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Investigation of temperature dependent microstructure evolution of pure iron during friction stir welding using liquid CO_2 rapid cooling

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Abstract The microstructure evolution of pure iron during friction stir welding was reconstructed by an ingenious experimental design, in which the rapid cooling friction stir welding combined with the tool "stop action" technique and the subsequent short-time annealing were adopted to "freeze" the transient microstructure during the stirring and reproduce the normal cooling during conventional friction stir welding, respectively. The microstructure evolution during the stirring and normal cooling was investigated along the material flow path and in the annealed "frozen" weld zone by high-resolution electron-backscatter-diffraction technique. The results show that the continuous and discontinuous dynamic recrystallizations occur simultaneously at the severe deformation stage in front of the tool both under low and high heat input conditions. However, during the material flow, the microstructure evolution involves the plastic deformation, recrystallization, high angle boundaries migration and dynamic recovery under the low heat input condition, while in a dynamic balance of deformation, recrystallization and grain growth under the high heat input conditions. At the cooling stage, normal grain growth occurs both for the low and high heat input welding conditions, while it is very limited for the low heat input condition.

Keywords: Friction stir welding; Rapid cooling; Annealing; Microstructure evolution; Pure iron