Hindawi
Journal of Chemistry
Volume 2023, Article ID 9864759, 1 page
https://doi.org/10.1155/2023/9864759

Retraction

Retracted: Surface Damage Coupling Mechanism of Plain Weave Art Ceramic Matrix Composites

Journal of Chemistry

Received 15 August 2023; Accepted 15 August 2023; Published 16 August 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] G. Li, "Surface Damage Coupling Mechanism of Plain Weave Art Ceramic Matrix Composites," *Journal of Chemistry*, vol. 2022, Article ID 3519967, 7 pages, 2022.

Hindawi
Journal of Chemistry
Volume 2022, Article ID 3519967, 7 pages
https://doi.org/10.1155/2022/3519967

Research Article

Surface Damage Coupling Mechanism of Plain Weave Art Ceramic Matrix Composites

Guangsong Li

Hunan University of Arts and Science, Changde, Hunan 415000, China

Correspondence should be addressed to Guangsong Li; 2013052129@stu.zjhu.edu.cn

Received 30 March 2022; Revised 1 May 2022; Accepted 6 May 2022; Published 27 May 2022

Academic Editor: Aruna K K

In order to solve the problem of the surface damage coupling mechanism of ceramic matrix composites, a method oriented to the damage coupling mechanism of the plain weave art ceramic matrix is proposed by the author. First, the author uses the composite material prepared by a chemical vapor infiltration process as the research object, and the damage mechanical behavior of materials under simple and complex plane stress states is studied. Second, the calculation of the mechanical property parameters of the material components and the research on the mechanical behavior of the material in-plane shear mesodamage are studied; Finally, the research on the damage coupling effect of materials under complex stress state is conducted, as well as the decoupling test research of the damage coupling effect. It is demonstrated that based on 0 and 45° off-axis tensile stress-strain behavior, a prediction model of off-axis tensile stress-strain behavior of the material was established, and the prediction results were in good agreement with the experimental results.

1. Introduction

As a new type of high temperature-resistant structural material, plain weave ceramic matrix composite, hot-end components have requirements on structural weight reduction and operating temperature [1]. To understand and master the damage mechanism of materials under different stress states and mechanical behavior is to optimize the material preparation process and promote the important theoretical basis for its engineering practical application. During the service process, the composite material of the component is usually in a complex stress state; at present, the damage mechanical behavior of materials under a single axial stress state is studied, and it can no longer meet the needs of engineering design. At the same time, under the complex stress state, during the evolution process of material damage caused by different stress components, there are significant coupling effects. The existence of the damage coupling effect will significantly accelerate the damage process of the material, change the failure mode of the material, and reduce the mechanical properties of the material; thus, it seriously affects the structural strength and service life of composite components, and it must be studied in a targeted manner, as shown in Figure 1.

2. Literature Review

Although a great deal of research has been done on the mechanical behavior of ceramic matrix composites, it is mostly about its elastic properties. Its nonlinear properties are rarely studied. Due to the complex process of production and preparation, there are a lot of defects in the material, and the damage gradually accumulates under the load, causing the material stiffness to degrade. This makes it difficult to accurately predict the nonlinear mechanical response. Further research is still needed to reveal its destruction mechanism. Based on the previous research results, the author adopts the method of combining experiment and finite element calculation, and the tensile damage failure mechanism of ceramic matrix composites was revealed. The macromechanical constitutive of the material is established, and the strength envelope and proportional limit envelope under in-plane loads are obtained.

