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SCIENTIFIC BASIS OF TEMPERATURE AND TIME INTERDEPENDENCE IN THE PROCESS OF HEATING AND TUNGSTEN CARBIDE-BASED SOLID ALLOY POWDERS

S. T. Parmonov
Tashkent State Technical University named after Islam Karimov,

Sh. M. Shakirov
Tashkent State Technical University named after Islam Karimov,

K. A. Sharipov
Tashkent State Economic University,

N. B. Khujakulov[3]
Navoi State Mining Institute

Introduction

Physico-mechanical and operational properties of hard alloys produced for different industries depend on many factors, the main of which are: production technology, the physicochemical composition of binders, size of carbide powder, cooking and cooling processes, level of internal stresses in-phase components, the structure of alloys.
This paper presents the results of scientific research on the effect of temperature and time on the quality of a solid alloy during the heating process of carbide powder.

Literature Review

The baking of hard alloys in vacuum furnaces is carried out in 2 stages: primary baking and final baking.
In primary baking, the powder is cleaned with an added plasticizer for good compression and the primary structure of the powder is formed [1] (Table 1).

Table 1 Primary baking mode (the same for all hard alloys)

Stage No	Initial temperature, ^{0}C	Finishing temperature, ^{0}C	Phase duration, min.
1	Room temperature	300	60
2	300	300	60
3	300	700	30
4	700	700	40
5	Cool with the furnace		

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The purpose of the final baking process is to obtain the final structure, physicomechanical composition, size, and shape. The final baking temperature varies depending on the brand of hard alloy and the groups VK, TK, TTK [1] (Table 2).

Table 2 The order of the final cooking stage of solid alloys containing VK (VK3 - VK-6 - VK8).

Stage No	Initial temperature, ^{0}C	Finishing temperature, ^{0}C	Phase duration, min.
1	Room temperature	700	120
2	700	1200	60
3	1200	1200	20
4	1200	1300	20
5	1300	1300	20
6	1300	1380	20
7	1380	1380	20
8	Cool with the furnace		

The temperature deviation limit shown in the tables may vary by +10 C at the upper limit and by +20 C at the intermediate value.

Details made of hard alloy are shortened during the cooking process. The standard calculated reduction is 18 ... 20 ... 22%.

At the same time, it is impossible to control the quality of the prepared mortar, the physical and mechanical composition of the raw material and rubber, and the reduction coefficient can not be said, the deviations can be +10%.

If the shrinkage size of the baked part is 5 ... 10% larger than the allowable size of the drawing, it can be reduced to the drawing size during final baking at high temperatures or during repeated baking. In this process, it is allowed to increase the cooking temperature to 20 ... 50 OS and the cooking time to 40 minutes. Experiments are performed on 2 to 3 samples to determine the exact limit of temperature and time. However, care should be taken when using this method because increasing how much cooking temperature and increasing the cooking time in the final baking will reduce the bending strength level and slightly increase the hardness.

Results of Scientific Work

Initially, 20 g of tungsten carbide powder is taken for 3 samples and 2 ml of plasticizer is added and pressed with a force of 2 t cm2 (Fig. 1 sample a, b, c). For another sample, 15 g of tungsten carbide powder is taken and 1.5 ml of plasticizer is added and pressed with a force of 2 t / cm2 (Figure 1 d sample). The amount of plasticizer and the degree

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of compaction have a significant impact on the quality of the final product [2,3]. The pressed samples were placed in a vacuum furnace and a vacuum was created (Fig. 1).

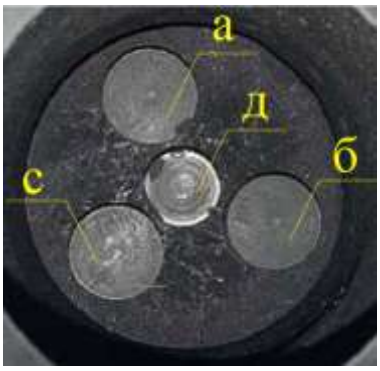

Fig. 1. Samples were placed in the furnace.

To determine the effect of time on the sampling process, the temperature inside the furnace was quickly raised rather than in the unit of time given in Tables 1 and 2 (Table 3).

Table 3 The final baking procedure of VK-containing hard alloys (VK 3 - VK 6 - VK 8).

