CALCULATION OF THE EFFECTIVE THERMAL PROPERTIES OF COMPOSITES BASED ON TITANIUM

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Recently, the scientific interest in Titanium-based composites has increased. Today titanium and its alloys are used in the aerospace industry, architecture, chemical processing, medicine, power generation, marine and offshore, sports and leisure, and transportation. This wide application is explained by its unique properties such as high strength, low density, good high temperature properties, biocompatibility and favorable corrosion resistance [1]. At the same time, the main disadvantages of this material, that has presented problems at some stages in its fabrication and in certain technological uses are lack of wear resistance and a susceptibility to galling [2]. For purpose of enhancing the surface properties of titanium alloys, different methods was employed to fabricate ceramics or intermetallics reinforced metal matrix composite coatings on the substrate. For example, TiC composite coatings offer significantly increased wear resistance and chemical stability [3]. TiB and TiC reinforcements can increase the oxidation resistance of titanium-matrix composites [4]. Dispersion hardening by particles of various compounds, for example, Ti_3Al and Ti5Si3 compounds, slightly improves the heat-resistant properties of titanium alloys. There are many studies on the mechanical properties of these composites [4]. However, these modifications can also affect the thermal properties of the resulting composite, which are also important for operation in extreme conditions.

To calculate overall thermal properties of the composites we will model them as a metal matrix containing spherical particles. The typical microstructure of metal matrix composite reinforced by particles can be represented as isotropic one. Properties required for calculations are presented in the Table 1 [1,5].

Table 1. Properties

Properties	Ti	TiC	Ti_5Si_3	TiB_2
CTE, K^{-1}	8,9-10,4 $\cdot 10^{-6}$	7,4$\cdot 10^{-6}$	7,3$\cdot 10^{-6}$	6,4-7$\cdot 10^{-6}$
Bulk moduli, GPa	103,7	272	110	226
Young's modulus, GPa	112	460	156	529
Poisson's ration	0,32	0,19	-	0,11
TC, W/(m·K)	15,5-20	34-39	45,9	60-120

In this work we evaluated the effective properties of composites based on titanium, reinforced by TiC, Ti_5Si_3 and TiB_2 inclusions. The effective properties are calculated using Maxwell's homogenization scheme in terms of contribution tensor of the inhomogeneity [6]. We analyzed change of effective thermal conductivity and effective coefficient of thermal expansion of composites with an increase of volume fraction of inclusions for two methods of calculation: the Maxwell method and mixture method. The results are compared with the experimental data.

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References

1. Titanium and titanium alloys. Fundamentals and Applications / ed. C. Leyens, M. Peters. – Weinheim : Wiley-VCH Verlag GmbH, 2003. – 532 p.. ISBN: 3-527-30534-3

2. P.D.Miller, J.W.Holladay. Friction and wear properties of titanium // Wear.- Vol.2, Issue 2.- 1958- p. 133-140
3. G. Rasool,S.Mridha,M.M.Stack. Mapping wear mechanisms of TiC/Ti composite coatings // Wear Volumes 328–329 (2015) p. 498–508
4. Shufeng LI, Katsuyoshi Kondoh, Hisashi Imai, BiaoChen, Lei Jia, Junko Umeda. Microstructur and mechanical properties of P/M titanium matrix composites reinforced by in-situ synthesized TiC–TiB // MaterialsScience & Engineering A 628(2015)75–83
5. G. FrommeyerR. Rosenkranz Structures and Properties of the Refractory Silicides Ti5Si3 and TiSi2 and Ti-Si-(Al) Eutectic Alloys // Metallic Materials with High Structural Efficiency pp 287-308
6. Anisimova M., Knyazeva A., Sevostjyanov I. Effective thermal properties of an aluminum matrix composite with coated diamond inhomogeneities // International Journal of Engineering Science. - 2016 - Vol. 106. - p. 142–154