

Mechanical behavior of materials

Dr. Niraj Mohan Chawake

Department of Materials Science and Engineering

Indian Institute of Technology, Kanpur

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Lecture-41

Intersections of Dislocations: Jogs and Kinks



Mechanical Behavior of Materials (Hindi)

Intersections of dislocations: Jogs and Kinks

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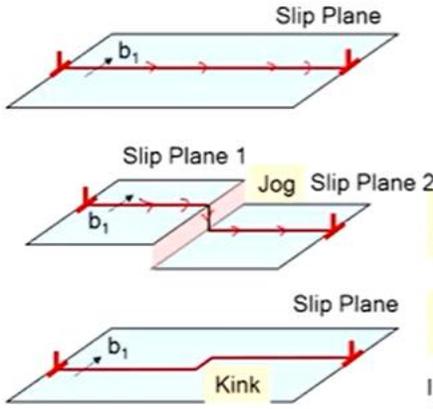
Namaskar phir se swagat karta hoon is course mein mechanical behavior of material jo ki hum hindi mein padhenge hum strain hardening ki baat kar rahe the abhi tak humne interaction of dislocation dekhe is part mein hum dekhenge intersection of dislocation jo humein jogs aur kinks dete hain intersection yaani do dislocation jab move hote hain tab ek dusre ke saath intersect karke chale jaate hain usi ko hum kahenge intersection of dislocations aur yeh kuch defects taiyaar karenge aur yeh jo defects hai jogs aur kinks yeh strain hardening mein madad karte hain to jab main intersections ki baat karunga dislocations ki inko hum acche se jaanenge to jo intersections dislocation line par taiyaar honge wo intersection taiyaar karenge ek break ko ek break taiyaar karenge mere dislocation line pe isi ko jogs aur kinks kehte hain aur isse kya hoga ki yeh jo dislocation line mein ek defect generate hoga yeh defect kaise hota hai abhi isko jaante hain maan lete hain mere paas ek slip plane hai is tarah se aur is slip plane pe ek dislocation hai yahan pe maine edge dislocation mark kiya hai kuch is tarah se aap dekh rahenge ki ye mera tangent vector hai is direction mein aur burgers vector kuch is direction mein abhi hum is dislocation mein break taiyaar karte hain yaani is dislocation line pe break taiyaar karte hain kuch is tarah se yaani maine is dislocation ko is tarah se draw kiya hai yahan par ek break mark kiya hai jo black color ka dikh raha hai ye break hai aur yeh meri dislocation line hai to main agar dekhunga ki ye break is tarah se taiyaar hua hai ek ye ek slip plane hai mera slip plane one hai ye ek mera slip plane two hai aur

yahan pe jo break taiyaar hua hai dislocation line pe agar main dislocation line bolu bol raha hoon to ye meri dislocation line hai yahan pe to aap dekh paa rahe honge ye meri dislocation line hai aur tangent vector hamesha current ki tarah flow karta hai to hum yahan pe bhi kuch is tarah se draw karenge to ye aap dekh rahe honge ki ye jo break hai ye out of slip plane hai yaani ye slip plane one pe nahi hai aur slip plane two pe nahi hai ye out of the slip plane hai isko hum kehte hain Jog ye jo break taiyaar hua hai isko hum kehte hain jog yeh jo jog hai iski definition is tarah se jab mere dislocation line par break taiyaar hota hai aur woh dislocation line yaani dislocation plane yaani original slip plane ke bahar hai out of the original slip plane hai to us tarah ke breaks ko main kahunga jog abhi agar ek break bahar hai mere slip plane ke to ek break andar bhi ho sakta hai kuch is tarah se to agar main is tarah se mark karunga mere dislocation line ko aur main yeh slip plane consider karunga to aap dekh rahe honge ki ye jo break taiyaar hua mere dislocation line pe yeh break mere slip plane mein hi reh raha hai ye slip plane se bahar nahi hai to is tarah ke break ko main kehta hoon Kink yaani ye jo kink hai yeh break hai mere dislocation line pe jo ki original slip plane mein hi rehta hai to mere paas aap dekh rahe honge ki ye kink aur jog ye do breaks taiyaar hue humne kaha hai ki isko ye defect hai mere dislocation line pe to agar aap dekh rahe honge ki agar meri dislocation line kuch is tarah se thi to yeh jo line segment hogi yeh extra hogi yaani jo breaks honge yeh extra line segment taiyaar karenge aur humne dekha hai ki agar dislocation ki length badhti hai to uski energy bhi badhti hai to yeh jo breaks hai uske corresponding energy bhi badhegi aur humne dekha tha energy per unit length $E = \alpha G b^2$ Ye energy per unit length hai agar mujhe yeh length pata hai break ki yaani jog ya kink ki length agar mujhe pata hai to main iski energy nikaal sakta hoon is break ya jog ya kink ki energy nikaal sakta hoon to energy of jog main yahan par is tarah se likhunga $\alpha G b^2 \cdot b_1$ Maan lete b_1 Ye meri length of jog hai to ye jab breaks taiyaar hote hain ye maine kaha ki ye dusre dislocation ki ya isi dislocation ki moment ko restrict karte hain aur hum jab dislocation ki moment yaani uski rukawat usmein uske motion mein rukawat daalte hain to mujhe strain hardening milti hai aap dekhenge ki strain hardening result hoti hai dislocation ke motion ko main jab rokta hoon.



