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RESEARCH ARTICLE

PREDICTION OF FATIGUE LIFE FOR AL8090 REINFORCED WITH TITANIUM DIBORIDE AND GRAPHENE COMPOSITE.

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Abstract

The fatigue performance of cast Al8090 alloy added with titanium diboride and graphene was examined. Al8090 is a widely utilized material in the aviation sector, recognized for its distinctive attributes such as decreased weight, increased stiffness, and superior fatigue resistance. These attributes render it ideal for high-performance and weight-sensitive applications, especially in aircraft structures and components. Fatigue tests controlled by stress and strain were performed to determine the fatigue strength. The performance of high-cycle fatigue was empirically investigated at several levels of stress concentration. The findings indicated that incorporating titanium diboride and graphene improves fatigue resistance.

Introduction:-

Ceramic particulate reinforced metal matrix composites are a type of multi-phase solid material that exhibit superior specific strength, specific modulus, fatigue performance, damping, and abrasion resistance in comparison to their metals. The fatigue performance of particle-reinforced metal matrix composites is a significant concern in order to incorporate them into engineering applications.

Liu et al. [1] investigated the Predictionof the in-situ TiB_2/2024 aluminum matrix composite's fatigue life. The fatigue properties of a 2024-T4 alloy matrix composite (TiB_2/2024Al) and a 2024-T4 aluminum alloy (2024Al) were examined. The fatigue strength were determined through stress-and strain-controlled fatigue experiments. Experimental research was conducted to investigate the efficacy of high-cycle fatigue under varying stress concentrations. The findings indicated that the fatigue resistance is improved by the inclusion of in-situ particulates. A damage-coupled Chaboche elastic–plastic constitutive model was employed to develop a fatigue life prediction method. The established method was employed to predict the fatigue life, which was then compared to the results of the investigations. The proposed procedure was found to accurately predict fatigue life.Mohammad Azadi et al. [2] examined tensile and low-cycle fatigue characteristics at extreme temperatures in aluminum-silicon piston alloys, with and without the incorporation of nano-clay particles and heat treatment.Piston aluminum alloy mechanical and low-cycle fatigue (LCF) properties were characterized in this research. The effect of nano-clay-particle reinforcement and heat treatment was also examined. Nanoparticles were added to aluminum alloy and heat-treated for this. Besides tensile tests, fully reversed strain-controlled LCF tests were done. The strain amplitudes were 0.20%, 0.25%, 0.30%, 0.35%, 0.40%, and 0.45% at 1%/s. Four temperatures (25, 200, 250, and 300°C) were used for the experiment. Results demonstrated no significant variations in yield stress, ultimate stress, and elastic modulus between heat treat and nano-clay-particle specimens. However, the heat-treated reinforced sample

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elongated slightly. At low temperatures, reinforcing did not affect LCF lifetime. However, reinforcing at 300°C dramatically reduced the LCF lifetime of the base material.

Girija Moona et al. [3] studied optimizationof the fatigue behavior of hybrid aluminum metal matrix composite. ANOVA was also used to determine how process factors affected composite fatigue life. Nine hybrid composite specimens and one as-cast Al7075-T6 specimen were manufactured according to ASTM E 468/606 and tested for low cycle fatigue resistance at 2 kg and 500 rpms on a rotating beam fatigue testing equipment. The as-cast Al 7075-T6 specimen survived only 94 load cycles, while the hybrid composite specimen with 1.5 wt% eggshell particles, 1.5 wt% SiC particles, and 1.5 wt% Al2O3 particles (total reinforce) survived 4560 load cycles at 30 °C.

