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Determination of Ti(C,N) Nanoprecipitates in a Low-Carbon Microalloyed Steel by HRTEM analysis

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Abstract – The formation of Ti(C,N) precipitates in a low-carbon microalloyed steel was confirmed by high resolution transmission electron microscopy (HRTEM) observation. Microalloyed steel with titanium was produced by casting in an electrical induction oven of 25 Kgs. capacity. Carbon content in steel was less than 0.1 % and titanium content of 0.04%. Steel was processed thermomechanically and reheated to 1250ºC and hot rolled on a laboratory mill to a 13.0 mm thick plate with a finish rolling temperature of 850ºC and a thickness reduction of 80% with an starting temperature of 1150 °C.

It is well known that Ti together with V is a strong carbide- and nitride-forming element. Dissolved Ti, as well as Ti(C,N) precipitates, have great effects on phase transformations and mechanical properties of microalloyed steels. Hence, the formation of Ti(C,N) precipitates during hot rolled improve the toughness of microalloyed steels [1] which have long been the subject of investigation. In order to quantitatively investigate the precipitation of Ti(C,N) and the effects on the mechanicals properties.

The principal advantages of microalloyed steels are good combination of strength and toughness, and also good weldability Considerable efforts are expended over the world to understand the precipitation phenomenon in these steels. This is crucial for the successful design of these alloys and the optimum thermomechanical treatments to be adopted in order to achieve the desired mechanical strength. Ti, Nb, and V are most commonly used as they precipitate as carbonitrides which induce grain refinement in these steels. In addition, Al is present in these steels as a result of the steel making process itself. The presence of these alloying elements makes the precipitation behaviour very complex. A comprehensive understanding of the precipitation behaviour is essential to achieve the desired properties. Usually, depending on the microalloying element, two different routes are considered as the main procedures to get the desired mechanical requirements: austenite grain size conditioning and precipitation strengthening. The presence of a second phase produces grain refinement when the material is heated at temperatures lower than the dissolution temperature of the precipitates, abnormal grain growth when the material is heated to temperatures first over the dissolution temperature, and normal grain growth when the material is heated to well above the dissolution temperature of the precipitates.

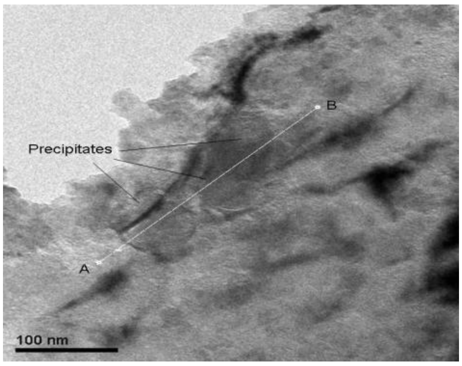

Figure 1: TEM image of carbonitride precipitates of Ti, with a diameter of 60 nm.

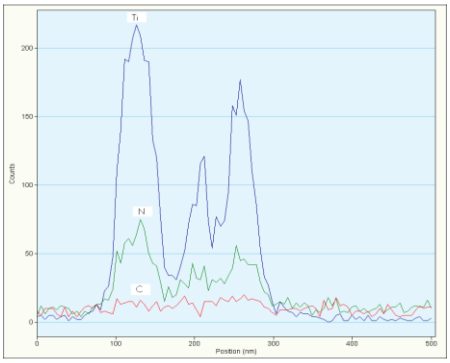

Figure 2: STEM-EDS image showing the profile elements of (Ti,N,C) from precipitates illustrated in the figure 1.

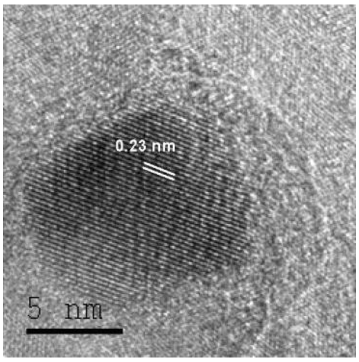

Figure 3: HRTEM image of carbonitride precipitate of Ti, with a size of 10 nm and interatomic distance of 0.23 nm.

[1] A.J. Craven, K. He, L.A. Garvie, T.N. Baker, ActaMater. 48 (2000) 3857.