TUESDAY, AUGUST 24, 2004, A.M.

SESSION 21: INTERNATIONAL SYMPOSIUM ON ULTRA-FINE STRUCTURED STEELS

PRODUCING ULTRAFINE STEELS II
Sponsor: Iron and Steel Section, The Metallurgical Society of CIM
Room: Webster C
Chairmen: E. ESSADIQI, J. THOMSON, CANMET, Ottawa, Ontario, Canada, and
M. MILITZER, University of British Columbia, Vancouver, British Columbia, Canada

PAPER 21.1 — 8:30
ULTRA-FINE GRAIN SIZE BY DYNAMIC RECRYSTALLIZATION IN STRIP ROLLING OF NB MICROALLOYED STEEL.
G. ZHU, S.V. SUBRAMANIAN, Department of Materials Science and Engineering, McMaster University, Hamilton, Canada
C. KLINKENBERG and K. HULKA, Niobium Products Company GmbH, Dusseldorf, Germany
A quantitative model based on strain accumulation in multi-pass rolling is developed to overcome a large critical strain for dynamic recrystallisation in a Nb microalloyed steel with high Mn content (HTP steel). The larger the critical strain for dynamic recrystallisation, the finer is the dynamically recrystallised grain size. The initial mill trial showed that it is feasible to achieve ultra-fine grain size by dynamic recrystallisation but the prevention of static recrystallisation in between passes is identified as an essential condition to suppress mixed grain size. The data-base on static softening kinetics at short interpass time was experimentally determined on WUMSI and incorporated in the model. The model is used to optimise the strip rolling schedule to prevent static recrystallisation in the interpass time. The rolling simulation of strip rolling schedule has validated the model prediction that it is possible to obtain a uniform ultra-fine ferrite grain size of about 1-2 micrometer diameter in final ferrite microstructure for industrial rolling parameters.

PAPER 21.2 — 9:00
TRANSFORMATION BEHAVIOUR OF A FINE GRAINED HSLA STEEL.
R. LOTTEY and M. MILITZER, The Centre for Metallurgical Process Engineering, The University of British Columbia, Vancouver, British Columbia, Canada
There is a significant demand for new high strength steels with fine grain sizes for structural applications. One approach in this regard is to develop hot-rolled HSLA steels where refining the microstructure leads to increased strength levels, e.g. 700 MPa yield strength, that can be attained by suitable modifications of chemistry and processing. Here, an HSLA steel is investigated that contains 0.05wt%C-1.65wt%Mn-0.20wt%Mo-0.07wt%Nb-0.02wt%Ti and approaches the above strength class. The ability to control and predict the mechanical properties of hot rolled steel depends strongly on the thermomechanical processes, which the steel undergoes. The final microstructure and, thus, the properties of the hot-rolled steel are a function of the austenite decomposition obtained during accelerated cooling on the run-out table and precipitation during coiling. The austenite-to-ferrite phase transformation under run-out table conditions has been investigated using a Gleeble 3500 thermomechanical simulator equipped with a dilatometer. The effects of cooling rate and initial austenite microstructure including the degree of work hardening on austenite decomposition kinetics and ferrite grain refinement have been quantified. Results show that grain refinement can be optimized by the presence of work hardened austenite and accelerated cooling. Based on the experimental results, a model is proposed to predict the transformation start temperature and the resulting ferrite grain size for run-out table cooling conditions.

PAPER 21.3 — 9:30
A KINETIC MODEL FOR DYNAMIC RECRYSTALLIZATION IN AUSTENITIC STAINLESS AND HYPEREUTECTOID STEELS.
G.R. STEWART, A.M. ELWAZRI, S. YUE and J.J. JONAS, Mining, Metals and Materials Engineering, McGill University, Montreal, Canada
Two important parameters for dynamic recrystallization can be derived from the changes in the strain hardening rate: the critical strain for initiation of dynamic recrystallization and the point of maximum softening. In this work, these values are determined from the flow stress-strain data obtained in continuous compression testing in the range 900-1100°C. The resulting strains are used to calculate a kinetic model of dynamic recrystallization for two materials: 304 austenitic stainless steel and a hypereutectoid plain carbon steel. The mechanical parameters used to define the proposed model are confirmed with quantitative metallographic analysis of the recrystallized microstructure.

