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Two Kinds of Calculation Methods in Whole Process and a Best New Comprehensive Figure of Metallic Material Behaviors

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Abstract: Based on the viewpoint that there are similarities to the genetic principles in the mechanics and the engineering fields; based on data in some referents and author's theoretical approach, this paper is to consider the microscopic-damage and the macroscopic-damage behaviors of materials that are distinct differences, thereby to propose computing models and methods of subsection calculations in whole process; to consider the behaviors between the short cracks and long ones both of which are always continuous, thereby to propose some computing models and methods of the successive calculations. These computing models refer to formulas of the threshold sizes of cracks (or threshold values of damages); the propagating rates of cracks; the predicting calculations of lifetime; Particularly, in which it provides a best new comprehensive figure that it could be including and describing all problems mentioned above. So it may be as a bridge to link the traditional material mechanics, the material discipline and the modern mechanics on fatigue-damage-fracture; perhaps, it can also be as route diagram to guide designs and calculations to some materials and structures. Therefore, above works realize calculations of the strength problems, the growth rate of cracks (damages) and prediction of lifetime in whole process that would have practical significances.

Key words: Genetic elements, subsection calculations, successive calculations, strength-rate-lifetime, in whole process.

1. Introduction

For the metallic materials included cracks, to calculate the strength, the growth rate and lifetime of cracks in whole process that are complicated problems, it can have two kinds of thinking:

To consider the behaviors between the short cracks and long ones there are distinct differences, and to consider the behaviors between elastic materials and plastic ones there are also distinct differences, according to these viewpoints, then it should make up some computing models with divided stages, for which author proposed some methods for subsection calculations [1, 2];

To consider behaviors of the short cracks and long ones although there are differences, for behaviors of them in the evolving process, both are always continuous. Based on this viewpoint, it can find some successive calculating models to describe them, for which it can be proposed for the methods of successive calculations.

Author thinks, in the mechanics and the engineering fields, there exists such a scientific law as similar genetic elements in life science [3-7], and the used theoretical approach presented some computing models about the problems of strengths, about the threshold values of damages, the rate ones of crack growth, the predictions of lifetime in whole process, and yet provided a comprehensive Fig. 1 of material behaviors, in which they refer to those linear elastic

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materials and elastic plastic ones; from microscopic damages to macroscopic ones, from short cracks to long ones, and under monotonous loading, low cycle fatigue, high cycle fatigue ones. For above works were all to be completed to use the methods of subsection calculation.

Recently it yet proposes some new computing models and methods of successive calculations for those works mentioned above; provides another some formulas to the strength criterions in whole process, to the rates and life under very high fatigue loading, etc.

For above problems, for which they were depended on traditional material mechanics, and modern material discipline, fracture mechanics and damage mechanics. To make all so complex problems sum up, and to form more integral concepts, it must set up many links as bridges. So, here now the author provides more integral as the comprehensive Fig. 1 of materials behaviours.

2. Computing Models Presented for Their Critical Points and Curves to Several Representative Problems

At first, here present several representative problems, then presents the complicated comprehensive Fig. 1 of material behaviors.

2.1 Calculations for Threshold Sizes a_{th} of Cracks or Threshold Values D_{th} of Damages

It can be seen from Table 1 [8, 9], for metallic materials, however always there are threshold sizes of cracks, or threshold values of damages which only depend on constants of material property, that is just the fatigue strength exponent b, but, the threshold sizes a_{th} or threshold values D_{th} are calculable, that could be calculated as following [10, 11].

$$a_{th} = (0.564)^{\frac{1}{0.5+b}} \times c_1, (mm) \tag{1}$$

$$D_{th} = (0.564)^{\frac{1}{0.5+b}}, (damage-units) \tag{2}$$

Here it must be defined in crack length of “1 mm” equivalent to “1 damage-unit”. The c_1 is a the unit of coefficient converted, $c_1 = 1mm$. If it is under fatigue loading, for that fish eye size under very high cycle fatigue, it may be at next surface of a material inside. Here yet it should explain, their geometrical locations of threshold sizes in Fig. 1 and should be set up near the point “a” or at point “b”, or at point “A” or at point “D” on the abscissa axis O1-I, and at point “j” on curve “j-k”, which are respectively described for various materials under different loading.

