Influence of dislocation on interaction between a crack and a circular inhomogeneity

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ABSTRACT

The investigation for the interaction problem between a Griffith crack and a circular inhomogeneity in the presence of an edge dislocation under the remote load is carried out. The expressions for the stress intensity factors (SIFs) at the crack tip are determined for different sets of geometric and material parameters with the distributed dislocation technique. The formulated singular integral equations are then solved numerically. The numerical results show that the edge dislocation can reduce the SIF or increase it, depending on the position of edge dislocation. When the distance between the edge dislocation and the inhomogeneity is fixed, there is competition between the effects of the inhomogeneity and the edge dislocation on the SIF. When the distance between the edge dislocation and the crack is less than a certain value, the edge dislocation is more distinct factor that influences the crack propagation. When the distance between the edge dislocation and the crack is equal to the certain value, the edge dislocation and the inhomogeneity counteract each other’s efforts. When the distance between the edge dislocation and the crack tip is more than the certain value, the effect of the inhomogeneity is more dominant. As the remote load increases, the influence of the edge dislocation on SIF decreases, while the effect of the inhomogeneity on it keeps unchanged.

1. Introduction

During the last several decades, the study of material defects (such as dislocations, inhomogeneities and cracks) has received a considerable amount of attention in the literature concerning the mechanical behavior of composite materials. Inhomogeneities either unwanted or deliberately introduced in the materials can dramatically change their mechanical properties. Therefore the study of inhomogeneities (or inclusions) has received a considerable amount of attention (see, for example [1–5]). The interaction between dislocations and inhomogeneities is a meaningful topic in studying the mechanical properties of materials. Dundurs and Mura [6] investigated the interaction between an edge dislocation and a circular inclusion. The interaction between a screw dislocation and an elliptic inhomogeneity had been studied by Gong and Meguid [7]. Luo and Xiao [8] investigated the interaction between a screw dislocation and an elliptical inhomogeneity embedded in an infinite matrix. Qaissaunee and Santare [9] investigated the interaction effect of an edge dislocation, which is located inside the inhomogeneity or inside the matrix, with an elliptical inclusion based on a three phase elliptic cylindrical model. Xiao and Chen [10,11] considered a screw dislocation and an edge dislocation interacting with a coated circular inclusion, respectively. The force acting on the dislocation was calculated and the equilibrium positions of the dislocation were discussed for various material property combinations and variations in coating thickness. Wang and Shen [12] obtained an elastic solution derived in a decoupled manner for the interaction problem between an edge dislocation and a three-phase circular inclusion with circumferentially homogeneous sliding interface. Liu et al. [13] investigated the interaction of a piezoelectric screw dislocation with an interphase layer between the circular inclusion and the piezoelectric matrix. Fang et al. [14] utilized the problem of the electroelastic interaction between a piezoelectric screw dislocation and an elliptical inclusion with electrically conductive interfacial rigid lines under antiplane shear and inplane electrical loads. Feng et al. [15] analyzed the image force and stability of a screw dislocation inside a coated cylindrical inhomogeneity with interface stresses. Chen et al. [16] investigated the problem of an edge dislocation interacting with a near a three-phase elliptic inhomogeneity. Zeng et al. [17] investigated the problem of the dislocation emission from the nanovoid with surface effects under combined loading. Zhao et al. [18] utilized a model of the generation for an edge misfit dislocation in the system of a nanowire surrounded by a coaxial film with surface/interface effects.
The interaction between a dislocation and a crack is an intriguing problem and has been extensively studied. The stress field, image force and strain energy of dislocation, and the stress intensity factor at the crack tip are the major concerns in these investigations. The stress intensity factor of a screw dislocation near a semi-infinite crack was obtained by Majumdar and Burns [19]. Chen et al. [20] investigated the electro-elastic interaction of a wedge-shaped crack with a screw dislocation in piezoelectric solid. Lung and Wang [21] evaluated the image force on a screw dislocation near a finite length crack tip and analyzed the influence of the crack length on the image force. Zhang and Li [22,23] investigated an edge dislocation and a screw dislocation interacting with a finite length crack. Lakshmanan and Li [24] obtained the stress field around the tip of a semi-infinite crack with an edge dislocation parallel to the tip but located in any nearby position in closed form. Weertman [25] presented some general solutions for crack tip shielding and antishielding by screw and edge dislocations.

