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Dynamic recrystallized grain size of the 38MnSiVS5 medium carbon microalloyed steel under hot working conditions

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Abstract – Dependence of dynamic recrystallized grain size with deformation conditions in a medium carbon steel strained by hot torsion test at elevated temperatures and strain rates was investigated. The flow stress curves displayed a characteristic shape of materials that softening by dynamic recrystallization after some amount of work hardening and dynamic recovery. The activation energy for hot working was determined and deformation conditions described by Z - Zener hollomon – parameter *(Z = (ε̇.exp (Q/RT))*. A relationship of the type: $D_\gamma = KZ^n$ was attained. The value of the exponent determined is in agreement with values described by literature for steels.

It is well known that the materials' behavior is substantially altered by recrystallization during metallurgical processing. During hot forging of components with complex shape, such as crankshaft, connecting rods and other parts for automotive industry, some areas are subjected to large straining due to deformation heterogeneities. As a consequence, while some regions only soften by recrystallization in the arrest time between deformations, the volume severely deformed recrystallizes during deformation. The aim of this work was to determine the dependence of the dynamic recrystallized grain size with deformation conditions in similar conditions of industrial processing. Isothermal torsion tests were carried out over the strain rate and temperature ranges $0.1s^{-1}$ to $10s^{-1}$ and 900ºC to 1200ºC. The samples were heated to 1200°C, maintained at this temperature for 300s, cooled to test temperature and strained to ε = 4.0. The dynamically recrystallized average grain size was measured in samples water quenched immediately after the end of deformation. Figure 1 displays some plastic flow curves determined from hot torsion tests at 1100°C with different strain rates. In all the curves is possible to observe that the stress increases with the deformation until a maximum and decrease to a steady state. This behavior is typical of materials that softening by dynamic recrystallization.

The apparent activation energy for hot working *(Q_{def})* was calculated using the method proposed by Sellars and Tegart [1] in which strain rate, temperature and peak stress are associated through a hyperbolic sine equation. The value found for Q_{def} was 328kJ/mol. Both the necessary stress level to deform the material and the recrystallized (D_γ) grain size depend on the deformation conditions; i. e., depend on deformation temperature and strain rate imposed. Figure 2 displays the dependence of the average grain size dynamically recrystallized with the Z parameter. It can be seen that the grain size increases together with the temperature increase and the strain rate decrease. This behavior is associated with the increase of grain boundary mobility and recovery easiness at high temperatures and low strain rates. Also, experimental data fits the equation $D_\gamma = 8{,}26x10^2.Z^{-0{,}134}$ and the value of 0,134 found for exponent of Z is in the range (0,12 <k <0,3) indicated by the literature. [3]

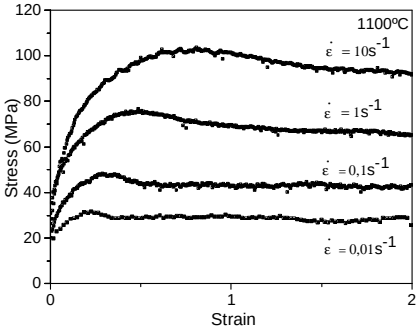

Figure 1: Some flow stress curves determined from hot torsion test at 1100°C with different strain rates.

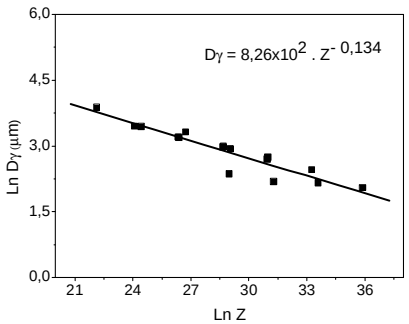

Figure 2: Dependence of the average recrystallized grain size with deformation conditions.

References

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