2.2 Calculations for Sizes of Crack Growth under Different Stresses

For growth sizes of crack under different stresses it can be described by below Eq. (3) [12, 13],

$$a_i = 2\left((\Delta\sigma/2)^{(1-n')/n'} \times \frac{E \times \pi^{1/2 \times n'}}{K^{1/n'}} \right)^{-\frac{2m' \times n'}{2n'-m'}} (mm) \tag{3}$$

Where a_i is size of crack growth under a stress; the n' is an exponent of strain hardening; the exponent $m' = -1/b$; the K is a fatigue strength coefficient; E is elasticity modulus. In Fig. 2 it is depicted as blue curve, in Fig. 1 it is depicted as pink curve “j-k”,

Table 1 Data of threshold sizes calculated cracks.

Materials [8, 9]	σ_b	σ_s	E	K	n	b_1	$a_{th}(D_{th})$
QT600-2	748	456	150,376	1,440	0.1996	-0.0777	0.258
QT800-2	913.0	584	160,500	1,777.3	0.2034	-0.083	0.253
ZG35	572.3	366	204,555	1,218	0.285	-0.0988	0.240
60Si2Mn	1,504.8	1,369	203,395	1,721	0.035	-0.1130	0.228
16MnL	570		200,700			-0.1066	0.233
16Mn	572.5	360.7	200,741	856.1	0.1813	-0.0943	0.244
20	432	307				-0.12	0.222
40CrNiMoA	1167					-0.061	0.271

for which the sizes of crack growth are grown with increasing stresses, which it is calculated for Eq. (3).

2.3 Subsection Calculations in Whole Process for the Crack Growth Rate and the Lifetime

2.3.1 Subsection Calculations for Crack Growth Rates in Whole Process

For a material (for example, steel 30CrMnSiNi2A), if it is loaded under a certain stress $\Delta\sigma_i$, when it is in process from short crack growth to long crack, then its formula simplified rates in whole process could be calculated as following form [14, 15],

$$(da_1/dN_1)_{a_{01}->a_{tr}} <= da_{tr}/dN_{tr} =< (da_2/dN_2)_{a_{tr}->a_{eff}} \qquad (4)$$

$$\frac{da_{1i}}{dN_{1i}} = \{A_1(\Delta\sigma_{1i})^{m_1} a_{1i}\}_{a_{01}->a_{tr}} <= \frac{da_{tr}}{dN_{tr}} =< \frac{da_{2i}}{dN_{2i}} = \{A_2 \times [y_2(a/b)\Delta\sigma_i\sqrt{\pi a_{2i}}]^{m_2}\}_{a_{tr}->a_{eff}}, (mm/cycle) \qquad (5)$$

Its expanded formula should be as below,

$$\frac{da_{1i}}{dN_{1i}} = \{[2\sigma_s' \times \alpha(1-R) \times \sqrt[m_1]{a_{1fc}}]^{-m_1}(\Delta\sigma_{1i})^{m_1} a_{1i}\}_{a_{01}->a_{tr}} <= \frac{da_{tr}}{dN_{tr}} =< \frac{da_{2i}}{dN_{2i}} = \left\{\frac{[y_2(a/b)\Delta\sigma_i\sqrt{\pi a_{2i}}]^{m_2}}{2[\sigma'_f\,\alpha(1-\sigma_m/\sigma'_f)\sqrt{\pi a_{2fc}}]^{m_2}}\right\}_{a_{tr}->a_{eff}}, \qquad (6)$$

$(mm/cycle)$

Where the $(da_1/dN_1)_{a_{01}->a_{tr}}$ is growth rates of cracks before the transition point between short cracks and long ones; the da_{tr}/dN_{tr} is just the rate at transition point; the $(da_2/dN_2)_{a_{tr}->a_{eff}}$ is growth rates after the transition point. The a_{1fc} is a critical size corresponded to the yield stress σ_s' under fatigue loading. The σ'_f is a fracture stress under fatigue loading (fatigue strength coefficient). Here considering the correction to refer effective values in Refs. [16, 17] so the coefficient α is corrected to apply; also to imitate correction method $(1-\sigma_m/\sigma'_f)$ for mean stress [18]. The R is a ratio, $R=\sigma_{\min}/\sigma_{\max}$; the $y_2(a/b)$ is a corrected factor related with shapes of crack and structure [19, 20]; the a_{2fc} is a fracture size in second stage.

