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New Concept of Hardware and Software Setup for Wettability and Surface Tension Analyzing System

1. Introduction

The phenomena on solid and liquid phases boundary are playing an important role in many processes in metallurgy, material and surface engineering areas such as: soldering technologies, composite materials production, pulver sintering processes, etc. The determination of physics – chemical phenomena between liquid and solid state is an important technological problem. Surface tension and liquid phase surface energy, wetting angle, including extreme basis wetting angle, adhesion energy, interphase tension are the parameters, which are significant related to modern soldering technologies. The basic phenomenon used in joining processes is the wetting of joined surfaces by liquid metal. In practice, wetting is defined by determination of adhesive tension. Full analysis of interphase phenomena needs the knowledge of surface tension and wetting angle parameters [1, 2].

In Poland, since 2006, the regulation of Economy and Labour Minister, which determines detailed requirements of using in electrical and electronical devices certain substances, which can affect on natural environment during its activity and till the end of its exploration, is valid. The introduction of EU directive RoHS (2002/95/WE) involve production technology change, ie. need of device production using non-lead soldering technologies. The main problems related to new technology application are the increase of production costs, products quality and reliability improvement. The research on wettability and surface tension analyzing system is carried out under the research grant N 519 441839 of Polish National Research Committee.

2. Concept of wettability and surface tension analyzing system

Wettability and surface tension analysing system is dedicated solution allowing design, carrying out and analysis of experiments to quantity determine above mentioned parameters.

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The system is integrated hardware and software platform ensuring devices cooperation and control in real-time, as well as monitoring and analytical analysis, which are helpful for end-user to interpret measurement results. The system, functionally, is the explication of the previous project of wettability analyzing system [3, 4]. Figure 1 shows the use cases for the wettability and surface tension analyzing system.

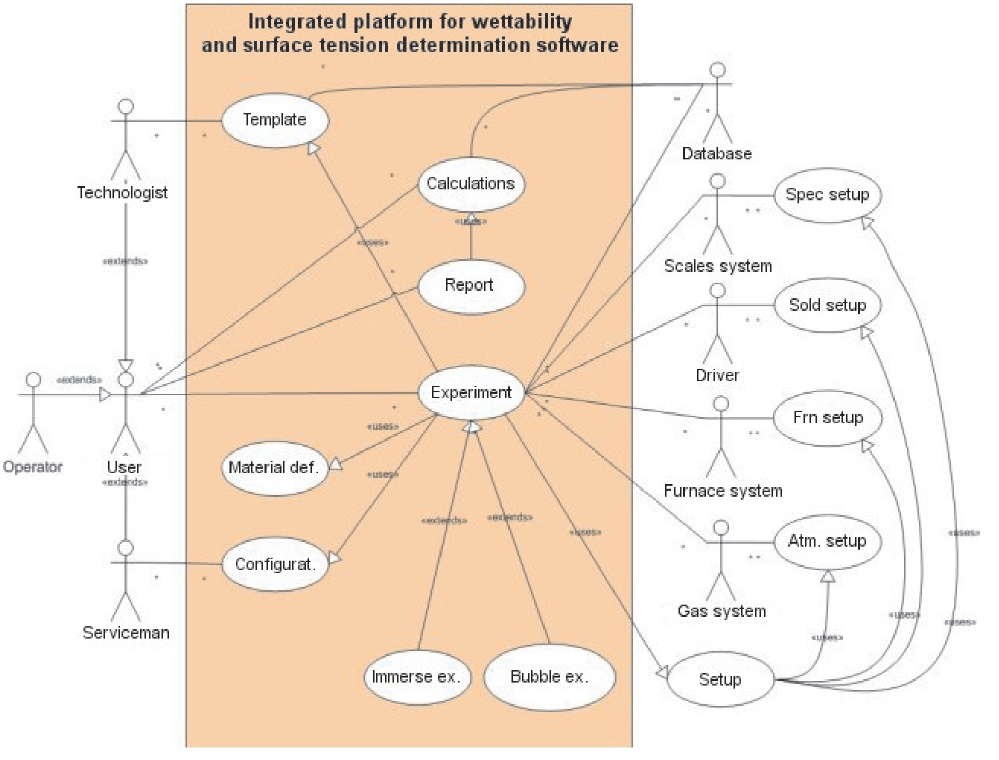

Fig. 1. Use cases of wettability and surface tension analyzing system

The structure of wettability and surface tension analyzing system including software and hardware group modules is presented on Figure 2. The central part of hardware group is the heating system in form of tubular resistance furnace. In the middle of furnace retort, the pot with solder material is placed, during heating process the solder is melting. From the top, into the furnace retort, the specimen hanging on scales module tie, is leading in and sinking during the experiment in liquid braze. The furnace retort is sealing on top through radially distributed nitrogen from the gas system, the inner of the furnace retort is filling with reduction gas mix based on argon and hydrogen. Control of furnace heating, protective and reduction gas atmosphere composition, furnace movement in vertical plane and data acquisition from scales module is made by software PLC controller equipped with extension I/O modules, which communicate with software system using Modbus TCP protocol or direct current / voltage inputs / outputs. Figure 3 shows the concept view of wettability and surface tension testing device.