Dislocation Intersections: Jogs & Kinks

- Break in the dislocation line



- Defect in the dislocation line
- Extra segment in the dislocation
- Increases the energy of dislocation

Energy of a dislocation per unit length
 $E = \alpha G b^2$

Energy of jog, $E_{jog} = \alpha G b^2 b_1$
where, b_1 : length of a jog

Dislocation line out of the original slip plane

Dislocation line remains in the original slip plane

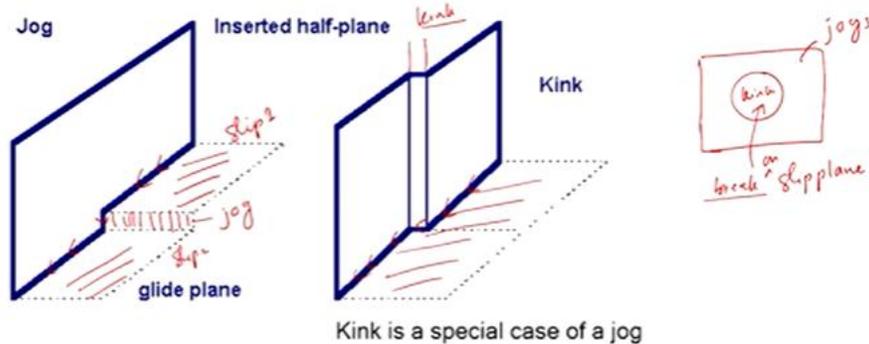
Impede motion of the dislocation
 Strain hardening

- Intersection of dislocations

To abhi ye dekhenge ki ye jog ye break ya kink kis tarah se taiyaar hote hai to yeh taiyaar hote jab mere dislocation ek dusre ke saath intersect karte hain to abhi main is jogs aur kinks ko aur acchi tarah se samjhata hoon to yahan par aap dekhenge ki maine jog mark kiya yahan par to yahan par yeh jo meri line hai yeh meri tangent vector yaani dislocation line hai to mera slip plane one tha is tarah se aur yeh slip plane two hai aur yahan par jo break ho raha hai ye mera jog hai agar yahan par aap dekhenge yeh meri tangent vector hai aur mera ye slip plane continuous hai yahan pe yeh jo break hai yahan par mila hai yeh mera kink hai yeh kink jo hota hai woh mere slip plane mein rehta hai to kink ek special case hai jog ka agar aap koi bhi standard textbook agar aap dekhenge to dono breaks ko yaani dislocation line par jo breaks taiyaar ho rahe hai unko jogs kehte hain par yeh kink jo hai ek special case hai jab jog slip plane mein hi rehta hai usko hum kehte kink to agar main agar sets theory dwara agar usko likhun to yeh ho gaya mera jog sab breaks ko main jog kehta hoon aur yeh ho gaya kink ye ek sub part hai jab break mera dislocation line break jo hai wo slip plane par hi rehta hai on slip plane to ek special case hai abhi ek ye breaks kis tarah se hote hain isko jaante hain to ek statement yahan par main likhna chahta hoon to jab do dislocation ek dusre ke saath intersect karte hain yahan par hum baat kar rahe hain intersect interaction nahi to yahan par ye jo dislocation hai yeh intersect karte hain to wo ek jog taiyaar karenge jog yaani break aur break kaisa hoga wo break wo break hoga in the direction and length of Burgers vector of other yaani do dislocation intersect kar rahe hain to break is tarah se taiyaar hoga jiski length aur direction Burgers vector jo dusra dislocation hai uske Burgers vector ke barabar hota abhi hum isko aur acche se samajhte hain kuch examples leke.



