production line facility with heating element which has been replaced

The equipment with heating element consisting of: support for mounting and fastening the piece, the cylinder for advance of the welding head with the thermal resistance, which ensures the longitudinal movement, and a pneumatic cylinder for positioning the head with transverse motion which ensures the discharge pressure (blue hose), as shown in figure 1.

The piece in the device is driving with a locking device, which is controlled by a pneumatic cylinder independently of the welding phase.

The welding head (Figure 2) has the following (hot-cold) rectangular pulse working cycle: there are seven cycles of which 6 are welding cycles and the last is a heating cycle in order to be able to withdraw the welding head;

The making of a welding joints lasts 90 seconds; The range of temperature is between 1600-1750^{0}C, this temperature is determined by the nature of the plastic material to be welded.

Figure 1. The equipment of thermal resistance welding

Figure 2. Welding head

The control of the equipment is done by a computer system through a specialized program for controlling pneumatic devices (cylinders);

The pulse regime is assured through a specialized program which is intended to introduce: the type of material, the thickness of the welded material, the temperature and time for the welding impulse, the basic impulse respectively. By adding the base time + welding time and the temperature the technological welding. parameters are controlled.

2. ULTRASONIC WELDING EQUIPMENT

The ultrasonic welding equipment has the following components: a high frequency generator - provides the energy necessary for welding; the ultrasonic system (unit) - converts the electrical energy into high frequency vibrating mechanical energy and forwards it to the welding place; a device for securing and moving the welding components (at inline welding); an application system for pressing force; a programmer of the welding process.

The composition of an ultrasonic system is illustrated in Figure 3.

Figure 3. Ultrasonic welding equipment

The ultrasonic block includes: a transmitter - converts electrical energy into mechanical high frequency vibrating energy; waveguide - coupling system; sonotrode.

The magnetostrictive ultrasonic transducer can be made of very hard nickel alloy;

There is a main board on which are mounted all peripherals and components. The main control of the device is on an external panel and is electronically controlled by PLC (Programmable Logic Controller).

The table consists of duralumin ITEM profiles (figure 4), of 40x40 and 80x80 sizes with associated brackets. This table is comprised of two columns and a beam for stiffening the whole equipment.

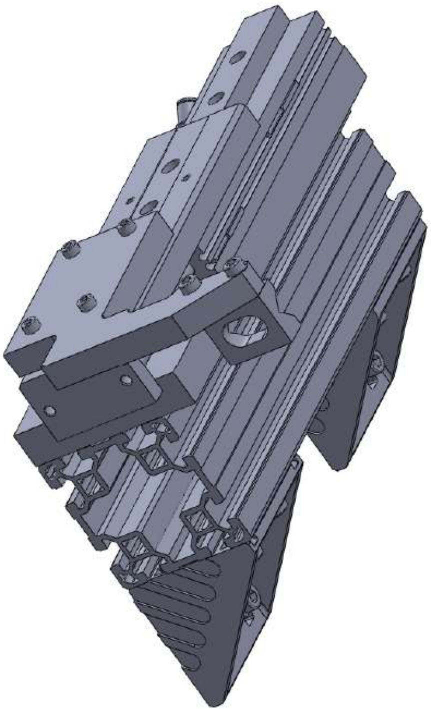

Figure 4. Duraluminiu ITEM profiles

There is also an intermediate plate located immediately above the main plate, which serves for positioning and adjustment of the entire welding device by means of special adjustment and locking screws. This plate serves for positioning of the individual welding device, without affecting the adjustment of the auxiliary positioning cylinders of the workpiece to be welded. The MXC pneumatic cylinder is mounted on the intermediate plate together with the electronic control for the main panel.

This cylinder drives the sonotrode during the welding. This is the most important subassembly. On this frame, there are mounted two guide columns which assure the positioning of the sonotrode cyclic at the same point of the welding by means of a cylinder (Figure 5).

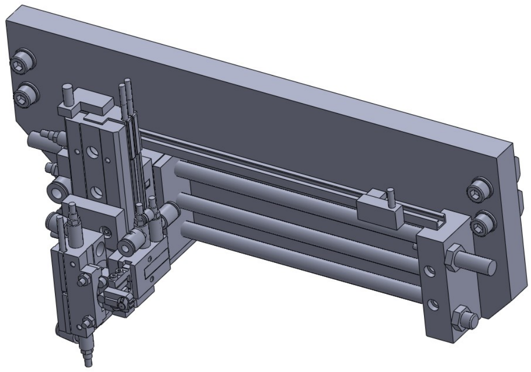

Figure 5. The sonotrode drive cylinder

The equipment designed for the optimization of production is composed of a number of 72 components (Figure 6). Here just the main components are presented (Figure 7 and 8). The machine has a table on which all the components are mounted.