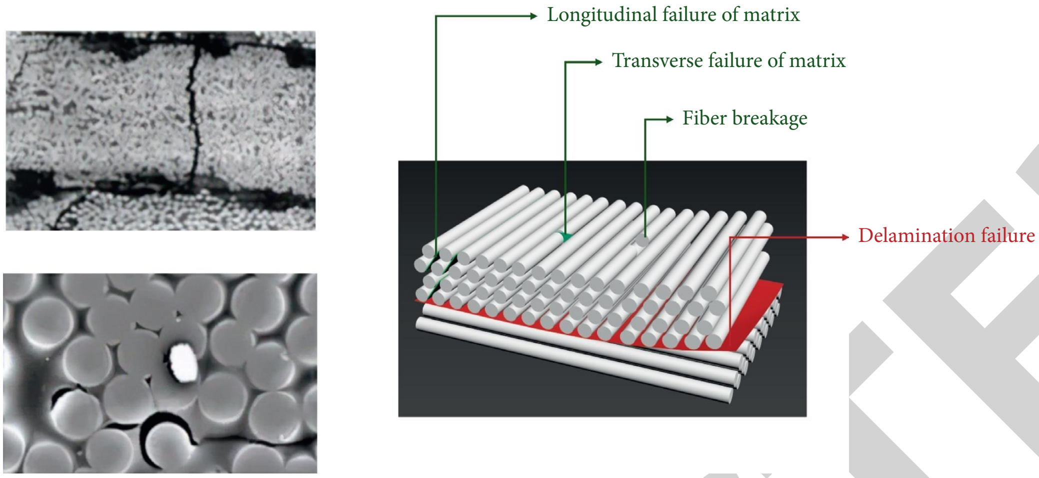

Figure 1: Damage coupling mechanism.

The study by Prasad, N. E et al. showed that matrix cracking is a significant shear nonlinear stress-strain behavior of ceramic matrix composites and is the main cause of large shear plastic deformation [2]. Reynaud, P. et al. and Rouby, D. et al. argue that the rigid body displacement of the longitudinal matrix fragments caused by a damage inside the material is the reason for the large irrecoverable strain of the material, and that it is controlled by the interfacial properties between the fiber and the matrix [3]. Ma, J. et al. found that under shear load, 2D-C/SiC composites, the included angles between the matrix crack and the fiber axis are basically 0°, 90°, and 45°; the 45° direction crack is the main reason for the final shear failure of the material [4]. Murthy, P. et al. established a multiscale finite element model, where the damage initiation, propagation process, and stiffness degradation law of laminate structural composites under a complex stress state are studied [5]. By the finite element method, suggested by Wang, Z. G. et al., the damage mechanical behavior of ceramic matrix composites under a complex stress state was studied, and the in-situ mechanical properties of the material components in the model were obtained by a 45° off-axis tensile test [1]. Prasad, N. E. et al. through cyclic off-axis loading and unloading experiments with different angles studied the damage initiation and propagation laws of resin matrix composites under a complex stress state [2]. Reynaud, P. et al. combined tension-torsion and tension-internal pressure loading on SiC/SiC composite circular tubes, and the damage and failure behavior of materials under complex stress states was studied [3]. Ma, J. et al. based on the biaxial tensile stress-strain behavior of ceramic matrix composites in the axial and 45° directions established a phenomenological constitutive model of the material under the plane stress state [4]. Prasad, N. E. performed off-axis tensile tests on 2D-C/SiC and 2D-SiC/SiC composites, respectively, using the obtained experimental data; the continuous damage constitutive model of the material was established and verified[6].

Based on the current research, a method for the damage coupling mechanism of plain weave art ceramic substrates is proposed. The axial tensile hysteresis model of plain weave ceramic matrix composites was established, the influence of the long and short fragments of the matrix on the hysteresis behavior of the material is analyzed. Four parameters to characterize the mechanical properties of the material components were obtained by calculation: Matrix cracking stress, thermal residual stress, interfacial debonding energy, and interfacial slip force [7]. Based on the off-axis tensile stress-strain behavior of 0 and 45°, a prediction model of off-axis tensile stress-strain behavior of the material was established, and the predicted results were in good agreement with the experimental results.

3. Study on the Surface Damage Coupling Mechanism of Plain Weave Art Ceramic Matrix Composites

3.1. Overview of Plain Weave Ceramic Matrix Composites

3.1.1. Material Overview. The reinforcing phase fibers of plain weave ceramic matrix composites are mainly C fibers and SiC fibers. The C fiber is one of the most successfully developed fibers with the best performance so far and has been widely used as a reinforcing phase material for composite materials. In an inert gas environment, its strength does not decrease at a high temperature of 2000°C, and it is the most stable type of fiber with high temperature performance among the current reinforcement fibers [8]. However, the poor oxidation resistance at high temperature is the biggest weakness of C fibers. By coating and modifying the surface of the fiber, it can effectively avoid its high temperature oxidation damage. As another important reinforcing phase of composite materials, SiC fiber has similar mechanical properties to C fiber at room temperature. Since the SiC fiber and the SiC matrix have similar thermal expansion coefficients, the thermal deformation mismatch problem during the process from the as-prepared state to the room temperature can be greatly alleviated, and the initial damage problem of the material can be improved. However, SiC fibers contain oxygen and free carbon impurities to varying degrees, which seriously affects their

Table 1: Main properties of plain weave ceramic matrix composite components.