Dislocation Intersections: Jogs & Kinks

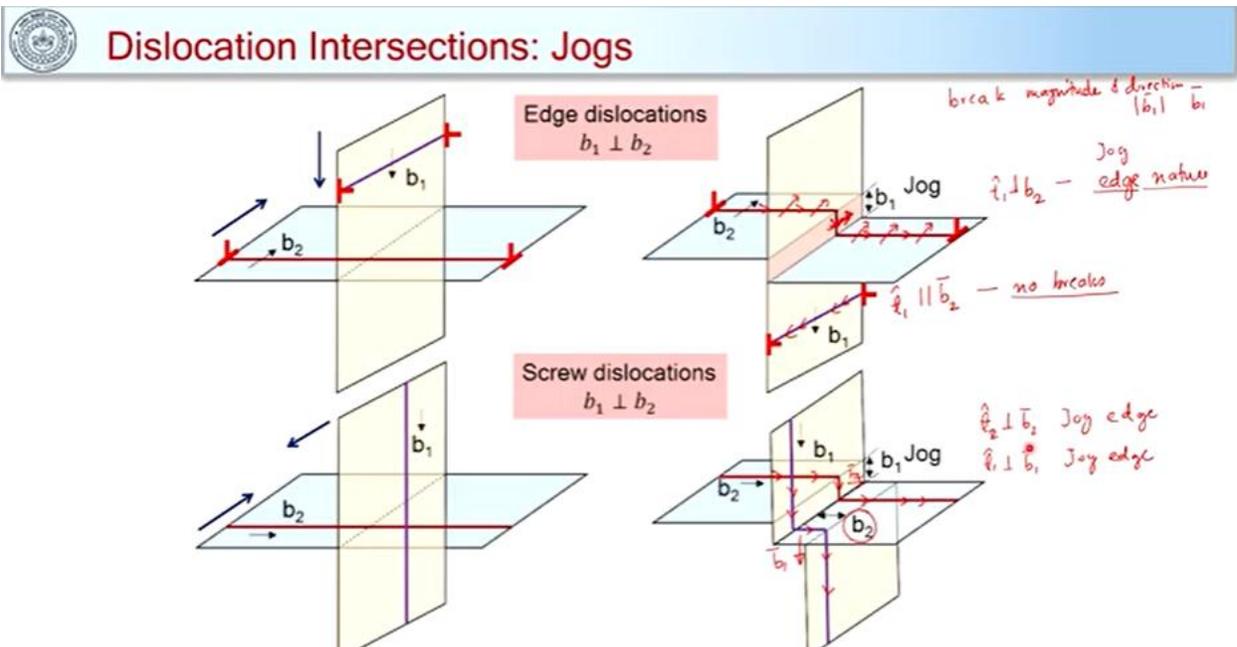


When two dislocations intersect each acquires a jog equal in direction and length to the Burgers vector of the other

To mere paas do slip planes maine is tarah se mark kiye aur abhi main ispe do dislocations mark karunga kuch is tarah se to pehla ek mera dislocation hai aur to yeh jo dislocation hai mera edge dislocation hai aur iska Burgers vector kuch is tarah se aur yeh mera dusra dislocation hai jo dusre slip plane pe aur kuch is tarah se hai to yeh bhi ek dislocation hai aur aap dekhenge ki yeh jo edge dislocation hai ismein yeh jo Burgers vector hai b_1 Yeh perpendicular hai mere dusre edge dislocation ke Burgers vector se to yahan par ek special case hai ye $b_1 \perp b_2$ Abhi hum dekhte ki jab ye dono dislocations ek dusre ke saath intersect karenge ye intersect yahan pe honge jahan pe ye do planes slip planes dusre ke saath intersect ho rahe hain is position pe tab yeh kab hoga jab main

