

Lecture 41: Preferred orientation- application

Questions:

1. Is it possible to infer whether a hot rolled steel plate would exhibit poor through thickness ductility by looking at its optical microstructure?
2. Why should polycrystalline alloys have different properties in different directions?
3. Why are nickel base single crystal super alloys the most preferred material for gas turbine blades?
4. Which crystallographic direction of Nickel base superalloy should have the highest strength?
5. Which properties will you look for while selecting steel for deep drawing application? Give reasons.

Answer:

1. The presence of inclusion (mostly MnS) elongated along the direction of rolling is responsible for poor through thickness ductility of steel plate. Microstructure of a longitudinal section would show elongated inclusions. The ratio of its length to thickness depends on the total deformation the plate has undergone.
2. The main reasons for polycrystalline alloys exhibiting different properties along different directions are (a) preferred orientation due to either cold work or re-crystallization texture (b) presence of elongated inclusions.
3. Gas turbine blades have to withstand high stresses at elevated temperature (850°C). Therefore the main mechanism of failure is creep. This occurs through nucleation & growth of cavities. Grain boundaries are the most preferred sites for cavitation. Absence of such sites in single crystal gives it the best creep resistance. Apart from this the crystal axis having maximum creep strength is oriented along the maximum principal stress to exploit its anisotropic behavior.
4. Nickel base superalloy has face centered cubic structure. Its preferred slip system is $\{111\}\langle\bar{1}\bar{1}0\rangle$. The axis having maximum strength should have minimum Schmid's factor. $\langle 111 \rangle$ has minimum Schmid's factor.
5. Deep drawing is a sheet forming process. The material should have high through thickness strength so that during forming there is minimum loss of thickness. Whereas along planar direction it should have identical formability. Plastic strain ratio R gives a measure of formability. Deep drawing grade of steel must have high \bar{R} and minimum ΔR . The former ensures minimum thickness strain whereas the latter indicates planar isotropy (this is needed to avoid earing problem).