Uematsu et al. [4] studied Fatigue of SiC-particulate-reinforced aluminum alloy composites with varied particle sizes at high temperatures. Smooth specimens of SiC-particulate-reinforced aluminium alloy composites with varied particle sizes at a constant wt.% SiC have been tested for fully reversed axial fatigue at 150 °C and 250 °C . Fatigue strength decreased with temperature, especially at 250 °C, regardless of particle size. Fatigue strength was obviously dependent on particle size at ambient temperature, but it decreased at 150 °C and almost disappeared at 250 °C. In all materials investigated, tiny crack growth rates were orders of magnitude faster at 250 C than at ambient temperature and 150 C. Crack initiation depended on temperature and particle size The observed temperature and particle size dependency of fatigue behavior was due to matrix softening and strength loss at elevated temperatures.

Joelton et al. [5] investigated the prediction of the fatigue life of metallic materials by utilizing an artificial neural network contemplating the effects of mean stress. This research aims to create a new continuous life diagram (CLD) technique for metallic materials employing Haigh diagram assumptions and artificial neural networks, utilizing probabilistic fatigue S-N fields. The fatigue resistance reduction factor, Kf, is estimated using machine learning artificial neural network algorithms to predict fatigue life in structural details with stress Rratios of 0, 0.15, and 0.3 in extrapolation regions.The objective of this study is to investigate the fatigue behavior of Al8090/TiB_2/C composites with varying weight percentages of titanium diboride and graphene. High-cycle fatigue testing was conducted in accordance with the ASTM E466 standard. The experiments were performed in a room temperature atmospheric condition regulated by a sine wave load. A stress ratio R = 0 is utilized with a loading frequency of 10 Hz.

1. Methodology:

Al8090 is obtained in the form of a billet, whereas titanium diboride can be obtained in the form of a powder with a particle size of 10 microns. The density is 4.52 g/cm³. A black powdered version of graphene that has between six and ten layers. Fabrication of Al8090/Ti B_2/C composites is performed by the utilization of a liquid metallurgical method that utilizes a stir casting technique, which is then followed by T6 heat treatment. Both graphene and preheated TiB_2 powder were added to the aluminum alloy, with the percentages of each component being different. The Al8090 alloy was subjected to mechanical agitation with reinforcement for a duration of ten minutes at a speed of 250 rotations per minute. At an elevated temperature of 800 degrees Celsius, the molten composite was poured into cast-iron molds that had been heated. The content of TiB_2 in the matrix alloy was altered at a number of different levels, including 2, 4, 6, 8, and 10 weight percent. At weight percentages of 0.5, 1, 1.5, and 2 percent, the alloy included graphene in varying amounts.

2. High cycle fatigue tests:

High cycle fatigue testing of Al8090/TiB_2/C composite were undertaken. High-cycle fatigue testing were performed in compliance with the ASTM E466 standard with computerized fatigue testing machine. The dimensions of the specimens are illustrated in Fig. 1. The specimen's total length measures 80 mm. The test section is conical, measuring 30 mm in length, with a minimum cross-sectional diameter of 5 mm. The cross-sectional diameter of each clamping portion is 8 mm. The experiments were performed in a room temperature atmospheric condition regulated by a sine wave load, as illustrated in Fig. 2. The stress ratio R = 0 is applied with a loading frequency of 10 Hz.

