Development of Ultrasonic Specifically Drilling Technology And Improvement of Construction of Ultrasonic Machine Tools

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***Abstract* – The article is devoted to development of specified ultrasonic equipment for specifically drilling of fragile and very hard materials.**

***Index Terms* – Ultrasonic, fragile and very hard materials, boring, drilling, equipment.**

I. Features of Ultrasonic Specifically Drilling

DEVELOPING of technique led to universal applying of fragile and very hard materials such as glass, semiconducting materials, ferrites and ceramics. Therefore general using of fragile and very hard materials in various industry fields is limited by absence and imperfection of existing technologies of mechanical treatment.

Using nowadays electrochemical, electro-erosion and electron-beam methods don't allow to solve the problems because the methods is useful for treating of only electrically conductive cloudy materials characterized by high energy cost of process and don't guarantee necessary accuracy of treatment.

Available results of researches of different authors [1,2] and researches carried out for many years in Laboratory of acoustic processes and equipment (BTI AltGTU) with OOO "Center of ultrasonic technologies" [3] are confirmed that the one of most effective and perspective methods of treating of fragile and very hard materials is ultrasonic specifically drilling.

Benefits of such method, with treatment speed exceeding in 10 times speed of diamond cutter treatment, are in low process energy (not exceed energy of traditional metalworking), in possibility of treating of almost every fragile and very hard materials and in absence of residual stresses excluding crack formation after treatment.

By the using of ultrasonic methods it can be carried out the effectively processing of such materials like agate, diamond, germanium, granite, graphite, boron carbide, quartz, ceramic, corundum, silicon, marble, nephritis, pearl, ruby, sapphire, glass, hard alloys, thermo corundum, porcelain, faience, ferrites, crystal, jasper etc.

Ultrasonic treating technology includes inserting of abrasive suspension in work area, that's the space between oscillating with high frequency working tool ending and surface of treating material. Abrasive grains under the action of oscillating tool strikes beat the surface of treated material and realize it destruction.

Applying of ultrasonic vibrations allows to intensify the process of fragile destruction of treating material. Usually abrasive material is the boron carbide or silicon carbide and a liquid is a water.

Starting since 70-ty years of last century the fundamental physical principles of ultrasonic treatment were studied in details, the common requirements to technical features of equipment of various functionality and productivity were defined. It allows to make many ultrasonic machine tools for размерной обработки of different products and materials. These machine tools were operated successfully at factories of national factories during last decade.

Therefore evolution of equipment, finding of modern materials and products and tightening of quality and productivity requirements were allowed to understand the fact that insignificant earlier disadvantages of applied machine tools limit using in high-tech fields of modern industry. Among such advantages there are limited diameter and depth of executable perforations, unreliable mounting of working tools and insufficient process productivity.

It has place the necessity to further perfecting of ultrasonic machine tools. The article is devoted to some technical solutions directed to making of ultrasonic machine tools.

II. Perfection And Development of Passive Working Tools For Specifically Drilling

At realization of technological processes of fragile and hard materials ultrasonic treating in industry conditions it is necessary to perform various technological procedures (to perform through and blind bores of different diameter and shape). Each of such technological procedures performs more efficiently with using of specific working tools.

It's known, the working tools strikes to abrasive grain in process of ultrasonic vibrating system working. Due to this it has place the destruction of working tools surface, change of it length and shape (upto 5 percents from depth of bores drilling in glass). This leads to change of: working resonant frequency, quality factor of ultrasonic vibrating system and treatment accuracy. Thereby for ultrasonic machine tool completion the working tools must be changeable.

Changeable working tools make in form of separate elements (nodes) of vibrating system and connect with ending surface of

cylindrical part of concentrator. Such tools (if length less than wavelength spreading in material of tool) are passive.

In practice different methods of connection of tools to vibrating system are used – with threaded connection, collet holders and soldering. Since using of collet holders and soldering don't allow to transfer ultrasonic vibrations with amplitude more 40 μm, cause additive energy waste this types of connections use only for connection of working tools of diameter more than 3 mm. Mounting by threaded connection allows to transfer vibrations upto 60…100 μm. Therefore it got the large distribution

The passive working tools affect to all parameters of vibrating system. At designing and using of tools it is necessary to take into account:

1) diameter or length of bigger side of working tool must be less than quarter of bending vibrations wavelength spreading in material of it;

2) longitudinal size of working tool must be less than quarter of wavelength of longitudinal vibrations spreading in it. At failure of this condition significant mechanical stresses leading to formation of cracks and to vibrating system destruction are arisen in area of working tool and concentrator connection;

3) at small diameter of working tool the length must to provide possibility bending vibrations arising.

