TECHNOLOGY OF PRODUCTION OF COMPOSITE POWDERS TI6Al4V-Al_2O_3 FOR ADDITIVE METHODS

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Abstract

The purpose of this work is developing of the method for producing the composite powder (Ti6Al4V-Al_2O_3) suitable for use in additive technology (AT). The method involves surface modification of metal powders as a second phase in a planetary mixer. The object of the study was mode of modification: 1) the speed of rotation of platform and container; 2) time of modification; 3) the mass ratio of the Ti6AI4V powder, Al_2O_3 powder and ZrO_2 fraction (mixing agent).

The efficiency of modification of powder was estimated by the optical analysis of the surface of the composite powders. The results of the study showed the presence on the surface of a sufficient amount of Al_2O_3 powder for production of composite materials.

The assessment of the feasibility of the produced composite powders in AT performed by comparing the composite powders with Ti6Al4V powder used in selective laser melting. The shape analysis showed that the composite powder has a spherical shape of the particles that allows using this powder in AT.

1. Introduction

The additive technologies (Selective Laser Sintering/Melting (SLS/SLM), Electron Beam Melting (EBM), Direct Metal Deposition (DMD)) are widely used for producing metal details in world now. In comparison with conventional metal part fabrication technologies SLM have some advantages, such as: ability to produce of details with complex 3D shape and internal cooling channels; cheapness and rapidity of single or low volume production of complex shape parts (surgical and dental implants, design prototype); minimal quantity of production residuals. For the development of additive technologies it is necessary to expand the range of used materials. One of the most promising directions is the creation of products from composite materials.

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Ti and Ti-based alloys have high corrosion resistance, high strength and low density. It explains using Ti-based alloys in aircraft manufacturing, automotive and aerospace industry. However Ti has several disadvantages. The main are insufficient heat resistance and wear resistance. For improvement of operational properties often use of composite materials [1-7]. Al_2O_3 is well-known hard material with high melting temperature. The combination of physical properties of Ti and Al_2O_3 is promising [8-10]. In this work the method of producing the Ti6AI4V-Al_2O_3 composite powder by using the SLM technology is developed.

2. Research methodology

The proposed method of production of composite powder includes modification of Ti6AI4V powder surface by mechanochemical treatment. The task was deposition second phase (Al_2O_3) without deformation spherical shape of particle Ti6AI4V powder. The subject of work was the mode of treatment. The modification was carried out by using the planetary mixer KURABO Mazerustar kk250 (Fig. 1).

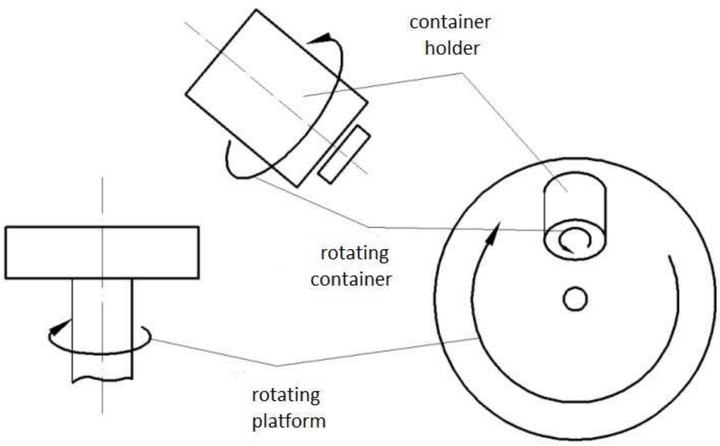

Figure 1. Scheme of modification.

The mixture of Ti6AI4V powder, Al_2O_3 powder and ZrO_2 fraction (mixing agent) was used in the mechanochemical treatment. The result the treatment depended on technological modes of planetary mixer and weight rate of mixture components. Parameters of modification presents in Table 1.

Table 1. The modes of modification.

Mode	Rotation speed of platform, rpm	Rotation speed of container, rpm	Weight of the mixture, g	The proportion of the Ti6AI4V powder in the mixture, %	The proportion of the Al_2O_3 powder in the mixture, %	Weight of the fraction (ZrO_2), g	Processing time, min
1	1580	1460	10	95	5	10	2
2	1580	1460	10	95	5	10	7
3	1580	1460	10	95	5	10	15
4	1700	1580	10	95	5	10	2
5	1340	1220	10	95	5	15	3
6	1580	1460	10	95	5	15	3

For characterization of surface modification quality scanning electron microscopy JSM-6400LV was used (Fig.2).

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The criterions were used for evaluation of technological modes:

1) The homogeneity of composite powder (efficiency of modification). The structure and mechanical properties of product in AT depend on homogeneity of used powder. The experiment showed that composite powders obtained by using modes 1, 5 have insufficient homogeneity. Apparently it is connected with short processing time (modes 1, 5) and low rotation speed (modes 5). Other modes allow obtaining composite powders with acceptable homogeneity.