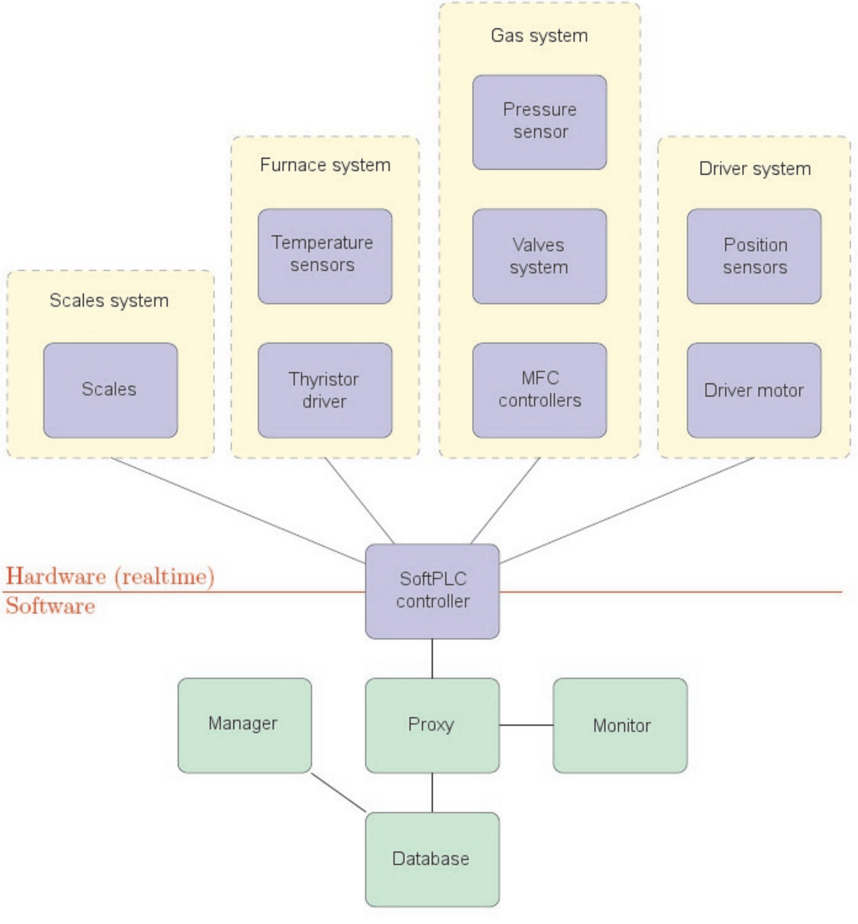

Fig. 2. Structure of wettability and surface tension analyzing system including software and hardware group modules

The interface between hardware and software group is the proxy application, which allows for message passing between visualization system and PLC controller and storing measurement results in external database system. The visualization application presents the current state of the process, allows for starting and halting the experiment, as well as displaying the values reading from all devices. The manager application is the database frontend allowing for modification of materials definitions, experiment templates, data analysis and visualization.

