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Analysis of the influence of warming on the quality of soldered instruments

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Abstract. The study is focused on the analysis of the influence of short-term exposure to high temperature on tungstenless hard alloy metal plates while soldering iron-carbon. According to the results of the research with macrohardness tester the macrohardness deviation amounted to ±3%.

During the production process of turning cutters with tungstenless hard alloy metal plates soldered on iron-carbon there were micro- and macrocracks registered in the hard alloy metal plates. In authors' opinion, the reasons for this could include several curcumstances:

- being warmed with high temperature the structure of a hard alloy is changed, more specifically, there is a possibility of the change of microhardness through phase structural change while being exposed to high-temperature;
- disturbance of instrument soldering process conditions;
- unreasonable choice of the correlation of thicknesses of the soldering alloy and tungstenless hard alloy metal plate;
- defects that occurred during the production of the tungstenless hard alloy metal plate.

Timeliness of the research

Currently Russian enterprises in the area of repair and rebuild of parts of agricultural machines are in the phase of intensive development. According to the National information service [www.pulset.ru], in 2007 there were in Russia 249 companies of various forms of ownership which were occupied with rebuild of machine parts, while in 2012 they were 474. In general, during the period of five years the number of enterprises acting in the area of repair and rebuild of agricultural machines has increased almost twofold. This is connected with ageing of the population of machines, large delivery times of foreign spare parts and, as a consequence, increased down time of the machines, which negatively affects the profit of the households, especially taking into account isolated location of some subjects of the Russian Federation from the areas of concentration of spare parts and components production of agricultural machines.

The procedure of parts repair constitutes a subsequence of building-up operations followed by mechanical processing. Over 75% of parts reconditioning methods of agricultural machines, as of their structure, include various kinds of welding, while it is possible to rebuild over 90% of component spectrum. When the welding is made with a high quality, at the concluding phase of reconditioning —

the mechanical processing — the precision and the quality of rebuilt surfaces, as well as the general part of material and labor costs has to be defined for the rebuilding of parts of agricultural machines.

The factors that decrease the precision and the quality of the surface include a relatively high hardness of the deposited surface, irregular chemical and physical composition and irregular allowance for mechanical processing. To reduce the negative effect on the processing of the parts of agricultural machines a special tool is used which must have a very firm, stable cutting head, which is able to carry alternating loads by a relatively high cutting speed.

Popular instruments, including authorial, do not meet the requirements of hardness, stableness and wearing out. Using the wolfram-free hard alloy metal might help to solve this issue, though mechanical mounting of such plates due to the low hardness causes frequent failure of hard alloy metal plates because of the influence of buff load. Fabrication of soldered tools on the basis of wolfram-free hard alloy plates with use of traditional welding alloy is impossible because of the low wetting angle (<300) of the alloy on the surface of wolfram-free hard alloys. This results in the increased tool expenditure, reduced machine utilization and high original cost of processing and reconditioning. The need for high quality tools at the enterprises of repair and rebuild of the parts of agricultural machines only in Kemerovo region amounts to 100 thousand items annually by precalculated lifetime 45 minutes.

Currently there are several ways of solving the targeted problem. One of this ways involves using high-endurance iron-carbon alloy for production of turning tools with wolfram-free hard alloy metal plates. Thereby large reserve of performance gain of lathing of parts of agricultural machines rebuilt by welding by means of increasing of effectiveness and stableness of welded tool.

Methods of research, authenticity and validity of the results:

Experimental research has been completed in laboratory conditions according to the schedule of single-factor experiment. In order to define the quality of the soldered junction of the tool holder — iron-carbon alloy — wolfram-free hard alloy metal — metallographic method was used. The rack resistance of the tool was calculated by the method of S.I. Petrushin. In order to define the authenticity and repetition of the results following methods were used which were confirmed by theoretical research: Student method, Mann-Whitney method and method of rank correlation by Spearman. The results of the research were used in practice.