For realization of various technological processes of fragile and very hard materials ultrasonic treatment different types of passive working tools were offered and designed.

1) Tools For Drilling of Specified Shape Bores.

The tools depicted on Fig. 1. are constructions providing drilling of specified shape bores. Size and shape of working surface can be selected according to solving of specific problems.

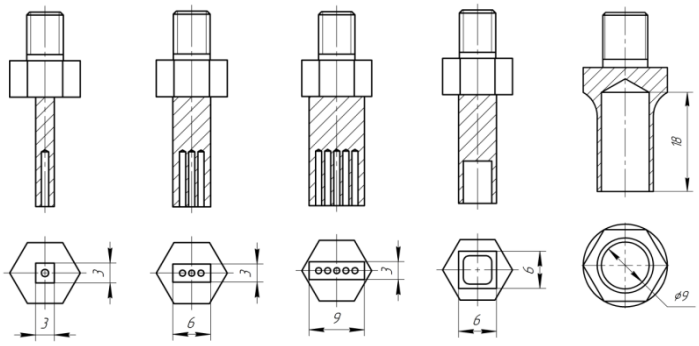
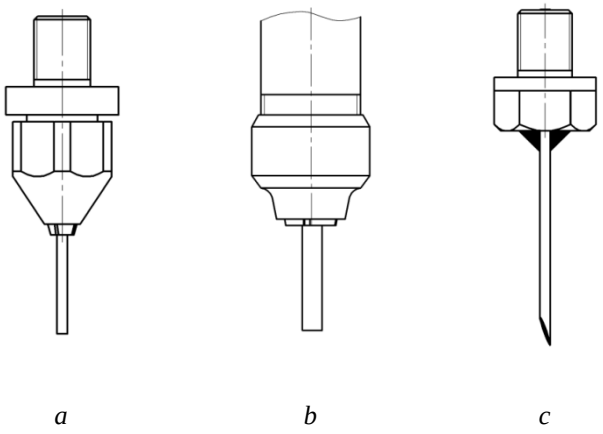


Fig. 1. Passive working tools for specifically drilling of complicate shape bores

2) Tools for making of bores in diameter from 0.4 to 3 mm

Tools constructions of such type are depicted at Fig. 2. Tools *a*, *b* are equipped with collet holders for connecting of additional working instrument as a needle. At tool *c* the additional instrument is connected with welding or soldering.



a *b* *c*

Fig. 2. Passive working tools for specifically drilling equipped with collet holders

There is more efficiently to use steel thin-walled tubes (medical syringe needles, steel wire) as working tool. Developed tools with collet holders are shown on Fig. 3.

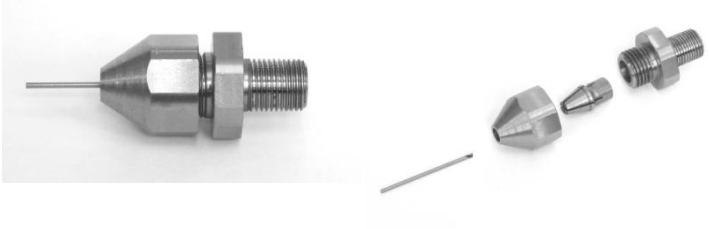


Fig. 3. Working tools with collet holders

Using of tools represented on Fig. 2 is difficult because of significant impaction on resonant frequency. Big mass focused in area of maximum vibration amplitude is the reason of breaking of collet holder parts.

For solving of this problem the collet holders like a construction fitting into ultrasonic concentrator were designed. The example of such construction is represented on Fig. 4.