Here for the subsection curves that are linked with a red rate curve and a green one, which are depicted as those forms in Fig. 2; it amounts equivalently to the blue curve "$D'-D-D_1$" and blue $D_1-B_1-D_2$ in Fig. 1; for which they are calculated by means of Eqs. (4)-(6), and depicted. The A_1 is defined as the comprehensive material constant in first stage, the physical meaning of the A_1 is a maximum power in this stage, also a maximum increment done work in one cycle; its geometrical meaning of the A_1 is an area of a maximum micro-trapezium in a triangle A_{1w} in Fig. 1. The A_2 is defined as the comprehensive material constant in second stage that physical meaning of the A_2 is a maximum power in the second stage, also a maximum increment done work in one cycle before fracture; its geometrical meaning of the A_2 is an area of a maximum micro-trapezium in a trapezium A_{2w} in Fig. 1.

2.3.2 Subsection Calculations for Lifetime $\sum N_i$ in Whole Process

For above same material, then its lifetime formula in whole process could be calculated as following form [21-23],

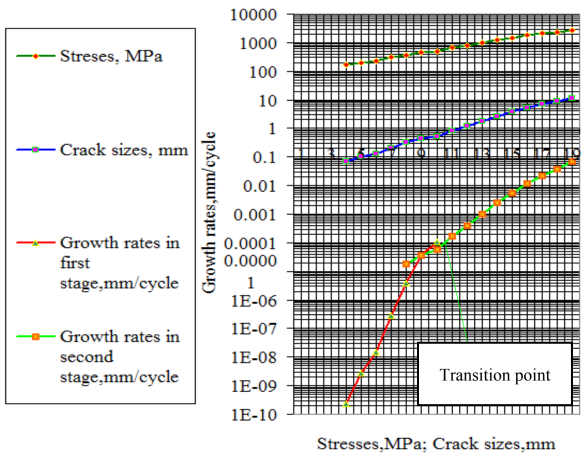

Fig. 2 Subsection curves of rates in whole process under a certain stress (material 30CrMnSiNi2A).

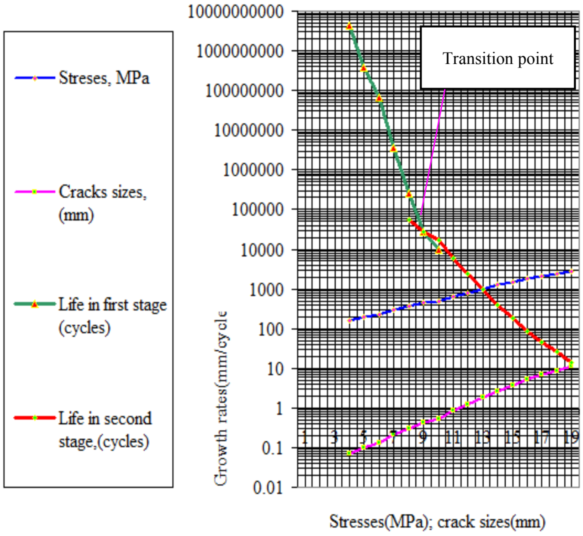

Fig. 3 Lifetime curves of subsection in whole process under a certain stress (material 30CrMnSiNi2A).

$$\sum N_i = N_{1i} + N_{2i} = \int_{a_{th}}^{a_{tr}} \frac{da_i}{2(\sigma_f^{'}(1\text{-}R)\alpha\sqrt[m_1]{a_{th}})^{-m_1} \times (\Delta\sigma_i)^{m_1} a_i} \times$$

$$+ \int_{a_{tr}}^{a_{fc}} \frac{da_i}{2(\sigma_f{'}\times(1\text{-}R)\alpha\sqrt{\pi a_{2fc}})^{-m_2} \times (\Delta\sigma_i{'}\times\sqrt{\pi a_i})^{m_2}}, (Cycles) \quad (7)$$

where N_{1i} is life in first stage (growth stage of short crack); N_{2i} is life in second stage (growth stage of long crack). The lifetime curves are described as those forms in Fig. 3.

