Mechanical behavior of materials

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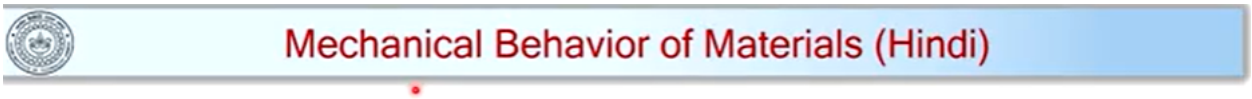
Lecture-43

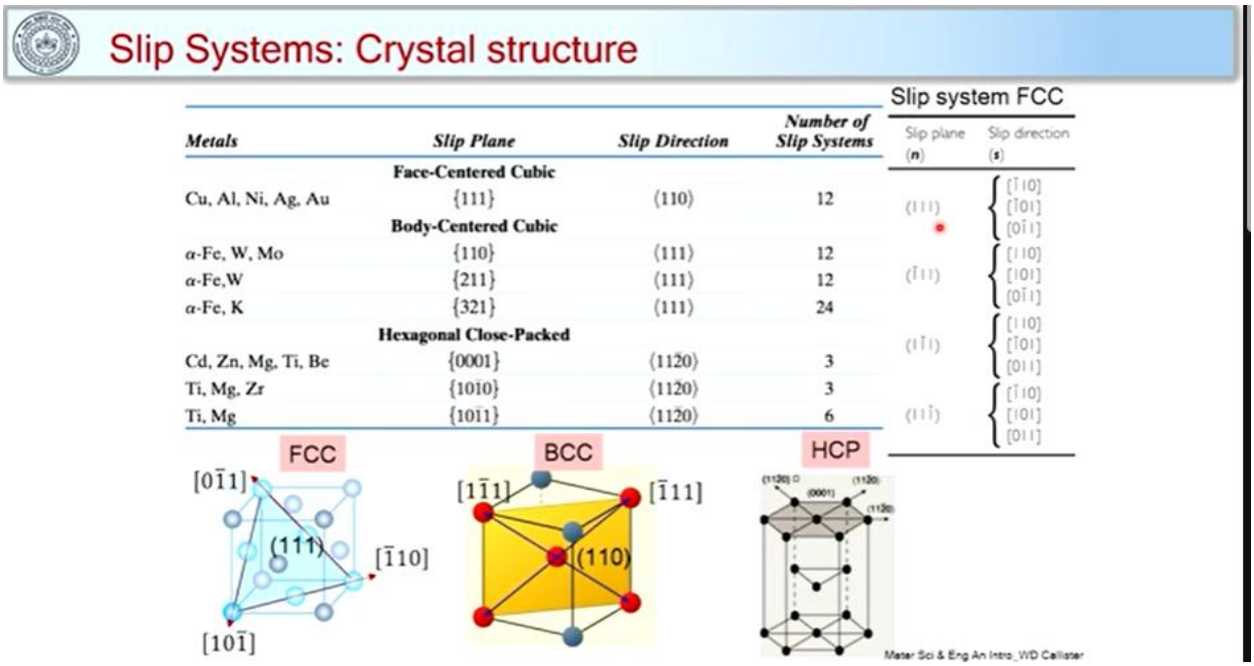
Independent slip System: Von Mises Criterion for plasticity



Independent slip systems: Von Mises Criterion for plasticity

Namaskar phir se swagat karta hoon aapka is course mein mechanical behavior of material jo ki hum hindi mein padhenge last part mein humne dekha tha ki strain hardening kya kaise hoti hai FCC material mein to usmein humne kuch polyslip ke baare mein baat ki thi pe jab hum baat karenge tab kitni slip systems active honi chahiye jo mujhe ek macroscopic plasticity degi jo strain hardening tha yeh microscopic plasticity mein aata hai but jab humein macroscopic plasticity chahiye wo define karne ke liye kitni slip systems lagegi yeh is part mein hum jaanenge aur is criteria ko kehte Von Mises criteria for plasticity aur jab hum slip systems ki baat karenge to humne FCC ke baare mein to dekha hi tha BCC ke baare mein bhi dekha tha ki mere paas {110} plane hai aur $\langle 1\bar{1}1 \rangle$ direction hai aur HCP material mein humne dekha tha ki ye basal planes hai aur kuch directions hai $\langle 11\bar{2}0 \rangle$ ye direction hai ye meri slip direction hai to jab hum slip systems ki baat karenge to humne kuch slip systems bhi likhi thi to mere paas FCC mein 12 slip systems hai body centered mein mere paas jab different slips planes hai aur ek hi slip direction yahan pe $\langle 111 \rangle$ aur kul milakar mere paas 48 slip systems hai hexagonal mein agar main different planes consider

