Determining Thermodynamic and Kinetic Paths for Austenite Decomposition above the Upper Ae1 in Fe-C-12Mn Steel

Abstract: Ternary steels often take non-equilibrium decomposition paths from the parent austenite, largely because of the widely disparate diffusivities between carbon and the substitutional element. The talk will analyze this type of path, the energy expended, and corrective mechanisms followed by an Fe-C-Mn alloy during its evolution towards thermodynamic equilibrium when isothermally heat treated. The phase transformations include formation of two lamellar reactions, pearlite and cellular, both producing non-equilibrium products. Carbon activity in the austenite matrix is calculated by combining detailed volume fraction analysis and manganese distribution data over times up to 180 days. Carbon isoactivity lines are then superimposed on isopleth sections of the phase diagram. In this fashion Gibbs free energy can be tracked to follow the alloy’s ‘missteps’ and corrections in its approach towards equilibrium. Most interesting is at 660 and 650°C where ferrite can form in association with cementite in a pearlite microstructure that is well within the austenite + cementite phase field.

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Gary J. Shiflet, William G. Reynolds Professor, joined the Department of Materials Science (and Engineering) in 1980. He has a BS and MS in physics and PhD in metallurgical engineering (1981), all from MTU. Shiflet’s primary interests are in solid-state phase transformations of crystalline and amorphous alloys, mostly concerning thermodynamics, nucleation and the kinetics associated with formation of new phases. He has published more than 290 papers (9200+ citations; h-index=52) and holds/licensed several patents concerning various amorphous metal alloys. He has been a visiting professor at four different universities: Hong Kong (HKUST), South Africa (UP & UNISA) and Japan (UT). Shiflet has been awarded two creativity awards from the National Science Foundation, the ASM Research Award (Silver Medal) and has been elected as a Fellow of the American Society for Materials and Japan Advancement of Science and was selected as a Scientific American 50 Innovator for Chemistry in 2004. One hobby is studying the history of metals and alloys.