2.4 Successive Calculations in Whole Process for the Crack Growth Rate and the Lifetime

2.4.1 Successive Calculations for Crack Growth Rates in Whole Process

For a linear elastic material (for example nodular cast iron QT800-2), if it is loaded under increasing stresses $\Delta\sigma_i$ under external forces, then it is placed in successive process from short crack to long crack growth, therefore its successive calculation for the rates in whole process can be described as following formula,

$$da/dN = A_w \times [y(a/b)\Delta\sigma_i]^m \cdot a, (mm/cycle) \quad (8)$$

$$da/dN = 2[2\sigma'_f \times \alpha(1-R)\times\sqrt[m]{a_{th}}]^{-m}[y(a/b)\Delta\sigma_i]^m \cdot a, (mm/cycle) \quad (9)$$

where the A_w is a comprehensive material constant in the whole process, and its physical meaning of the A_w is a power value in whole process; its geometrical meaning of the A_w is an area of a pink-maximum-micro-trapezium in pink-large-trapezium in Fig. 1. The rate curve of crack growth with increasing stresses is depicted as that pink curve in Fig. 4, for which it is just equivalent to that blue curve " $D'-D-D_1(C_1)-B_1^{'}-D_2$ " in whole process in Fig. 1, they are calculated and depicted based on Eqs. (8) and (9).

2.4.2 Successive Calculations for Lifetime in Whole Process

For same nodular cast iron QT800-2, its formula of lifetime N in whole process can be calculated as below,

$$N = \frac{\ln a_{eff} - \ln a_{th}}{2[2\sigma'_f \times \alpha(1-R)\times\sqrt[m']{a_{th}} \times \Delta\sigma^{m'}}, (Cycle) \quad (10)$$

Then its curve of lifetime is described as that blue successive one in Fig. 5; for which it is just equivalent to that blue reverse curve " $D_2 - B'_1 - D_1(C_1) - D - D'$ " in whole process in Fig. 1, they are calculated and depicted based on Eq. (10).

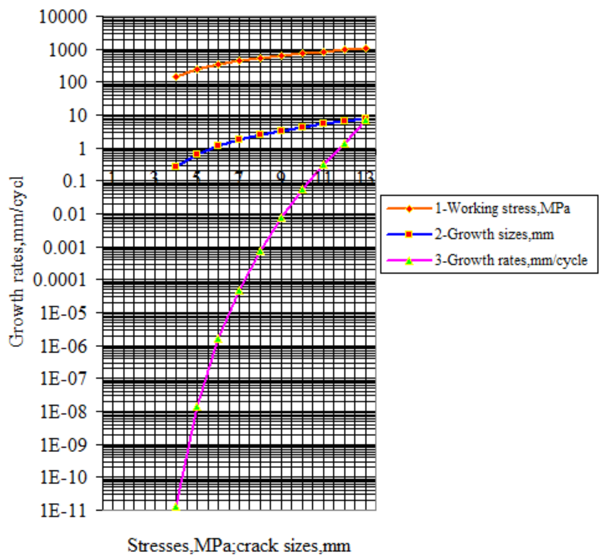

Fig. 4 The rate curve in whole process for crack growth with increasing stresses (nodular cast iron QT800-2).

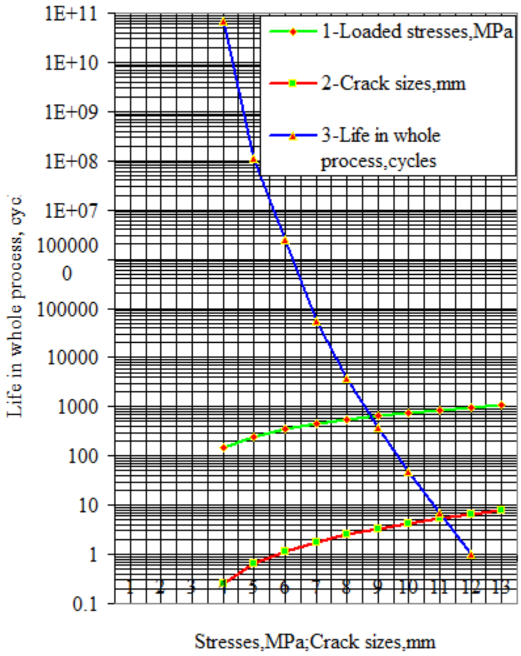

Fig. 5 Lifetime curves in whole process under different stresses (material QT800-2).

