

# Combined effect of microstructure, particles and crystallographic texture on the impact transition behaviour of low-C ferritic steels

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The effect of thermomechanical processing on microstructural parameters, crystallographic texture and Charpy impact transition behaviour of low-carbon ferritic steels has been studied. Specified level of Charpy impact toughness is an essential requirement for the steel plates / components used in structural, linepipe, automotive, naval and defence applications. Special emphasis has been paid on understanding the effect of ferrite grain size distribution, micro-texture and particles / inclusions on the impact toughness. Low-carbon steels samples were finish rolling (935 °C-650 °C) and normalized (1250 °C-940 °C) at different temperatures to generate different microstructure and texture. Finish rolling within the austenite-ferrite two-phase region leads to the formation of low-angle boundaries, which strengthen the ferrite matrix but are ineffective in restricting the cleavage crack propagation; thereby deteriorate the upper shelf energy (USE) and increase the ductile to brittle transition temperature (DBTT). The presence of coarse cuboidal TiN particles (>1µm) also increase the DBTT, whereas, stringer shaped MnS inclusions deteriorate the USE. In spite of the presence of large TiN particles, refinement in 'effective grain size' of ferrite can improve the impact toughness. Figure 1(a) and 1(b) showing a TiN particle at the cleavage crack initiation site and the crack deflection across the ferrite grain boundaries (studied using EBSD analysis), respectively. The effective grain size depends on the angle between the {001} cleavage planes of the neighbouring crystals, rather than the grain boundary misorientation angle as determined from electron backscattered diffraction analysis considering the angle-axis pair. The severity of delamination on the fracture surface of Charpy impact tested samples of low-carbon steel has been found to be dependent on finish rolling temperature and the consequent, texture. The severity of the formation of fissures has been found to increase with the decrease in finish rolling temperature (820°C - 650°C). Through thickness texture band composed of cube (ND  $\parallel$  <001>) and gamma (ND  $\parallel$  <111>) orientations developed during the intercritical-rolling treatment. Strain incompatibility between these two texture bands causes fissure cracking on the main fracture plane. Finish rolling just above the austenite to ferrite transformation start temperature (~820 °C) or normalizing of as-rolled plates at low austenitization temperature (~940 °C) develop fine strain-free ferrite grains with small 'effective grain size', and therefore, can be recommended for achieving high USE and low DBTT.

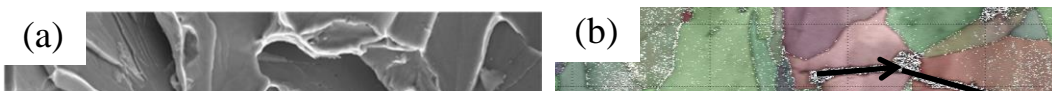


Fig. 1: Generation of crack from (a) TiN inclusion and (b) the propagation of the crack through the ferrite grains having different orientations.

**Keywords:** Low-carbon ferritic Steel, Crystallographic texture, Inclusions, Charpy impact testing, Effective grain size, Fissure.