Stage No	Initial temperature, ^{o}C	Finishing temperature, ^{o}C	Phase duration, min.
1	Room temperature	400	3.58
2	400	500	3.01
3	500	900	9.55
4	900	1100	5.56
5	1100	1150	4.02
6	1150	1380	7.28
7	1380	1380	20.30
8	Cool with the furnace		

It can be seen from the samples taken from the furnace that cracks appeared in the samples since the temperature was raised too quickly (Fig. 2), and in one of the samples, the sample was scattered during the sampling due to a large number of cracks.

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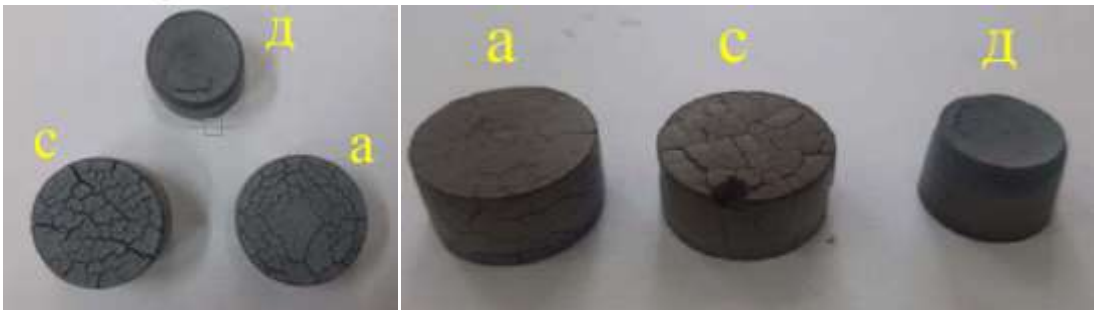

Fig. 2. Samples were taken from the furnace.

20 g of tungsten carbide powder is taken for 1 sample and 2 ml of plasticizer is added and pressed with a force of 2 t / cm2. A vacuum was placed in the oven to create a vacuum environment and the primary cooking process began. The duration of the primary cooking process is given in Table 4 (Figure 3).

Table 4 Sample primary cooking procedure (VK6).

Stage No	Initial temperature, °C	Finishing temperature, °C	Phase duration, min.	Overall, min.	Electric power consumption of the vacuum furnace	
					Current power, A	Voltage, V
1	Room temperature	300	58.03	58.03	25...34	2.5...4
2	300	300	62.27	120.30	34	4
3	300	700	30.35	151.05	34...55	4...5.9
4	700	700	42.00	193.05	50	5
5	Cool with the furnace				0	0

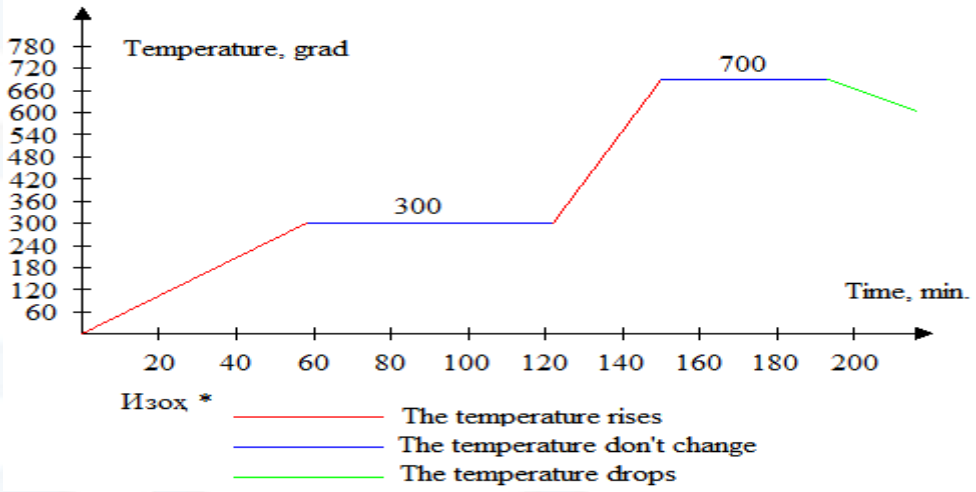

Fig. 3. Primary baking graph of a solid alloy sample.

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The primary cooking process was carried out for 193 min and 5 seconds and the vacuum oven was turned on. The oven and samples were cooled together to room temperature.

Before starting the final baking, another vacuum was created in the oven and the final baking process began. The duration of the final cooking process is given in Table 5 (Figure 4).

Table 5 Sample final baking procedure(VK6).