karunga aur direction consider karunga to mere paas kuch 3 3 6 aur yeh cheh mila ke 12 slip systems to par jab main plastic deformation ki baat karunga to inmein se kaun si slip systems aapko macroscopic plasticity degi ab isko iske liye jaanne ke liye hum dekhenge ki jahan pe jab main baat kar raha hoon FCC mein ye ek example lete hain mere paas yeh 12 slip systems hai humne chaar planes dekhe the aur yeh teen directions hai ek-ek plane pe to kul milakar 12 slip system se in 12 slip systems mein se kaun si slip system jo hai jo mujhe strain accommodate karegi aur wo arbitrary shape change degi macroscopic level pe isko kehte hain.



Von Mises criteria dete hain isko hum detail mein nahi padhenge yahan par sirf yahan par iska ek introduction dekhenge jo is course ke liye kaam mein aayega to jab ductility ki baat karte hain material ki tab hum dekhte hain ki ductility aisa aisi honi chahiye jahan par mera koi bhi arbitrary shape change usko content karna chahiye yaani wo arbitrary shape change ko bhi jo strain mera develop ho raha hai woh usko correct karna chahiye yaani usko sustain karna chahiye agar koi bhi mera material hai usko is tarah se samajhte hain agar mera ek shape hai aur woh kuch is tarah se deform ho raha hai to yeh arbitrary shape change hai yeh arbitrary shape change hai to is shape change mein aap dekh paa rahe honge jo strain lagega mujhe woh meri ductility ko define karega aur jab Von Mises is postulate ke baare mein baat karenge tab mujhe paanch independent slip system chahiye jo ki is tarah se mera arbitrary shape change generate kar sake to jab hum slip systems ki baat karte hain tab hum microscopic plasticity ki baat karein yaani microscopic level par jaake baat kar rahe slip systems ki baat karenge tab yaani ek slip system ki main baat karunga tab aur jab main shape change ki baat karunga tab yeh hoga macroscopic yaani macroscopic plasticity ki main baat kar raha hoon to Von Mises batata hai ki mujhe paanch independent slip system chahiye ye arbitrary shape change develop karne ke liye to jab main strain ki baat karunga to strain ke paas mere mere paas nau components hai strain ke aur humne dekha tha ki ye jo ϵ_{ij} Hai ye strain tensor jo hai ye symmetric hai aur symmetric ka matlab yaani main is tarah se likh sakta hoon $\epsilon_{ij} = \epsilon_{ji}$ To aap dekh paa rahe honge agar mere paas yeh components mujhe pata hai off-diagonal component to mujhe dusre off-diagonal component pata honge to mere paas cheh independent components hai strains ke yaani $\epsilon_{xx}\epsilon_{yy}\epsilon_{zz}\epsilon_{yz}\epsilon_{xz}$ Aur ϵ_{xy} In cheh independent strain components isko bhi humne padha tha abhi jab main plastic deformation ki baat karunga tab mujhe

