Prediction of Austenite Grain Size Evolution in Wire Rod Rolling

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A set of integrated mathematical models for predicting microstructure evolution during hot rolling has been developed through laboratory research work. It consists of several models which include static and dynamic recrystallization mechanisms. Generally, dynamic recrystallization falls under the continuous hot rolling process. The model has been applied to compute the changes in grain at individual passes during hot rolling. The initial grain size with different heating temperatures and dwell times was computed using constitutive equation, and grain size at the individual passes was calculated using different pass schedules at individual passes. The model has been validated by comparing predicted austenite grain size with measurements made on quenched samples taken from end-cut shears. Different grades and sizes have been validated in this model. The predicted results agree well with measured values in samples.

Wire rods are produced from a 160 x 160 mm as-cast billet at high temperature. The products of various sizes range from 5.5 mm to 32 mm diameter. It is suitable for further processing such as drawing, cold rolling, cold heading, cold upsetting, cold extrusion, cold or hot forging. Wire rod is used for many products. It is the raw material for the wire drawing units. Its uses for various application include wire ropes, springs, electrodes, steel reinforcement for aluminium conductor and pre-stressed concrete, wire mesh, fasteners, automobile components and hardware manufacturers, etc. It requires some suitable properties for particular applications. Fig. 1 shows the process layout of the wire rod mill, which consists of 30 stands with a 6-pass roughing mill, 14 passes in a continuous mill, four passes in an intermediate mill and 10 passes in a finishing mill with horizontal and vertical configurations of oval and round pass, respectively. Four water cooling zones are used in the rolling line, where the intermediate water box is installed before the finishing stand block to control the temperature of rolled stock entering into the finishing stand. Behind the finishing stand, three water cooling zones are used to control the finishing rolling temperature. The wire rods are then transferred in a Stelmore conveyor and then discharged to the coil collecting station.

In the production of high-speed wire rod, the following transitions occur metallurgically: austenizing, recrystallization, grain growth and transformation from austenite to pearlite. These metallurgical changes had been expressed by several models including static and dynamic recrystallization. In this work, an integrated model is used to visualize the grain evolution in individual passes. Different grades of different product sizes were considered for this model from the wire rod mill of JSW Steel Ltd., Salem Works, India.

Experimental Work

Industrial Trial — As-cast billets 160 x 160 mm in dimension were reheated in a blast-furnace-gas-fired furnace. Billets were heated in the furnace with three zones: Pre-heating zone, heating zone and soaking zone with temperature 930–940°C, 1,000–1,030°C and 1,150–1,160°C, respectively, and held about 100–110 minutes. After reheating, the hot billet is subjected to multi-pass rolling with strain of 0.1 to 0.65 and a strain rate of 1.5 to 2,500 s^{-1}. The strain and strain rate at individual passes were calculated using pass profile, speed, length of arc of contact and interpass