Stage No	Initial temperature, ^{o}C	Finishing temperature, ^{o}C	Phase duration, min.	Overall, min.	Electric power consumption of the vacuum furnace	
					Current power, A	Voltage, V
1	Room temperature	700	118.54	118.54	25...55	2.5...5
2	700	1200	61.01	179.55	65...70	6
3	1200	1200	20.03	199.58	70	6.1
4	1200	1300	19.59	219.57	80...84	7
5	1300	1300	19.23	239.20	84	7
6	1300	1380	21.03	260.23	86...96	8.1
7	1380	1380	20.59	281.22	96	8.1
8	Cool with the furnace				0	0

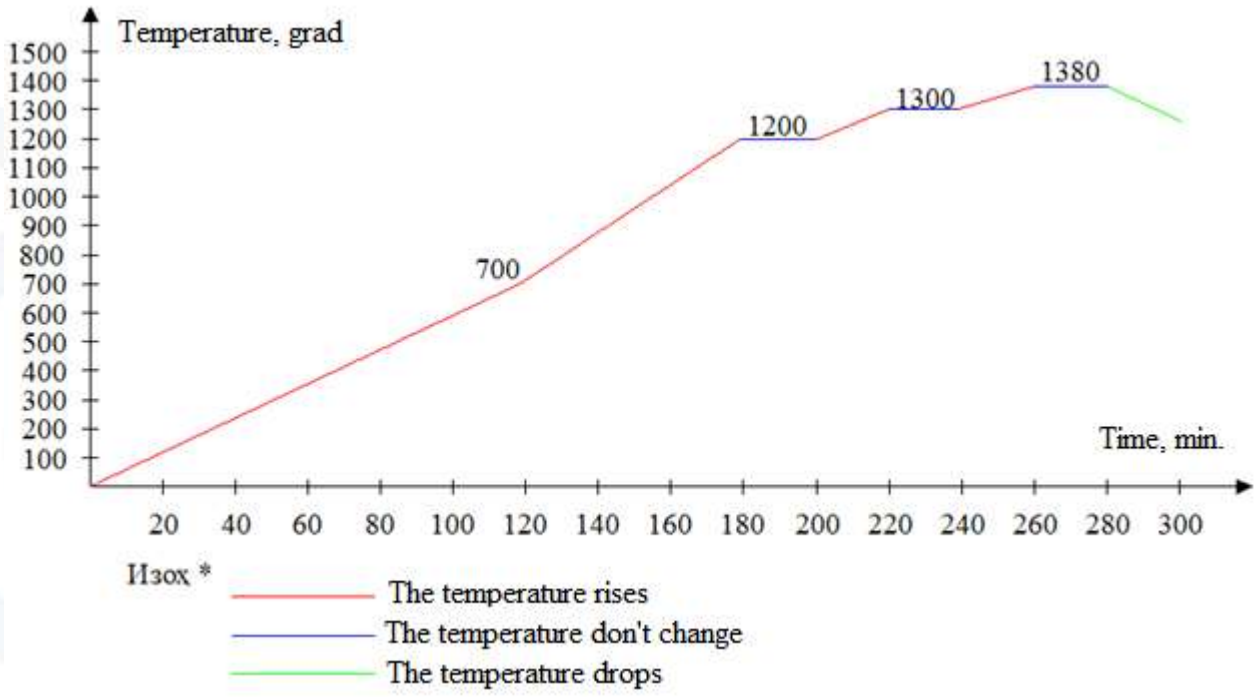

Fig. 4. Baking graph completing the solid alloy sample.

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The final baking process was carried out for 281 min 22 seconds and the vacuum oven was turned on. The oven and samples were cooled together to room temperature. Samples were taken from the oven, and no cracks were observed in the sample (Fig. 5). The shrinkage of the sample decreased from 20 mm in diameter to 17.4 mm (13%) and height from 10.5 mm to 8.9 mm (15.2%). This contraction is at the level of contraction defined in the overall calculation.

Fig. 5. Sample from the furnace.

Conclusion

Scientific and practical research has shown that the interdependence of time and temperature during the cooking of hard alloys has a significant impact on the quality of the baked part (hardness, strength, abrasion resistance).

Complete removal of the plasticizer in the pressed sample, slow waiting of the temperature for the cobalt, which is the binding element, to melt completely with tungsten carbide to form an alloy, 60 minutes at 300 C in the initial baking stage, 700 C at 40 minutes and 1200 ^{o}C, 1300 C, 1380 C in the final baking. It is advisable not to change the temperature for more than 20 minutes.

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