The interaction between cracks in the surrounding matrix and nearby fibers (inclusions) is an important problem when attempting to understand and predict the strengthening and hardening mechanisms of composite materials. Tamate [26] studied the effect of a circular inclusion on the stresses around a line crack in a sheet under tension. Erdogan et al. [27] considered the interaction between an isolated circular inclusion and a line crack embedded in an infinite matrix with the distributed dislocation method. The distributed dislocation method is an effective tool to solve various kinds of crack problems [28–33]. The investigation for a crack near an elliptic inclusion was carried out in terms of the body force method by Nisitani et al. [34]. Luo and Chen [35] investigated the matrix cracking in fiber-reinforced composite materials. Liu et al. [36] studied the effects of imperfect bonding on stress intensity factors calculated at a radial matrix crack in a fiber composite subjected to various cases of mechanical loading. Xiao and Chen [37] studied the interaction between a radial matrix crack and a three-phase circular inclusion. Kim and Sudak [38] investigated the interaction between a radial matrix crack and a three-phase circular inclusion with imperfect interface in plane elasticity.

The influence of the coexistence of the inhomogeneity, the dislocation and the crack on the material behavior has received increasing interests from researchers in recent years. Song and Gao [39] studied the interaction between a screw dislocation and a wedge crack with an elastic circular inhomogeneity at the tip by means of conformal mapping. Shen et al. [40] investigated the interaction between a screw dislocation and a piezoelectric fiber composite with a semi-infinite wedge crack. Zhang et al. [41] studied the interaction between a screw dislocation and a circular nano-inhomogeneity with a semi-infinite wedge crack penetrating the interface. Li et al. [42] investigated the screw dislocation interacting with a nanoscale circular inclusion and a mode III crack. Wang et al. [43] derived the closed-form solutions for a mode III radial matrix crack penetrating a circular inhomogeneity. The loadings considered in this research include: (i) remote uniform anti-plane shearing; (ii) a screw dislocation located in the unbounded matrix; and (iii) a radial Zener–Stroh crack. Wang et al. [44] derived the closed-form solutions for a semi-infinite crack penetrating a piezoelectric circular inhomogeneity with a viscous interface. The loadings considered in this research include: (i) nominal Mode-III stress and electric displacement intensity factors at infinity; (ii) a piezoelectric screw dislocation located in the unbounded matrix; and (iii) a piezoelectric screw dislocation located in the inhomogeneity. Wang and Pan [45] obtained the closed-form expressions of the stress intensity factors at the two crack tips of a Mode-III finite slit crack partially penetrating two circular inhomogeneities. The loadings considered in this research include: (i) remote uniform anti-plane shearing; (ii) a straight screw dislocation at any position of the three-phase composite system; and (iii) a Zener–Stroh crack.

However, the aforesaid research work do not take into account the situation that is the inhomogeneity, the edge dislocation and the Griffith crack exist at the same time. The study that the influence of dislocation on interaction between a crack and a circular inhomogeneity in composite materials has important theoretical significance and scientific value for further studying the fracture toughness and other mechanical behavior of composite materials. So the objective of the current study is to investigate the interaction among a Griffith crack, an edge dislocation and a circular inhomogeneity. The influence of such parameters as the elastic mismatch between the inhomogeneity and matrix, the crack position, the edge dislocation position, the magnitude of the remote load and inhomogeneity size, on the SIF of the crack has been analyzed. The obtained results could serve as a guide in the design of the fiber-reinforced composites to ensure that the stress intensity factor is kept as small as possible to guarantee that failure does not occur within the intended lifetime.

2. Problem description

As shown in Fig. 1, an infinite elastic matrix contains a circular inhomogeneity of radius R. The domains occupied by the matrix and the inhomogeneity are denoted by $S^-$ and $S^+$, respectively. The matrix and inhomogeneity are assumed to be both isotropic elastic. The shear modulus and Poisson’s ratio of the matrix and inhomogeneity are given by $\mu_1$ and $\nu_1$ ($i = 1, 2$), respectively, where ‘1’ denotes the inhomogeneity and ‘2’ denotes the matrix. Perfect bonding condition is assumed at the matrix-inhomogeneity interface. A crack with length c contained in the matrix locating near the inhomogeneity. An edge dislocation $(b_x + ib_y)$, which is assumed to be straight and infinite along the direction perpendicular to the xy-plane at the point $z_0$ in the matrix phase. The x-coordinate of the left crack tip is given by d. $r$ is the distance between the left tip and the dislocation and $\theta$ is the angle of r. The matrix is subjected to a far field in-plane uniform tension $\sigma$. The boundary conditions for the current problem are

$$\sigma_{xy}(x, y)|_{y = \pm \infty} = 0, \quad \sigma_{xy}(x, y)|_{y = \pm \infty} = \sigma$$

$$\sigma_{xy}(x, 0) = 0, \quad \sigma_{xy}(x, 0) = 0, \quad (d \leq x \leq d + l)$$

