EVALUATING THE CORROSION RESISTANCE OF THE NOVEL AL-ALN METAL MATRIX COMPOSITES PRODUCED OF HOT DIRECT EXTRUSION

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This study reports the corrosion resistance of novel metal matrix composites (MMCs) based on aluminium (Al) and the reinforcing component – 8.8 and 14.7 vol.% aluminium nitride (AlN) labelled as Al10AlN and Al16AlN. In humid environments the corrosion rates of Al10AlN and Al16AlN were below 0.001 mm/year, showcasing a high level of corrosion resistance. In artificial acid rain, their stability persists - corrosion rates staying below 0.005 mm/year. This high corrosion resistance in adverse conditions, makes Al-AlN MMCs well-suited for applications where durability is of utmost importance.

Keywords: aluminium alloy, aluminum nitride, metal matel matrix composite, corrosion resistance, hot direct extrusion

The development of metal matrix composites (MMCs) is expedient in connection with the demand for lightweight materials that combine excellent properties with the economic cost demanded. Aluminium (Al) combines well with hard materials such as ceramics and offers promising MMCs showcasing enhanced properties. Aluminium nitride (AlN) has garnered significant interest as an encouraging reinforcement within Al matrix composites. The properties of Al-AlN MMCs make them suitable for potential applications in the transportation and energy segments [1-4].

This study is a continuation of the leading study in which extruded MMCs were developed based on Al and reinforced AlN component. In this approach, readily available powders were used, which formed the initial mixture of powders: Al + 2 wt.% Mg + 1 wt.% Sn. After that, permeable powder billets (residual porosity of 30.8 ± 1.6%) were formed using cold isostatic pressing. In the subsequent step, billets were partially nitrided at atmospheric pressure below the melting point of Al. The nitrided billets were consolidated through the process of hot direct extrusion (DE), resulting in the formation of a composite rod with 8.8 and 14.7 vol.% of AlN and residual porosity 0.5 %, and 1.1 % respectively. Developed extruded Al-AlN MMCs have excellent complex mechanical properties: high hardness, increased Young's modulus, and high tensile strength in combination with excellent creep and thermal conductivity indicators. Collectively, these attributes make them potential candidates for various load-bearing applications operating under elevated temperature
conditions [2, 3]. It should be noted all powders and techniques utilized are available. In addition, the fabrication approach used is feasible from a large-scale industrial standpoint.

Analysing the work of researchers, it has been found that introducing reinforcement into Al alloys increases their corrosion rate compared with unreinforced alloys. It was also established that AlN particles are prone to hydrolysis and thus cause deterioration of the corrosion resistance of MMK in neutral chloride solution [4]. Therefore, the main of this work was to determine the corrosion resistance of the novel extruded Al-AlN MMCs in a humid environment and an artificial acid rain solution [5].

To determine the corrosion rate of the studied composites, immersion studies were carried out according to ASTM Standard G31-72(2004). Immersion was – 5 months at room temperature. After a detailed analysis of the obtained results, we established that Al10AlN is more actively exposed to corrosion attacks than Al16AlN. It is obvious that reinforcing nanoparticles are not dominant in reducing corrosion resistance. According to the SEM results, corrosion attack occurs preferentially in the vicinity of the phase Mg2Sn and there disrupts the natural protective oxide layer (passive film). In the solution of acid rain, the formation of pitting near this phase, which causes it to drop out, was recorded. However, with further immersion, a passive film is formed in this place. Within a humid environment, the corrosion rate of both Al10AlN and Al16AlN remains under 0.001 mm/year, indicating a high level of corrosion resistance. Even with immersion in artificial acid rain solution, they are quite stable - the corrosion rate does not exceed 0.005 mm/year.

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