Author's Accepted Manuscript

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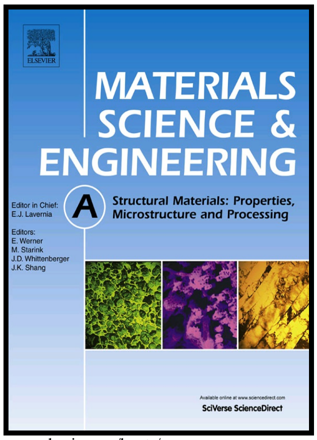

www.elsevier.com/locate/msea

PII: S0921-5093(18)31243-7
DOI: https://doi.org/10.1016/j.msea.2018.09.046
Reference: MSA36927

To appear in: *Materials Science & Engineering A*

Received date: 9 July 2018
Revised date: 12 September 2018
Accepted date: 14 September 2018

Cite this article as: Hanghang Liu, Paixian Fu, Hongwei Liu, Chen Sun, Mingyue Sun and Dianzhong Li, A Novel Large Cross-Section Quenching and Tempering Mold Steel Matching Excellent Strength–Hardness–Toughness Properties, *Materials Science & Engineering A*, https://doi.org/10.1016/j.msea.2018.09.046

A Novel Large Cross-Section Quenching and Tempering Mold Steel Matching Excellent Strength–Hardness–Toughness Properties

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Abstract

According to the synergistic effect of multiple elements, a novel large cross-section pre–hardened mold steel is designed with higher strength and hardness as well as toughness (HSTPM steel) compared with industrial high–end 718H steel during the normal tempering temperature range (530 to 650 °C). The achievements on the strength and hardness of HSTPM steel are attributed to the effects of 0.5 wt% molybdenum (Mo) and 0.1 wt% vanadium (V) additions on the matrix structure, including misorientation gradient, dislocation density, and nano–sized precipitates. The main strengthening precipitate (V, Mo)C was finely characterized by high angle annular dark field–scanning transmission electron microscope (HADDF–STEM) analysis. In addition, it was found that rare earth (RE) additions of 0.015 wt% in HSTPM steel highly effective in refining inclusions for changing the morphologies of strip MnS and Al_2O_3 to tiny spherical RE_2O_2S, and the number of coarse inclusions (diameter exceeding 5μm) is significantly decreased in the same statistical volume (4.69×10^8 μm^3) by three–dimensional X–ray microtomography statistical technique. The purification of molten steel and modification of inclusions by RE treatment are responsible for the improvement of impact toughness. Simultaneously, the lower carbon (C) content in HSTPM steel (high–end 718H, 0.34 wt %; HSTPM, 0.23 wt %) also plays a large role in improving impact toughness. Finally, the synergistic effect of multiple elements delayed and eventually reduced the transformation range in pearlite compared with that in 718H steel.