Remote monitoring software for induction soldering installation

R S Dremin\textsuperscript{1}, Yu S Bets\textsuperscript{1}, V S Tynchenko\textsuperscript{1,2}, V V Bukhtoyarov\textsuperscript{1,2}, A V Milov\textsuperscript{1}, D V Egorova\textsuperscript{1} and V V Kukartsev\textsuperscript{1,2}

\textsuperscript{1}Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russian Federation
\textsuperscript{2}Siberian Federal University, 79, Svobodny pr., Krasnoyarsk, 660041, Russian Federation

E-mail: roman-dremin@mail.ru, bets96@mail.ru, vadimond@mail.ru

Abstract. In this article, a comparative analysis of the existing software was carried out, a description of the subject area of the developed system was given, existing software tools, such as integrated development environments as Xcode, Xamarin, FireMonkey were analyzed. As a result of the work, software was developed that made it possible to obtain experiment data, edit and delete experiments, change the parameters of the installations leading to emergencies and lead to the installation of induction soldering automation systems remotely and internally in the existing information infrastructure.

1. Introduction

Nowadays, induction soldering is used in the aerospace industry for the drawing of parts. The application of this method allows the use of waveguide tubes with wall thicknesses from 0.5 mm with flanges up to 7 mm, couplings and angles [1]. However, induction brazing is a complex technological process that requires constant monitoring and timely adjustment of all technological parameters. Based on these requirements, there was a need to create an automated system. These data allow you to measure the power measured in the soldering zone. These systems have improved working conditions and improved working conditions for staff.

However, in the production environment, middle and senior managers can rarely be present at the soldering site, which makes it difficult to make timely decisions on managing the induction brazing process. The creation of a remote monitoring system by installing an induction soldering will allow the technologist and the main welder both to monitor the process under consideration and to make adjustments to its parameters.

2. Theoretical research

Soldering, according to the definition of Russian Standard 17325-79, is the process of forming a compound with interatomic bonds by heating the materials to be connected below their melting point, wetting them with solder, flowing the solder into the gap and then crystallizing it [2].

In turn, induction brazing refers to a type of soldering in which the brazed materials and solder are heated by the heat released in them under the influence of an electromagnetic field.
The use of induction soldering provides the connection of any conductive materials - any metals and alloys, as well as ceramics with metal spraying. In addition, induction soldering allows you to:

- Heat only a specific part of the part.
- Control the soldering process using measuring instruments.
- Reduce human participation in the process.

Owing to this, induction brazing is widely used in such industries as aviation and automobile. Induction heating plants do not have many drawbacks, but they still exist [3]. Let’s highlight the main disadvantages:

- Increased complexity of the equipment, qualified personnel are required for adjustment and repair.
- With poor coordination of the inductor with the workpiece, a greater heating power is required than in the case of applying heating elements, electric arcs and electric heating spirals for the same task.
- A powerful source of electricity is required, which may be absent in the field. In this case, the use of, for example, gas burners is more justified.
- Despite the small size of the inductor, the induction heating unit as a whole is rather bulky and small-sized, and is more suitable for stationary installation in the room than for field work.

Despite the existing disadvantages, induction brazing has many advantages:

- Obtaining uniform results due to the precise dosage of energy transferred to the product.
- The ability to control the action, both with the help of devices, and personally.
- Improvement and improvement of working conditions of workers.
- High speed of heating parts.
- High productivity of the process, provided by the concentration of power in a small volume, especially when using high-frequency currents.
- The possibility of automation and mechanization of work.
- Heating in a protective gas atmosphere, in an oxidizing (or reducing) medium, in a non-conductive liquid, in a vacuum is possible.
- Ease of use due to the small size of the inductor.
- The inductor can be made of a special shape - this will allow uniformly warming up the details of a complex configuration over the entire surface, without leading to warping or local heating.
- Easy automation of equipment and conveyor production lines. The simplicity of controlling the heating and cooling cycles. Simple adjustment and holding of temperature, stabilization of power, supply and removal of workpieces.
- Cheaper process (compared with soldering when heated by gas burners and in electric furnaces) with its high productivity.

In many fields of science and technology, the study of phenomena or processes is possible only through experience or experiment. Experimental studies are the main source of knowledge and a criterion for the truth of theories and hypotheses [4]. Experimental studies require significant financial and resource costs. This forces us to pay great attention to the competent organization of the experiments themselves. The development of a remote-control system allows you to organize experiments anytime, anywhere [5].