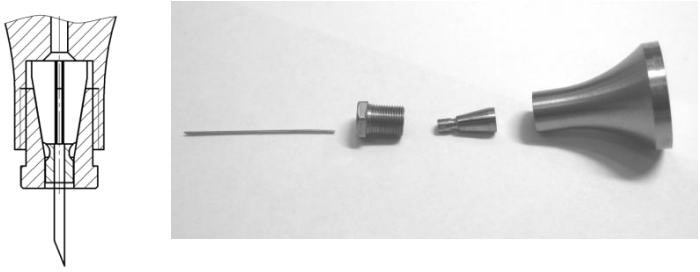


Fig. 4. Passive working tool with "back type" collet holder for specifically drilling

This construction makes lesser changes in resonant frequency of ultrasonic vibrating system and has more higher strength characteristics.

3) Tools For Drilling of Bores With Diameter From 3 To 15 mm

For drilling of bores with diameter from 3 to 15 mm the metal tubular tools are used (see Fig. 5).

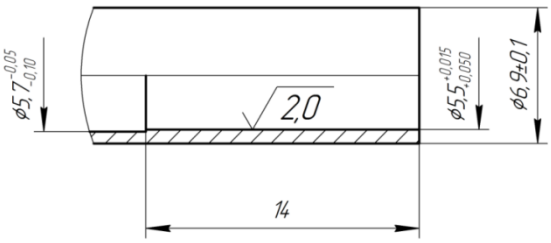
Fig. 5. Passive working tools for specifically drilling of bores in diameter from 3 to 15 mm.

In composition of every ultrasonic machine tool it can be many various working tools. Maximum speed of bores drilling achieves at using of hollow working tools.

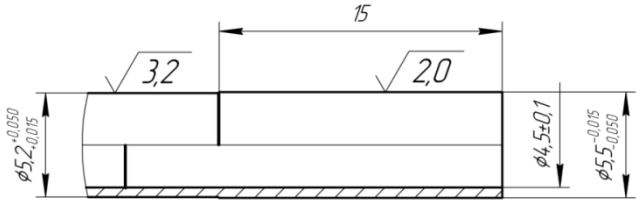
III. Development of Active Working Tools for Drilling of Deep Bores

Two problems occur at drilling of deep bores: big contacting area of side surface of tool with treating material and deterioration of conditions of fresh abrasive inserting in treatment area. For solving of these problems the active working tools with central channel for abrasive suspension injecting and with stepping form of working ending for significant decreasing of contacting surface were designed.

Such types of tools were designed for drilling of continuous bores in quartz rods in order to making of mating pare (core-bore). Designs of working endings of designed tools are shown on Fig. 6.



a) instrument fo boring of core



b) tool for boring

Fig. 6. Designs of working tools

The cylindrical part of tool defining depth of boring was selected equable to 55 mm. The tool was designed on the basis of half-wave constructive scheme.

The external view of working tools is shown on Fig. 7.

Fig. 7. External view of working tools

Time of core drilling of 50 mm length in quartz was about 60 minute. The diameter of core was about 5.4 mm. Decreasing of core diameter relatively to working tool diameter causes by action of abrasive grains.

On the second stage it was carried out drilling of channel for placing of core. Time of bore (channel) drilling of 50 mm length was about 50 minute. Diameter of bore was received a little more than diameter of working edge of tool.

The external view of designed ultrasonic vibrating system with working tool mounted in support is shown on Fig. 8.

Fig. 8. External view of designed ultrasonic vibrating system

Using of such construction was allowed to increase the depth of obtained bores. And there is the perspective of obtaining of 150 mm depth bores and significantly increasing of process productivity.

IV. Development And Improvement of Electronic Ultrasonic Generators

Electronic unit consists of generator of ultrasonic vibrations, unit of automotive controlling and treatment process controlling and managing part.

Managing part of electronic unit provides control of output power level and level of working tool vibration amplitude. Adjusting parameters of output power level allow to apply ultrasonic machine tool for treating of wide range of materials, different in mechanical and physics features. Ultrasonic machine tool is equipped with built-in system of automotive maintenance of out-

put power level and with system of automotive frequency adjustment (at all possible changes of parameters and features of treating materials). It allows to provide stable productivity of treatment.

Herewith applying of microprocessor control allows to realize new modes – drilling with low amplitude, gradual increasing of power as deepening and decreasing on output for exclusion of breaking.

V. CONCLUSION

The results of performed researches:

1) It was detected the necessity of passive and active working tools perfecting.

2) New passive and active working tools allowing significantly increase productivity of specifically drilling were developed.

3) New principles of electronic ultrasonic generator controlling were developed.

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