

MONDAY, AUGUST 23, 2004, P.M.

SESSION 7: INTERNATIONAL SYMPOSIUM ON MATERIALS FOR FUEL EFFICIENT AUTOMOBILES

MICROSTRUCTURE DEVELOPMENT IN AUTOMOTIVE ALLOYS

Sponsor: Iron and Steel, The Metallurgical Society of CIM

Room: ALBION C

Chairmen: D. WILKINSON, T. PETRIC and M. JAIN, McMaster University, Hamilton, Ontario, Canada

PAPER 7.1 — 14:00

ON THE FORMATION OF METASTABLE PHASES IN MULTICOMPONENT ALLOYS.

D.V. MALAKHOV, G.R. PURDY, McMaster University, Hamilton, Ontario, Canada, and

H.S. ZUROB, Domaine Universitaire de Grenoble, Saint Martin d'Hères, France

Metastable phases are frequently seen in as-cast alloys. Their presence is especially pronounced when casting techniques are characterized by high cooling rates leading to deep supercooling. The concept of the driving forces for the onset of precipitation is used to explain and predict the nature of phases and a sequence of their formation. Methodological and computational aspects of the approach suggested as well as its limitations are discussed. The method is illustrated by applying it to solidification of automotive aluminium alloys and hot-dip galvanizing. Necessities for and particularities of experimental determination of the thermodynamic properties of metastable phases are discussed.

PAPER 7.2 — 14:20

THE EFFECTS OF COILING PARAMETERS ON M/A PHASE CHARACTERISTICS IN THERMOMECHANICALLY-PROCESSED MULTIPHASE TRIP-ASSISTED STEELS.

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E. ESSADIQI, CANMET, Ottawa, Ontario, Canada, and

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The low-silicon multiphase TRIP-aided steels, the microstructures of which consist of polygonal ferrite, bainite, retained austenite, and martensite, may result in a spectacular combination of strength and ductility. To achieve these desired properties, the state of each phase should be precisely restrained through controlling the applied process variables. In the present work, a low-carbon, low-silicon steel was subjected to the various thermomechanical processing routes through hot compression testing facilities. In this way, the final compression hit was followed by accelerated cooling the specimen to different bainite formation temperature. The states of micro-constituents in the microstructure were altered through different isothermal holding period. The results indicated that the increase of coiling time would change the microstructure from a two-phase (ferrite and martensite) to a multiphase (ferrite, bainite, retained austenite, and martensite) one. The latter results to an improved combination of strength and ductility in comparison with dual phase and triple phase (ferrite matrix, bainite, and retained austenite) microstructures. The optimum amount of formability index was achieved in the specimens, which were treated at intermediate coiling temperature for a short holding period.

PAPER 7.3 — 14:40

MICROSTRUCTURAL DEVELOPMENT DURING THERMOMECHANICAL PROCESSING OF STRIP CAST ALUMINUM ALLOYS.

H.N. AZARI, D.V. MALAKHOV and D.S. WILKINSON, McMaster University, Hamilton, Ontario, Canada

The twin-belt strip cast aluminum alloys have received increasing attention from the automotive industry in the development of fuel-efficient vehicles. However, the relatively limited thermomechanical processing (TMP) available when starting from a thin as-cast strip may pose a challenge in tailoring properties such as formability and ductility in alloys for more critical applications. The present investigation was, therefore, undertaken to examine the effect of various TMP parameters on the development of deformation and recrystallization microstructures in twin-belt strip cast AA5754 aluminum alloy. The results indicate that the TMP schedules employed influence the development of deformation and recrystallization microstructures by affecting the initial texture, grain size and particle content of the material prior to the final rolling deformation. Therefore, the denser distribution of large constituent particles and a greater scattering of the initial texture in the as-cast alloy are effective in restricting deformation by shear banding and randomizing the rolling texture. Homogenizing the as-cast alloy at 560°C for 6 hours, however, promotes extensive grain growth and dissolution of large Mg₂Si particles besides imparting a characteristic CH component. The rolling texture then develops at a much faster rate with strain and shear banding becomes more extensive promoting a rolling

texture that is characterized by strong Brass and Cu components. On annealing at 450°C, the recrystallization texture in the heavily cold rolled as-cast alloy is dominated by Cube and R components indicating the prevalence of orientated growth processes. On the other hand, homogenizing the as-cast alloy prior to cold rolling imparts a characteristic recrystallization texture with strong H and CH components that is most likely due to selected growth of grains following particle-stimulated nucleation.

COFFEE BREAK — 15:10 – 15:30

PAPER 7.4 — 15:30

THE EFFECT OF PRECIPITATION ON THE RECRYSTALLIZATION BEHAVIOUR OF COLD ROLLED AA6111.