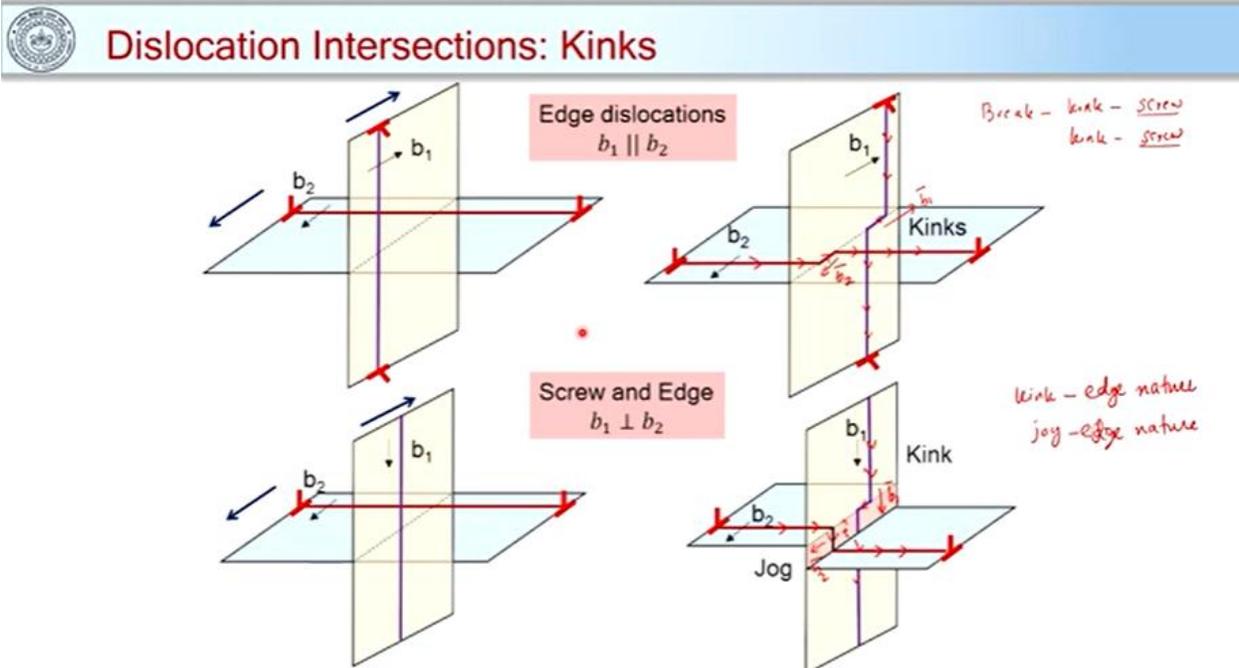
kuch stresses apply karunga mere material pe aur in stresses ke karan yeh dislocation move honge to hum yahan pe do pure edge dislocation consider kar rahe hain aur humein pata hai edge dislocation ho ya screw dislocation ho inki movement jo hogi wo perpendicular to tangent vector hogi to agar main tangent vector consider karunga to unke perpendicular direction par dislocation move honge to abhi dekhte ki yeh dono jab intersect karte to breaks kis tarah se taiyaar hote hain to main jab pehla dislocation consider kar raha hoon b_2 Yahan par to aap dekh rahe honge ki humne jo statement likha tha woh statement is tarah se tha ki is dislocation par break kis direction mein taiyaar hoga wo taiyaar hoga mere dusre dislocation ke Burgers vector ke direction pe aur uski magnitude rahegi dusre dislocation ki Burgers vector to yahan pe aap dekh rahe honge ki ye jo break hai iski magnitude b_1 Ke barabar hai aur break kis direction mein taiyaar hoga break taiyaar hoga ye direction pe b_1 Direction pe aap dekh rahe honge ki break is direction mein taiyaar hua to yeh break jo hai humne dekha tha ki yeh break ko hum kehte hain jog kyunki yeh slip plane ke bahar hai to agar main is direction mein tangent vector draw karoon to yeh mera tangent vector hoga abhi main dusra dislocation jo mera b_1 Hai uspe kaise break taiyaar hoga to is dislocation par koi break taiyaar nahi hoga agar aap dekh paa rahe honge ki humne bola tha ki break kis direction mein taiyaar hoga aur kis magnitude se taiyaar hoga to yahan par yeh jo Burgers vector hai b_2 Yeh parallel ho jayega mere tangent vector pe to agar main b_1 Ka tangent vector nikaalu kuch is direction mein to aap dekh paa rahe honge ki tangent vector pehle ka jo tangent vector hai wo parallel hai mere dusre Burgers vector to abhi yahan par jab is condition mein rahegi to yahan par koi breaks taiyaar nahi honge is condition mein agar Burgers vector dusre us equation ke tangent vector se parallel hai to koi bhi breaks taiyaar nahi honge yahan pe mujhe break mila hai is direction mein jo b_1 Ke direction pe hai abhi hum is jog ka nature dekhenge iska nature kya hai to nature dhundhne ke liye pehle to mujhe is break ka tangent vector aur Burgers vector nikaalna padega to humne dekha tha ki yeh jo Burgers vector hai wo invariant hota hai kisi bhi dislocation ke to iski direction kuch is direction mein rahegi to kyunki ek yeh line segment hai mere dislocation ki to yeh jo aap dekh rahe honge tangent vector to current ki tarah jaata hai to tangent vector t_1 Is tarah se rahega aur is break ka jo Burgers vector rahega kuch is direction mein rahega yeh Burgers vector rahega mere b_2 Direction pe aur aap dekh paa rahe honge ki yeh dono perpendicular hai to yeh jo jog hoga wo jog mera hoga edge nature ka abhi phir se hum samajh lete hain is example ke dwara mera break kis direction mein taiyaar hoga mera break taiyaar hoga b_1 Ki direction mein aur uska magnitude rahega b_1 Par yeh jo break hai yeh jo magnitude hai aur direction b_1 Ki taraf hai iska tangent vector to same rahega kyunki ye dislocation line to ek hi hai to tangent vector mera initial tangent vector ke current ki tarah hi pass karega aur dusra jo iska Burgers vector hai to humne dekha tha ki dislocation line koi bhi dislocation line ke liye Burgers vector wo invariant rehta hai to iska Burgers vector jo rahega wo b_2 Rahega aur b_2 Ke direction mein rahega to mujhe ek line segment jo break mil raha hai uska magnitude b_1 Hai aur direction b_1 Hai aur uska nature jo hai wo edge nature hai to yahan par break ka jo magnitude b_1 Hai aur Burgers vector mera b_2 Hai aur nature jo mila mujhe edge nature mila hai to ye ho gaya mera jog abhi dekhte hain kuch aur condition yahan par aur do slip planes maine mark kiye aur yahan par jo dislocations main mark kar raha hoon yeh do hai screw dislocations aap dekh paa rahe honge ki ye mere tangent vector hai aur Burgers vector jo hai yahan pe parallel hai in dono cases mein aur aap dekhenge ki yeh jo Burgers vector hai ye ek dusre ko perpendicular hai aur main jab in do screw dislocations ko pure screw dislocations ko move karunga kuch is direction mein to yeh jo screw dislocation hai ye perpendicular hai ek dusre ko to ab dekhte ki kya kaun se type ke breaks yahan par taiyaar honge to pehla agar main case dekhunga b_2 Ka main case dekh raha hoon to b_2 Pe break kis direction mein banega break banega mere b_1 Direction pe aur is break ka jo magnitude rahega woh