	Strength/Mpa	Modulus/Gpa	Density (g/cm^3)	Tce/(10^{-6}K^{-1})
Sic matrix	602	460	3.26	4.1
T-300 fiber	3101	230	1.77	0.1~0.6
Hi-Nicalon fiber	2801	270	2.75	3.6

high-temperature mechanical properties [9]. At present, the low oxygen content SiC fiber (Hi-Nicalon) produced by the Nippon Carbon Corporation has good high temperature stability, and its strength can be guaranteed to change little at 1500~1600°C.

The matrix phase materials of plain weave ceramic matrix composites are mainly non-oxide matrix, mainly referring to SiC ceramics and Si: N ceramics. Compared with other inorganic nonmetallic materials, non-oxide ceramics have higher hardness and strength, excellent wear resistance, and high temperature resistance; in particular, it has good high temperature strength and thermal shock resistance, and the SiC ceramic matrix is the earliest and most successful example of research. In addition to the fiber reinforcement phase and the ceramic matrix phase, the material composition also includes an interface phase material, generally a flexible pyrolytic carbon (PyC) material. The interface is the key to improve the brittleness of the material, and it is an important factor to control the load transfer mechanism and damage failure mode between the fiber and the matrix inside the material [10]. Table 1 gives some basic properties of the C fiber, SiC fiber, and SiC matrix in the form of a single substance. After the composite material is formed as a whole, due to the influence of factors such as preparation damage and thermal residual stress, the mechanical properties of the above components will decrease to varying degrees, so the mechanical properties listed in Table 1 cannot be directly used for the prediction and calculation of the overall mechanical properties of the material.

3.1.2. Application Status. Ceramic matrix composites are widely used in aviation (including aeroengine) aerospace field. In addition, it also has good application prospects in the fields of nuclear energy applications and hypersonic aircraft thermal protection systems [11]. Since the 1950s, western countries have begun to try to apply SiC/SiC ceramic matrix composites to high-temperature parts of aeroengines. Among them, SNECMA of France and General Electric of the United States have carried out initial research studies in this field, and the technology is relatively mature and has high industrialized water. In the early eighties, the SiC/SiC ceramic matrix composite material was developed by the French SNECMA company, and it was applied to the engine nozzle adjustment sheet. In the mid-1990s, SNECMA and PW jointly conducted exploration and research on the engineering application of SiC/SiC ceramic matrix composites: The nozzle seal adjustment piece made of SiC/SiC ceramic matrix composite material passed the ground acceleration task test [12]. Since the late 1980s, the preparation and industrial application of SiC/SiC ceramic matrix composites have been explored. With the support of projects such as IHPTET, EPM (Enabling Propulsion Materials), UEET (Ultra Efficient Engine Technology Program), and NGLT (Next Generation Launch Technology), the preparation process of SiC/SiC ceramic matrix composites tends to be mature, and the company has conducted a large number of experiments and engineering verifications on the hot end components of aeroengines using SiC/SiC ceramic matrix composites. In addition, many companies in the United Kingdom and Japan have also designed and tested SiC/SiC composite combustion chamber linings, heat shields, turbine blades, turbine rotors, and other hot-end components. The application of foreign SiC/SiC composite materials in aeroengines is shown in Table 2.

Table 2: Application of composite materials in the aeroengine.

Engine model	Applied parts
M88-2E4 development type	Inner nozzle adjustment plate
F100-pw-229·F100-pw-220	Nozzle seal adjuster
CFM56	Mixer
XTC76/3	Combustion chamber fire chimney

The development of SiC/SiC composite components began in the 1980s, and the main development units include AVIC Composite Center, Aerospace Materials and Technology Research Institute, Northwestern Polytechnical University, National Defense Science and Technology University and other units. Among them, the combustion chamber floating wall simulation and the tail nozzle adjustment piece were developed by Northwestern Polytechnical University, and they have passed the preliminary verification and short-term assessment of the aeroengine environment, and the regulator developed by the National University of Defense Technology has also passed the relevant test runs [13]. In short, it has the capability of component development and small batch production, but there is still a clear gap with the western developed countries in terms of engineering industrialization.

3.2. Damage Behavior of Ceramic Matrix Composites

3.2.1. Damage Mechanics of Composite Materials. The damage of solid materials under the action of an external load is generally a process of accumulation of damage, and physically, it is a process of accumulation of microstructure changes; mechanics is the cumulative process of the generation and development of macroscopic defects. Under a certain load environment, the microstructural change that causes the deterioration of material properties is called damage. Damage mechanics is the study of the mechanical laws of materials under various loading conditions, in which damage evolves with deformation and eventually leads to the failure process. Initial defects and damage activity in composites accompany the material throughout its use stage; in order to optimize the design of materials and correctly evaluate the performance of composite materials, it is necessary to deeply study the damage and failure mechanism of composite materials; furthermore, the damage evolution law of composite materials is revealed, and the influence of the existence of damage on the macroscopic properties such as stiffness and strength of composite materials is predicted [14].

