Combined Ultrasonic Welder of Polymeric Containers

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Annotation – Procedure of collection, processing and storage of donor blood preparations in conditions of medical institutions is connected with necessity of reliable hermetic sealing of polymeric container. To solve this problem combined ultrasonic welder is developed, which provides a juncture of high quality about 8 mm in width. As temperature of ultrasonic welding is below melting point of the polymeric material, it excludes excretion of harmful substances in donor blood and an environment.

Key words – Ultrasonic welding, polymeric container, combined welder.

I. INTRODUCTION

REAL PROGRESS in the field of public health services is directly connected with perfection of activity of donor blood service. It is especially important at the time, when severe shortage of donor blood is observed. Thus, development of donor blood service is one of the priority directions in medicine.

Extensive use of blood preparations causes special requirements and features of their collection and storage. Refusal to utilize glass tare and wide application of plastic tare (polymeric container) demanded corresponding changes of material and technical base of hemotransfusion stations and hematological departments [1].

Automatic instrument ways of hermetic sealing of polymeric containers were widely adopted. They realize thermal welding of bringing connecting polymeric tubes close to polymeric container (distance is no more than 3...5 mm).

The way of hermetic sealing of containers for storage and processing of blood components with the use of dielectric welder was implemented. It can be described as follows: the part of connecting tube is heated and a thermal juncture is formed due to supply of high-frequency energy. At the zone of power influence tube overclamping occurs, and then cooling and keeping of compression force last till the stabilization of the thermal juncture. After that unused part of the connecting tube is separated manually. For the realization of the above mentioned method dielectric welder is applied (models Hematron 2, Biosealer CR2, Biosealer CR3, described in works [3] – [5]).

Essential lacks of a dielectric way of hermetic sealing are caused by following aspects.

At formation of a weld juncture 2 mm in width on a polymeric tube 8 mm diameter the area of a welding joint does not exceed 25 mm². At formation of such welding joint dielectric welder consumes no less than 250...300 W of electric energy. It is not profitable. To form a welding joint about 8 mm in width it is necessary to spend much more electric energy [2].

It is necessary to carry out separation of polymeric container and unused tubes along a sealing joint weld. Otherwise liquid blood preparations from deleted parts of containers get on cutting tool and surrounding subjects. It results in necessity of the immediate tool cleaning and sterilization of the used equipment or else the process of welding will be impossible.

In addition, dielectric welders are sources of high-frequency interference. It does not satisfy the requirements to medical electronic equipment.

Alternative method of a weld joint formation in thermoplastic materials, which are used for polymeric container, is application of mechanical vibrations of high-intensity ultrasonic frequency.

II. PROBLEM STATEMENT

The new way of welding for the decision of a problem of hermetic sealing of blood preparations containers showed doubtless advantages of an ultrasonic way. The ultrasonic equipment practically realizing stated above way was considered in article [6].

The studied equipment included stationary ultrasonic welder, intended for hermetic sealing of connecting (bringing) tubes close to polymeric container, and manual welder, intended for hermetic sealing of connecting (bringing) tubes in any place, which is convenient for the operator.

Operating experience in conditions of hemotransfusion stations, on the one hand, has confirmed high reliability and quality of formed joint welds, and, on the other hand, has revealed some disadva-
tages and defects. In particular, manual welder is not ergonomic, has the greater weight (about 380 gram). On the front panel of the stationary block there is an operating control, which does not allow carrying out 100% sterilization of welder elements, contacting with polymeric container and connecting (brining) tubes.

Thus, it is necessary to design, develop and create ultrasonic combined welder, including stationary and manual welding units, without any defects.