pata hai ki volume mera conserved hota hai to volume wahan pe change nahi hoga aur volume wahan pe jab change nahi hoga tab main ek condition aur apply kar sakta hoon $\epsilon_{xx} + \epsilon_{yy} + \epsilon_{zz} = 0$ yaani to teen normal strains ka jo summation hai wo shunya hona chahiye yaani mera constancy of volume ye maintain rahe tab agar yeh relation agar mujhe pata hai to maan lete hain mujhe paas ϵ_{xx} Ki value pata hai ϵ_{yy} Ki value pata hai to main ϵ_{zz} Ki value nikaal sakta hoon to in teenon mein se sirf do components jo hai wo independent rahenge yaani agar do pata hai to main teesra nikaal sakta hoon to mere paas cheh components the yahan pe aur cheh mein se in teenon mein se abhi sirf do hi independent hai to mere paas kul mila ke paanch independent components hai to hamare paas paanch independent slip systems honi chahiye jo ki ye strain develop kar sake mere arbitrary shape change ke liye to isliye Von Mises ka criteria kehta hai ki mere paas paanch independent slip systems hone chahiye abhi ye jo humne slip systems ke baare mein padha hai abhi independent kya hai ye humein samajhna hai to reason to aapko pata chal gaya ki paanch kyun chahiye kyunki hum ye strain component jab consider karenge to mere cheh independent strain components the symmetric nature ki wajah se aur plastic deformation ke constraint ki wajah se mere paas do hi strain component jo hai normal strain components wo independent rahenge to isliye mere paas kul mila ke paanch slip systems honi chahiye jo yeh paanch independent strains taiyaar kar sake to jab main independence ki baat karta hoon tab woh is tarah se define ki jaati hai ki jo crystal shape change ho raha hai woh agar koi slip system usko crystal shape change mein contribute kar raha hai woh dusre slip systems ke dwara produce nahi honi chahiye isko hum acche se samjhenge par yeh point bahut important hai to Taylor ne bataya ki jab 12 slip system se mere FCC aur BCC mein to mujhe paanch independent slip systems milna aasaan ho jaata hai yaani in 12 mein se to isliye BCC aur FCC metals ye acchi ductility dikhate hain HCP material mein aap dekhenge ki mere paas teen slip systems hai basal aur prismatic agar main milaunga to in teen slip systems mein sirf do hi jo slip system hai wo independent hai to aap dekh paa rahe honge ki HCP jo materials hai wo unmein ductility kam rehti hai aur agar yeh arbitrary shape hona hai un material mein jaise jinmein hexagonal close packed structure hai tab wahan jaake humein twinning ki zarurat padti hai twinning ke bhi baare mein hum padhenge apne course mein aur aage mein padhenge yahan ke liye hum dekh sakte hain ki FCC aur BCC material ductility kyun dikhate hain kyunki yahan pe mujhe paanch independent slip system milna aasaan hai as compared to HCP material.

Von Mises Criterion: Independent slip systems

- Ductility of a material depends on its ability to withstand a general homogeneous strain involving an arbitrary shape change
- Von Mises postulated that the above is possible when there are 5 independent slip systems.

$$\varepsilon_{ij} = \begin{pmatrix} \varepsilon_{xx} & \varepsilon_{xy} & \varepsilon_{xz} \\ \varepsilon_{yx} & \varepsilon_{yy} & \varepsilon_{yz} \\ \varepsilon_{zx} & \varepsilon_{zy} & \varepsilon_{zz} \end{pmatrix}$$

6 independent strain components

During plastic deformation Constancy of volume $\varepsilon_{xx} + \varepsilon_{yy} + \varepsilon_{zz} = 0$

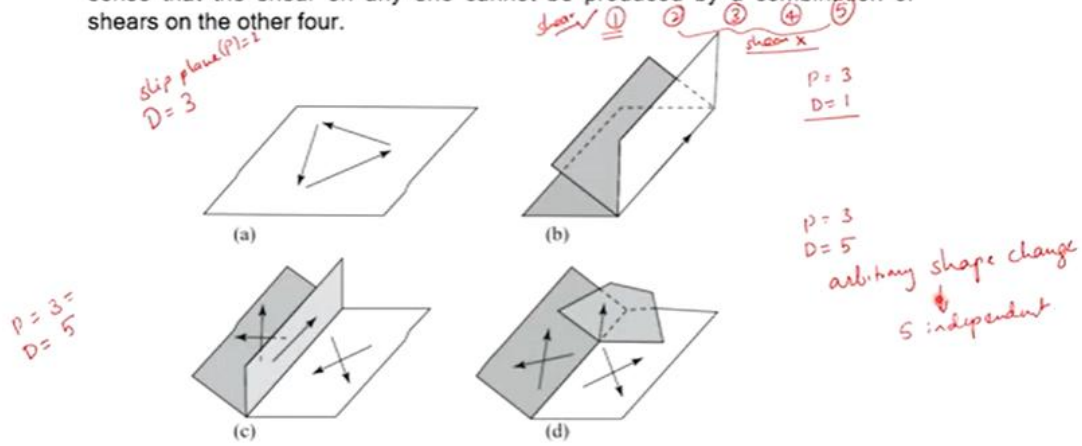
- Hence, 5 independent slip systems.
- Defined as one producing crystal shape change that can't be reproduced by any other slip system.
- Taylor (1938): Of the 12 possible slip systems in FCC and BCC, 5 are independent. Hence, BCC and FCC metals show good ductility.
- For HCP, only two out of three (basal or prism) slip systems are independent. Hence, HCP metals lack ductility and need twinning.