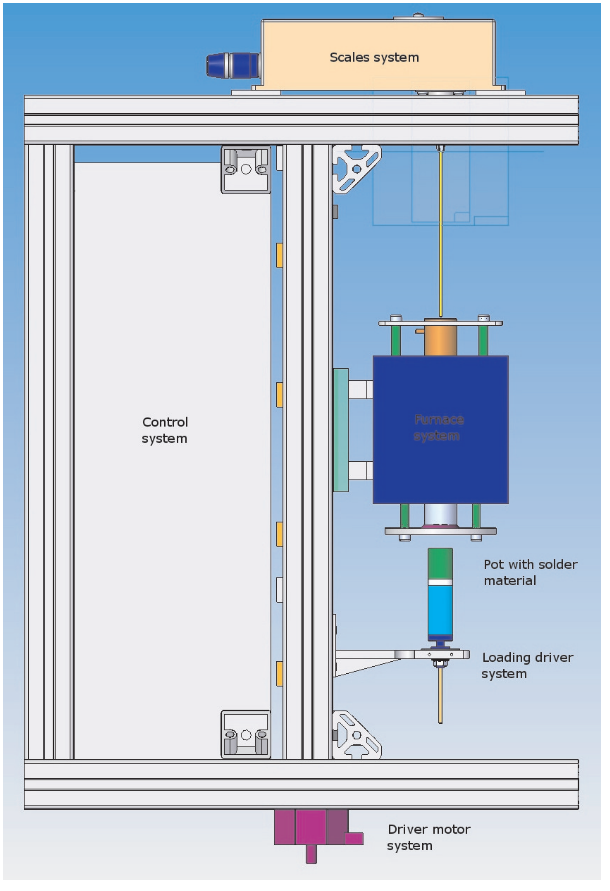

Fig. 3. The concept view of wettability and surface tension testing device

3. Wettability and surface tension measurement methods

Wettability and surface tension analysing system allows to quantity determine the parameters of wettability and surface tension. Therefore there exist two different experiment types to get data necessary for above mentioned parameters determination.

The first experiment type is the immerse experiment, where the specimen is immersing in fluid braze, while the specimen weight changes are continuously observed during the process. The stages of immerse experiment are as followed (the state diagram of the immerse experiment is presented on Figure 4):

– The specimen made from wettable material hanging on solid weight module tie is introduced into the furnace retort heated to the working temperature. The bottom surface of the specimen is placed over the liquid braze bath. In defined time, the surface of the specimen is activated.

- After activation time the pot placed in the furnace retort is moved with the whole furnace system upwards into to specimen direction, with defined velocity. The specimen is sunk on appropriate depth.
- The specimen stays on appropriate depth for desired time, while the force changes acting on strain gauge (wetting and buoyancy forces) are registered by the scales module.
- After stabilization time, the furnace system is moved downwards with desired velocity. The specimen is pulling out from the braze, while the weight changes are still registered.
- The experiment results (experiment parameters, measured data, …) are stored in database system and ready for further calculations.

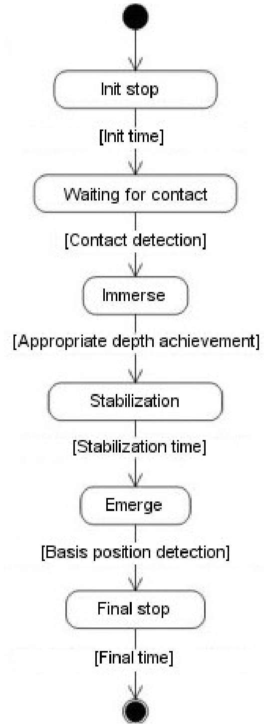

Fig. 4. The state diagram of the immerse experiment

Next experiment type is the bubble experiment based on maximum pressure in gas bubble method, where the gas flow in unwettable capillary immersed in fluid braze causes the pressure changes, while the gas bubbles are released from the pipe. The experiment is based on pressure changes observation. The stages of bubble experiment are as followed (the state diagram of the bubble experiment is presented on Figure 5):

- The capillary made from unwettable material, connected to gas source, is introduced into the furnace retort heated to the working temperature. The bottom surface of the capillary is placed over the liquid braze bath. In defined time, the surface of the capillary is heated.

- After activation time the pot placed in the furnace retort is moved with the whole furnace system upwards into to capillary direction, with defined velocity. The capillary is sunk on appropriate depth.
- The gas flows through the capillary with linear pressure increase. During the process, the pressure changes are registered.
- After the pressure in capillary is decreased, the furnace system is moved downwards with desired velocity. The capillary is pulling out from the braze.
- The experiment results (experiment parameters, measured data, …) are stored in database system and ready for further calculations.

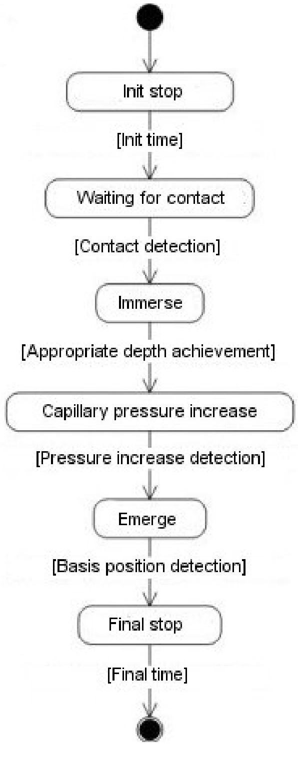

Fig. 5. The state diagram of the bubble experiment

4. Conclusions

The main aim of the project is to design an automated system allowing for carrying out the measurement experiments to determine the surface tension for different solder types and process settings in temperature ranges up to 1000 ^{o}C. The integration of few measurement methods in one system stand using modern, accurate measurement and calculation algorithms allows for getting reference materials and process parameters. The project is particular significant related to EU directive RoHS (2002/95/WE), valid since 2006, which limits the usage of lead based solders. The application of the system is the design of new technologies of producing joins using new solder materials, fluxes or optimization of existing one in joins quality and production economy aspects.

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