Fig. 1. Influence of dislocation on interaction between a crack and a circular inhomogeneity.
3. Solution scheme

By employing the superposition principle of elasticity, the solution of the present problem can be obtained through the sum of two sub-problems. The first sub-problem shown in Fig. 2 is a circular inhomogeneity interacting with an edge dislocation under uniaxial tension load. For the second sub-problem shown in Fig. 2, the only external loads are the crack surface tractions which are equal in magnitude and opposite in sign to the stresses obtained in the first problem along the line which is the presumed location of the crack. Therefore, the original problem shown in Fig. 1 can be decomposed into two sub-problems as shown in Fig. 2.

In sub-problem I, an edge dislocation interacts with a circular inhomogeneity while in sub-problem II, an array of edge dislocations with unknown densities \( B_x \) and \( B_y \) (the subscripts \( x \) and \( y \) represent different components of the edge dislocations) interacts with a circular inhomogeneity of the same radius. The elastic stress fields of sub-problem I can be obtained through \( \Psi(z) \) and \( \Phi(z) \) by Muskhelishvili [46]

\[
\sigma_{rr} + \sigma_{\theta\theta} = 2[\Phi(z) + \overline{\Phi(z)}] 
\]
\[
\sigma_{\theta z} = \Phi(z) + \overline{\Phi(z)} - \Phi(z) + (2/z)\Psi(z) 
\]
\[
2\mu(u'_r + \overline{u'_r}) = iz[\epsilon\Phi(z) - \overline{\Phi(z)} + 2\Phi(z) + (2/z)\Psi(z)] 
\]

where \( u'_r = \partial u_r / \partial \theta, u'_\theta = \partial u_\theta / \partial \theta \), and \( \Phi(z) = d[\Phi(z)]/dz \), the over-bar represents the complex conjugate.

The complex potentials \( \Phi(z) \) and \( \Psi(z) \) in the matrix region can take the following forms

\[
\Phi(z) = \Gamma + \frac{\gamma_1}{z-z_0} + \Phi^*(z), |z| > R
\]

\[
\Psi(z) = \Gamma' + \frac{\gamma_1'}{z-z_0} + \Phi^*(z), |z| > R
\]

where \( \gamma_1 = \mu(b_2 - ib_3)/\alpha(1 + \kappa) \), \( \Gamma = (\sigma_1 + \sigma_2)/4 \) and \( \Gamma' = -(\sigma_1 - \sigma_2) \epsilon^{2/3}/2 (\sigma_1 - \sigma_2) \epsilon^{2/3}/2 \) (\( \sigma_1 \) and \( \sigma_2 \) are the remote principal stresses, \( \alpha \) is the principal direction). \( \Phi^*(z) \) and \( \Psi^*(z) \) denote the perturbation terms resulting from the interaction of the edge dislocation and remote combined load with the circular inhomogeneity.

Based on the work of Fang et al. [47], we obtain the complex potentials \( \Phi(z) \) and \( \Psi(z) \) in the matrix.

\[
\Phi(z) = \Gamma + \frac{\gamma_1}{z-z_0} + \sum_{k=0}^{\infty} A_{-k} z^{-k}, |z| > R
\]

\[
\Psi(z) = \Gamma' + \frac{\gamma_1'}{z-z_0} + \sum_{k=0}^{\infty} B_{k} R^{2k} z^{-k}, \quad |z| > R
\]

where

\[
A_0 = \frac{c_1}{(c_2)^2 - 1} \left( \frac{c_2 (\Gamma'-\Gamma)}{z_0} + \frac{\gamma_1}{z_0} \right),
\]

\[
B_0 = \frac{c_1}{(c_2)^2} \left( \frac{c_2 (\Gamma'-\Gamma)}{z_0} + \frac{\gamma_1}{z_0} \right),
\]