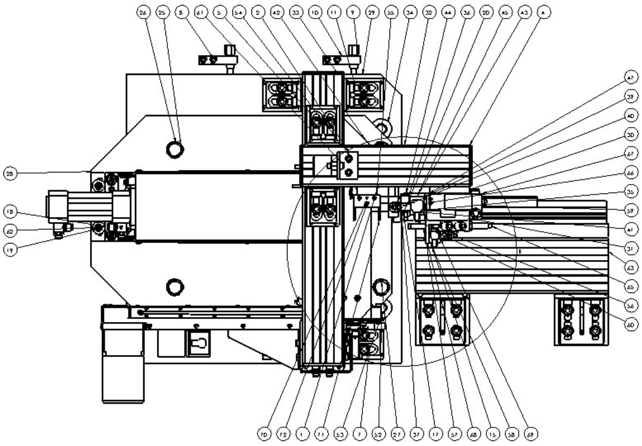

Figure 6. Structure of the machine

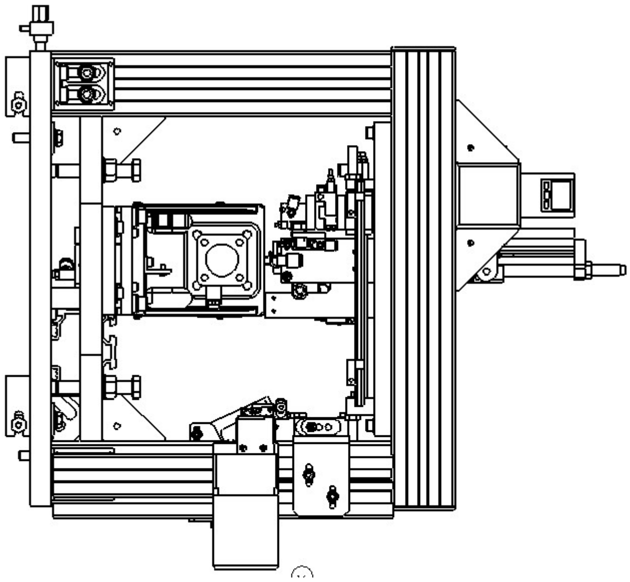

Figure 8. Top view of the machine

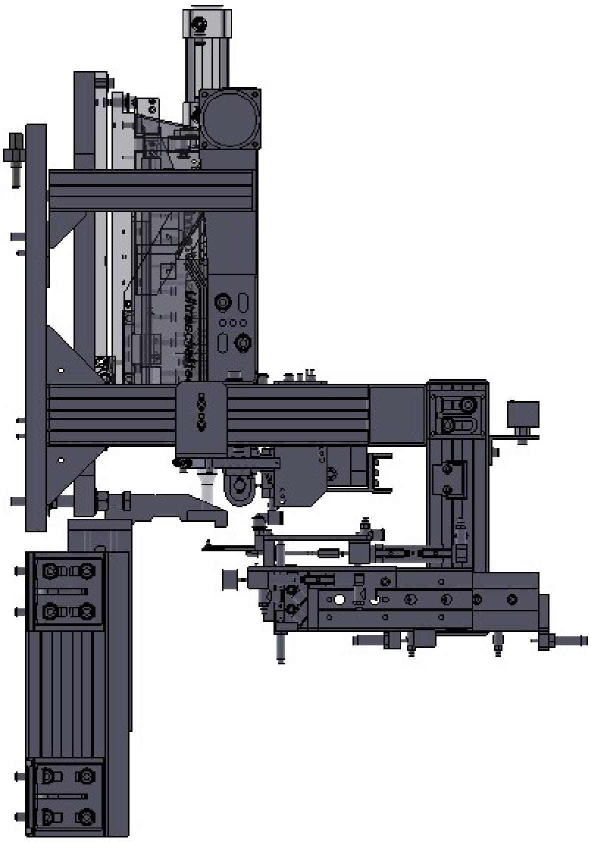

Figure 7. The view from the side of the machine

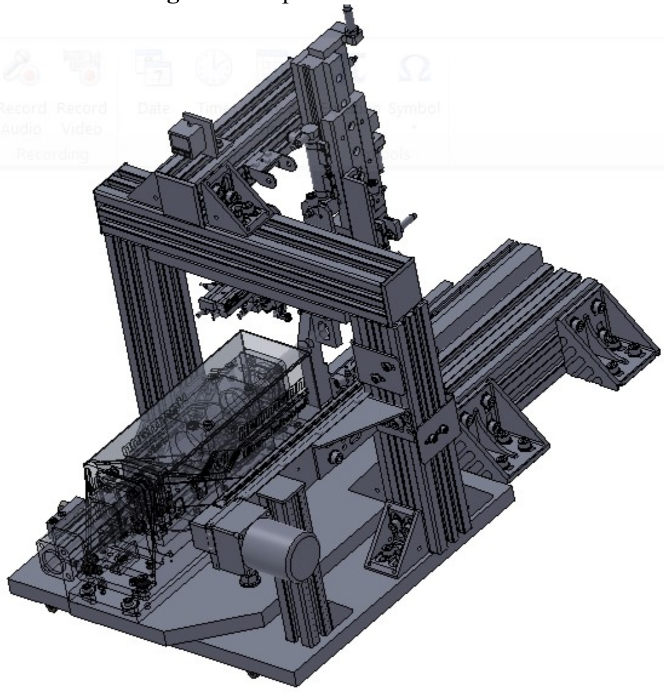

Figure 9. The ultrasonic welding equipment isometric

One of the key checks performed visually after joining is the position of the point which must be located in the centre of the piece.

The Herrmann type sonotrode, is protected by a fairing which prevents accidental touch of the components by the operator. While working, the sonotrode has a cyclical movement. There are two auxiliary pneumatic cylinders too that have a role in controlling the positioning of the workpiece during welding. This device blocks any movement of the workpiece in the moment of welding.

These cylinders have on the piston a metal pad which activate a magnetic sensor, to communicate to PLC the position of the cylinders to sense the incompleteness of the sonotrode's track.

All components of the equipment are drawn in the assembly drawing.
The joint is a steel - polyethylene dissimilar joint a type of joint unachievable by conventional methods.

2.1 Working parameters

The power supply from AC single phase industrial network, 220V / 50Hz. The power is being under 4000 W so there are no connection problems.