Scientific novelty:

1. The composition of the iron-carbon alloy has been established for welding of wolfram-free hard alloy metals with increased contact angle.
2. The strains have been determined which occur during tool welding, as well as new method of crack resistance calculation has been suggested.
3. The effectiveness has been defined of using of turning tools with wolfram-free hard alloy metal plates, which are welded with iron-carbon alloy while lathe turning surfaced coats of the parts of agricultural machines.

Practical implications:

1. The developed alloy composition provided a secure junction of the tool holder with wolfram-free hard alloy metal plates.
2. The suggested method of forecasting of imposed and operating stress while welding the tools helped to increase the production quality by 15% due to the reduction of defect ratio.
3. The suggested lathe turning tool with wolfram-free hard alloy metal plates raised the productivity by 30-40% with increase of stableness thrice-fivefold depending on technological processing modes.

Utilization:

The results of the research have been utilized by way of pilot batch of tools and released for implementation into repair and technical enterprises of Kemerovo Oblast.

Objects and methods of research

Now we analyze the reasons why the micro- and macrocracks occur in the tungstenless hard alloy metal plate soldered on iron-carbon.

Results of the research

The ability of the instrument to execute its functions in many ways depends on the real damages that occur during its production. The most dangerous defects are pores, contaminating impurities, structural irregularity, inhomogeneous granularity, micro- and macrocracks. The research objective is the influence of warming on the quality of cutters soldered on iron-carbon alloy.

Turning cutters with a tungstenless hard alloy metal plate were produced with iron-carbon soldering alloy. The parts ready for soldering were covered with a 3–4 mm layer of flux in order to avoid corrosion. The completely soldering-ready construction was put into the power coil of the HFC oven for 50 seconds. During this time the soldering alloy is partially melted and solidly bond with instrument holder and tungstenless hard alloy. Soldering temperature equals 1,160–1,200°C, however during such short period of time the structure of hard alloy is not changed, which means that physical and mechanical features of the hard alloy are preserved. The produced instrument from the power coil was put into sand for smooth cool down. High cool down speed provokes macrocracks in the hard alloy along the soldering line.

The warming temperature for FeC-soldering, with corresponding composure of the alloy, amounts to 1,160–1,200°C, taking into account possible technologic overwarming (30–50°C) in comparison with the start of alloy melting temperature (≈ 1,147°C). According to the literature data [1,2,9], as a result of high-temperature influence during instrument soldering hard alloy tends to durability reduction. The authors [3,4,5] however in most cases do not indicate the duration of the influence and reinforce their conclusions with the data obtained during long-lasting (several hours) exposure to oven heating.

This issue was analyzed during the research of microhardness with a microhardness tester of turning cutters produced with the given technology. In all samples the interface of hard alloy and soldering alloy corresponded with the coordinate x=0. The hardness was measured in Vickers units upon the diagonals of impression under applied force of 2,94 N and 1,96 N for cutters with KHT16 and TH20 plates respectively. The results of the research are presented on figures 1, 2.

Moreover, the influence of a short-term warming wa analyzed on the macrohardness of tungstenless hard alloy plates KHT16 and TH20, the results of which are presented in table 1.

Table 1: The influence of high-temperature HFC warming (warming up to 1,200°C, holding 25–30 s) on the microhardness of hard alloys

Alloy brand	Microhardness, MPa						Hardness change, %
	before warming			after warming			
	H_o min	H_o max	H_o	H_o min	H_o max	H_o	
KHT16	14080	19320	16480	12840	18320	17300	+ 5
TH20	15840	18650	17300	15240	18440	16870	– 2,5