\[
A_{-k} = - (k + 1) c_1 \left( \frac{\gamma_1}{z_0} \right)^k, \quad k \geq 1,
\]

\[
B_k = \frac{1 + k^2 c_4 / c_2}{k!} \left[ \frac{\gamma_1 (z_0)^{k-1} - \gamma_1 \delta_{1k} - \gamma_2 R^{2k} - \gamma_1 R^{2k} (z_0 - z_0^*)(k-1) (z_0^*)^{k-2}}{z_0^*} \right],
\]

\[
k \geq 1,
\]

\[
c_1 = \frac{\mu_1 (1 + k_2)}{\mu_2 k_1 + \mu_1}, \quad c_2 = \frac{\mu_2 - \mu_1}{\mu_2 k_1 + \mu_1}, \quad c_3 = \frac{\mu_1 + \mu_2 k_1}{\mu_1}, \quad c_4 = \frac{\mu_2 k_1 + \mu_2}{\mu_1 k_2}, \quad z_0^* = R^2 / z_0
\]

and \( \delta_{ij} \) is the Kronecker delta.

The stress fields of sub-problem I are related to the complex variables through

\[
\sigma_{xx}' = \text{Re}[2\Phi(z) - \overline{\Phi(z)} - \Psi(z)]
\]

\[
\sigma_{yy}' = \text{Re}[2\Phi(z) + \overline{\Phi(z)} + \Psi(z)]
\]

\[
\sigma_{xy}' = \text{Im}[2\Phi(z) + \Psi(z)]
\]

The stress field of sub-problem II can be obtained through an integral over the fundamental solutions of a unit edge dislocation interacting with a circular inhomogeneity along the crack line.

\[
\sigma_{yy}(x, 0) = \int_0^{d+L} B_x(z) G_{yy}(x, 0; z, 0) dz
\]

\[
\sigma_{xx}(x, 0) = \int_0^{d+L} B_y(z) G_{xx}(x, 0; z, 0) dz
\]

where \( d \leq x \leq d+L \), \( B_x(z) \) and \( B_y(z) \) are the dislocation density components at the point \( (x, 0) \), \( G_{xx}(x, 0; z, 0) \) is the shear stress introduced at \( (x, 0) \) by a unit glide dislocation at \( (z, 0) \) and \( G_{yy}(x, 0; z, 0) \) is the normal stress introduced at \( (x, 0) \) by a unit climb dislocation at \( (z, 0) \). These fundamental solutions can be found in Hills et al. [48]. Some terms are omitted in the above two equations since we have \( G_{yy}(x, 0; z, 0) = 0 \), \( G_{yy}(x, 0; z, 0) = 0 \).

The traction free boundary condition given by Eq. (2) requires that the normal and shear stress components along the crack surface are zero, i.e.

\[
\sigma_{xy}(x, 0) + \overline{\sigma_{xy}(x, 0)} = 0
\]
\[ \sigma_{yy}(x,0) + \sigma_{yy}'(x,0) = 0 \]  
where \( d \leq x \leq d + l \). It is easily determined that Eq. (15) has the solution \( B_0(\xi) = 0 \). This leaves only \( B_n(\xi) \) in Eq. (16) unsolved. Eq. (16) can be rewritten in term of \( B_n(\xi) \) as

\[ \int_d^{d+1} \frac{B_n(\xi)}{\xi - x} \, dx = \int_d^{d+1} B_n(\xi)k(x, \xi) \, d\xi = \frac{(1 + k_2)\pi}{2\mu_2} \sigma_{yy}'(x,0) \]  

where \( k(x, \xi) \) represents the regular part of the fundamental solution of the edge dislocation interacting with a circular inhomogeneity and its detailed expression are given by Wang et al. [49] as

\[ k(x, \xi) = A + \frac{\beta - \alpha}{1 + \beta} Q = \frac{(1 + \alpha)(1 - \alpha)}{(1 - \beta)(1 + \alpha - 2\beta)} \]

\[ + \frac{\pi}{2\mu_2} \{ A + \frac{\beta - \alpha}{1 + \beta} \left[ A \left( \frac{2^2}{\rho^2} - 1 \right) + Q \right] \} + 2\pi a^2 \frac{\alpha^2}{\rho^2} \left( \frac{\rho^2 - \rho_0^2}{\rho^2 - \rho_{0,2}^2} \right) \]