Previously, during various studies, automated data storage systems were not used. Records were made manually and there are not rare cases of their loss. Charts for the experiments were made
manually. Over time, such a model for storing experimental data began to be abandoned, giving preference to computers. However, the created systems were incomplete and fragmented. For example, the written programs were not able to interact with each other due to the fact that they were based on different operating systems. Thus, in order to obtain a graph according to the obtained experimental data, it was necessary to manually transfer the results of studies from one application to another. At this stage, there were also cases of loss of results due to their fragmentation of the output data [6].

Thus, the main task of automation is to create a software application with minimal functionality:

- Recording and storage of data with the possibility of their subsequent extraction.
- Reporting on the results of experiments.
- Formation of graphs based on the results of experiments.
- Ability to work remotely.

The main advantages of remote monitoring by induction soldering installation is to increase the quality control of the solder joint, due to the presence of a video camera that allows you to monitor the soldering process in real time, without being directly at the workplace. As regards the control of the induction soldering installation, the user can set the technological parameters before the start of the soldering process, as well as stop the process in case of an emergency [7].

As a means for implementing remote monitoring, the greatest preference is given to the use of smartphones and cellular communications, as they allow you to control the installation of induction soldering, regardless of the user's location.

Figure 1 shows a diagram of the interaction between a smartphone and an experimental stand. The software application for the experimental stand of the system implements the client-server concept of organizing work with the database [8]. Access to the database is through a mobile and local network.

3. Software system development
The study analyzed existing software tools, such as integrated development environments such as Xcode, Xamarin, FireMonkey.

A comparative analysis showed that Xcode is the most suitable option for developing a software application, since this environment has a large number of advantages compared to others.
To develop a software application, the Swift programming language was chosen, since it is part of the Xcode integrated development environment, and JSON was also used to connect the application to the installation database [9].

The final product is conceived as a full-fledged application, working absolutely smoothly, with a high level of security, with the function of changing the parameters of the induction installation and the possibility of an emergency stop in case of an unforeseen situation.

There is a user of the application - a person directly interacting with the application. He must go through the authorization process in order to further view the experiments or change the installation parameters.

Table 1. Comparison study of integrated development environments.

| Parameters                  | Xcode                  | Xamarin              | FireMonkey            |
|-----------------------------|------------------------|-----------------------|-----------------------|
| Supported platforms         | iOS, macOS, watchOS, TVOS | Microsoft, macOS, iOS, Android | Microsoft, macOS, iOS, Android |
| Benefits                    | - High speed and small application size; | - Easy to change platforms; | - Unified code for all platforms; |
|                            | - The ability to test the application | - The speed of work is close to naive; | - Direct access to each platform’s native API is provided. |
| Disadvantages               | Only work on macOS | Great compilation time for projects; | Larger application size and lower speed |
|                            |                        | - High cost; | |
|                            |                        | Impossible to implement specific things in iOS | |

All service data is stored securely on the server. The user can get access to the program only having identification data and having passed the authorization process [10].

The full structure of the program is presented in figure 2. The user enters his identification data, the service confirms that the user with such data exists and allows access to the application. Then, the user makes the necessary manipulations. Upon completion of work, the service automatically displays and transfers it to the server database and to the user’s screen of the service.
Figure 2. Use case diagram.

Figure 3 shows a flowchart of the procedure for outputting experimental data. The procedure begins with the choice of experiment. Then the database query is formed and after receiving the answer, the report is displayed on the screen [11].

Figure 3. Flowchart for Experiment Data Output Procedure.

4. System approbation
The program is designed to automate the storage and processing of information about the data of conducted induction soldering experiments. For this, the program has the following functionality:

- Display a list of experiments.
- Display of data from experiments.
- Change the parameters of induction soldering.
- Deletion of experiments.
- Graphing.
- Emergency stop of the soldering process.
In order to start the program, you must run the file soldering.app. Then the authorization page will open.

The main page is shown in figure 4 and is a form with a set of buttons that allows you to switch to the desired form.

The main window provides information about each experiment in the form of a list. This list can be edited by deleting an experiment that is not needed. Deletion is performed by moving the screen left to delete the experiment after the list is updated automatically. Adding an experiment also happens automatically after the start of the experiment [12].