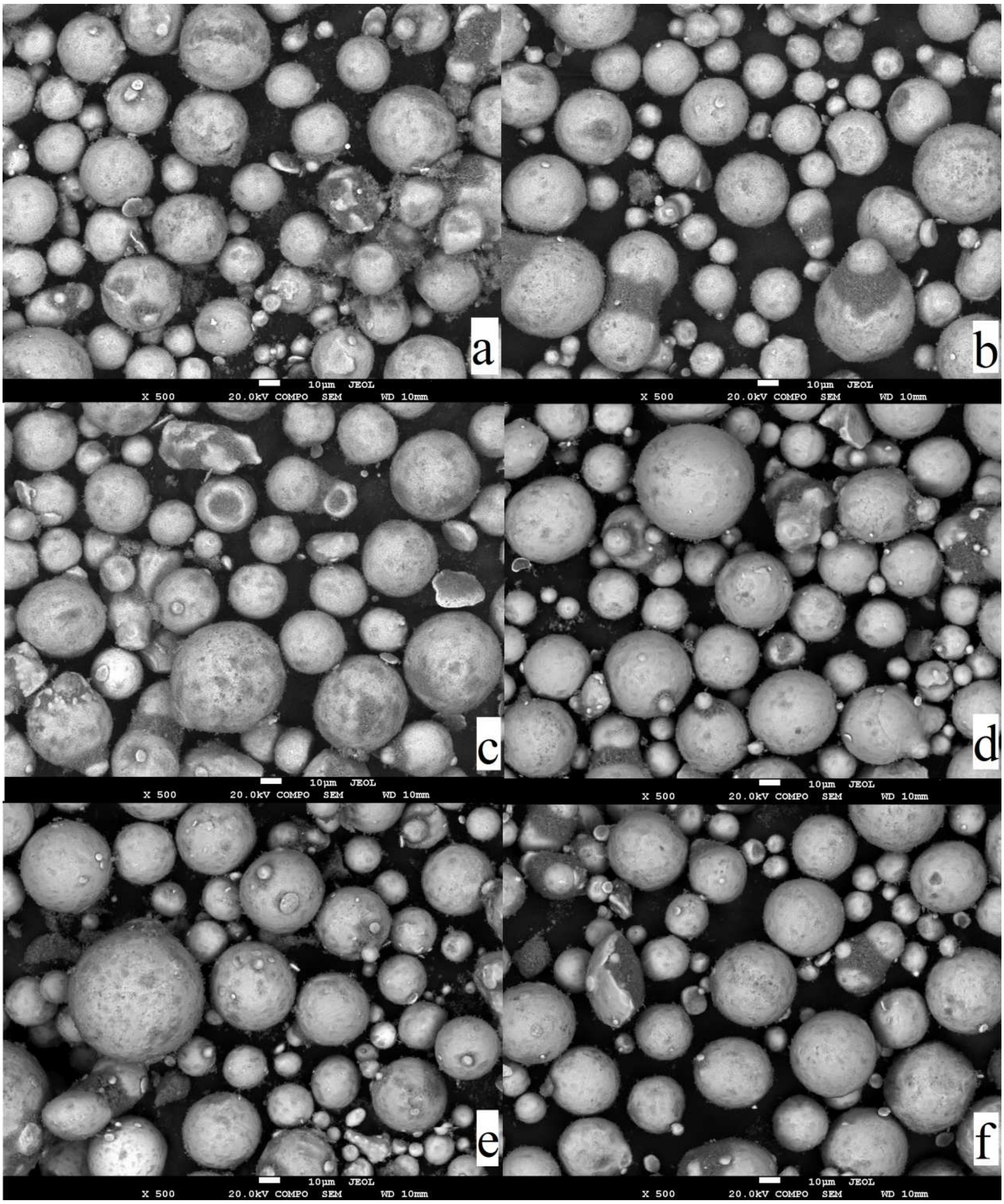

Figure 2. Images of composite powders (scanning electron microscope JSM-6400LV): a – mode 1, b – mode 2, c – mode 3, d – mode 4, e – mode 5, f – mode 6