Moreover, the dislocation densities \( B_n(x) \) must satisfy

\[ \int_d^{d+1} B_n(\xi) \, d\xi = 0 \]  

4. Numerical scheme

Eq. (17) is a Cauchy singular integral equation. The numerical method of Gerasoulis is applied to solve this equation [50]. To shift the integral interval from \( (d, d + l) \) to \((-1, 1)\), we apply the following coordinate transformation

\[ \xi = \frac{l}{2} + \frac{x}{d} + d, \quad x = \frac{l}{2} + \frac{1}{d} + d. \]  

Thus, Eq. (17) can be rewritten in terms of \( s, t \) \((-1 \leq s, t \leq 1)\) as

\[ \int_{-1}^{1} B_n(t) \, dt = \int_{-1}^{1} B_n(t)k(t, s) \, dt = \frac{(1 + k_2)\pi}{2\mu_2} f(s) \]

where

\[ k(t, s) = \frac{l}{2} \left( \frac{l}{2} + d, \frac{l}{2} + d, \frac{l}{2} + d \right) \]

\[ f(s) = \sigma_{yy}' \left( \frac{l}{2} + d, \frac{l}{2} + d, 0 \right) \]

Similarly, Eq. (19) is recast into

\[ \int_{-1}^{1} B_n(t) \, dt = 0 \]

Following the procedure developed by Gerasoulis [50], let \( B_n(t) = w(t)\phi_n(t) \)

where \( \phi_n(t) \) is a continuous function in \(-1 \leq t \leq 1\), and

\[ w(t) = (1 - t^2)^{-1/2} \]

is the weight function. The discretized forms of Eqs. (21) and (24) are obtained as

\[ \sum_{k=0}^{2n} \left[ w(s_k) - v_k^2 s_k, t_i \right] \phi_n(t_i) = f(s_k), k = 0, 1, ..., 2n - 1 \]

\[ \sum_{i=0}^{2n} v_i \phi_n(t_i) = 0 \]

where the detailed expressions of the coefficients \( w_i(s) \) and \( v_i \) can be found in Gerasoulis [50].

The above two equations form a system of \( 2n + 1 \) linear algebraic equations to determine the values of \( \phi_n(1), ..., \phi_n(2n) \).

With the numerical solution of the dislocation density function, the SIF of the crack tip can be given by Weertman [25] as

\[ K_I^s = \frac{2\mu_2 \sqrt{\pi / 2}}{(1 + k_2)} \phi_n(-1) \]

\[ K_I^p = \frac{2\mu_2 \sqrt{\pi / 2}}{(1 + k_2)} \phi_n(1) \]

where the superscripts \( L \) and \( R \) represent the left and right crack tips, respectively.

5. Results and discussion

For the numerical examples, the SIFs of the crack are normalized by

\[ K_I^s = \sigma \sqrt{\pi / 2} \]

Since we are more interested in the fracture behavior of the left crack tip (it is closer to the inclusion), only the SIFs at the left crack tip for various conditions are discussed below.

5.1. Influence of the crack location on SIFs of the crack

The variation of normalized SIFs versus \( d/l \) without the edge dislocation under uniaxial tension load is depicted for different values of shear modulus ratio \( \mu_1/\mu_2 \) in Fig. 3. \( R/l \) is taken as 10. It is shown that compared with one phase case (without the inhomogeneity), a "hard" inhomogeneity (having a higher shear modulus than the matrix) decreases the SIF while a "soft" inhomogeneity increases it. As the distance between the inhomogeneity and the crack increases, the effect of the inhomogeneity will be getting weaker. This conclusion is consistent with that drawn by Tamate [26].

