

國立交通大學

工學院精密與自動化工程學程

碩士論文

奈米顆粒對複合材料機械行為的影響

**Effect of Nanoparticles on Mechanical Performance
of Composites**

研究生：黃寶鴻

指導教授：蔡佳霖教授

中華民國九十七年六月

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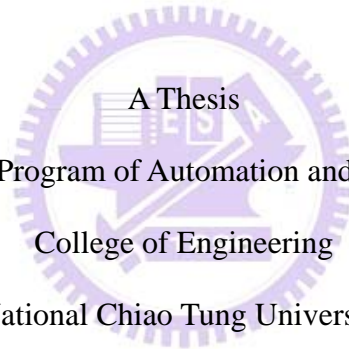
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摘要

本研究主要探討奈米級的氧化鋁、二氧化矽和橡膠顆粒對於環氧樹脂複合材料機械性質的影響，機械性質測試探討包括拉伸、彎曲及破壞韌性實驗。

結果顯示加入不同尺寸的氧化鋁顆粒，在拉伸、彎曲試驗的模數和強度值差異並不大，但破壞韌性實驗的韌性值則提升約 20%。

而添加橡膠顆粒對於環氧樹脂基材之破壞韌性的提升有顯著效果，同時二氧化矽顆粒可以補償因橡膠所造成的剛性下降現象。

利用穿透式電子顯微鏡(TEM)進行奈米顆粒在複合材料的分散性探討，結果顯示奈米級的氧化鋁顆粒，在複合材料中有明顯的團聚現象，而奈米級的二氧化矽顆粒與橡膠則有良好的分散性。

場發射電子顯微鏡(FESEM)觀察複合材料表面破壞後的微觀現象變化，與破壞韌性增益表現比較，可推論破壞韌性的提高，是由奈米顆粒顆粒導致裂紋的初始生長與延伸受到阻礙，以及顆粒的脫落和空孔化後，在空孔的周圍應力集中使得基材塑性變形，達到消散能量的作用提升破壞韌性值。

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Abstract

This research aims to investigate nanoparticles effect on mechanical behaviors of epoxy matrix. Mechanical tests including tensile, flexure and fracture toughness experiments were conducted on the sample with alumina, silica and rubber nanoparticles.

Based on the experimental observations, it was found that the tensile, flexural and fracture behaviors of the particulate composites were not affected by the particle sizes.

The fracture toughness of epoxy resin can be improved significantly by the inclusion of rubber particles. In addition, it was found the reduction of the stiffness caused by the rubber particles can be compensated by the silica nanoparticles

SEM observations on the fracture surface of rubber particle reinforced composites indicated that the increment of fracture toughness in the composites could be due to the formation of plastic deformation as well as the particle debonding and cavitations which can dissipate fracture energy dramatically.