The resulted parameters of the study were as follows (Figure 10):

- The welding current time range between 1,030 - 1,156s;
- The base current time 1.00 s;
- The discharge force 400-450 N;
- The maximum power 493W - 515W;
- Frequency 35268 Hz and 35189Hz;
- The welding speed 1.79 mm / s and 1.77 mm / s.

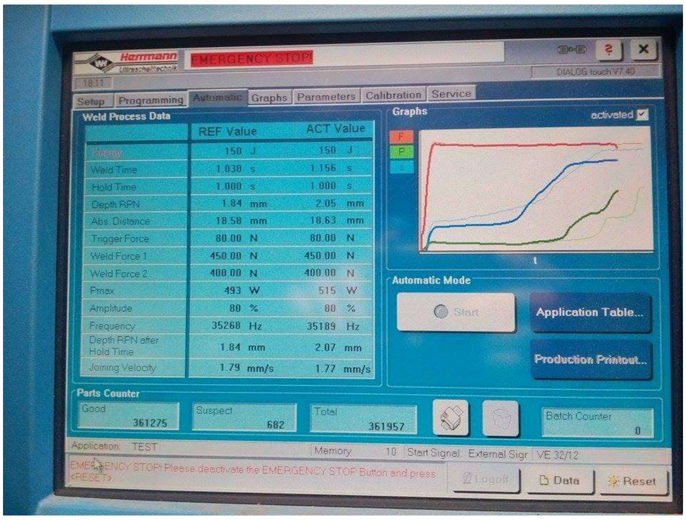

Figure 10. Welding parameters

Inside the welded material under normal atmospheric environment (pressure 1 atm and temperature 20^0C) the temperature increases, the material is crystallized by the annealing effect and the hardness decreases.

The metallographic analyses show the presence of an intermediate layer of about 1 μm and the formation of diffusion and reaction layers.

3. COMPARISON BETWEEN THE ULTRASONIC WELDING AND THE WELDING WITH HEATING ELEMENT

The joint is a dissimilar steel – plastic joint, a merge that's unachievable by conventional methods. The figure 11 presents a merge without defect. This joint does not accept defects (pores, cracks, shrinkage faults, etc.)

Figure 11. Dissimilar steel-plastic joint without defect

On figure 12 a joint can be seen made with heater element. The surface is rough and has shrinkage on the side-line. When the parameters are set, a breaking test is performed according to the previous paragraph.

