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A review: Assessment of the Theories of Fundamental Mechanisms, Designing, and Failure on Structural Adhesive Joints Bond

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Abstract

Adhesives have been around for millennia. Nevertheless, this technique for joining has only seen significant development within the past 70 years. Professional technical engineering applications primarily use adhesives derived from synthetic polymers, a development that dates back to the mid-1940s. Its characteristics facilitate their strong adhesion to most substrates, as well as their ability to transfer substantial loads. This paper presents an extensive assessment of the current knowledge in the field of adhesives and related technologies, with a focus on adhesion theories and their parameters, as well as designing, joint configuration, geometric aspects, and failure modes. The paper also explores the interplay between research and development efforts, industrial standards, and regulatory aspects, with the goal of fostering collaboration between academia and industry. Over the past years, the development of new materials, methods, and models has resolved many of the shortcomings. Nonetheless, it is still possible to evaluate and estimate the optimal combination of aspects that will give the greatest efficiency and performance for adhesive bond joints (ABJs).

1. Introduction

Nowadays, the adhesive bond joints ABJs are an element of the essential assembly technologies in the fabricating and synthetic industries. It serves extensively to tiny, small, Mid-sized and massive structures for instance in furniture, Application-Specific Integrated Circuits ASICs, automobiles, aircraft, aerospace, wind turbines, ship hull structures. Furthermore, may be combined with other fastening methods mechanics to enhance it is effectiveness. Consequently, the durability and strength of the adhesive bonding influence the elements and entire system strength. Owing to the advantages resulting from the use of adhesives, the use of their integration is rapidly increasing in various industries, as these functionally graded materials (FGMs) have provided multi-functional spread in different human needs in daily life [1].

Massive structures that are conventionally loaded, for instance marine structures and bridges, exhibit the problem of excess weight, and corporations aspire to seek for durable and reliable solutions and technologies to reduce their weight without compromising their mechanical properties and withstanding various loads and harsh environmental conditions. Moreover, in other similar structures, such as aerospace applications and automobiles, there is also a need to reduce weight, as reducing weight by 10% can lead to reducing fuel consumption by 8%, ABJs Joining techniques based on sustainable composite materials are the best solution to reduce energy consumption and achieve greater environmental benefits [2-3]. This has stimulated the economic industrial sector to explore for lightweight composites materials that have the strong capability to withstand high loads and ensure safety. Combining metals and composite materials can minimize weight whereas maintaining strength, leading to High-strength low-weight materials. Adhesives are the most suitable bonding technique for joining various stress-prone materials when compared to other classical joining techniques, such as welds, screws, bolts, nails, and rivets [4]. In general, the following unique key points can be identified through comparison:

1. The adhesive-bonded joints (ABJs) allow for the efficient joining of similar or dissimilar adherent materials devoid of the need for fabrication or destruction of the joint adherent material. This is particularly useful for lightweight materials that aim to create lightweight structures.
2. The modulus of elasticity of adhesives is generally approximately between 2 and 7 GPa, which is substantially less than the adherent's modulus of 20-200 GPa (assuming the free form of several materials with negligible modulus figures). Therefore, the aforementioned and obvious distinction can significantly influence the mechanical characteristics and component features of an ABJ's structure.
3. The energy transmission method and principal loading mode between the adhesive and an adherent is shearing stress that is generally substantial than the energy elements and peel load. Additionally, deformations caused by bending may result in increased peel stress when Adhesive