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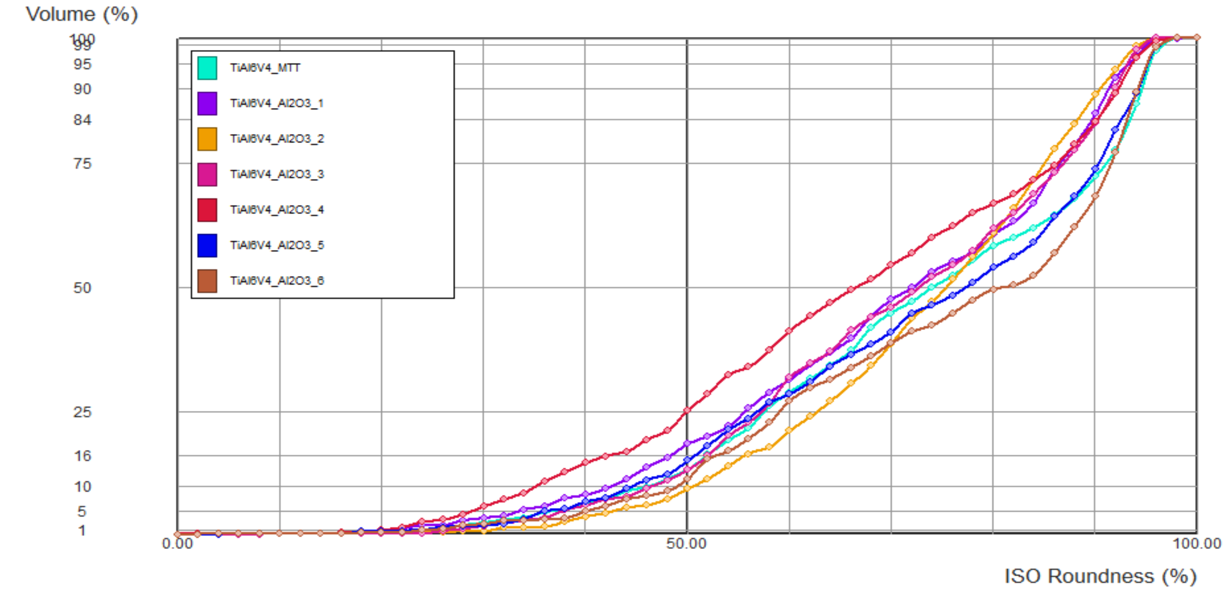
2) The shape of composite powder. Metal powder (Ti6AI4V) is characterized by the spherical shape of particles. The experiment showed that modes of modification insignificant affect on shape of particles. Even increase processing time (mode 3), rotation speed (mode 4) or weight of the mixing agent (mode 5, 6) did not lead to significant deformation of particles.

3) The time of the treatment. The productivity is important parameter of process. The modes 1, 4-6 have the maximal productivity.

For estimation of powder shape ISO Roundness parameter was chosen. The optical analyzer OCCHIO 500 nano was used for determination of powder roundness (Fig.3). The assessment of the suitability of the produced composite powders for using in AT was determined by comparing the composite powders with Ti6AI4V powders that used in selective laser melting.



Shape Distribution by Volume

	Mean	D[4,3]	StdDev	Min	P1	P5	P10	P16	P25	P50	P75	P84	P90	P95	P99	Max
ISO Roundness	72.46	82.43	19.15	5.98	24.40	38.09	46.97	51.96	57.76	74.07	91.28	93.42	94.53	95.35	96.47	100.0
	69.70	75.18	19.08	9.34	21.86	34.22	42.61	48.36	55.42	72.02	86.88	89.83	91.26	93.34	95.07	100.0
	72.75	78.42	15.35	5.05	31.85	43.93	51.40	55.77	62.75	75.56	85.24	88.62	90.44	92.72	94.61	100.0
	70.68	77.78	17.68	9.96	27.51	38.63	47.71	52.03	57.25	73.09	86.96	90.25	91.96	93.41	95.42	100.0
	65.86	77.48	21.08	1.20	21.21	29.35	35.48	42.61	50.10	66.48	86.42	90.44	92.42	93.65	95.61	100.0
	72.78	77.97	19.39	5.01	25.05	37.86	45.49	50.90	56.77	77.37	90.46	92.70	94.25	95.35	96.23	100.0
	74.82	79.54	18.88	2.81	25.34	40.78	49.08	53.17	59.04	81.42	91.66	93.27	94.20	95.31	96.33	100.0

Figure 3. ISO Roundness of Ti6AI4V-Al_2O_3 composite powders (modes 1-6) in comparison with commercial Ti6AI4V powder (MTT Technologies Ltd.)

According to the analysis results, we might conclude that the shape of particles of the composite powders (mean ISO Roundness are from 65.86% to 74.82%) insignificantly differ to the shape of particles of the commercial Ti6AI4V powder (mean ISO Roundness is 72.46%) that it is suitable for AT, especially for selective laser melting. The composite powder obtained with using mode 6 is characterized by the highest mean ISO Roundness (74.82%).

As result research was chosen mode 6 for product of composite powder. This mode is characterized by high productivity and allows obtain homogeneous composite powder with mean ISO Roundness (74.82%).

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3. Conclusions

The production method for composite powders is developed. The proposed method includes modification of the surface of metal powders as a result of the mechanochemical treatment. The mode of treatment was chosen. The shape of the resulting composite powder particles is nearly spherical. The homogeneity of resulting composite powder is sufficient. The obtained composite powder can be use in AT.

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