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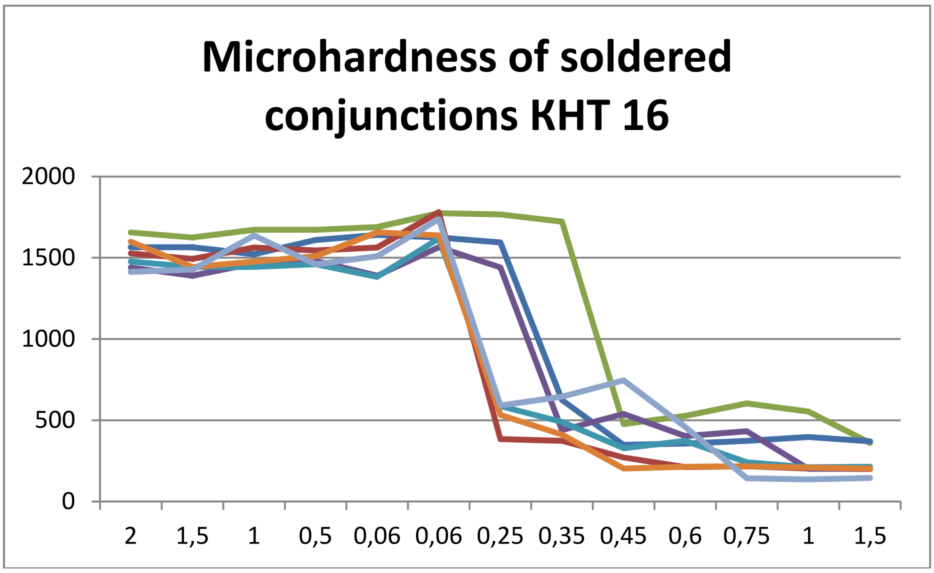

Fig.1: Microhardness of the samples with alloy plates KHT16

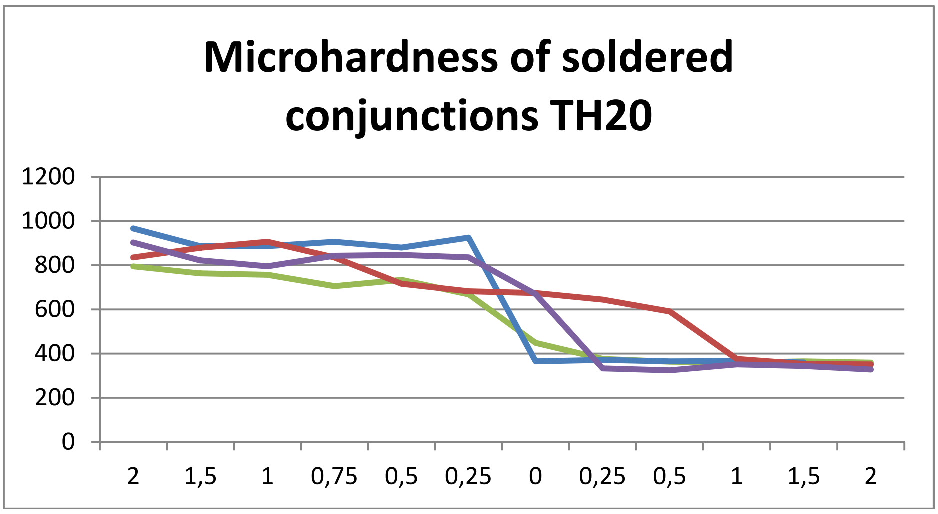

Fig.2: Microhardness of the samples with alloy plates TH 20

In the publication [7,8] a forecasting method is suggested for residual and operating stress in the tungstenless hard alloy plates soldered on iron-carbon alloy. Based on the results of the suggested measures the quality of the instruments has been enhanced (no micro- or macrocracks) by 60%.

Conclusions

As a result of the conducted research we can draw following conclusions:

- the microhardnes of the tungstenless hard alloy plates by short-term (40–50 sec) high-temperature (1,100–1,200°C) warming changed within the range of ±3% which is a statistically non-significant factor;
- with usage of the forecasting method of absence of residual and operating stress described in publication the quality of the instrument is enhanced by 60%;
- while soldering turning cutters the process conditions of time (40–50 seconds) and temperature (1,100–1,200°C) should be followed.

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