rahega mere pehla jo dislocation hai dislocation ek hai uske magnitude ke dwara to yeh jo magnitude hai aur direction hai break ka woh mere Burgers vector one hai uska rahega to abhi hum dekhte hain ki b_1 Par kis tarah se break banega to b_1 Pe mera break banega b_2 Ke direction ki taraf aur uska magnitude rahega dusre dislocation ke Burgers vector ke dwara to yeh jo magnitude rahega b_2 Rahega to ab dekhte hain yahan par dono par breaks taiyaar ho gaye to aap dekh paa rahe honge ki mere paas do jogs taiyaar ho gaye yahan par aur abhi inke nature dekhte hain to pehle ke case mein jaise b_2 Ke case mein tangent vector kuch is tarah se rahega aur dekhenge ki yeh b_2 Isi direction par hai to main dekh paa raha hoon ki tangent vector jo hai t_2 Yeh perpendicular hai yahan par jog ke liye to yeh jo hoga jog hoga wo edge nature ka hoga aur yeh yahan par tangent vector kuch is tarah se hai aur agar hum dekhenge to mera jo break hai yaani agar main tangent vector is tarah se break mera b_2 Ke direction pe hai par yahan par tangent vector is tarah se aur iska Burgers vector mera b_1 Rahega kuch is tarah se to yahan par bhi main dekh paa raha hoon ki ye jog hai jismein edge nature hai to in dono cases mein mujhe edge nature milte hai.



