ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 3, Issue 7 , July 2016

Sintered powder composition on the basis of Mo-TiC

Norkhudzhaev F.R., Nazarov A.M., Yakubov L.E.

Doctor of Philosophy, Department of Materials Science, Tashkent State Technical University, Tashkent, Uzbekistan
Professor, Doctor of Technical Sciences, Department of Radio Devices and Systems, Tashkent State Technical University, Tashkent, Uzbekistan
Doctor of Philosophy, Department of Materials Science, Tashkent State Technical University, Tashkent, Uzbekistan

ABSTRACT: The paper is devoted to the theory and technology of the development of sintered powder composition based on Mo-TiC for use in a variety of tools. The results of the study on composition and structure as well as physical and mechanical and technological properties are presented.

KEYWORDS: solid state alloy, tungsten, cutting tools, titanium carbide, molybdenum, powder composition.

I. INTRODUCTION

Modern tool production is based on high-quality tool materials: steel cutters, hard alloys, mineral ceramics and synthetic super-hard materials. Solid compounds for tools are developing with increasing pace which account for about 70% of the removable chip when machining materials. However, production of tungsten cannot keep pace withgrowing appetite for hard alloysthat usually use tungsten. This can only be ensured by adopting specific measures aimed at design of alternative materials that do not contain tungsten.

Work on the creation tungsten-free hard alloys is underway in many countries. Along with tungsten-free trial versions, hard alloys with a minor percentage of tungsten are also being developed.

Properties tungsten-free hard alloys substantially differ from properties of conventionally used tungsten-cobalt alloys, so the conditions of their application have their own specifics. In addition, the process of production of Mo-TiC eutectic alloy casting is time consuming and is quite an energy intensive process, since it melting and filling are carried out in vacuum or in an inert gas environment of argon or helium in electrical furnaces at a temperature 2400-2500ºC. Besides machining of these alloys requires special tools equipped with cutting elements of super-hard materials. Moreover, the ratio between TiC and Mo in the eutectic alloy is about 7 to 1, which makes the alloy more expensive due to high Mo content. Ultimately, these factors reduce the efficiency of application of the eutectic Mo-TiC alloy.

In order to address these shortcomings, relevant manufacturing technology of obtaining Mo-TiC alloy system is required based would be based on powder metallurgy technique which would also surely be considerably flexible and more cost-efficient in comparison with cast eutectic Mo-TiC [1-2].

II. STATEMENT OF A PROBLEM

One of the main objectives of research was to establish the composition and development of the technology of obtaining of sintered powder composition of Mo-TiC. Beyond the basic components of TiC and Mo the elements of Ni, Fe, W, and LaB6 were also deposited into the composition in order to improve process performance [1-3]. Introduction of Ni in the composition is motivated by the necessity to ensure technological process of the system. Ni ensures proper compressibility and density required in sintering, which positively affects the performance properties. Iron is also introduced into the composition in order to ensureprocess conditions by reducing oxides on the surface of titanium carbide particles and solid-solution strengthening of the matrix by assimilation of Ti molybdenum. Tungsten is added in a solid-solution for strengthening of molybdenum substrate. Doping by hexaborides of rare-earth metals REM, particularly of LaB_6 in the alloy is based on the fact of partial dissociation of $LaB_6 = La + 6B$ at high temperatures. In the manufacture of the alloy, lanthanum hexaborideis an active supplier of lanthanum and boron atoms. Boron atoms because of their chemical reactivity to form borides, molybdenum and lanthanum atoms bind contaminants in chemical compounds. The formation of molybdenum borides increases the hot hardness and heat-resistance. Preliminary experiments showed that the eutectic alloy is reproduced by sintering a powder composition comprising the same content seems not possible, since the sintered alloy does not meet the requirements on any parameter. Therefore,

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 7 , July 2016

development of a substitute alloy was carried out, on the one hand in the direction of increasing of content of TiC, and, on the other hand, in the direction of introducing additional additives to improve the technological and operational characteristics of the alloy [1-3].

Comparative alloy assessment was conducted by two specifications of flexural strength (σ_{fl}) and hardness (HRA). As is well known, these characteristics are correlated well with the cahargteristics such as hot hardness and heat resistance determining serviceability and durability of punching tools for hot forming. Therefore, in the process of design of the alloy for determining optimal composition of the alloy σiz and HRA criterion were taken as the basis. Optimization of composition was conducted with the method of mathematical planning of experiments [4]. The starting point in the development, the alloy with content of 30%; TiC; 4% Fe; 2% Ni; 0,2% LaB_6; 1% Wwas chosen and the rest is molybdenum (Table. 1), which had a perfectly acceptable level of controllable specification (σ_{fl} = 390 MPa, HRA 70).