III. DEVELOPMENT OF MANUAL WELDER

Ultrasonic welding of thermoplastic materials is realized as follows: ultrasonic vibrations of radiating surface of the working tool are passed to a welding polymeric material. Such material is characterized by very high rate of energy absorption of ultrasonic vibrations, and range of absorption is proportional to the frequency of ultrasonic influence [6]. Thus there is a fast softening of weld materials. The diffusive processes, taking place under action of high-intensity ultrasonic vibrations, provide interpenetration of materials at temperatures, which are lower than melting point of a polymeric material. Welding materials do not decompose and do not emit harmful substances.

Transformation of electric vibrations of ultrasonic frequency in mechanical ones occurs in ultrasonic vibrating system. Piezoelectric rings (APC-841) are used as an electromechanical transducer. For hermetic sealing of the majority of polymeric containers, produced in Russia and abroad, it is necessary to generate a juncture in width no less than 6...8 mm.

Taking into account the requirements of ergonomics and achievement of necessary and sufficient characteristics for formation of a reliable tight juncture in any place of a polymeric tube, ultrasonic welder has been developed and created, which is shown in a Fig. 1.

![Fig. 1. Manual welder](image)

1 – clamping rod with a tube fixator 2 – concentrator, 3 – handle, 4 – button, 5 – stop, 6 – lever

Manual welder consists of the transducer of electric oscillations into mechanical ultrasonic vibrations, devices for delivering of a sealed tube in a zone of ultrasonic energy influence, the clamping rod on which the device for a sealed tube placement (fixator) is situated. The manual welder weight (in assembly) is 200 grams.

By pushing the lever of manual unit up to the stop, using muscular force of a hand of the operator, the button is pressed, and the automation device turns on the generator of electric oscillations. The electric oscillations developed by the generator enter on the transducer providing formation of ultrasonic vibrations. Ultrasonic vibrations are concentrated by a metal rod of variable section – the concentrator. Vibrating with ultrasonic frequency and amplitude 25-30 microns the concentrator is in direct contact with polymeric tube pressed to it.

Ultrasonic vibrations of the concentrator are passed to walls of a tube. The polymeric material of a tube is characterized by high level of energy absorption of ultrasonic vibrations that provides a softening of a material of tubes walls. After the formation of the sealing juncture specified in width ultrasonic influence is stopped automatically. The static pressure compressing a polymeric tube lasts several seconds (about 2 second) for cooling of the sealing juncture. This action is continued with the use of muscular force up to a sound signal.

At end of process it is necessary to stop muscular force. Thus the clamping rod is reverted to an initial state, and the polymeric tube with the generated sealing juncture removes from a zone of welding. Hermetization is completed.

At hermetic sealing of the container the cut of a tube in the center of a sealing juncture is performed that allows easily separate the container and a deleted part of connecting tubes.

IV. DEVELOPMENT OF COMBINED ULTRASONIC WELDER

Applying experience of the previous ultrasonic welders design and the equipment for ultrasonic welding of thermoplastic materials ultrasonic combined welder has been developed and created (Fig. 2).

Characteristics are resulted in Tab. I

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>CHARACTERISTICS OF COMBINED ULTRASONIC WELDER</th>
</tr>
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<tbody>
<tr>
<td>AC power, V</td>
<td>220±10%</td>
</tr>
<tr>
<td>Operating frequency, kHz</td>
<td>30±2.25</td>
</tr>
<tr>
<td>Maximal power consumption, W</td>
<td>130</td>
</tr>
<tr>
<td>Complete cycle of hermetic sealing, s, no more than</td>
<td>5</td>
</tr>
<tr>
<td>Time of ultrasonic influence, s</td>
<td>0.5…3.0</td>
</tr>
<tr>
<td>Diameter of sealed tubes, mm</td>
<td>4…8</td>
</tr>
<tr>
<td>Width of a sealing juncture, mm</td>
<td>8</td>
</tr>
<tr>
<td>Stationary block weight, kg, no more than</td>
<td>8</td>
</tr>
<tr>
<td>Manual welder weight, gram, no more than</td>
<td>200</td>
</tr>
<tr>
<td>Time of continuous work, min.</td>
<td>60</td>
</tr>
<tr>
<td>Number of continuous welding (with the following 30 minutes interval), no less than</td>
<td>100</td>
</tr>
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</table>
The area of a formed weld joint is 60 mm² at the maximal power consumption in 130 W. It is in 5–6 times less than of dielectric welder with similar purposes.

