Combustion of Ti-Si-C powder system with infiltration by molten copper

E.I. Latukhin, A.P. Amosov, E.R. Umerov, V.A. Novikov

Samara State Technical University, 244, Molodogvardeiskaya str., Samara, Russia, 443100

umeroff2017@yandex.ru

In [1] it was shown, that placing the Cu powder briquette between two adjacent charge briquettes 3Ti+1,25Si+2C for the self-propagating high-temperature synthesis (SHS) or combustion synthesis of MAX-phase of Ti_3SiC_2, it was possible to use a large heat effect of SHS for melting of Cu and spontaneous infiltration of Ti_3SiC_2 porous skeleton by this melt to prepare the Cu-Ti_3SiC_2 composite. However, this experimental scheme significantly limited the size of the resulting composite within a few centimeters. In addition, due to the lack of combustion energy for melting copper in a volume sufficient to fill the entire volume of pores, such a scheme did not allow to create a homogeneous composite with minimal residual porosity.

In this work, a new scheme was tested with the immersion of Ti_3SiC_2 hot skeleton after a certain pause after the SHS end in melts of copper or alloys Cu-10%Si or Cu-20%Sn at a melt temperature T=1120 ºC [2]. At a pause of 6-8 s, partial impregnation of Ti_3SiC_2 skeletons with copper-based melts was observed, which was evident from the significant residual porosity. At the same time, microstructure analysis showed traces of Ti_3SiC_2 plates in samples partially impregnated with Cu-10%Si and Cu-20%Sn alloys and almost complete absence of traces of Ti_3SiC_2 when impregnated with pure copper.

In order to reduce the cooling rate of SHS skeletons, a new approach was considered, in which a charge powder briquette Ti-Si-C of cylindrical shape with a length of 200 mm and a diameter of 22 mm was horizontally placed on a sand base, and the copper melt was prepared separately in a melting furnace in the required volume, after which the copper melt was poured into a sand mold so that direct contact with the end of horizontal charge briquette was provided. The initiation of the combustion of the charge briquette Ti-Si-C occurred at a distance of 40 mm from the place of contact with the copper melt, which caused two combustion fronts moving in opposite directions of the charge briquette. This was done to provide a temporary pause between the combustion front, moving in the opposite direction from the melt, and the infiltration front, which began to move at the moment of reaching the second front of the combustion end of the charge briquette in contact with the copper melt. But the pure copper melt was not infiltrated in Ti_3SiC_2, probably due to insufficient melt temperature, and as a consequence poor wetting. The addition of 10% Si to copper, which reduces the melting point of copper to ~830 ºC, made it possible to impregnate the cylindrical Ti_3SiC_2 skeleton by ~90 mm in length. In the resulting composite, a different phase composition along the length was observed. In general, the addition of 10% Si to copper contributed to spontaneous infiltration of Cu melt and, at the same time, ensured the preservation of Ti_3SiC_2 in the area from 40 to 90 mm. The resulting composite is highly brittle, probably due to saturation of the copper matrix with oxygen, which, according to chemical analysis, reached up to 1% by weight.

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References

1. A.P. Amosov, E.I. Latukhin, A.M. Ryabov, E.R. Umerov, V.A. Novikov. *J. of Physics: Conf. Series.* **2018**, 1115 (4), 042003. DOI :10.1088/1742-6596/1115/4/042003.
2. A.P. Amosov, E.I. Latukhin, E.R. Umerov. *Pat. 2733524 (RF)*. **2020**.