Abhi aur kuch cases dekhte hain aur isko samajhte hain ki yeh breaks kis tarah se hote hain abhi main do planes agar maine mark kar liye yahan pe aur abhi main do dislocations is tarah se mark kar raha hoon yahan pe yeh dono edge dislocations hai aur yeh inke Burgers vector jo hai yahan pe parallel hai to yahan pe yeh do hi dislocations se in do slip plane pe move rahe hain aur inke Burgers vector parallel hai aur main agar inko is direction mein move karta hoon to breaks kis tarah se banenge to pehle dekhte hain b_1 Pe kis tarah se break ban raha hai to b_1 Pe break is tarah se banega b_2 Direction pe to b_2 Direction pe break bana hai aur yeh bana hai iska magnitude rahega b_2 Yaani is break ki jo length hogi wo mere b_2 Ke barabar hogi abhi hum iska tangent vector draw kar lete hain agar main iska tangent vector draw karu to tangent vector kuch is tarah se hi hoga aur Burgers vector iska mera b_1 Ke hi direction par rahega kyunki Burgers vector invariant rehta hai kisi bhi dislocation line ke liye to aap dekh paa rahe honge ki yeh jo hai yeh break bana hai yeh slip plane par hi hai to yeh ho jayega mera kink aur yeh kink ka nature kya hoga yeh kink ka nature hoga screw nature aap dekh paa rahe honge ki tangent vector yahan par hai parallel to Burgers vector to yeh ho jayega screw nature aur abhi hum dekhte hain ki b_1 Par

kaise break banega yeh b_1 Pe dekha tha humne abhi b_2 Pe dekhte hain to b_2 Pe bhi break banega wo mere b_1 Ke direction pe banega yahan pe dekhiye yeh b_1 Ki direction mein bana hai aur yeh jo break ki magnitude hogi ya length hogi yeh barabar hogi mere Burgers vector one ki magnitude ke to yahan par bhi main tangent vector draw karta hoon aur yahan par jo Burgers vector rahega mera b_2 Hi rahega aur tangent vector mera b_1 Ke direction pe hai to yahan par aap dekh paa rahe honge ki t_2 Parallel hai b_2 Ko abhi hum dekhenge yahan par bhi mujhe kink mila hai aur in dono kink ka nature hai screw pure screw nature hai in dono kink ka abhi dekhte hain aur ek case jahan par mere paas ek screw dislocation hai aur ek edge dislocation hai abhi hum dekhenge ki inke jo Burgers vector hai b_1 Perpendicular b_2 Se hai agar yeh is direction mein move hote aur intersect karte ek dusre ko to aapko agar main b_1 Ka case consider karunga to b_1 Par break kis tarah se banega b_1 Par break banega b_2 Ke direction par aur uska magnitude rahega is break ka magnitude rahega b_2 Aur aap dekh paa rahe honge ki tangent vector mera kuch is tarah se hai aur Burgers vector mera kuch is tarah se to yeh dono parallel hai t_1 Parallel to b_1 To yahan par dekhenge ki yeh kink bana hai kyunki slip plane par hi break hai aur kink jab bana hai to ab dekhenge ki yeh kink bana hai mere edge nature ka aur abhi hum dekhenge ki b_2 Par kis tarah se break bana hai to b_2 Par break banega mere b_1 Ke direction par aur jo length hogi us break ki wo b_1 Ke magnitude ke barabar hogi abhi hum tangent vector aur Burgers vector dekh lete hain to tangent vector aur Burgers vector kuch is tarah se perpendicular hai to yahan par aap dekh paa rahe honge ki yeh jog banega kyunki out of the slip plane hai to yeh jog banega aur yeh jo tangent vector hai aur mera Burgers vector yahan pe is tarah se b_2 Ka to yahan pe jog jo milega jog mujhe jo mila hai wo mujhe milega edge nature ka.

