# Outline



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# List of Notations and Symbols

| | |
|---|---|
| k | Kappa carbide |
| γ | Austenite |
| $\beta$ | Beta Manganese phase |
| δ | Delta ferrite |
| λ | Wavelength |
| $\varepsilon$ | Equivalent strain |
| $\sigma_{ss}$ | Solid solution Strengthening |
| $C_i$ | Concentration in mass percentage for the $i^{th}$ element |
| $K_i$ | Coefficient for the $i^{th}$ element |
| $\Delta\sigma_g$ | Difference in grain size strengthening effect |
| $K$, $K_3$ | Grain size strengthening parameter |
| $g$ | Grain size |
| $g_0$ | Initial grain size |
| $g_f$ | Grain size during MAF |
| $\Delta\sigma_\rho$ | Dislocation strengthening |
| $\rho_0$ | Initial dislocation density |
| $\rho_f$ | Dislocation density during MAF |
| α | Taylor constant |
| $M$ | Average Taylor factor |
| $K_1$, $K_2$ | Dislocation strengthening constant |
| $G$ | Shear modulus |
| $E$ | Elastic modulus |

| | |
|---|---|
| $v$ | Poisson's ratio |
| Fe | Iron |
| Cr | Chromium |
| Al | Aluminium |
| Ni | Nickel |
| C | Carbon |
| Si | Silicon |
| Mn | Manganese |
| Mg | Magnesium |
| Cu | Copper |
| Ti | Titanium |
| $S_1$, $S_2$, $S_3$ | Orthogonal sample reference axes |
| $L_1$, $L_2$, $L_3$ | Orthogonal laboratory/beam axes |
| $\omega$ | Incident angle |
| $\chi$ | Rotation angle of the sample |
| $\psi$ | Angle between axis normal to sample surface and plane normal. |
| $\Phi$ | Angle of sample rotation about its surface normal |
| $2\theta$ | Diffraction angle |
| d | Interplanar spacing |
| $\varepsilon_N$ | Normal strain |
| $d_0$ | Interplanar spacing of annealed sample |
| $\varepsilon_{33}$ | Strain on $L_3$, plane and along $L_3$ direction |
| P | Indices for sample axes |
| q | Indices for plane normals |
| $\varepsilon_{pq}$ | Strain in the p plane and in the q direction |

| | |
|---|---|
| i | Index for laboratory axes |
| $a_{ij}$ | Direction cosine |
| $a_1$ | Average macrostrain |
| $a_2$ | Mean macrostrain |
| $\delta_{pq}$ | Kronecker delta |
| $\sigma_{eq}$ | Equivalent stress |
| $A$ | Initial yield strength |
| $B$ | Strength coefficient |
| $C$ | Strain sensitivity |
| $m$ | Thermal softening exponent |
| $n$ | Stain hardening exponent |
| $\dot{\varepsilon}$ | Strain rate |
| $\dot{\varepsilon}_o$ | Reference strain rate |
| $T_r$ | Room temperature |
| $T_m$ | Melting temperature |
| $m_0$ | Slopes at Φ=0° |
| $m_{45}$ | Slopes at Φ=45° |
| $m_{90}$ | Slopes at Φ= 90° |
| $n_0$ | Slopes at Φ=0° |
| $n_{90}$ | Slopes at Φ=90° |
| $c$ | Intercept |
| $\sigma_{11}$, $\sigma_{22}$, $\sigma_{33}$ | Normal residual stresses |
| $\sigma_{12}$, $\sigma_{23}$, $\sigma_{13}$ | Shear residual stresses |

# List of Abbreviations

| | |
|---|---|
| MAF | Multiaxial forging |
| FEA | Finite element Analysis |
| SPD | Severe plastic deformation |
| IF | Interstitial free |
| HSS | High strength steel |
| AHSS | Advanced high strength steel |
| HSLA | High strength low alloy |
| H13 | Hot worked tool steel |
| BCC | Body centred cubic |
| FCC | Face centred cubic |
| DDRX | Discontinuous dynamic recrystallization |
| cDRX | Continuous dynamic recrystallization |
| ECAP | Equal channel angular pressing |
| HPT | High pressure torsion |
| ARB | Accumulative roll bonding |
| JC | Johnson-Cook |
| KH | Khan-Haung |
| GA | Genetic algorithm |
| CPFEM | Crystal plasticity finite element method |
| XRD | X-Ray diffraction |
| EBSD | Electron back scatter diffraction |
| SEM | Scanning electron microscopy |
| TEM | Transmission electron microscopy |
| SFE | Stacking fault energy |

| | |
|---|---|
| YS | Yield strength |
| UTS | Ultimate tensile strength |
| TE | Total elongation |
| VHN | Viker hardness number |
| TWIP | Twinning induced plasticity |
| TRIP | Transformation induced plasticity |
| MSBs | Micro shear bands |
| WQ | Water quenched |
| S1 | Fe-30Mn-9Al-0.8C steel |
| S2 | Fe-20Mn-10Al-1C steel |
| FS1 | Hot forged & WQ Fe-30Mn-9Al-0.8C steel |
| FS2 | Hot forged & WQ Fe-20Mn-10Al-1C steel |
| SS1 | Solutionised & WQ Fe-30Mn-9Al-0.8C steel |
| SS2 | Solutionised & WQ Fe-20Mn-10Al-1C steel |
| MAF-0 | Zero pass solutionised & WQ workpiece |
| MAF-1 | One pass solutionised & WQ workpiece |
| MAF-2 | Two pass Solutionised & WQ workpiece |
| MAF-3 | Three pass solutionised & WQ workpiece |
| MAF-5 | Five pass solutionised & WQ workpiece |
| ASTM | American society for testing and materials |
| AARE | Average absolute relative error |
| $R^2$ | Correlation coefficient |
| 3D | Three dimensional |
| C3D8R | 8-node linear hex element |
| CD43 | 4 node tetrahedral element |

| | |
|---|---|
| SDVs | State-dependent variables |
| VUMAT | Vectorized user material |