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Research on elevated temperature resistant aluminum alloy drilling pipe for deep and ultra-deep wells

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Drill pipe as part of one of the most important components in drilling engineering, is the media to connect the drilling rig on the ground and drilling bit in the bottom of well. Moreover, it has the function of transmitting weight on bit (WOB), torque and drilling fluid to the drilling bit [1].

As an important approach to geosciences research, scientific drilling has been attracting world-wide attentions [2]. Since International Continental Scientific Drilling Program (ICDP) was founded in 1996, great advances have been brought about in many fields of earth science by continental scientific drilling, among which is the Kola Super-deep Borehole (SG-3 Well) in Former Soviet Union [3] and SongKe-2 well in China. Lightweight and high strength aluminum drilling pipe have been used in SG-3 well for its advantage of higher special strength and higher corrosion resistance. It is more power saving and efficient than traditional steel drill pipe in deep and ultra-deep wells. Unfortunately, the formation temperature increases as drilling deeper (usually 3-4 ºC/100m). The mechanical properties of conventional aluminum alloy drill pipe decreases rapidly when soaking at elevated temperature under ultra-deep drilling wells [4], which will result in a great security question.

In this paper, we investigate an elevated temperature resistant aluminum alloy drilling pipe material for deep and ultra-deep wells. As preliminary research, we study Mg_2Si reinforce Aluminum alloy. Mg_2Si is an intermetallic compound which is frequently used to reinforce the light alloys. Mg_2Si exhibits a high melting temperature (1085 ºC), low density (1.99×10^3 kg m^{-3}), high hardness (4.5×10^3 MPa), a low coefficient of thermal expansion (7.5×10^{-6} K^{-1}) and a high elastic modulus (120 GPa) [5]. After the combined addition of Sr–Sb modifiers, the morphology of primary Mg_2Si in as-cast Al–18Mg_2Si–4.5Cu alloys transforms from equiaxed-dendrite to cube, and the particle size decreases from ~50 to ~20 μm. Eutectic Mg_2Si changes from Chinese script to short rod shape. The UTS increases from 229 to 288 MPa in hot-extruded Al–18Mg_2Si–4.5Cu alloys at room temperature, while it increases from 231 to 272 MPa at 100 °C. The microhardness improves from 116 to 141 Hv. The tensile strength of the alloy at room temperature and 100 ºC improves by 59MPa and 41MPa, respectively. The mechanical properties are strongly dependent on the morphology and size of Mg_2Si. The thermally stable Mg_2Si phase can effectively improve the high temperature mechanical properties of aluminum alloys [6], which makes it possible to manufacture drilling pipes for ultra-deep exploration with Mg_2Si/7075Al and Mg_2Si/2024Al alloys for continents and oceans.

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