Fig 1: Specimens for Fatigue experimenrs

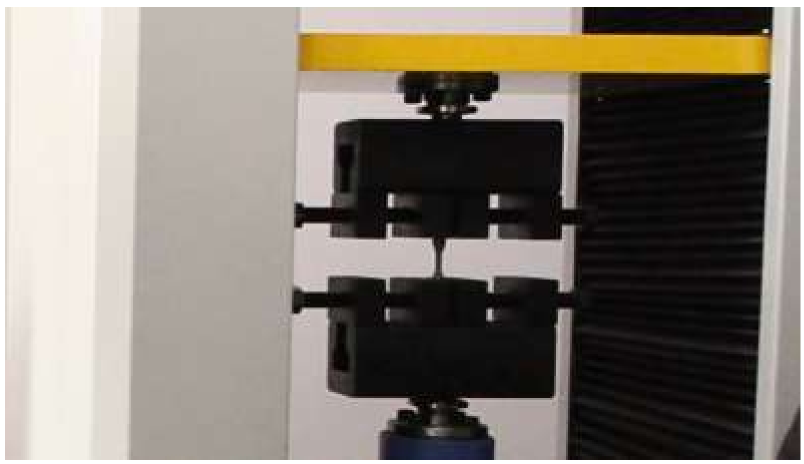

Fig 2 :**Fatigue Test conducted using computerized fatigue machine**

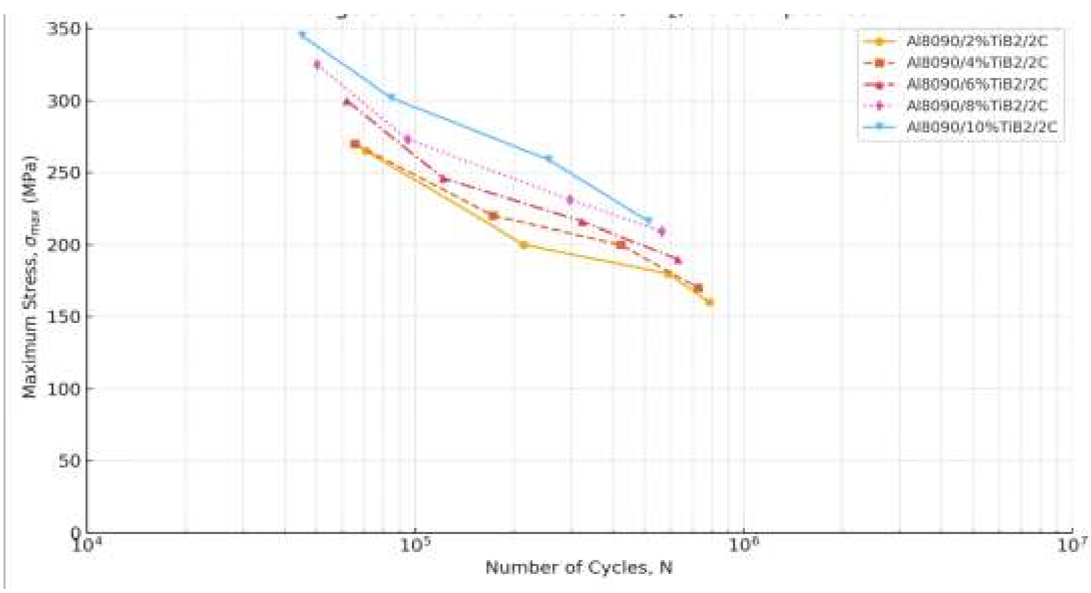

Fig 3 ; S N curve for Al8090/TiB2/C composite

The *S-N* curves of the Al8090/TiB_2/C composites under different stress levels are compared in Fig. 3. It is seen that Al8090/10%TiB_2/2C composites have more fatigue strength in compared to composites with different wt% of reinforcement. Al8090/10%TiB_2/2C composites have more fatigue strength because of addition of 10wt% of titanium diboride and 2wt% graphene.The energy-absorbing mechanisms that give Al8090/10%TiB_2/2C composites a longer fatigue life are reinforcement pull-out mechanisms [6-10].

3. Conclusions:

In the current experimental investigation, Al8090 hybrid composites were synthesized using the stir casting method. The high cycle fatigue test was conducted on the developed hybrid composites, and it was observed that the fatigue resistance increased as reinforcements were infused into the metal matrix.The fatigue test of Al8090/TiB_2/C composites was performed utilizing the ASTM standard specimen and a computerized fatigue testing apparatus. The results indicated that Al8090/10%TiB_2/2C composites have superior fatigue strength compared to composites with varying weight percentages of reinforcement. The incorporation of reinforcements enhanced the damage resistance of Al8090 alloy, hence increasing the number of stress cycles required for fracture.

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