Abhi hum jaante hain ki independent slip systems hote kya hai to yahan pe ek statement likha hai ki jo arbitrary shape change hum baat kar rahe unmein se jo five systems hai woh independent hone chahiye is tarah se ki shear kisi plane mein jo ho raha hai woh Cannot be produced by combination of shears on other four yaani mere paas paanch independent slip system maine maan li 1 2 3 4 aur 5 to agar mere paas ek slip system operative hai maan lete 1 slip system meri operative hai to yahan par jo shear develop hoga yeh jo shear hai woh in charon ke combination se nahi hona chahiye to tab jaake yahan par jo shear develop hoga in charon se kisi bhi combination se humein is 1 ka shear develop nahi hona chahiye tab jaake main kahunga ki yeh jo slip system hai wo independent hai isko is tarah se samajhte hain to kuch kuch example leke samajhte hain to maan lete hain mere slip plane hai aur ye teen slip directions se to isko bhi likh sakte hain ek slip plane hai aur slip direction hai teen hai isko main p likh leta hoon to mere paas slip plane 1 hai to aap dekh paa rahe honge agar main is direction mein shear jo develop hoga is slip system dwara in dono ke combination ke saath likh sakta hoon ki kyunki ye jo vector hai slip direction hai in dono ka combination hai to main keh sakta hoon yeh jo slip system hai wo independent nahi hai kyunki main isko in dono ke combination se likh sakta hoon usi tarah aap dekh paa rahe honge yahan pe teen slip planes hai mere paas teen slip planes hai aur ek slip direction hai agar mera slip system maan lete ye plane act ho raha hai to ye jo yahan pe jo shear deformation hogi main in dono planes ke dwara likh sakta hoon to yeh yeh hogi meri yeh bhi meri independent slip system nahi hogi phir similarly yahan par main kuch is tarah se likh sakta hoon yahan par mere paas teen slip system hai teen slip planes hai okay aur yahan par jo directions hai mere paas woh paanch directions hai to aap dekh paa rahe honge ki yahan par jo slip ho raha hai is plane par wo main in dono ke combination se likh sakta hoon yahan par jo slip ho raha hai aur yahan par bhi jo slip ho raha hai yaani shear jo ho raha hai is plane par jo shear ho raha hai wo in dono ke shear ke combination ki tarah main likh sakta hoon yahan par agar hum dekhenge jaise mere paas planes teen hai aur yahan par direction paanch hai yahan par jo direction thi woh inke intersection par parallel thi aur yahan par jo direction hai woh perpendicular in inke intersection par is case mein bhi yahan par jo shear ho raha hai wo main in do ke combination se likh sakta hoon to yahan par maine kuch combination likhe the slip systems ke jo independent nahi hai to Von Mises ka criteria humein yeh kehta hai ki

agar mere paas arbitrary shape change mujhe chahiye arbitrary shape change ke liye mujhe paanch independent slip system chahiye to yeh criteria hai yeh aapko yaad rakhna hai aur is criteria ke wajah se hum explain kar payenge ki mere FCC aur BCC material kyun ductile hai aur HCP material ductile kyun nahi hai.

Independent slip systems

- For an arbitrary shape change, the five systems must be independent in the sense that the shear on any one cannot be produced by a combination of shears on the other four.



Combinations of slip systems that are not independent

Fundamentals of Engineering Plasticity Hosford

To is part mein hum yahin par liye rukte hain abhi tak humne saare strain hardening aur plastic deformation mein uska kya contribution ye dekha tha humne slip systems ke bhi baare mein padha hai aur humne abhi jo microscopic slip systems se usko macroscopic kaise connect kar sakte hain yeh bhi dekha hai next part se hum padhenge solid solution strengthening material mein kya hoti hai abhi ke liye rukta hoon dhanyavad