Implementation of the plan to process the data was expressed in the form of regression equations of the form: У=45,87

$$+ 3{,}88X_1 - 1{,}63X_2 - 2{,}13X_3 - 1{,}25X_4 - 1{,}63X_5$$

After the statistical evaluation of the significance of the equation coefficientsit was determined that were significant in the range of concentrations of selected components of the composition, only two at the X1 and X3 (corresponding to the content of titanium carbide and nickel)

$$У=45{,}87 + 3{,}88X_1 - 2{,}13X_3$$

Using the method of steep ascending in the optimization (Table. 2) composition of the powder compositionhas been defined, which was adopted as a basis for further research (Table. 2) and provides a level of σ_{fl} strength = 800 MPa and HRA = 85-88.

Table 1

Terms and conditions of the experiment

Factors	TIC, %	Fe, %	Ni, %	LaB_6 %	W %
Baselevel X	35	4	2	0,2	1
The interval of variation, X_0	5	2	1	0,1	0,5
Top level	40	6	3	0,3	1,5
	30	2	1	0,1	0,5

The optimum composition of the powder composition comprises: 45-47 % TiC; 1,5-25% Fe; 1,5-2% Ni; 0,5-1% W; 0,1-0,2% LaB_6; Mo – rest.

III.THE CONCEPT OF THE PROBLEM DECISION

An important role in achieving a high level of mechanical properties,the technology of preparation of the composition and its modes of sintering do play. Preparation of the powder mixture was carried out in the laboratory ball mill at a ratio of mixture volume to the volume of balls of 20-40 mm diameter carbide BK6 1: 4. The components of the composition were divided into two groups: the first included Mo, Ni, LaB6 and W, the second TiC, Fe and ammonium paramolibdenat ($(NH_3)\cdot MoO\cdot 5H_20$). Both groups were loaded into different components and mill werepre-blendedinethylene alcohol for 12-16 hours. Then the compositions were combined and the final mixing was continued for 6-8 hours. Afterwards, the mixture was dried at a temperature in the distiller 100-120ºC within 8-12 hours. The dried mixture wasblended at plastificator- 3% rubber solution in gasoline, then re-dried in the drying furnace at 100-120ºC temperature for 16-24 hours [1 - 4].

Table 2.

Optimization plan of the composition of the sintered alloy based on Mo-TiCcompound by steep ascending.

Factors	TiC,%	Fe, %	Ni, %	LaB_6,%	W, %	$\sigma_{из}$
Bi	3,88	-1,63	-2,13	-1,25	-1,63	-

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 7 , July 2016

Bi*	19,4	-	213	-	-	-
Step (.)	1	-	0.1	-	-	-
Assumedexperiment results	41	2	2,9	0,1	1	-
- - -	42	2	2,8	0,1	1	-
De-factoexperiment results	43	2	2,7	0,1	1	70
Assumedexperiment results	44	2	2,6	0,1	1	-
-	45	2	2,5	0,1	I	-
-	46	2	2,4	0,1	1	-
De-factoexperiment results	47	2	2,3	0,1	1	80
Assumedexperiment results	48	2	2,2	0,1	1	-
---	49	2	2,1	0,1	1	-
---	50	2	2,0	0,1	1	-
De-factoexperiment results	51	2	2,0	0,1	1	76
Assumedexperiment results	52	2	2,0	0,1	1	-
--	53	2	1,9	0,1	1	-
--	54	2	1,8	0,1	1	-
De-factoexperiment results	55	2	1,7	0,1	1	72

The finished mixture is compressed to form a pressure of 50 N at a press unit P4626. After pressing the product was dried in an oven at 100-120 °C for 18-24 hours and then were preliminarily sintered in the atmosphere of hydrogen at temperature 600-700 °C for one hour [1.4].

Final sintering mode is selected depending on the purpose of the product as well as for punching tools for working at high temperature and pressure sintering is carried out under the regime: in vacuum of not less than 10^{-3}mm of Hg column.

sintering temperature - 1450 - 1500 °C;

sintering time - 4-6 hours.

The first priority after the completion of the first phase of the study was to assess the composition, structure, level of physical, mechanical and technological characteristics of the obtained alloy [4].

