Carousel-Type Device For Ultrasonic Welding Of The Articles Made Of Thermoplastic Materials

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***Abstract* – The article is devoted to development and design of the carousel-type automated line for ultrasonic welding of the article made of thermoplastic materials. Developed automated line is intended for ultrasonic ring welding of two work pieces of spherical articles from thermoplastic materials.**

Index Terms – Automated line, vibrating system, ultrasonic welding.

I.INTRODUCTION

FROM ANCIENT times rattle was and still remains the first toy of the baby. This oldest toy is based on the simple mechanisms influencing on baby development up to one year and forming visual and auditory skills, which stimulate independent actions and develop its motor activity.

The rattle is the simplest device; it is produced from the article, which is hollow with small elements inside, the elements utter noise or ring at shaking.

At present time the choice of the rattles is great. For their production various materials and their combinations are used. The rattles made of plastics are widely applied. They are hygienic, they can be washed up easily and dry quickly.

The use of plastic allows make the design of the rattle difficult and multifunctional with transparent walls, through which the baby can watch the stuffing of multicolored rotating figures and pouring small balls. In some models the element can be filled with colored liquid gurgling at shaking and flowing from one part to another.

The rattle is not a universal toy; the baby plays with it only the first year of its life.

That is why it is necessary to guarantee maximum safety of the baby's health at playing with the rattle. At the production of the rattle only high-quality plastics and safe methods of the joining of the rattle parts in order to avoid their separation and pouring out of the stuffing should be used.

II.PROBLEM DEFINITION

At present for the joint of the rattle plastic parts (the elements of the ball) gluing, thermal and ultrasonic welding are applied.

Gluing is traditional and the most simple method of plastic joining, which can be easily automated. The essential disadvantages of gluing are low productivity, the necessity to use special non-toxic glues and careful cleaning of the surfaces to be glued from fat, oils and other pollutions, as even light impurities of the surfaces decrease the strength of junction.

At the thermal welding the plastic should be heated no more than the decomposition temperature. Normally the temperature of the heating tool is in 100…120ºC higher than the plastic flow temperature. Under these conditions on the border of the contact of the tool with the part to be welded intensive melting and thermal-oxidative breakdown, which can be accompanied by the liberation of low-molecular gases, occur. Being in superheated state the melt oxidizes quickly. The junction obtained by thermal welding features high strength, but the appearance becomes worse due to displaced melted material from the welding area. It requires additional processing of the junction place that makes difficult the automation of the process.

Thus, gluing and thermal welding cannot provide automated process of obtaining of quality junction of the ball elements in a short period of time [1].

The analysis of the ultrasonic welding possibilities as applied to the solution of the problem of the joint of the ball parts allows reveal its certain advantages [2]:

– high strength of the joining of welded materials;
– repeatability of welding quality;
– absence of internal stress of the welding seam;
– absence of liberation of harmful volatile matters;
– excluding of accessory material (glue, deoiler, solvent) costs, which are used at the traditional methods;
– formation of hermetical welding seam at the time not exceeding a fraction of a second at the temperature, which is less than the thermal decomposition temperature of the material [3];
– possibility of welding of the surfaces polluted by both liquid and free-flowing materials;
– possibility of quality control of the ultrasonic welding allows operate the process and apply it for the automated lines [4].

Thus, ultrasonic welding is the most efficient and safe method of hermetic junction of the ball parts of the rattles. However such welding cannot be realized, as there is no single approach to the design and production of the ultrasonic vibrating system, which is able to provide the formation of hermetic ring welding seams at the production of the balls with different diameter.

Moreover it is necessary to make easy the work of the operator due to the automation of the supply of the balls to be welded to the welding area and unloading of the ready balls.

In this connection there is a need to develop and produce automated lines for ultrasonic welding of the balls of various sizes, where the formation of hermetic ring welding seams is required.

At the design of automated line it is necessary:

– to carry out the analysis of the efficiency of possible approaches to increase of automation degree of the ultrasonic welding of spheric articles consisting of two parts;

– to propose and realize the automation of ball element transportation to the zone of introduction of acoustic energy;

– to design and produce piezoelectric ultrasonic vibrating system, which is able to provide even introduction of acoustic energy into the welding zone of the balls of different standard sizes;

– to develop the pressing unit of the ultrasonic vibrating system to the article to be welded.

The article is devoted to the solution of stated problems.

III. MAIN PART

At mass production for the manufacture of the similar parts carousel-type devices allowing transport initial articles, which consist of several separate parts to be welded, to the zone of energy action on them by the devices realizing their welding with the throw of joined parts from the travel unit for further manufacturing operations or packaging are used.