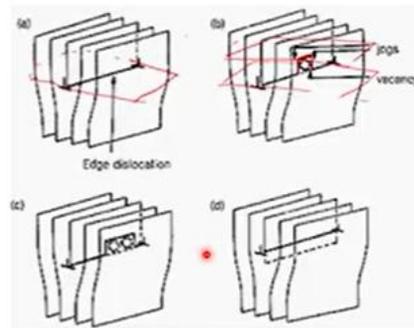
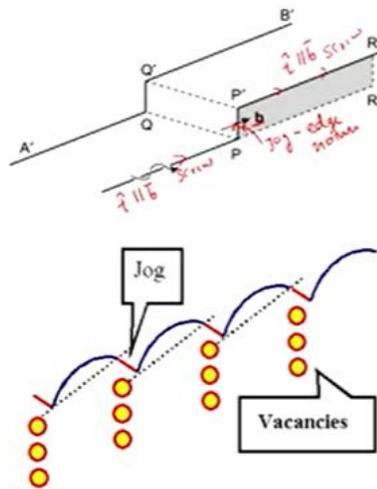


To abhi humne kuch ek special conditions dekhiye intersections of dislocations ki ab hum jaante hain ki iska mahatva kya ho sakta hai strain hardening mein to ek simple example lete hain ki jab jog move karte hain to yeh jab dislocation move karenge aur mere paas break hai mere dislocation line pe to kis tarah se movement ho sakti hai to dekhte hain ek dislocation hai mere paas is tarah se yeh jo dislocation hai aur iska Burgers vector is direction pe hai tangent vector kuch is direction pe hai to aap dekh paa rahe honge ki yeh jo nature hai yeh mera screw nature hai aur yeh jo nature

