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论文

铝合金/不锈钢钨极氩弧熔--钎焊接头界面层的微观结构分析

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摘要:

运用OM, SEM和EDS分析了铝合金/不锈钢TIG熔-钎焊接头界面层的结构特征, 并通过微压痕和SEM原位拉伸实验测试了其力学性能. 研究结果表明: 界面处
形成了厚度不均一的锯齿状金属间化合物层, 厚度为4-9 μm, 满足界面层的要求(≤10 μm); 界面反应层包括两类化合物层, 即焊缝一侧的τ_5层和钢基体一侧$\theta+\eta+\tau_5$层, 在界面处首先形成τ_5相, 抑制了粗大枝晶状$\theta+\eta$二元相的生长. 微压痕测试得出: τ_5层平均硬度值为HV1025, $\theta+\eta+\tau_5$层硬度值为HV835. τ_5层压痕处产生裂纹, 表明τ_5相是一种硬脆相. SEM原位拉伸实验 显示, 界面层起裂于$\theta+\eta$相, 在外力作用下沿$\theta+\eta+\tau_5$层迅速开裂, 界面层抗拉强度达到120 MPa.

关键词: 铝合金 不锈钢 钨极氩弧熔-钎焊 界面层 金属间化合物

MICROSTRUCTURE ANALYSIS OF INTERFACIAL LAYER WITH TUNGSTEN INERT GAS WELDING–BRAZING JOINT OF ALUMINUM ALLOY/STAINLESS STEEL

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Abstract:

Against the background of the required weight reduction in transportation through lightweight construction, the application of hybrid structures, where aluminum alloy and steel are jointed together, has a high technical and economical potential. But jointing of material combinations of aluminum alloy and steel is problematic by fusion welding since brittle intermetallic compounds (IMCs) are formed between aluminum alloy and steel. Nowadays, tungsten inert gas (TIG) welding–brazing offers a great potential for aluminum alloy and steel jointing. In this process, the sheet and filler metal are heated or melted by TIG heat, and the joint has a dual characteristic: in aluminum alloy side it is a welding joint, while in steel side it is a brazing joint. However, in the dynamic heating process, the heating temperature changes so quickly and the reaction time between the liquid filler metal and solid steel is so short that it is more difficult to control the IMC layer's growth, predominantly its thickness and microstructures. Most of past reports about the brazing of aluminum alloy and steel indicate Al–Fe binary IMC layers, *e.g.*, Fe_2Al_5 and $FeAl_3$, formed in the brazing joint, which are detrimental to the mechanical properties of the joint. Si additions are used to limit the growth of the brittle Al–Fe IMC layer between aluminum alloy and steel by replacing Al–Fe phases with less detrimental Al–Fe–Si phases in aluminizing and furnace brazing of aluminum alloy and steel. By now, there have been few reports of investigating the interfacial layer of TIG welding–brazing joint of aluminum alloy and stainless steel. In this paper, a butt TIG welding–brazing joint of aluminum alloy/stainless steel was formed using Al–Si eutectic filler wire with modified Noclock flux precoated on a steel surface. The microstructure characteristics of the welded seam–steel interfacial layer were analyzed by OM, SEM and EDS and its mechanical properties were measured by dynamic ultra–microhardness tester and SEM in situ tensile tester. The results show that a nonuniform and sawtooth IMC layer forms at the seam–steel interface and its thickness changes from 4 to 9 μm, less than the maximum permissible value (about 10 μm). The interfacial layer is composed of two types of IMC layers, which are τ_5 IMC layer on the seam side and $\theta+\eta+\tau_5$ IMC layer on the steel side. τ_5 phase forms preceding $\theta+\eta+\tau_5$ due to its lower growth energy than Al–Fe phases and the primary τ_5 layer inhibits the growth of rough dendritic $\theta+\eta+\tau_5$ phases. The ultra–microhardness test results show the microhardnesses of $\theta\tau_5$ and $\theta+\eta+\tau_5$ layers reach HV1025 and HV835, respectively. Indentation cracking of τ_5 layer at higher loads indicates that τ_5 is a type of hard brittle phase. SEM in situ tensile test results confirm that cracking initiates from $\theta+\eta$ phases and then fracture rapidly generates along $\theta+\eta+\tau_5$ layer while suffering external force. The tensile strength of IMC layer reaches 120 MPa.

Keywords: aluminum alloy stainless steel tungsten inert gas welding–brazing interfacial layer i9!a ntermetallic compound

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