COFFEE BREAK — 10:00 – 10:30

PAPER 21.4 — 10:30

PRODUCTION OF ULTRAFINE FERRITE USING DESIGNED EXPERIMENTS

D.J. HAMRE, D.K. MATLOCK, and J.G SPEER, Advanced Steel Processing and Products Research Center, Colorado School of Mines, Golden, Colorado, U.S.A.

Ultrafine ferrite (UFF) grains may be produced in surface layers of plate steels using controlled intermediate cooling followed by deformation. Experiments were conducted using a 0.12 C – 1.26 Mn steel on a Gleeble 1500 hot deformation simulator. Taguchi designed experiments were used to evaluate prior austenite grain size, intermediate cooling rate, intermediate cooling temperature, intermediate hold time and amount of reduction in order to observe the effects of variables and their interactions on the final microstructure while minimizing the number of required test runs. Evaluation of resulting microstructures and mechanical properties revealed a preferred thermal and mechanical history for developing ultrafine microstructures in surface layers of plate steels. Application of the fundamental concepts of phase transformations to industrial plate rolling is considered.

PAPER 21.5 — 11:00

GRAIN REFINEMENT AND AUGMENTED RATE IN TRANSFORMATION OF HOT WORKED AUSTENITE.

H.J. MCQUEEN, E.V. KONOPLEVA, Concordia University, Montréal, Québec, Canada
V.M. Khlestov, Priazovsky State Technical University, Mariupol, Ukraine

In addition to increasing grain boundary area during hot working of austenite, the dislocation substructures create potential sites for nucleation of ferrite both at original grain boundaries and at transition boundaries between deformation bands. This development gives rise to a marked increase in the rates of nucleation, of growth and of transformation to ferrite. The combined net effect is product grain refinement that requires less stringent cooling between finish rolling and coiling; hence determination of the above rates would advance process optimization. The important control parameters are the preheat temperature (degree of homogenization), finishing temperature, strain (accumulation near finishing) and the extent of recrystallization after finishing. These effects vary greatly with steel composition; nevertheless, some general rules have been formulated. Moreover, there is also potential for deformation of the refined ferrite. There are other thermo-mechanical processes such as warm forming of metastable alloy austenite to provide a dense substructure that is carried into the martensite on quenching. In other processes, the austenite may be deformed during cooling through the transformation to develop a dense substructure in the ferrite that is stabilized by fine carbides.

PAPER 21.6 — 11:30

TRANSITION FROM ACTIVE GRAIN BOUNDARY FERRITE INTO THE INERT ONE THROUGH THERMOMECHANICAL PROCESSING OF LOW CARBON MICROALLOYED STEELS.

H. AZIZI-ALIZAMINI, A. ZAREI-HANZAKI, S. M. H. HOSSEINI, and O. GOLMAHALLEH, Department of Materials and Metallurgy, Faculty of Engineering, University of Tehran, Tehran, Iran,

The main importance of acicular ferrite microstructures arises from their desired combination of mechanical properties in comparison with the bainite and ferrite-pearlite microstructures. Several factors affect the microstructural transition from bainite microstructure into the acicular ferrite one. As is well established any factor corrupting the prior austenite grain boundaries nucleation potential, such as the thin layer of allotriomorph ferrite and the austenite deformation inhomogenities may promote the acicular ferrite formation instead of bainite. Accordingly, this study deals with the effects of the aforementioned features on the acicular ferrite formation in low carbon microalloyed steel. The results indicate that the formation of strain-induced ferrite at the prior austenite grain boundaries accompanied by deformation inhomogenities in the austenite grains change the effectiveness of allotriomorph ferrite on acicular ferrite formation from active to inert one.