The vast majority of the devices operates according to described above principles and they represent the carousel-type device for the assembly of the articles made of thermoplastic materials containing the anvil, the unit for installing of the welded parts of the articles, the travel unit of the parts into the welding zone and the source of ultrasonic action [5].

The carousel-type device for ultrasonic welding of the articles made of thermoplastic materials [6], which is taken as a prototype and which contains the anvil, the unit for installing of the welded parts of the articles, the travel unit of the parts into the welding zone and the source of ultrasonic action, is the closest in technical nature and achieved result to proposed technical solution.

The device taken as a prototype operates in a following way. The work pieces of welded article is placed into the bed, after that the bed with the parts is travelled to the radiating surface of the source of ultrasonic vibrations. After time necessary for the welding the articles are released from the welding zone. The travel unit turns for the supply of new article to the welding zone. The turn of the travel unit is carried out by the motor drive installed at the base of the device, and released article is removed by the operator.

The disadvantage of known device is its dependence on form and sizes article work pieces and low productivity. It is caused by the fact, that interior form and sizes replicate exterior form and sizes of the article to welded, and the presence of manual work of the operator at the unloading of the articles decreases the productivity significantly.

Proposed technical solution is aimed at elimination of disadvantages of existing devices namely at the development of new carousel-type device for ultrasonic welding of the articles made of thermoplastic materials, which is able to provide the possibility of welding of the article of various sizes and different forms without changes of the device construction and increase its productivity.

The main point of the proposed technical solution is in the following, in the carousel-type devices for ultrasonic welding of the thermoplastic materials the installing unit is provided with two support elements faced to each other, which are made with the possibility of vertical travel and have centering surfaces contacting with the article. The travel unit is equipped with the catching mechanisms of the articles to be welded; the inner surface of the catches replicates the form of side surface of the welded articles, the pressing unit of the source of ultrasonic action is made mobile. The form of the working ending of the source of ultrasonic action repeats the form of the work piece surface of the welded article, on which ultrasonic action is carried out, contacting with opposite surface of welded article the pressing unit has welding anvil made with the possibility of vertical travel, and the form of contacting surface of the welding anvil repeats the form of the surface of the welded articles opposite to the area, on which ultrasonic action is realized.

Thus, in proposed technical solution the task of providing the possibility of welding of the articles with various sizes and shapes and productivity increase is accomplished due to:

– providing of possibility of vertical travel of the support elements, which allow set the articles of various sizes;

– producing of the surface of the support elements contacting with the article in a special way, that allows press the work pieces of different forms with their simultaneous centering;

– producing of the anvil and the source of ultrasonic action with the possibility of vertical travel and fixation of the work piece in the welding zone.

The carousel-type device for ultrasonic welding of the articles made of thermoplastic material is shown in Fig. 1 and Fig. 2: 1 – anvil, 2 – travel unit disk; 3 – step motor; 4 – drive shaft of the rotation system; 5 - bearing unit; 6 – the work pieces of the article to be welded; 7 – support elements; 8 – grippers; 9 – input tray for ready articles; 10 – source of ultrasonic action; 11 – pneumocylinder of the source of ultrasonic action; 12 – pneumatic gripper; 13 – passive support.

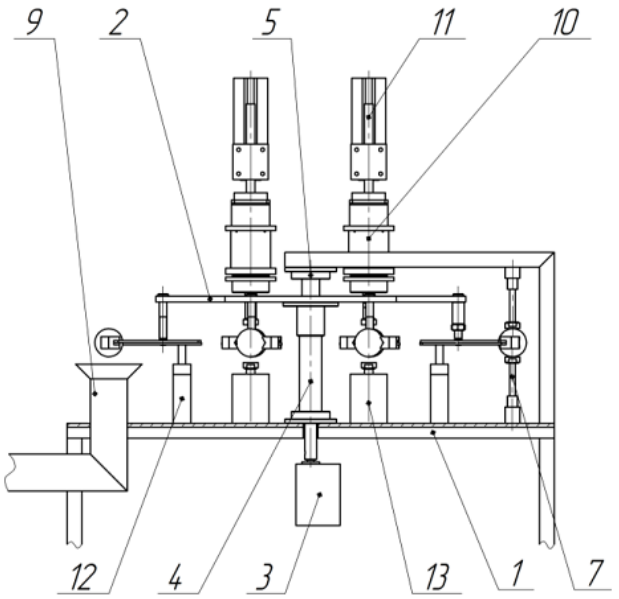

Fig. 1. Scheme of the carousel-type device.

The carousel-type device for ultrasonic welding of the articles made of thermoplastic materials operates in a following way. Welded work pieces 6 (for example, two hemispheres) are placed manually between support elements 7 faced to each other. The possibility of vertical travel of the support elements by the pneumocylinder allows install the articles of various diameter, the surface of the support elements made in a special way contacting with the article lets press the installed work piece with its simultaneous centering.

