Synopsis

Title of Document: **Hot deformation of 18%Ni Maraging steels: Analysis of stress-strain curves and microstructural evolution**

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Abstract

Maraging Steels are ultrahigh strength steels which fall under the category of low and medium stacking fault energy materials. These steels are deformed at elevated temperatures to the required shape and desired properties are achieved through discontinuous Dynamic Recrystallization mechanism (DDRX). The Stress (**σ**)-Strain (**ε**) behavior should be understood during hot deformation to get the fine prior austenite grain (PAG) size. In order to get fine PAG size, analysis of **σ**-**ε** curves have been performed at both M250 and M350 grade maraging steels. For this purpose, the stress –strain curves obtained at different combination of temperatures and strain rates have been studied and a **σ**-**ε** curve which typically shows a single peak DRX has been

selected. Experiments have been conducted on the selected curves at T=950^{o}C and $\dot{\boldsymbol{\varepsilon}}$ =0.01s^{-1} for M350 and T=1100^{o}C and $\dot{\boldsymbol{\varepsilon}}$ =0.1 s^{-1} for M250 grade maraging steels. Interrupted hot isothermal compression tests have been conducted in the different strain values and microstructures are recorded for analyzing the microstructural evolution. The mathematical analysis for the DRXI and DRXT has been predicted based on the models of Jonas[1] and Aashrant[2]. The critical strain values for DRXI and DRXT have been experimentally determined on specimens subjected to interrupted strain values. It was noted that the theory could predict well both the DRXI and DRXT. Based on the study, the critical strain and stress values for DRXI and DRXT as a function of peak stress and peak strain have been determined and the values are approximated to $\boldsymbol{\varepsilon}_{DRXI}/\boldsymbol{\varepsilon}_{p}$=0.4, $\boldsymbol{\varepsilon}_{DRXT}/\boldsymbol{\varepsilon}_{p}$=1.564, $\boldsymbol{\sigma}_{DRXI}/\boldsymbol{\sigma}_{p}$=0.9 and $\boldsymbol{\sigma}_{DRXT}/\boldsymbol{\sigma}_{p}$=0.953 for M350 and $\boldsymbol{\varepsilon}_{DRXI}/\boldsymbol{\varepsilon}_{p}$=0.457, $\boldsymbol{\varepsilon}_{DRXT}/\boldsymbol{\varepsilon}_{p}$=1.882, $\boldsymbol{\sigma}_{DRXI}/\boldsymbol{\sigma}_{p}$=0.939 and $\boldsymbol{\sigma}_{DRXT}/\boldsymbol{\sigma}_{p}$=0.926 respectively for M250 grade maraging steels. The specimen in hot compressed condition was subjected to double solution treatment at 950^{o}C for 0.5hour followed by aging at 480^{o}C for 3.5 hours. The microstructures were recorded, PAG size and hardness were measured after double solution treatment followed by aging. It was found that double solution treatment refines the PAG size. A significant decrease in PAG size is observed and the mechanism for grain size reduction is attributed to the shear strains, contributing to the nucleation of fine PAG during thermal cycling as proposed by Saul[3]. The hardness value after double solution treatment followed by aging is found to be around 625 to 700 VHN and 300 to 350 VHN in as deformed condition. An Increase in hardness is due to the precipitates and fine PAG size coupled with fine lath martensitic structure. Based on the hot isothermal compression, the region of DRX, DRV and grain growth have been clearly identified in the plot of flow stress versus log (Z). The variation of average PAG size with respect to log (Z) showed a significant change in PAG size after double solution treatment and aging. Finally, the optimum strain values were identified on the Stress ($\boldsymbol{\sigma}$) – Strain ($\boldsymbol{\varepsilon}$) curve of the material when deformed at T=950^{o}C and $\dot{\boldsymbol{\varepsilon}}$=0.01s^{-1} for M350 and T=1100^{o}C and $\dot{\boldsymbol{\varepsilon}}$ =0.1s^{-1} for M250 grade maraging steels results in fine PAG size.