3. A Comprehensive Figure of Materials Behaviours of a New Supplement

About problems among branch disciplines on fatigue-damage-fracture; about problems between the traditional material mechanics and the modern mechanics, for connecting and communicating their relations with each other, we must study and find out their correlations between the equations, even the relations between variables, between the material constants, and between the curves. This is because all the significant factors are to be researched and described for materials behaviours at each stage even in the whole process, and are also all to have a lot of significations for the engineering calculations and designs. Therefore, we should research and find an effective tool used for analyzing the problems above mentioned. Here, the author provides the "Comprehensive figure of materials behaviors" as Fig. 1 that is both a principle one of materials behaviors under monotonous loading, and is one under fatigue loading. It is also a comprehensive one of multidisciplinary. Here two problems are to present as below:

3.1 Explanations on Their Geometrical and Physical Meanings for the Compositions of Coordinate System

In Fig. 1 it was provided by the present author [24, 25], at this time it has been corrected and complemented, which is, diagrammatically shown for the damage growth process or crack propagation process of materials behavior at each stage and in the whole course.

For the total coordinate system, it consists of seven abscissa axes O' I", O I', O_1 I, O_2 II, O'_2 II', O_3 III, O_4 IV and a bidirectional ordinate axis O'_1 0_4. In this coordinate system, for the abscissa axis O' I that is the best original one among other 6 abscissa axes; and those parameters for stress σ and strain ε on this axis ($0'$ I) are also the best initial ones. In addition, for the ordinate axis O'O4, it is the best original one among other ordinate axes (OO1, O1O2, O2 O2', O2'O3 and O3O4); the parameter of the life N on this axis (O'O4) is just the best original one. Therefore, the primal coordinate system consists of the axes $0'$ I" and the O'O4 can be called as "the genetic coordinate one".

For the area between the axes $0'$ I" and O_1 I, it was an applied one for the traditional material mechanics, that is thought as continued and homogeneous for a material. Currently, it can also be applied on micro-damage mechanics under the very high cycle fatigue. The area between the axes O I and O_2 II, it is applied on mesoscopic damage mechanics and the mesoscopic-fracture mechanics. In the areas among the abscissa axes O_2 II, O'_2 II', the O_3 III and O_4 IV, they are applied and calculated for the macro-damage mechanics and the macro-fracture mechanics. Due to differences of various materials behaviors, where those areas are among the abscissa axes O_2 II, O_2' II' and O_3 III they are calculated and applied, some time both for the micro-, mesoscopic damage mechanics; and for the macroscopic damage mechanics, or some time both for the micro-, mesoscopic fracture mechanics, and for the macroscopic fracture mechanics.