Figure 12. Defective dissimilar steel - plastic joint

Further describing the plant at the time of the fixture onto the device, as shown in Figure 12. One very important thing is the laser sensor which acts to determine the existence of these two elements in the welding area, Figure 13. The lack of an element may lead to the destruction of sonotrod.

Figure 13. The workpiece clamping device - top view without the workpiece

As shown in Figure 11, 12 and 13 of the mechanical point of view, there are the following steps:

- Releasing the fastener
- Insertion of the components
- Execution of the joint with ultrasound

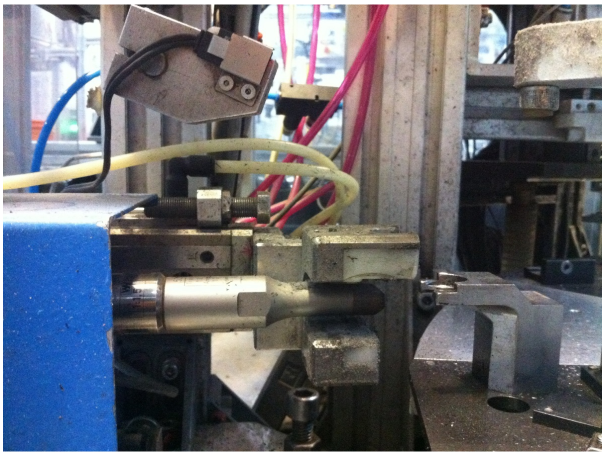

Figure 14. The welded joint when it's ready.

Finally, a random sample breaking test is performed

4. CONCLUSIONS

As a final conclusion, the equipment has two directions of individual adjustment:

- One of the sonotrode with the corresponding actuating cylinder;
- And the second of positioning fastening and locking the piece on which the thermovalve is mounted by ultrasonic welding.

The ultrasonic welding of plastics creates a molecular bond in the weld seam. Higher than 35 kHz longitudinal vibration frequencies with amplitudes between 5 mm and 50 µm are introduced into plastics. The ultrasonic vibrations are focused by special design of components or materials. This specific geometry in a component is referred to as energy director. The contact points of the joint are shaped actively through energy consumption to achieve an elastic deformation. Rubbing the contact points of the surfaces of materials makes the molecules chain of the material to generate heat and thus the material melts.

5. REFERENCES

1. Shin-ichi Matsuoka, Hisashi Imai, Direct welding of different metals used ultrasonic vibration, Journal of materials processing technology 209 (2009), pp 954-960.
2. H. Bisadi, A. Tavakoli, M. Tour Sangsaraki, K. Tour Sangsaraki. The influences of rotational and welding speeds on microstructures and mechanical properties of friction stir welded Al5083 and commercially pure copper sheets lap joints, Materials and Design 43 (2013), pp 80–88.
3. D. Savu, Procedee de îmbinare a materialelor plastice, Procedeul de sudare cu ultrasunete, Curs de Inginer Sudor Internațional/European IWE/EWE, 2012, pp 1-26.
4. GH. AMZA, M. A. BĂLĂCEANU, C. AMZA, Cercetări teoretice prin metode de simulare matematică a procesului de sudare cu ultrasunete a unor discuri piezoceramice, The 4th International Conference – Innovative technologies for joining advanced materials.
5. E. Muncut, A.Perianu,D.Glavan,Ghe.Sima, Structural Analysis for Joining Dissimilar Thin Sheets with CMT (Cold Metal Transfer) Process, Structural Integrity of Welded Structures XI 03-05.06.2015, Advanced Materials Research ISSN 1022-6680, volume 1111, pp. 49-55.
6. Gh. Sima, R. Lile, D. Glavan, E. Muncut, Management, Traceability and Control ol Industrial Processes, Proceedings of the 6th International Workshop on Soft Computing Applications SOFA 2015, Volume 1, Series: Advances in Intelligent Systems and Computing, Vol. 357, Editors: Valentina E. Balas, Lakhmi C. Jain, Branko Kovačević, Springer Verlag, 2015, ISBN 978-3-319-18415-9 (ARC Cat. C, SCOPUS, ISI Proceedings),
7. Mark V. Brook, Ultrasonic Inspection Technology Development and Search Unit Design: Examples of Practical Applications, ISBN 9781118104781, 02.06.2012
8. C. T. Truong, D.-H. Kang, J.-R. Lee and C. R. FarrarComparative Study of Laser Doppler Vibrometer and Capacitive Air-coupled Transducer for Ultrasonic Propagation Imager and the New Development of an Efficient Ultrasonic Wavenumber Imaging Algorit