Compared with other kinds of materials, the reason why composite materials can have a comprehensive and excellent mechanical behavior is because the material is composed of component materials with different mechanical properties, and the advantages of each component material are coupled at the same time [15]. Under the action of external load, the mesoscopic damage failure mechanism of component materials is the internal determinant of the overall macroscopic mechanical behavior and properties of the material. The research on the mechanical behavior of composite materials has become one of the most active and important fields of meso-mechanics; the purpose of micromechanics is to develop fundamental principles and methods based on the relationship between the microstructure of materials and their macroscopic physical properties. These principles and methods can not only guide people to synthesize composite materials with desired mesostructures in a targeted manner but also predict the mesoscopic and macroscopic mechanical behaviors of these composites in use [16].

Combining the above two research ideas, the purpose of the mesodamage mechanics research of composite materials is to establish the corresponding relationship between the macroscopic properties of the composite material and its component material properties and microstructure, reveal the intrinsic mechanism of different macroscopic properties of different material combinations, and to elucidate the mesoscopic mechanism of action that endows composites with high strength, high modulus, and good fracture toughness. Conversely, based on the study of mesodamage mechanism, it can also provide direct feedback suggestions for the selection of composite material components, the selection of preparation process, and the optimization of process parameters and help design composite material systems with optimal mechanical properties [17]. Therefore, there is a clear engineering application background to study the mesodamage mechanical behavior of composite materials, which is an important theoretical basis for the development of composite materials.

3.2.2. Research Status of Material Damage Mechanical Behavior. Ceramic matrix composites are typical brittle matrix materials; usually, the fracture strain (1%~1.5%) of the fiber is greater than the fracture strain (0.1%~0.2%) of the matrix. At the same time, the thermal expansion coefficient of the matrix is generally greater than that of the fibers. When the temperature of the material is lowered from the prepared state to room temperature, the thermal residual stress inside the material appears as tensile stress inside the matrix, and as axial and radial compressive stress inside the fiber, this in turn leads to an initial damage to the material such as matrix cracking and interfacial debonding. Under the action of an external load, matrix cracking is the initial mesoscopic damage mode of the material. With the increase of the load, the microcracks in the matrix will continue to initiate and expand. When a matrix crack propagates to the interface layer between the fiber and the matrix, its propagation path depends on the relative strength of the interface and the fiber. When the interface is strong, the crack penetrates the interface layer into the fiber and causes the fiber to fracture, and the composite exhibits brittle fracture similar to pure ceramic. When the interface is weak, the cracks deflect and propagate along the interface, the fibers do not break, and interface debonding and slip damage occur, resulting in the material exhibiting ductile failure behavior [18, 19]. As the load continues to increase, the proportion of bridging fibers between adjacent matrix crack surfaces to the overall fiber continues to increase, and the proportion of the load borne by them also increases, causing the fibers to begin to break. When the broken fiber reaches a certain proportion, the material loses its continuous bearing capacity and the overall failure occurs.

For the mesodamage mechanical behavior of plain weave ceramic matrix composites, the research on axial tensile damage is the most thorough, the theoretical model is the most complete, and the research results are very remarkable: The research work is mainly based on the shear lag model (ACK theory), combined with the random cracking of the matrix and the random fracture of the fibers, the axial tensile stress-strain behavior of the material can be completely predicted [20]. Among them, by studying the stress-strain behavior of axial tensile cyclic loading and unloading, the relationship between the macroscopic tensile mechanical behavior of the material and the mechanical properties of the components can be directly established, which lays a necessary foundation for the quantitative study of the damage mechanical behavior of the material.

