STRUCTURAL EVOLUTION OF 321 STAINLESS STEEL IN ELECTRON BEAM FREEFORM FABRICATION

*A.V. CHUMAEVSKII**, *S.YU. TARASOV***, *A.V. FILIPPOV**

**Institute of Strength Physics and Materials Sciences SB RAS, Tomsk, Akademicheskii av. 2/4, Russia*
***National Research Tomsk Polytechnic University, Tomsk, Lenin av. 30, Russia*

Additive manufacturing is the most advancing and fast developing process for making complex near net shape and important components of air space applications.

Electron beam processes have earlier been used for welding [1], coating deposition on various substrates [2-4] as well for forming wear-resistant subsurface structures [5-7]. Both vacuum-base and non-vacuum processes are used. The EBF3 process has some advantages such as high deposition rate, high deposited metal density, no oxidized layers, etc. [8].

Laboratory EBF3 equipment has been used for making samples. The EBF3 process parameters were as follows: current 33 мA, voltage 33 kV, scanning speed 200 mm/min, scanning step 0.8 mm.

Stainless steel 321 grade 1 mm diameter wire was used for forming samples which then have been cut into smaller sample for microstructural examination. These sample have been mechanically ground using abrasive sand paper, then polished using first 1 mkm grit diamond paste and then colloid quartz suspension 60 nm grit. Etching has been carried out using electrochemical cell where anode was sample and cathodes were two steel plate electrodes. Solution of 10% oxalic acid was used as electrolyte. The etching voltage and current were 6.1 V and 0.05 A, respectively. Process duration 30-40 s.

On etching, the samples have been examined using an optical microscope thus obtaining optical images of the sample both cross sections.

Mechanical tests have been carried out using a tensile machine Testsystems 110M-10 at room temperatures. The tensile axis coincided with the sample's building direction. Samples for mechanical tests have been EDM cut out from three different zones such as substrate, fusion line between substrate and as-clad metal and as-clad metal. Fractography studies have been performed using a scanning electron microscope NIKKISO SM3000.

Metallographic studies allowed showing that as-clad metal consists of dendritic structures (Fig.1). The cross section panoramic view in Fig.1a shows a fusion line between as-clad metal and substrate as well as fusion lines between as-clad metal layers. The very first as-clad layer has the less thickness (450 mkm) as compared to that of further deposited layers which are almost equal thickness ones (800-900mkm). The latter is a evidence of the EBF3 process stability since that thickness corresponds to the vertical scanning step.

The fracture surfaces of as-clad metal contains some microscopic pits which may be < 5mkm size pores (Fig.4a). Larger 20-30 mm size and numerous small 3-5 mkm pits are observed on the fracture surface of sample cut out of the as-clad/substrate fusion line zone (Fig.4b). The base metal fracture surface predominantly shows up large pits (Fig.4c).

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