J. GO, W. POOLE, M. MILITZER and M. WELLS, University of British Columbia, Vancouver, British Columbia, Canada

It is well known that fine and closely spaced precipitates retard recrystallization by suppressing the movement of high angle grain boundaries. However, the pinning force can be relaxed if the precipitates undergo coarsening or phase transformation during annealing. In this study the interaction between recrystallization and precipitation in AA6111 was studied using a series of samples where the initial precipitation state was systematically varied. The microstructure of the annealed specimens was analyzed using a variety of techniques including EBSD, XRD, optical microscopy and resistivity measurements. The softening kinetics was characterized by following the evolution of yield stress with respect to isothermal annealing time. The results indicate that the onset of recrystallization was severely delayed in all cases and the majority of the stored energy was released by extended recovery reactions. The premature loss of stored energy combined with the pinning effect of precipitates evidently makes the recrystallization a particular difficult process. The effect of concurrent precipitation and recovery on the nucleation and growth of recrystallized grains will be discussed. A preliminary modeling framework based on the internal state variable approach will be presented.

PAPER 7.5 — 15:50

DEVELOPMENT OF COATED TRIP STEELS FOR AUTOMOTIVE APPLICATION.

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The use of Advanced High Strength Steels (AHSS) such as Dual Phase steels and TRIP steels has been aggressively pursued by automotive industry to balance the need for vehicle weight reduction and the improvement in vehicle crashworthiness. TRIP steel which utilizes the effect of Transformation Induced Plasticity by retained austenite has excellent balance between strength and formability. Despite its attractiveness the manufacturing of TRIP steel using conventional hot-dip galvanizing lines is a challenge from steel design point of view. A lab scale experimental work based on C-Mn-Si-Al chemistry design was carried out as part of coated TRIP steel development at Dofasco. The thermal cycles of typical hot-dip galvanizing line were used for processing simulation by Gleeble. The chemistry designs and the effects of galvanizing/galvannealing parameters, such as line speed, annealing soak temperature, and galvannealing temperature, on mechanical properties were investigated. Based on the simulation, the chemistry design and optimum processing conditions were selected for coated TRIP 590 and TRIP780.

PAPER 7.6 — 16:10

MECHANICAL PROPERTIES OF ULTRA FINE PRECIPITATION HARDENED HOT ROLLED HIGH STRENGTH STEEL.

A. KOBAYASHI, Y. FUNAKAWA and K. SETO, JFE Steel Corp., Kawasaki, Japan

A new hot rolled high strength steel consisting of ferrite matrix and nanometer-sized precipitates was developed. The ultra fine precipitates were identified as $TiMoC_2$, and the strengthening by the precipitates was evaluated more than 300MPa in case of TS/800MPa grade steel. It is notable that the steel shows very high yield strength (730MPa in case of TS/800MPa) and very high local elongation leading to excellent stretch flangeability at the same time. The mechanical properties of the steel are attractive for chassis parts and structural parts of auto body. The steel has been produced commercially, and applied to the parts successfully.

PAPER 7.7 — 16:30

DEVELOPMENT OF NEW MICROALLOY STEEL GRADES FOR LIGHTWEIGHT SUSPENSION SYSTEMS.

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T. KING, Arvin Meritor Suspension Systems Company, Milton, Ontario, Canada

This paper describes recent developments that have been made by auto parts suppliers and the steel industry to address the requirement for lighter weight suspension components by North American vehicle manufacturers. The need for lighter weight suspension components is being driven primarily by the mandate to reduce the overall mass of the vehicle in order to improve fuel efficiency. Also the “packaging envelope” into which the spring components must fit is getting smaller due to improved aerodynamic styling of vehicles. As a result of this continuing pursuit for mass reduction, design engineers have had to increase the operating stresses in the suspension springs in order to achieve the specified functional and durability requirements.

Weight reduction in a steel suspension coil spring is achieved by reducing the diameter and the effective length of the steel bar used in producing the spring. The end result is an increase in the operating stresses in the spring. In order for lightweight springs to perform at these higher stresses they must be heat treated to higher hardness levels than for conventional springs. Conventional steel grades used to manufacture springs will not perform at these higher hardnesses, mainly due to their inherent lower fracture toughness properties, and the increased susceptibility for crack propagation due to non-metallic inclusions in the steel. These primary factors tend to have an adverse effect on fatigue life and sag performance of the springs during their service life. To address these concerns, the steel industry has had to develop new, higher strength microalloyed steel grades with improved fracture toughness properties. These new grades of microalloy spring steels are replacing standard steel grades for some coil spring applications, and is resulting in weight savings of up to 25%.