

Advanced Compound Coating for Delaying Corrosion of Fast-Dissolving Alloy in High Temperature and Corrosive Environment

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Abstract : Fast dissolving magnesium (DM) alloy technology has contributed significantly to the "Shale Revolution" in oil and gas industry. This application requires DM downhole tools dissolving initially at a slow rate, rapidly accelerating to a high rate after certain period of operation time (typically 8 h to 2 days), a contradicting requirement that can hardly be addressed by traditional Mg alloying or processing itself. Premature disintegration has been broadly reported in downhole DM tool from field trials. To address this issue, "temporary" thin polymers of various formulations are currently coated onto DM surface to delay its initial dissolving. Due to conveying parts, harsh downhole condition, and high dissolving rate of the base material, the current delay coatings relying on pure polymers are found to perform well only at low temperature (typical $\leq 100^\circ\text{C}$) and parts without sharp edges or corners, as severe geometries prevent high quality thin film coatings from forming effectively. In this study, a coating technology combining Plasma Electrolytic Oxide (PEO) coatings with advanced thin film deposition has been developed, which can delay DM complex parts (with sharp corners) in corrosive fluid at 150°C for over 2 days. Synergistic effects between porous hard PEO coating and chemical inert elastic-polymer sealing leads to its delaying dissolution improvement, and strong chemical/physical bonding between these two layers has been found to play essential role. Microstructure of this advanced coating and compatibility between PEO and various polymer selections has been thoroughly investigated and a model is also proposed to explain its delaying performance. This study could not only benefit oil and gas industry to unplug their High Temperature High Pressure (HTHP) unconventional resources inaccessible before, but also potentially provides a technical route for other industries (e.g., bio-medical, automobile, aerospace) where primer anti-corrosive protection on light Mg alloy is highly demanded.

Keywords : dissolvable magnesium, coating, plasma electrolytic oxide, sealer

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