hai yeh bhi mera screw nature hai to ye jo nature hai jog ka isko main isko main maan leta hoon jog to yeh jo nature hai yeh mera hai edge nature kyunki yeh mere paas ek slip plane hai ye ek slip plane hai aur ye break hai mera out of the slip plane to yeh jog ho gaya aur iska nature hai edge nature abhi hum dekh sakte hain ki agar mere screw dislocation ko jaise $P'R'$ Ko move karna hai move kahan karna hai mere $Q'B'$ Ki taraf to yeh is plane par move hoga kyunki yahan par tangent vector parallel hai Burgers vector pe yahan par bhi tangent vector parallel hai Burgers vector ki tarah to aap dekhenge ki yeh jo part hai mere dislocation ka $P'R'$ Wo aasaani se move ho sakta hai $Q'B'$ Ki taraf similarly yeh jo part hai ye mera screw part wo $S'Q'$ Ki taraf move ho sakta hai aaram se kyunki yeh parallel hai to is glide plane mera yeh glide plane ho sakta hai mere screw dislocation ke liye par agar hum dekhenge yeh jo jog hai jo edge nature ka jog hai to iske liye glide plane kaun sa hoga iske liye glide plane hoga mera $PP'R'R$ yeh isliye kyunki humne dekha tha ki jab edge dislocation hota hai ya edge nature hota hai mere dislocation ka wo ek hi slip plane pe move ho sakta hai jis slip plane par dono tangent vector aur Burgers vector lie karte hain ya rehte hain to aap dekh rahenge ki yeh jo plane hai yahi mera slip plane hoga sirf yeh dislocation line segment jo edge nature ka hai iske liye to mera yeh jo line segment hai sirf is plane par move hota hai agar mujhe is dislocation ko yahan par move karna hai to aap dekh rahe honge ki yeh jo movement hai wo movement hogi yeh perpendicular plane par hai to aap dekh rahe honge ki is yeh jo movement hogi yeh climb ke dwara hogi aur climb ke liye mujhe jyada energy chahiye jo mujhe strain hardening degi to isiliye agar in parts ko bhi move hona hai to yeh jo part hai yeh in dono screw parts ko rok ke rakhega to yahan par main dekh sakta hoon ki dislocation ki movement yahan par ruk jaye to aapko strain hardening milegi kuch is tarah se samajhte abhi main climb ki jab baat karunga to yahan pe yeh jo hai yeh jog nature hai jo maine red mein mark kiya hai aur yeh jo hai mera screw nature hai to aap dekh paa rahe honge ki jab is part ko yahan par move karna hai dusre slip plane pe to yahan pe meri vacancies taiyaar honi chahiye to jab jog formation hoga aur jog ki movement hogi tab mujhe vacancies ki zarurat hogi kyunki yeh climb ke process ke dwara hoga ya up climb ya down climb to humne dekha tha ki up climb aur down climb mein vacancies involve hoti hai aur yahan par mujhe vacancy assisted movement milegi jogs ki isko is tarah se samajh sakte hain jaise mera ek edge dislocation hai abhi aap dekhenge ki is dislocation par main ek jog taiyaar karunga jog yaani wo out of the slip plane to aap dekh rahe honge yahan par yeh mera slip plane tha is dislocation ka kuch is tarah se aur yahan par dekh rahe honge ki yeh jo line hai yeh climb up ho gayi hai yaani dusre slip plane par move ho gayi hai kuch is tarah se aur yeh jo original slip plane tha kuch niche tha uske to yeh jo jog hai yeh taiyaar hua yeh taiyaar hoga is dislocation line pe to yeh jo dislocation line par jog hua yahan par yeh taiyaar hoga jab yahan par koi vacancies hogi yahan par aap dekh paa rahe honge ki ye meri dislocation line yahan par climb up ho rahi hai aur yahan par kuch vacancies generate ho rahi hai aur jab yeh vacancies kuch is direction mein badh jayegi to aap dekh rahe honge ki ye dislocation niche tha is plane pe yahan par abhi dotted line par dikha raha hai yeh ek uske upar wale plane pe climb up ho jayega to humein jog ke movement ke liye agar edge nature hai to usmein climb ki aavashyakta padti hai aur humne dekha hai ki climb mera stress aur thermally activated to is process ko mujhe thermally thermal activation aur stress dono ki zarurat padegi to abhi is part mein humne dekha hai ki dislocations jo hai woh uspe breaks taiyaar ho sakte hain jab woh ek dusre ke saath move hote hain jab dislocation ek dusre ke taraf move hote hain to woh ek dusre ke saath intersect ho sakte hain.



Movement of Jogs



Stress and thermal activation is needed to move jogs

Introduction to dislocations, Hull & Bacon

Material Science for Engineers, Entomology, Laxmi, Bangalore, Lakshmi

Yeh jo intersection hai yahan par main ek aur point batana chahta hoon ki yeh jo dislocation intersection yahan par humne baat ki hai aap intersection ki jab main baat karunga tab yeh jo intersection hai mere repulsive intersection humne yahan par sirf repulsive intersection ki baat ki hai yaani main keh sakta hoon ki jo agar mere do dislocation hai $b_1^2 + b_2^2$ Yeh hamesha jo b_3^2 Rahega yaani product rahega usse kam rahenge to yeh mere repulsive intersections hai to aap attractive intersections ki bhi baat kar sakte hain to yahan par ek point yeh aapko yaad rakhna hai ye jo discussions hue woh mere repulsive intersections se aur ab jab hum strain hardening ki baat kar rahe hain to strain hardening mein jogs ki movement difficult hoti hai aur jab do dislocation intersect karte ek dusre ke saath to ek dusre ki motion rokne hain aur isliye mujhe strain hardening milti hai abhi ke liye yahan par rukta hoon next part mein jaanenge hum ki dislocations ke ye strain hardening ke contributions kya hote hain strength ki taraf overall strain hardening ke yaani hamare interaction dislocations ke aur intersections in dono ka contribution kya hai strength ki taraf dhanyavad