4. Experiments and Analysis

4.1. Monotonic Loading and Damage Distribution. The stress-strain behavior and damage distribution of a uniform section of the specimen under a single axial load were obtained through monotonic axial tensile, axial compression, and in-plane shear tests, respectively, where typical monotonic axial tensile and compressive stress-strain curves measured are given in Figure 2; the longitudinal axis is the average tensile and compressive stress of the uniform section of the specimen [21]. As can be seen from Figure 2, under the same tensile stress level, the tensile strain measured by the strain gauge closer to the edge of the specimen is larger; this shows that there is obvious strain concentration phenomenon in the middle section of the specimen during the tensile process. Under the action of axial compressive load, the stress-strain curves corresponding to different strain gauges all behave as approximate linear elasticity. During the compression process, there is still a certain strain concentration phenomenon in the middle section of the specimen,

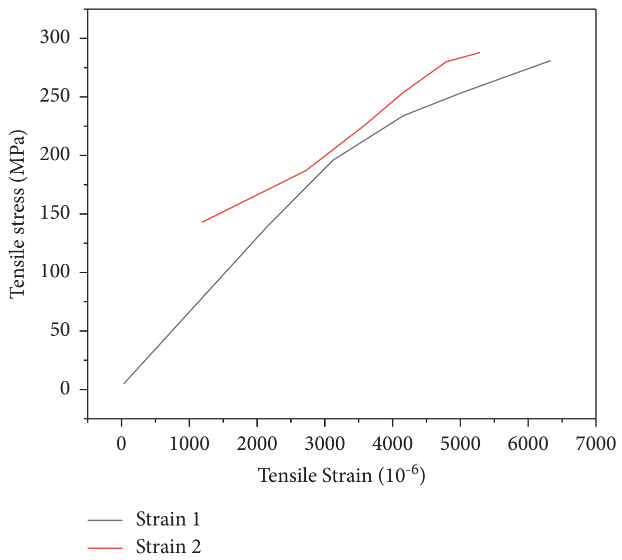

FIGURE 2: Monotonic axial tensile and compressive stress-strain curves.

but the concentration degree is significantly smaller than that in the axial tension state.

Under axial tension and compression loading, the strain concentration phenomenon on the middle section of the specimen shows that the axial tensile and axial compression damage distributions of the uniform section of the specimen are nonuniform, and this will bring errors and inconveniences to the quantitative decoupling analysis of the subsequent tensile-shear and compression-shear damage coupling effects, as well as the calculation of the damage coupling components D16 and Do1. In order to minimize the error, in the subsequent analysis, the average strain of the loaded section will be used, the real-time elastic modulus of axial tension and compression of the entire uniform segment material is fitted and calculated, that is, the damage degree is characterized. At the same time, in order to be consistent with the subsequent strain measurement scheme, it is also necessary to establish the overall average strain of the material in the uniform section of the test, the corresponding relationship with the strain data at the center position, and the degree of damage. To this end, the typical variation curves of the calculated ratio of E_ε to e, with the applied tensile and compressive stress are shown in Figures 3 and 4. The calculation steps are as follows in formula (1):

$$R\left(\varepsilon_{Aw},\varepsilon_{1m}\right)=\frac{\varepsilon_{AW}}{\varepsilon_{1W}}=\frac{1}{7}\sum_{lm1}^{7}\frac{\varepsilon_{1}}{\varepsilon_{1w}}. \tag{1}$$

As shown in Figure 3, during the monotonic axial tensile loading process, the value of R(εxe, E) slightly increases with the increase of tensile stress, which is mainly due to the high stress level. Due to the influence of stress concentration, the tensile damage of the local material at the edge of the loaded section in the middle of the specimen develops rapidly, and the corresponding strain value increases rapidly. On the whole, the abovementioned ratios did not change much and remained at around 1.38. In order to simplify the subsequent calculation and analysis process, in the following, ε of 1.38 times will be used as the average axial tensile strain of the loaded section, and the fitting calculation of the axial tensile elastic modulus of the material will be performed, as well as the characterization of the degree of tensile damage. During the axial compression process, the value of R (e., e) basically remains around 1.05. Similarly, in the subsequent calculation analysis, 1.05 times ε will be used as the average axial compressive strain of the loaded section, in order to characterize the degree of compression damage of the test uniform section material, and the fitting calculation of compressive elastic modulus.

Typical shear stress-strain curves obtained under monotonic in-plane shear loads are shown in Figure 5. The corresponding curves of the strain gauges basically overlap, but the strain values measured by the strain gauges under the same stress level are significantly smaller than the first three. The above differences show that on the sheared cross section

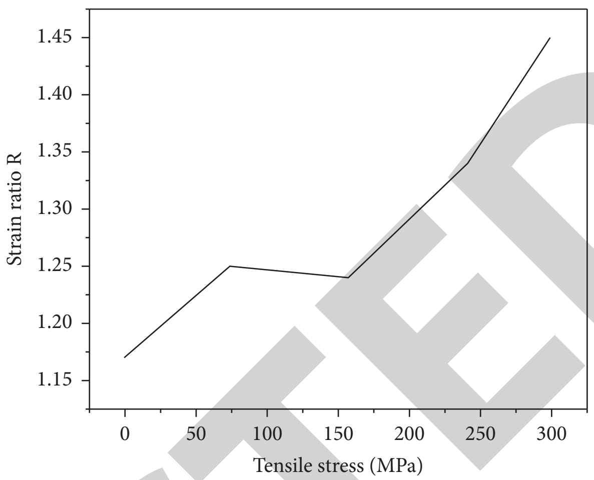

FIGURE 3: Variation curve of monotonic axial tensile strain to cross ratio.