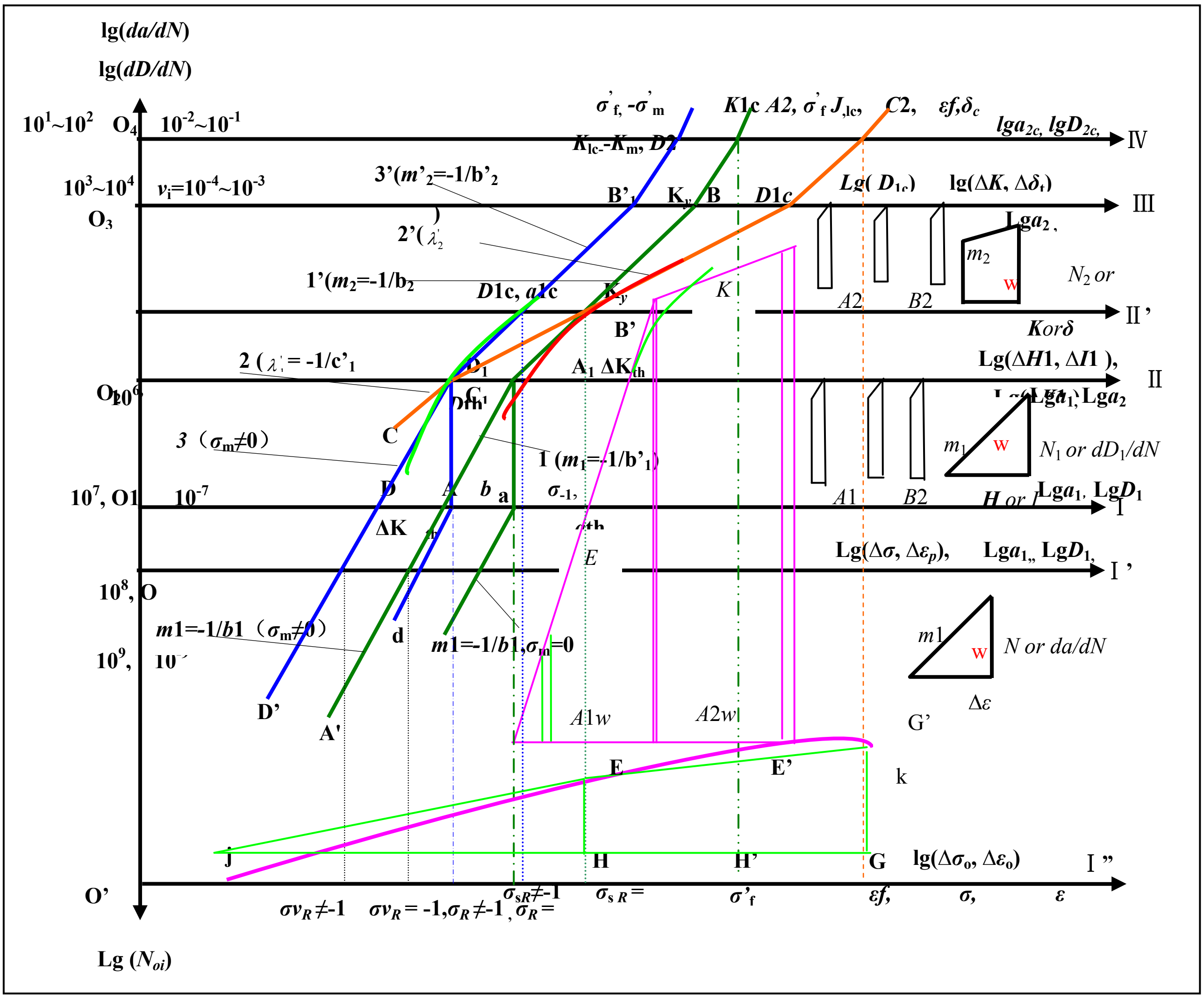

Fig. 1 Comprehensive figure of new materials behaviors.

On the abscissa axis O' I", it represented parameters of the stress σ and the strain ε as variables. On the abscissa axis O_1 I there are the fatigue limits σ_{-1} at point "a" $(\sigma_m = 0)$ and "b" $(\sigma_m \neq 0)$ and they just are the locations placed at threshold values of some materials; for the abscissa axis O_1 I or O_2 II that is also the boundary for short crack at first stage and long crack at second stage. On this axis O_1 I, there are points "a" and "b" that just are the locations placed at threshold values for some materials, that are also the boundary of growth behaviors between short crack and long crack; on this axis O_2 II, there are points "A1" and "D1" that are also the locations of threshold values for another materials, that are the boundary of growth behaviors between short crack and long crack too. On the abscissa axes O I', and O_1 I they could represent as variables with the stress intensity factor range ΔH_1 of short crack, and the strain intensity factor ΔI, or with short crack size a_1 and microscopic damage value D_1; On the abscissa axis O_2 II that could represent as variables with the stress intensity factor range ΔH_1 of short crack, and the strain intensity factor ΔI, and the stress intensity factor range ΔK_1 of long crack. On the other hand, they both could yet represent as variables with the short crack a_1 and the long crack a_2 (or damage D_1 and D_2). On the axes O'_2 II' and the O_3 III, they are represented as variable with the stress intensity factor ΔK_1 (or $\Delta\delta_t$) of long crack, here there are material constants of two that are defined as the critical factor K_y of a crack-stress-intensity and the critical factor K'_y of the damage-stress-intensity, where they are just two parameters corresponded to the critical size a_{1c} of a crack or the critical value D_{1c} of a damage, they are just placed at the point B $(\sigma_m = 0)$ and at point B_1 $(\sigma_m \neq 0)$ corresponded to yield stress, some brittle materials would happen to fracture to this point when their stresses are loaded to this level.

