15th International Symposium on Flow Visualization
June 25-28, 2012, Minsk, Belarus

DIAGNOSTIC OF PLASMA SPRAY PROCESS USING HIGH SPEED IMAGING AND NUMERICAL SIMULATION

V. GRIGAITIENĖ[c], R. KĖŽELIS, V. VALINČIUS, M. MILIEŠKA

Plasma Processing Laboratory, Lithuanian Energy Institute, Kaunas, LT-44403, Lithuania

[c]Corresponding author: Tel.: +37037401898; Fax: +37037; Email: fomin@hmti.ac.by

KEYWORDS:
Main subjects: plasma spraying, plasma and dispersed particles flow visualization
Fluid: high speed plasma flow, high temperature multiphase flow
Visualization method(s): high speed camera imaging
Other keywords: mineral fiber production, DC plasma torch

ABSTRACT: The research presents results of experimental and numerical investigation on behaviour of dispersed particles, granules, also melted ceramic material domains outflowing from the atmospheric pressure plasma torch. High thermal resistant granules and fibre have been produced from aluminium oxide, copper oxide, zeolites, dolomite and its mixture with quartz sand employing a specific atmospheric pressure plasma spray technique. Produced fibre can be used as high temperature insulation, as filter for ultrafine particles or as a concrete additive for strenghtening of building materials. Experimental installation was developed for operating by feeding air, nitrogen or hydrocarbon containing gases mixed with dispersed particles. The power of plasma torch was in the range of 53 – 85 kW, the mean temperature of gas leaving the reactor – 1800 – 3000 K, plasma flow velocity in the outlet – 500 – 1300 m/s. A high-speed RedLake MotionPro video camera was used for instantaneous imaging of plasma spray process. The plasma spray process, the interaction of plasma jet and dispersed particles is showed in Fig. 1. The velocity of plasma jet is supersonic: the shock diamonds of the flow visually can be observed. Observations by camera suggest that multiphase jet in exhaust plasma chemical reactor nozzle consists of melted domains, grains of different sizes and fiber filaments. Experimental tests showed that dolomite+SiO_2 or zeolites powder, injected into high temperature jet, is melted very quickly. The high-speed imaging let to distinguish moving structures, determine the spraying stream geometry, and calculate the magnitude and speed of sprayed materials. The produced fibre is showed in Fig. 2.
The interaction of plasma jet and hard ceramic particles were numerically investigated by means of "Jets&Poudres" software, applied to simulate plasma spraying processes.

Performed experimental and analytical studies showed that process of plasma melting and conversion of melt into microfibre depend on following main factors: - plasma generator characteristics and operating regimes; - plasma flow formation, spraying characteristics; - plasma forming gas and powder injection mode and place; - size and fraction of sprayed particles, the injection rate parameters and specific details of ceramic fiber formation.

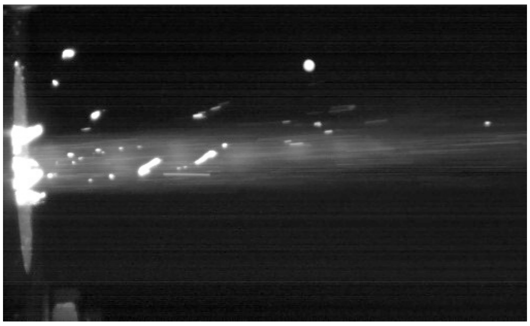

Fig. 1. Flow visualization of spraying process in supersonic plasma jet.

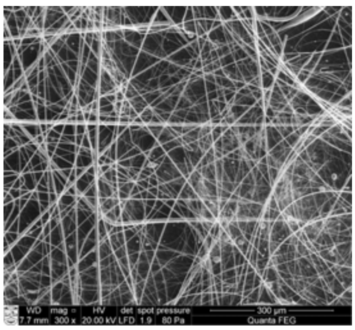

Fig. 2. Zeolite fibers, produced by plasma spraying method.