The variation of normalized SIFs versus \( d/l \) with the edge dislocation under uniaxial tension load is depicted for different values of shear modulus ratio \( \mu_1/\mu_2 \) in Fig. 4. The distance between the inhomogeneity–matrix interface and the edge dislocation keeps unchanged. The other parameters are \( \sigma / \mu_2 = 0.005, b_x = 0, b_y = 0.002, (d - r)/l = 25, \theta = 0 \) and \( R/l = 20 \). It is shown that the edge dislocation increases the SIF (anti-shielding effect), as the
distance between the edge dislocation and the crack increases, the effect of the edge dislocation will be getting weaker. The presence of a ‘soft’ inhomogeneity increases the SIF, so the ‘soft’ inhomogeneity enhances the anti-shielding effect. While a ‘hard’ inhomogeneity decreases the SIF (shielding effect), so there is competition between the effects of the ‘hard’ inhomogeneity and the edge dislocation on the SIF. When \( d/l < 25.1105 \), the SIF is more than 1, the edge dislocation is more distinct factor that influences the crack propagation. When \( d/l = 25.1105 \), the SIF is 1, the edge dislocation and the ‘hard’ inhomogeneity counteract each other’s efforts. When \( d/l > 25.1105 \), the SIF is less than 1, the ‘hard’ inhomogeneity is more dominant. As the distance between the inhomogeneity and the crack increases, the effect of the inhomogeneity will be getting weaker.

### 5.2. Influence of the edge dislocation location on SIFs of the crack

When \( b_x = 0 \), normalized SIFs against the position of the dislocation with different values of shear modulus ratio \( \mu_1/\mu_2 \) under uniaxial tension load are plotted in Figs. 5 and 6. When \( b_y = 0 \), normalized SIFs against the position of the dislocation with different values of shear modulus ratio \( \mu_1/\mu_2 \) under uniaxial tension load are plotted in Figs. 7 and 8. The other parameters are \( \sigma/\mu_2 = 0.005, d/l = 23, b_x/l = b_y/l = 0.002 \) and \( R/l = 20 \). It is shown that the edge dislocation can reduce the SIF (shielding effect) or increase it (anti-shielding effect), depending on the...
position of edge dislocation. The presence of a ‘hard’ inhomogeneity decreases the SIF (shielding effect) while a ‘soft’ inhomogeneity increases it (anti-shielding effect) under uniaxial tension load.

5.3. Influence of the remote load on SIFs of the crack

The influence of the remote load on the SIFs of the left crack tip with different values of shear modulus ratio $\mu_1/\mu_2$ are depicted in Fig. 9. The other parameters are taken as $d/l=23$, $R/l=20$, $b_0/l=0.002$, $r/l=0.2$ and $\theta=1$. For the uniaxial tension case, it is shown that the influence of the edge dislocation on the SIF decreases with increasing the remote load. While the influence of the inhomogeneity on the SIF keeps unchanged with increasing the remote load.

5.4. Influence of the inhomogeneity size on SIFs of the crack

The variation of $K_\Gamma^f/K_\Gamma^l$ over $R/l$ for different shear modulus ratios $\mu_1/\mu_2$ is plotted in Fig. 10. The other parameters are taken as $(d-R)/l=2$, $b_0=0$, $b_0/l=0.002$, $r/l=1.5$, $\theta=0$ and $\sigma/\mu_2=0.001$. As shown in Fig. 10, when the inhomogeneity ‘harder’ than the matrix, $K_\Gamma^f/K_\Gamma^l$ decreases as $R/l$ increases. While the inhomogeneity is ‘softer’ than the matrix, the conclusion is reversed.

6. Conclusions

The interaction between a Griffith crack and a circular inhomogeneity in the presence of an edge dislocation is investigated under uniaxial tension load. The inhomogeneity can be seen as precipitates in alloys or strengthening particles in composite materials. The influence of such parameters as the elastic mismatch between the inhomogeneity and matrix, the crack position, the edge dislocation position, the magnitude of the remote load and inhomogeneity size, on the SIF of the crack has been analyzed. Some conclusions are summarized as follows.

(1) When the distance between the edge dislocation and the inhomogeneity is fixed, there is competition between the effects of the inhomogeneity and the edge dislocation on the SIF. When the distance between the edge dislocation and the crack is less than a certain value, the edge dislocation is more distinct factor that influences the crack propagation. When the distance between the edge dislocation and the crack is equal to the certain value, the edge dislocation and the inhomogeneity interact each other’s efforts. When the distance between the edge dislocation and the crack is more than the value, the effect of the inhomogeneity is more dominant.

(2) The edge dislocation can reduce the SIF (shielding effect) or increase it (anti-shielding effect), depending on the position of edge dislocation.

(3) As the remote load increases, the influence of the edge dislocation on the SIF decreases, while the effect of the inhomogeneity on it keeps unchanged.

(4) When the inhomogeneity ‘harder’ than the matrix, the SIF decreases as the inhomogeneity size increases. While the inhomogeneity is ‘softer’ than the matrix, the conclusion is reversed.

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