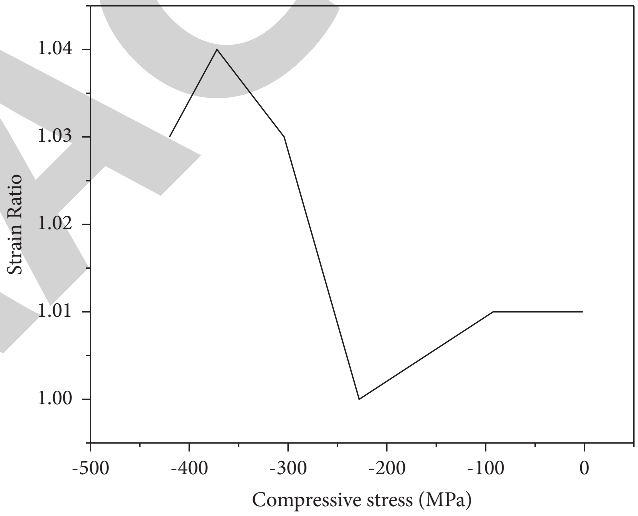

FIGURE 4: Variation curve of monotonic axial compression strain ratio.

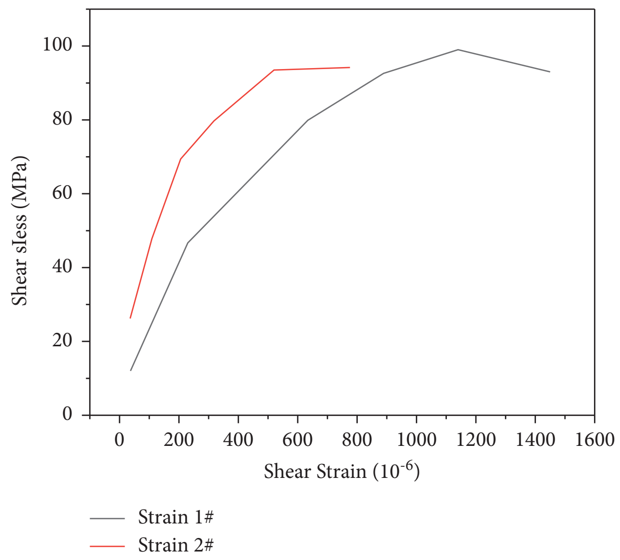

Figure 5: Monotonic in-plane shear stress-strain curve.

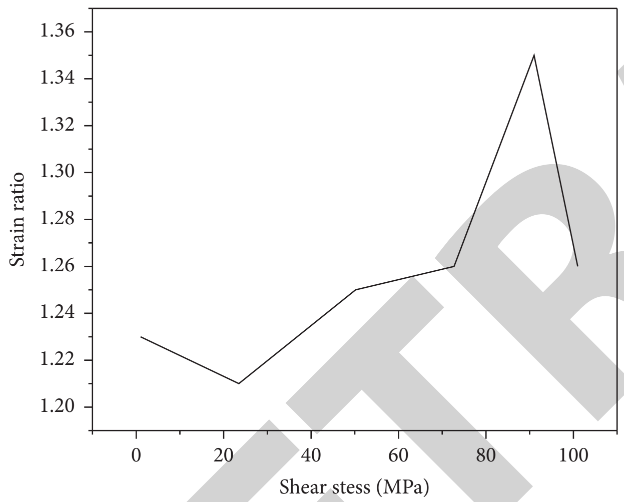

Figure 6: Variation curve of shear strain ratio in the monotonic plane.

of the specimen, there is also an obvious uneven distribution of shear strain, that is, uneven distribution of the shear damage.