Installation of a sealing tube in stationary and manual units of ultrasonic welder is carried out manually. All the subsequent operations (delivering of a tube in a welding zone, compression of a tube, ultrasonic influence, exposure under optimal static pressure, relief, squeezing and removal of a tube from a welding zone) are performed in automatic mode (for stationary unit) and in manual mode (for manual one).

Stationary welder consists of the transducer of electric oscillations in mechanical ultrasonic vibrations and electromechanical unit. The electromechanical unit which delivers a sealed tube in a zone of influence of ultrasonic energy includes an electromagnet with a moving rod, the clamping rod mechanically connected with a rod of an electromagnet, and on the rod there is a device for sealed tube placing (fixator).

At hermetic sealing of the plastic container with blood preparations by means of stationary welder, the polymeric tube is positioned on the clamping rod in the fixator in such a way that the place on which it is necessary to make sealing juncture is in a fixator opposite to the working ending.

By pressing the clamping rod of stationary welder and its small moving (from 1 mm up to 1.5 mm) by the operator, the device automatically turns on drawing electromagnet. Strap together with a polymeric tube fixed in the fastening device start to move in a direction to the working tool. The force created by an electromagnet provides compression of a polymeric tube up to the set level. After achievement of the set compression of a polymeric tube the automation device turns on the generator of electric oscillation.

Actions and processes taking place in a polymeric tube at ultrasonic influence were described above.

After the set time providing stabilization of the sealing juncture the automation block disconnects an electromagnet of stationary welder and transfers it in an initial state. Thus, process of hermetic sealing in stationary welder is considered to be completed.

As it has been noted above, ultrasonic combined welder is completed with two ultrasonic vibrating systems. For identical efficiency of ultrasonic influence at hermetic sealing both on stationary, and on the manual block a necessary and sufficient condition is identity of applied ultrasonic vibrating systems. It is difficult to provide 100% technological identity, therefore used ultrasonic oscillatory systems differ on the parameters - resonance frequency, an amplification factor, capacity of piezoelectric elements, amplitude of vibrations of radiating surface.

Thus, for the account and compensation of distinction in the electronic generator the algorithm of identification and automatic tuning up is used on ultrasonic vibrating systems of both stationary and manual welders.

Work of the algorithm can be considered as follows. During the choice of welder type (manual or stationary) pressing the button in the front panel the electronic generator searches resonance frequency of the chosen system and remembers it. Later during the hermetization process ultrasonic welding is carried out immediately, without search, on the found frequency. After switching-off of ultrasonic influence the generator automatically repeats the search of resonance frequency and remembers new value if it has been changed. Preparation for the subsequent hermetic sealing is realized. If power is switched on default, stationary welder is chosen automatically. Realization of the above described algorithm let increase the speed of hermetic sealing of normal quality formed a juncture up to 10 welds in a minute.

VI. CONCLUSION

Designed, developed ultrasonic welder for hermetic sealing of plastic polymeric container with blood preparations has successfully passed tests in conditions of hemotransfusion stations.

The obtained results prove the efficiency and correctness of the applied engineering and charted decisions, allowing to obtain a reliable sealing juncture of all types in a tube from 4 mm up to 8 mm in diameter. Quality of a formed juncture does not worsen at presence of foreign matters (for example, blood, a sterilizing and disinfectant solution) on the internal and external sides of a bringing tube.

Sealing properties of the juncture executed by ultrasonic welder do not change in conditions of long-term storage at low temperatures. Besides properties
of a juncture do not worsen at various mechanical influences (overbending, stretching, etc.).

REFERENCES


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