For the abscissa axes O'_2 II' and O_3 III, they may be boundaries as the residual strength for some brittle materials or elastic-plastic materials. On the axis O'_2 II', there are the critical values D1c (a1c) at point B' (Ky) for mean stress $\sigma_m = 0$; on the axis O_3 III there are the critical values D1c (a1c) at points B'1 $(\sigma_m \neq 0)$ and B (Ky) for mean stress $\sigma_m = 0$. On abscissa O_4 IV, the point A_2 is corresponding to the fatigue strength coefficient σ'_f, the critical stress intensity factor values $K_{1c}(K_{2fc})$ and the critical values D'_{2c} and a_{2c} for the mean stress $\sigma_m = 0$; the point D_2 is corresponding to the $\sigma_m \neq 0$; the point C_2 corresponds to the fatigue ductility coefficient ε'_f and critical crack tip open displacement value δ_c. In addition, on the same O_4 IV, there are yet another critical values $J'_{1c}(J_{1c})$, etc. in the long crack propagation process.

For an ordinate axis, the upward direction along the ordinate axis is represented as crack growth rate da/dN or damage growth rate dD/dN in each stage and the whole process. But the downward direction is represented as life N_{oi}, N_{oj} in each stage and the whole lifetime ΣN.

In the area between axes O' I" and O_2 II, it is as the fatigue history from un-crack to short crack growth. In the area between axes O_1 I' and O_2 II, it is as the fatigue history relative to life $N_{oi}^{mic-mac}$ from short crack growth to long crack forming. Consequently, the distance $O_2 - O'$ on ordinate axis is as the history relating to life N_{mac} from grains size to short crack initiation until long crack forming; the distance O_4 - O' is as the history relating to the lifetime $\sum N$ from micro-crack initiation until fracture.

In the crack forming stage, the partial coordinate system made up of the upward ordinate axis $O'\,O_4$ and the abscissa axes O' I", O I', O_1 I and O_2 II is represented as the relationship between the crack growth rate dD_1/dN_1 (or the short crack growth rate da_1/dN_1) and the crack-stress factor range ΔH_1 (or the damage strain factor range ΔI_1). In the long crack growth stage, the partial coordinate system made up with the ordinate axis $O_2\,O_4$ and abscissa O_2 II, O'_2 II', O_3 III and O_4 IV at the same direction is represented to be the relationship between the growth rate of long crack and the stress intensity factor range ΔK, J-integral range ΔJ and crack tip displacement range $\Delta\delta_t$ (da_2/dN_2 - ΔK, ΔJ and $\Delta\delta_t$). Inversely, the coordinate systems made up of the downward ordinate axis $O_4 O_1$' and the abscissa axes O_4 IV, O_3 III, O'_2 II', O_2 II, O_1 I, O I' and O' I" are represented respectively as the relationship between the ΔH-, ΔK- range and each stage life N_{oi}, N_{oj} and the lifetime $\sum N$ (or between the $\Delta\varepsilon_p$-, $\Delta\delta_t$- range and the life $\sum N$).

3.2 Explanations on the Physical and Geometrical Meanings of Relevant Curves

In Fig. 1, there are curves of two groups: (1) one is the curve of a croup between the abscissa axes O' I" and O I', which are about strength problem, that is the curve "j-k" of cracks (damages) growth sizes with increasing stresses (or strains), that may be under monotonous or fatigue loading; (2) the other is the curve of a croup about cracks growth (damages) rate and file problems between the abscissa axes O' I" and O_4 4, which are under fatigue loading, they are the curves "$C_1B_1C_2$" (brown), "$A'AA_1BA_2$" (green) and "$D'DD_1D_2$" (blue) etc.

The green curve $A'AA_1$ (or 1) between the abscissa axes O' I" and O_2 II is represented as the varying laws as the behaviors for the linear-elastic materials or some elastic-plastic ones under high cycle fatigue loading, or very high cycle fatigue loading, that is defined as in the long crack forming stage (or called the first stage): positive direction green $A'AA_1$ represented as the relations between dD_1/dN_1 (or da_1/dN_1)- ΔH; inverted green A_1A, between $\Delta H_1 - N_{oi}$. The brown curve $CC_1(2)$ between the abscissa axes O_1 I and O_2 II is represented as the varying laws of the behaviors of the elastic-plastic materials or some plastic ones under low-cycle loading at the long crack forming stage: positive direction brown CC_1 is represented as the relations between da_1/dN_1 - ΔJ_1; inverted brown C_1C, the relations between the $\Delta\varepsilon_p - N_{oi}$.