![Figure 4. The main application window with the ability to delete.](image)

By clicking on the line with the experiment, you can view the experiment data. After clicking, a form will open on which the following values will be shown: “Pressure”, “Axial load”, “Fluid flow rate”, “Date and time of the experiment”, “Temperature”, and a temperature graph will also be shown. In the same window there is a “Back” button at the top of the screen to exit viewing the experiment data. This form allows you to monitor the process of induction soldering, track deviations from the norm, in order to exclude them in the future.

When you go from the “Experiments” tab to the “Soldering parameters” tab in the main window, it is highlighted in blue and the corresponding form, which allows you to change the settings for induction soldering. This tab contains the following parameters: “Maximum power”, “Heating rate, stabilization time”, “Stabilization temperature”, “Clearance setting”. All these parameters are changed using a special switch. Use the “+” button to add to the specified number of units, and the “-” button to decrease. In this way, a smooth and precise adjustment of the parameters is achieved. In case of emergency, you can try to stop the installation remotely by pressing the Stop button. In order to go to the experiments tab, just click on it. Exit the application by pressing the "Home" button.

5. Conclusion
In the course of the study, a comparative analysis of the existing software was carried out, a description of the subject area of the system being developed was given, existing software tools, such integrated development environments as Xcode, Xamarin, FireMonkey were analyzed.

A comparative analysis showed that Xcode is better suited for developing a software application, as this environment has a large number of advantages compared to others.
To develop a software application, the Swift programming language was chosen, since it is part of the Xcode integrated development environment, and JSON was also used to connect the application to the installation database.

An algorithm for the operation of the system was developed that describes the operation of the application and the system. For the application to work, certain tables were selected from the installation database.

As a result, a software application was implemented that allows you to view experiment data, delete experiments, change the parameters of the induction brazing installation and, in case of emergency, stop the installation remotely and integrate into the existing information infrastructure of induction brazing automation systems.

The presented study was carried out under the Grant of the President of the Russian Federation to support young scientists No. MK-6356.2018.8.

The reported study was partially funded Scholarship of the President of the Russian Federation for young scientists and graduate students SP.869.2019.5.

References

[1] Tynchenko V S 2019 Intellectualization of the technological processes of permanent joints formation at the rocket-space enterprises IOP Conference Series: Materials Science and Engineering 537(3) 032062
[2] Murygin V A, Laptenok V D, Tynchenko V S, Emilova O A and Seregin Y N 2018 Development of an Automated Information System for Controlling the Induction Soldering of Aluminum Alloys Waveguide Paths 3rd Russian-Pacific Conference on Computer Technology and Applications (RPC) 1-5
[3] Lanin V L 2018 Sizing up the efficiency of induction heating systems for soldering electronic modules Surface Engineering and Applied Electrochemistry 54(4) 401-6
[4] Tynchenko V S, Petrenko V E, Kukartsev V V, Tynchenko V V and Antamoshkin O A 2018 Automation of experimental research of waveguide paths induction soldering Journal of Physics: Conference Series 1015(3) 032188
[5] Tynchenko V S, Murygin A V, Petrenko V E, Seregin Y N and Emilova O A 2017 A control algorithm for waveguide path induction soldering with product positioning IOP Conference Series: Materials Science and Engineering 255(1) 012018
[6] Lanin V L and Sergachev I I 2012 Induction devices for assembly soldering in electronics Surface engineering and applied electrochemistry 48(4) 384-8
[7] Zinn S and Semiatin S L 1988 Coil design and fabrication: basic design and modifications Heat treating 12(3) 32-6
[8] Rudnev V and Totten G E 2014 Design and fabrication of inductors for heat treating, brazing and Soldering ASM International 4C 619-32
[9] Kakosimos P E, Sarigiannidis A G, Beniakar M E, Kladas A G and Gerad, 2013 Induction motors versus permanent-magnet actuators for aerospace applications Transactions on Industrial Electronics 61(8) 4315-25
[10] Detty R 1999 Induction heating for brazing, soldering and joining Technical papers-society of manufacturing engineers 184-9
[11] Xu H, Li M, Fu Y, Wang L and Kim J 2009 Local melt process of solder bumping by induction heating reflo Soldering & Surface Mount Technology 21(4) 45-54
[12] Bayer T, Schledewski R and Mitschan P 2012 Induction heating of thermoplastic materials by particulate heating promoters Polymers and Polymer Composites 20(4) 333-42