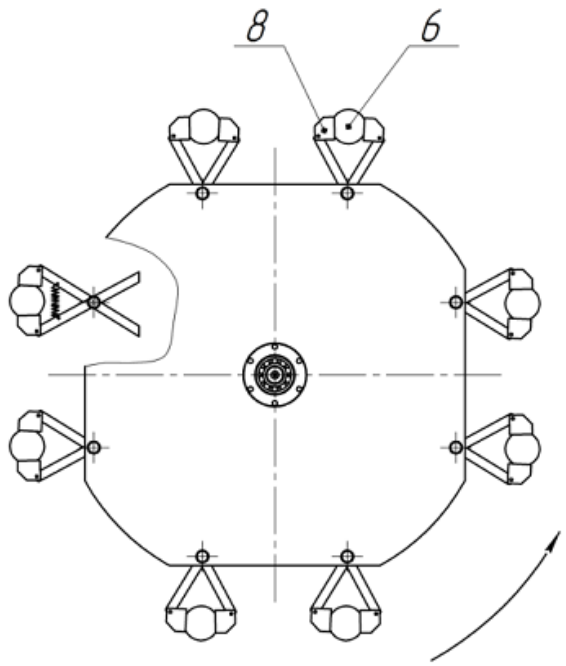

Fig. 2. Scheme of the carousel-type device (top view).

Further installed work pieces are pressed by the grippers 8 placed on the travel unit disk 2. The pressing of the grippers is made by the spring, and unclasping is made by the pneumatic grippers 12. At that interior surface of the grippers replicates the form of side surface of the articles to be welded. After the installation of the work pieces and adjustment of the gripper system the travel mechanism turns by 90º with the help of the step motor 3 and drive shaft 4 fastened in the bearing units 5 fixed on the anvil 1. The turn of the disk of the travel unit lets the operator to install new work pieces. After the stop of the travel unit the welded work pieces being in the welding zone are pressed between passive welding anvil 13 made with the possibility of vertical travel by the pneumocylinder and the source of ultrasonic action 10. The source of ultrasonic action is also mobile due to the application pneumocylinders 11, at that the form of the working tool of the source of ultrasonic action replicates the form of the work pieces surface of the article to be welded. Further the system of grippers is unclasped and ultrasonic action is turned on. After some time, which is necessary for the welding, the work pieces are pressed by the grippers unit, and welding anvil and the source of ultrasound are taken away from the detail. Further the travel unit turns by 90º in the same direction. At the moment of stop the grippers unit is unclasped and welded articles locating in the unloading zone come to the input tray 9 for ready articles.

Developed device has following performance features shown in Tab I:

TABLE I
MAIN PERFORMANCE FEATURES

1. Performance features of the device	
1.1 Voltage of power system with the frequency of 50 Hz, V	220±22
1.2 Maximum consumed power, W	600
1.3 Time of continuous operation, h, no more than	8
1.4 Overall dimensions, mm	850x850x1350
1.5 Mass, kg, no more than	70.0
1.6 Pressure of compressed air power pneumatic line, MPa, no less than	0.5
1.7 Pressure of compressed air power pneumatic line, MPa, no more than	0.7
1.8 Consumption of compressed air, l/min, no less than	100
2. Performance features of the source of ultrasonic action	
2.1 Principle of transformation of electric oscillations into mechanical vibrations	piezoelectric effect
2.2 Frequency of mechanical vibrations, kHz	22±1.65
2.3 Amplitude of longitudinal vibrations of welding tool at maximum power, micromicron, mo less than	40
2.4 Power control range, %	30-100
2.5 Cooling system	forced, air

The appearance of developed and produced device is shown in Fig. 3.

Fig. 3. Appearance of automated line.

Proposed device was designed and tested under the industrial conditions of the enterprise “Center of ultrasonic technologies”. The productivity was no less than 3000 pieces per hour at the operation of the line with two sources of ultrasound.

IV. CONCLUSION

As a result of carried out researches we design and produce automated line for the ultrasonic welding of plastic balls of various sizes providing hermetic ring joint. At the development of automated line following technical tasks were solved:

– the analysis allowed to reveal the most efficient method of the increase of automation degree of ultrasonic welding;

– the automation method of transportation of the ball elements into the zone of acoustic energy introduction was proposed and realized;

– piezoelectric ultrasonic vibrating system providing even introduction of acoustic energy into the welding zone of the balls of various sizes was designed and produced;

– the pressing unit of the ultrasonic vibrating system to welded article was developed.

Carried out studies showed; that developed automated line provided high quality and repeatability of welding joint.

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