Similarly, in order to reduce the analysis error, the average shear strain of the section will be used to indicate the degree of shear damage of the material in the uniform section of the test. At the same time, the shear strain 7 measured by the strain gauge is obtained. The typical change curve of the ratio R(y,7) to the average shear strain γ ne of the section changes with the application of shear stress, as shown in Figure 6, and the calculation steps are as follows in formula (2):

$$R(y_{1w}, y_{Ave}) = \frac{y_{1m}}{y_{Ave}} = \frac{5y_{1w}}{\sum_{i-1}^{5} y_3}. \quad (2)$$

It can be seen that in the whole shear loading process, the above ratio is basically constant at about 1.36. In the subsequent calculation and analysis, y/1.36 will be used as the average shear strain of the loaded section to characterize the degree of the shear damage of the material in the test uniform section and to perform the fitting calculation of the shear modulus.

5. Conclusion

The author first discusses the composition, mechanical properties, preparation process, application status, and prospects of plain weave ceramic matrix composites in aerospace high-temperature thermal structures; additionally, the main problems that need to be solved in terms of the mesoscopic damage mechanical behavior of materials and their research status are introduced. The main research subjects are 2D-C/SiC and 2D-SiC/SiC composites prepared by a chemical vapor infiltration (CVI) process, and the damage mechanical behavior of materials under simple and complex plane stress states is studied systematically. The focus is on the calculation of the mechanical property parameters of the material components, the research on the mechanical behavior of the material in-plane shear mesoscopic damage, research on material damage coupling effect under complex stress state, and decoupling test research on damage coupling effects. The specific research work and conclusions are as follows:

(1) By conducting axial tensile, compression, and in-plane shear tests on 2D-C/SiC and 2D-SiC/SiC composites under various loading forms, the basic stress-strain behavior and mechanical properties parameters of the material are obtained. Based on this, the damage mechanical behaviors of the two materials were compared and analyzed. During this period, the effects of different loading histories on the damage failure process and mechanical properties of materials were mainly studied.

(2) Based on off-axis tensile and off-axis compression tests, the effects of off-axis angle on the stress-strain behavior, damage process, failure mode, and mechanical properties of 2D-C/SiC composites were compared and analyzed. Based on the off-axis tensile stress-strain behavior of 0 and 45°, a prediction model of off-axis tensile stress-strain behavior of the material was established, and the predicted results were in good agreement with the experimental results.

(3) Based on the shear lag theory, the axial tensile hysteresis model of plain weave ceramic matrix composites was established, the influence of the long and short fragments of the matrix on the hysteresis behavior of the material is analyzed. To characterize the mechanical properties of the material components, four parameters are obtained by calculation: Matrix cracking stress, thermal residual stress, interfacial debonding energy, and interfacial slip force. According to the calculation results, the effects of fiber properties and interfacial layer thickness on the above parameters were compared and analyzed.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

The research in this paper was supported by Hunan Provincial Social Science Achievement Appraisal Committee Project: Research on Protection and Inheritage of Intangible Cultural Heritage of North-West Hunan Taoyuan Embroidery (NO. XSP21YBC140), 2021 Education Reform Project of Education Department of Hunan Province: Research on the Reform of Online-and-Offline Mixed Teaching Mode of Flipped Classroom ""Design Fundamentation"", National Innovation and Entrepreneurship Training Program for College Students Project: Research on Product Development of Tie-Dye Intangible Cultural Heritage (NO. 202110549011)."

References

[1] Z. G. Wang, C. Laird, Z. Hashin, W. Rosen, and C. F. Yen, "The mechanical behaviour of a cross-weave ceramic matrix composite," *Journal of Materials Science*, vol. 26, no. 19, pp. 5335–5341, 1991.

[2] N. Eswara Prasad, S. Kumari, S. V. Kamat, M. Vijayakumar, and G. Malakondaiah, "Fracture behaviour of 2d-weaved, silica–silica continuous fibre-reinforced, ceramic–matrix composites (cfccs)," *Engineering Fracture Mechanics*, vol. 71, no. 18, pp. 2589–2605, 2004.

[3] P. Reynaud, D. Rouby, and G. Fantozzi, "Effects of interfacial evolutions on the mechanical behaviour of ceramic matrix composites during cyclic fatigue," *Scripta Metallurgica et Materialia*, vol. 31, no. 8, pp. 1061–1066, 1994.

[4] J. Ma, Y. Xu, L. Zhang, L. Cheng, J. Nie, and N. Dong, "Microstructure characterization and tensile behavior of 2.5d c/sic composites fabricated by chemical vapor infiltration," *Scripta Materialia*, vol. 54, no. 11, pp. 1967–1971, 2006.

