Metal matrix nanocomposite production using contactless electromagnetic interaction

Andris Bojarevics[1], Toms Beinerts[1], Imants Kaldre[1], Ilmars Grants[1,2], Gunter Gerbeth[2]

[1]Institute of Physics, University of Latvia, Latvia

[2] Helmholtz-Zentrum Dresden - Rossendorf, Germany

e-mail: imants.kaldre@gmail.com

Nanoparticle dispersed metal matrix nano composites (MMNC) has qualitatively different properties and thus specific applications in technology and nuclear industry. One of the best known material of such type is oxide dispersion strengthened (ODS) steel, which consists of steel matrix and dispersed yttria nanoparticles. Dielectric micro and nanoparticles dispersion in liquid metals is a technical challenge. Currently powder metallurgy is the most common method to produce these materials. This work analyses the possibility to mix and disperse nanosize particles into molten metal using intense contactless electromagnetic interaction. Superimposed AC and DC magnetic fields create oscillating pressure in the liquid metal. If magnitude of this pressure is sufficiently high, acoustic cavitation in the liquid metal can be achieved. Cavitation bubbles are expanding and collapsing very rapidly causing intense microscale jets which can overcome Van der Waals forces and disperse added particles. Experiments have been done using 10-20 kHz AC magnetic field with amplitude of 0.09 T to melt the samples and 0.35 T DC magnetic fields either in axial or transverse direction. These values turned out to be insufficient for some metals to achieve intense cavitation. To achieve higher pressure experimental facility using superconducting magnet to create up to 4 T magnetic field has been developed.Results show that for different metal and particles combination required interaction intensity can be very different. Contactless electromagnetic method for metal matrix nanocomposite production can be feasible for some combination. Particle dispersion and influence on material structure are examined using optical micro scopy, scanning electron microscopy and X-ray fluorescence spectroscopy. Most promising experimental results in terms of particle dispersion are aluminiummatrix and SiC particles and Fe or FeCr steel matrix and and TiN particles.