IV. IMPLEMENTATION OF THE CONCEPT

Phase X-ray analysis showed that the optimal composition of the alloy corresponding to its composition includes the following phases: TiS, Mo2C, Mo (Ti). Analysis of interference maxima and their form suggests a significant degree of doping of the main phase and the presence of micro-scale defects in the lattice. Investigation of the structure of this alloy also showed that equiaxed grains having very small differences in size represent the core of this alloy, with an average grain diameter in the range 10-20 microns. At the heart of the system are distributed fine inclusions of the

second phase. The distribution of different grain evenly throughout the body, with some rare clusters along the boundaries. Across grain boundaries allocation of excess phase are found, indicating the formation of a liquid phase during sintering.
Physical and mechanical characteristics of the composition, namely, density, hardness HRA and flexural strength were determined according to the procedures established by the State Standard for hard sintered alloys

density - by hydrostatic weighing;
HRA hardness - the instrument Rockwell or Vickers;
σ_{fl} - on the tensile testing machine UMM-5.

To do this, we prepared standard samples size6x6x40mm.
In addition, we measured hot hardness of sintered composition of Mo-TiC system in a special unit of high-hardness - UHT temperatures ranging 20-1600ºC. Tests were carried out in the laboratory of the Department "Physical metallurgy of steel and high-strength alloys," of the Moscow Institute of Steel and Alloys. For this purpose, samples were manufactured from a composition Mo TiS in cylindrical shape with a diameter of 8 mm system and 5.7 mm. To determine the hot hardness, the indentation method using the statistic sapphire indenter was implemented type the correct standard four-sided pyramid with an angle between opposites faces of 136°. Hot hardness was measured in an atmosphere of inert gas of high purity, as the material selected for the heater tungsten. After applying multiple impressions on the surface of the specimen, cooled to room temperature and exerted from the hopper, the measurements on the microscope diagonal prints.
Tests have shown that the entire temperature range 20-1600^{0}C the sintered composition Mo-TiS system has a higher hardness than the cast eutectic alloy of the same system. Especially noticeable difference is achieved at high temperatures (1000-1600^{0}C), where the level of hardness in sintered composition is 1.5-2 times higher.
The studies revealed that the sintered composition Mo-TiC system, has the following physical and mechanical properties [4]:
Coefficient of linear expansion grad^{-1} - 6,61·10^{-6}
Density g/ cm^3 - 6.4 - 6.6;
HRA hardness - 88 - 90;
bending strength MPa - 900-1100.

V. CONCLUSION

Thus, as a result of studies we have been able to develop a new powder alloy based on titanium molybdenum carbide Mo - TiC. A method of forming of optimal quantity composition of powder Mo - TiC, which includes: 45-47% TiC; 1,5-25% Fe; 1,5-2% Ni; 0,5-1% W; 0,1-0,2% LaB_6; Mo –the rest, was developed. The structure, physical-mechanical and technological properties of Mo-TiC composition were studied. On the basis of technological tests of tungsten-free hard alloys based on molybdenum and titanium one can conclude the possible application of the above material for processing of carbon steel, bearings, tools and constructional and alloyed steels as a cutting tool.

REFERENCES

[1] Norkhudzhaev F.R. Development of composition of the sintered powder composition based on Mo- TiC for punching tools // j.Vestnic TSTU, №1, pp. 23-26, 2000.
[2] Norkhudzhaev F.R. Development of technology for tungstenfree carbide-based Mo-TiS for the cutting tool // Proceedings of the Russian Scientific Conference with international participation "Modern trends in the development of the automotive industry in Russia", pp.123-125, 2004.
[3] Norkhudzhaev F.R. Application tungsten free carbide-based Mo-TIC for metal cutting // Proceedings of the Second International Scientific and Technical Conference “High technology and the development of higher education in the XXI century”, pp. 351-352, 2004.
[4] Norkhudzhaev F.R. Some physico-mechanical and technological properties of the sintered alloy of Mo-TIC// j.Vestnic TSTU, №1, pp. 91-93, 2001.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 7 , July 2016

AUTHOR'S BIOGRAPHY

Norkhudzhaev Fayzulla Ramazanovich -Doctor of Philosophy,Professor of the Department «Materials Science» of the Tashkent State Technical University named after Beruni. Author of one monograph and four textbooks, and more than 40 scientific publications, including 3 patents.

Nazarov Abdulaziz Muminovich - Doctor of Technical Sciences, Head of the Department "Radio Devices and Systems"of theTashkent State Technical University named after Beruni. Author of two monographs and three textbooks, and more than 80 scientific publications, including 5 patents.

Yakubov Lazizkhan Ergashkhanovich- Senior Teacher of the Department « MaterialsScience» of the Tashkent State Technical Universitynamed after Beruni. Author