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DEVELOPMENT OF THICK HOT ROLLED AND NORMALISED STEEL PLATES WITH SUPERIOR IMPACT TOUGHNESS FOR SUB-ZERO APPLICATIONS

Md Serfraj Alam[1*], K.K Singh[1], P.K Thakur[1], Kundan Prakash[1], R Sudhir[2], Vinod Kumar[1]

[1] R&D Centre for Iron and Steel, SAIL, Ranchi-834002, India

[2] Bhilai Steel Plant, SAIL, Bhilai-490001, India

*Corresponding author

ABSTRACT

High strength and excellent impact toughness at sub-zero temperatures are the critical metallurgical requirements of steel for some strategic applications viz. shipbuilding, offshore oil and gas etc. R&D initiatives have been taken to develop the steel with high strength and high toughness at sub-zero temperatures.

As a step towards development of special steel for applications at sub-zero temperatures, experimental heat made with chemical composition, having C (0.08 – 0.10), Mn (1.15 – 1.65), P (0.02 max), S (0.012 max), Si (0.15 – 0.40), Al (0.02 – 0.05), Cr (0.30 max), Mo (0.05 max), Nb (0.05 max), V (0.01 – 0.05), Ti (0.01 – 0.06), Cu (0.30 max) and Ni (0.65 – 1.05) by following the process route of BOF-CC-LF-RH-PM. Continuously cast slabs of 250 x 1500 mm sizes were rolled into 24 mm steel plates following modified processing parameters and were subsequently normalized. Ultrasonic test for assessment of internal soundness, which is perceived as a significant requirement for aforesaid applications, was carried out as per ASTM A-578 Level B. Mechanical properties in terms of tensile strength and Charpy impact value were evaluated. The YS, UTS and % Elongation were found to be in the range of 412 – 449 MPa, 551 – 578 MPa and 28-29% respectively against the usually required values in excess of 390 MPa for YS, 490 MPa for UTS and 20% for Elongation for such applications. The average measured Charpy Impact value of 87 J has been obtained at -60 0C in transverse direction which is considered adequate for many sub-zero applications. A significantly higher Charpy Impact values in the range of 222 – 233 J were found in the rolling direction. The superior impact toughness values along high strength are primarily due to ferrite-bainite microstructure with ferrite grain size averaging ~6 μm. Ductile Brittle Transition Temperature (DBTT) is lower than -600 C indicating adequate toughness of the steel plate of 24 mm thickness.

Keywords: Ferrite-bainite microstructure; Grain refinement, Solid solution and precipitation strengthening, Impact Toughness; Product Development