[5] P. L. Murthy, N. N. Nemeth, D. N. Brewer, and S. Mital, "Probabilistic analysis of a sic/sic ceramic matrix composite turbine vane," *Composites Part B: Engineering*, vol. 39, no. 4, pp. 694–703, 2008.

[6] N. E. Prasad, D. Loidl, M. Vijayakumar, and K. Kromp, "Elastic properties of silica–silica continuous fibre-reinforced, ceramic matrix composites," *Scripta Materialia*, vol. 50, no. 8, pp. 1121–1126, 2004.

[7] R. M. Rocha, C. Cairo, and M. Graca, "Formation of carbon fiber-reinforced ceramic matrix composites with polysiloxane/silicon derived matrix," *Materials Science and Engineering A*, vol. 437, no. 2, pp. 268–273, 2006.

[8] H. M. Akil, C. Santulli, F. Sarasini, J. Tirillò, and T. Valente, "Environmental effects on the mechanical behaviour of pultruded jute/glass fibre-reinforced polyester hybrid composites," *Composites Science and Technology*, vol. 94, no. 4, pp. 62–70, 2014.

[9] C. Luo and P. E. Desjardin, "Thermo-mechanical damage modeling of a glass–phenolic composite material," *Composites Science and Technology*, vol. 67, no. 7-8, pp. 1475–1488, 2007.

[10] R. Khan, R. Alderliesten, S. Badshah, and R. Benedictus, "Effect of stress ratio or mean stress on fatigue delamination growth in composites: critical review," *Composite Structures*, vol. 124, pp. 214–227, 2015.

[11] X. Yu, T. Zhou, Y. Zhao et al., "Surface magnetism in pristine α rhombohedral boron and intersurface exchange coupling mechanism of boron icosahedra," *Journal of Physical Chemistry Letters*, vol. 12, no. 29, pp. 6812–6817, 2021.

[12] N. Liu, M. Becton, L. Zhang, and X. Wang, "Mechanism of coupling nanoparticle stiffness with shape for endocytosis: from rodlike penetration to wormlike wriggling," *The Journal of Physical Chemistry B*, vol. 124, no. 49, pp. 11145–11156, 2020.

[13] H. Yang, J. Cheng, Z. Liu, Q. Liu, L. Zhao, and J. Wang, "Dynamic behavior modeling of laser-induced damage initiated by surface defects on kdp crystals under nanosecond laser irradiation," *Scientific Reports*, vol. 10, no. 1, p. 500, 2020.

[14] X. Pu, L. Wang, and P. Wang, "Study of shaking table test on dynamic response characteristics and failure mechanism of the loess slope," *Earthquake Research in China*, vol. 34, no. 01, pp. 128–142, 2020.

[15] T. Zhang, D. Holiharimanana, X. Yang, and Q. Ge, "Dft study of methane activation and coupling on the (0001) and (112 0) surfaces of α-wc," *Journal of Physical Chemistry C*, vol. 124, no. 49, pp. 26722–26729, 2020.

[16] J. Santatiwongchai, K. Faungnawakij, and P. Hirunsit, "Comprehensive mechanism of co 2 electroreduction toward ethylene and ethanol: the solvent effect from explicit water–cu (100) interface models," *ACS Catalysis*, vol. 11, no. 15, pp. 9688–9701, 2021.

[17] Y. Han, S. Wang, L. Han, L. He, and X. Luo, "Continuous movement mechanism of oil droplets adhered on surfaces with different wettability in the flow field," *Langmuir*, vol. 36, no. 49, pp. 15169–15180, 2020.

[18] R. Huang, S. Zhang, W. Zhang, and X. Yang, "Progress of zinc oxide-based nanocomposites in the textile industry," *IET Collaborative Intelligent Manufacturing*, vol. 3, no. 3, pp. 281–289, 2021.

[19] X. Liu, J. Liu, J. Chen, and F. Zhong, "Degradation of benzene, toluene, and xylene with high gaseous hourly space velocity by double dielectric barrier discharge combined with Mn3O4/activated carbon fibers," *Journal of Physics D: Applied Physics*, vol. 55, no. 12, Article ID 125206, 2022.

[20] M. Raj, P. Manimegalai, P. Ajay, and J. Amose, "Lipid data acquisition for devices treatment of coronary diseases health stuff on the internet of medical things," *Journal of Physics: Conference Series*, vol. 1937, Article ID 012038, 2021.

[21] S. Kannan, G. Dhiman, Y. Natarajan et al., "Ubiquitous vehicular ad-hoc network computing using deep neural network with iot-based bat agents for traffic management," *Electronics*, vol. 10, no. 7, p. 785, 2021.