COATING COMBUSTION SYNTHESIS CONTROLLED BY MOVING ELECTRON BEAM [1]

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The methods of materials synthesis using combustion or Combustion Synthesis (CS) (Self propagating High temperature Sythesis (SHS), Thermal Explosion (TE)) allow obtaining the materials with different properties [1,2]. Combustion synthesis processes are characterized by high-temperatures, fast heating rates and short reaction times [3]. This is interested for the technologies of intermetallic or composite coating deposition. Today this is interested for the development of Additive Manufacturing (AM) technologies [4-6]. When electron-beam is used for intermetallic coating or detail formation, the features appear [7,8].

In this paper, the some models of authors are discussed applicable to electron beam melting of metals forming intermetallic phase and composite formation controlling by electron beam.

Firstly, the possibility of self-propagating mode under the conditions of coating synthesis on substrate is presented. The kinetics of exothermic reaction is described in this model by summary reaction scheme; however the coupling between mechanical and thermal processes is taken into account. The problem on stationary reaction front propagation is solved analytically using asymptotic method, similarly to [9,10]. The simplest model is generalized further to composite synthesis when reaction mixture contains inert inclusions.

When green powder mixture is low–energy, self-sustaining mode is not possible. However, using electron-beam one can use to control the synthesis. The corresponding model includes thermal conductivity equations with two heat sources – from electron-beam heating and from chemical reaction. Different variants of the model are studied in [11-13], where the coupling effect was shown on the coating composition formation under electron-beam controlling taking into account the detailed reaction kinetics; the phase formation in the melting pool during particle dissolution in direct metal deposition technology was demonstrated; critical phenomena dividing the composite and homogeneous coating formation were detected.

During recent years, the models with detailed kinetics were refined to take into account shrinkage effect. It was demonstrated, for example in [14-16], that similar model obey prognostic properties and can predict irreversible composite change during coating and objects formation in AM-technologies.

REFERENCES

[1] *Varma A, Rogachev AS, Mukasyan AS, Hwang S. //* Adv Chem Eng. – 1998 – 24 – 79–226.
[2] *Kashinath C. Patila, S.T. Arunab, Tanu Mimani //* Current Opinion in Solid State and Materials Science. – 2002. – 6. – 507–512.
[3] *Patil KC, Aruna ST, Ekambaram S. //* Current Opinion in Solid State and Materials Science. – 1997. –2. –158–163.
[4] *S.L. Sing, L.P. Lam, D.Q. Zhang, Z.H. Liu, C.K. //* Materials Characterization. – 2015. – 107. – 220–227.
[5] *Fei Weng, Huijun Yu, Chuanzhong Chen, Jianli Liu, Longjie Zhao, Jingjie Dai* // Journal of Alloys and Compounds. – 2016. – 686. – 74-81.
[6] *Shishkovsky I.V. //* Laser-controlled intermetallics synthesis during surface cladding. – in Laser Surface Engineering. Processes and Applications. A volume in Woodhead Publishing Series in Electronic and Optical Materials. – Elsevier. –2015. – 237–286. *http://dx.doi.org/10.1016/B978-1-78242-074-3.00011-8*
[7] *Murr L.E.* // Additive Manufacturing. – 2015. – 5. – 40–53.
[8] *Schiller S. and Panzer S.//* Ann. Rev. Mater. Sci. – 1988. – 18. – 121-140.
[9] *Timokhin A.M., Knyazeva A.G.* // Chemical physics. – 1996. – 15. – 10. – 85-100
[10] *Knyazeva A.G., Sorokova S.N.* // Combustion, Explosion, and Shock Waves. – 2006. – 42. – 5. – 549-558
[11] *Sorokova S.N., Knyazeva A.G. //* Theoretical Foundations of Chemical Engineering. – 2010. –.44. – 2. –172–185
[12] *Knyazeva A.G., Pobol I.L., Gordienko A.I., Demidov V.N., Kryukova O.N., Oleschuk I.G*. // Phys. Mesomech. – 2007. – 10. – 3-4. – 207-215
[13] PMTF
[14] *Knyazeva A.G., Kryukova O.N. // IOP Conf. Series: Journal of Physics: Conf. Series – 2017. – 899. – P 072001*.
[15] *Knyazeva A. //* Journal of Physics: Conference Series. – 2016. – 754 . – 042009
[16] *Knyazeva A.G., Pobol I. L., Demidov V.N. //* IOP Conf. Series: Materials Science and Engineering. – 2016. – 140. – 012021

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