The green curve A_1BA_2 between the abscissa axes O_2 II and O_4 IV that is defined as the crack growth stage (or called the second stage): positive direction A_1BA_2 shown as da_2/dN_2 - ΔK (ΔJ); inverted A_2BA_1, between the ΔK_2, $\Delta J - N_{oj}$. The brown $C_1B'C_2$ is shown as: the positive, relation between the da_2/dN_2 - $\Delta\delta_t$ under low-cycle loading, inverted brown $C_2B'C_1$, between $\Delta\delta_t$ (ΔJ)- N_{oj}. By the way, those green curves $A'A, ea$ ($\sigma_m = 0$) and the blue curves $D'D, db$ ($\sigma_m \neq 0$) between the abscissa axes O' I" and O_1 I are represented as the evolving laws under the very high cycle fatigue. Due to differences of various materials behaviors, where those curves are among the abscissa axes O_2 II, O_2 II' and O_3 III sometimes they both belong to the first stage; sometimes, and belong to the second stage.

It should yet point those curves between abscissa axes O_1 I and the O_4 IV, in which the green curve AA_1BA_2 (1-1') is depicted as the rate curve of damage (crack) growth in whole process under symmetrical cycle loading or high cycle fatigue loading (i.e. zero mean stress); the blue curve DD_1D_2 (3-3'), as the rate curve under unsymmetrical cycle loading (i.e. non-zero mean stress); the brown curve $CC_1B_1C_2$ (2-2') is depicted as the rate curve under low cycle loading. Inversely, those curves are between abscissa axes O_4 IV and the O_1 I, for example: the green curve A_2BA_1A is depicted as the lifetime curve under symmetrical cycle loading (i.e. zero mean stress), the blue curve $D_2B_1D_1D$, as the lifetime curve under unsymmetrical cycle loading; the brown curve $C_2B'C_1C$ is depicted as the lifetime curve under low cycle loading. On the other hand, for those curves between abscissa axes O 'I" and the O_4 IV, for instance: the positive green curves $A'AA_1BA_2$, eaA_1BA_2, which are depicted as the curves on damage (crack) growth rates in whole process under very high cycle loading ($\sigma_m = 0, da/dN < 10^{-7}$), and those blue curves $D'DD_1DA_2$ and dbD_1D_2 are all depicted as ones of the damage (crack) growth rates in whole process under very high cycle loading ($\sigma_m \neq 0, da/dN < 10^{-7}$). Inversely, the reversed green curves A_2BA_1A' A_2BA_1ae are as the lifetime one in whole process which included very high cycle fatigue ($\sigma_m = 0, N > 10^7$); and the blue curves $D_2B'_1D_1DD'$ and $D_2B'_1D_1bd$ are all depicted as the lifetime ones in whole process ($\sigma_m \neq 0, N > 10^7$).

Here it may roughly be seen from above described and explained for Fig. 1, a lot of calculating parameters and material constants on fracture mechanics and damage mechanics, are calculable depending on those stress and strain etc. as "genetic parameters". Therefore the comprehensive Fig. 1 of the materials behaviors may be as a complement for the fundamental knowledge of a material subject; that is a tool to design and calculate for various kinds of structures and materials under different loading conditions, and it is also a bridge to communicate and link the traditional material mechanics and the modern mechanics.

4. Conclusions

(1) The metallic materials always there are threshold sizes a_{th} of cracks, or threshold values D_{th} of damages however under monotonous or fatigue loading, which only depended on strength exponent b, and the a_{th} and D_{th} are calculable.

(2) The strength problems, the growth rates and the life predictions of cracks (damage) in whole process, here can propose two kinds of computing models and methods: the methods of successive calculations, and subsection calculations.

(3) For the strength problems, the growth rates and the life predictions in whole process, which are based on the data in some references and the theoretical approaches, should say that they can be calculable for every critical point, every curve and even linked curve in whole process in Fig. 1.

(4) The comprehensive Fig. 1 of material behaviors may be as a bridge to link the traditional material mechanics, the material discipline and the modern mechanics on fatigue-damage-fracture; perhaps, it can be as route diagram to guide designs and calculations for the structures and materials.

(5) The author sincerely hopes that researchers of relevant fields will be collaborated by better experiments to examine, thereby to obtain checking and revisions, to do contributions for engineering applications.

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