

COMPOSITES FOR HIGH PERFORMANCE STRUCTURE AND CUTTING MATERIALS

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**INSTRUMENT DESIGN DEVELOPMENT CENTRE
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Composites for High Performance Structure and Cutting Materials

by

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CERTIFICATE

This is to certify that the thesis entitled “**Composites for High Performance Structure and Cutting Materials**” submitted by Mr. **Mumtaz Ahmad** to the Indian Institute of Technology Delhi for the award of the degree of **Doctor of Philosophy** is a record of original research work carried out by him. He has worked under my guidance and supervision and has fulfilled all the requirements for the submission of this thesis, which to our knowledge has reached the requisite standard.

The results contained in this thesis have not been submitted, in part or full, to any other university or institute for the award of any degree or diploma.

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ABSTRACT

Recent advancements in various technologies demand the development of new materials to sustain external loads at extremely high temperatures, as well as, corrosive environments. Composite materials have high specific strength, high specific stiffness, better fatigue life, better wear resistance and good mechanical properties. The aim of this study is to develop a new composite cutting tool, as well as, composites that may be used for structural purposes, such as, roofing tiles by using appropriate fabrication techniques. Cutting tool must be resistant to a combination of mechanical, thermal and chemical attacks. Ceramics exhibited good wear resistance even when machining hardened carbon steels. Industries are focusing on improving the materials, manufacturing processes using automatic mass production machines with latest technology. Therefore, there is a need for improving the existing cutting tools for mass production or to develop a new tool which may be an alternative to existing tools. Many commercial processes are available for making these types of composites. Manufacturing methods include hand lay-up and spray techniques, resin transfer molding, compression molding, autoclave molding, injection molding, filament winding, pultrusion etc. It was observed that addition of reinforcement produced better mechanical properties, such as toughness and hardness. Composites were developed for high performance structures and the materials developed can also be used for abrasive cutting.

This dissertation work focuses on the possibility of polystyrene polymeric materials coated with metallic layer for high performance structure and roofing tiles application. Roofing tiles can be ceramic or fabricated from composite material using ceramic powder, polymer composite and other materials, such as, cement and concrete. Advantages of roofing tile include light weight, low transportation cost, easy manufacturing and durability. For future application solar power shingles are promising environmental friendly approach for producing renewable electricity. They appear like regular roof (asphalt) shingles, which have a special photovoltaic substance in the form of a thin film on the top, with ability to transform solar radiation (light) directly into electricity without ruining the aesthetic value of the building.

शोध सार

विभिन्न तकनीकों में हालिया उन्नतियां अत्यधिक उच्च तापमान पर बाहरी लोड को बनाए रखने के लिए नई सामग्री के विकास की मांग करती हैं, साथ ही संक्षारक वातावरण की भी। कम्पोजिट सामग्री में उच्च विशिष्ट शक्ति, उच्च विशिष्ट कठोरता, बेहतर फैटिंग लाइफ, बेहतर वीयर रेसिस्टेंस और अच्छे यांत्रिक गुण हैं। इस अध्ययन का उद्देश्य एक नए कम्पोजिट काटिंग टूल और साथ ही कम्पोजिट का विकास करना है जो संरचनात्मक प्रयोजनों के लिए उपयोग किया जा सकता है, जैसे कि उपयुक्त निर्माण तकनीकों का उपयोग करके छत की टाइलें काटना। कटिंग उपकरण यांत्रिक, थर्मल और रासायनिक अटैक्स के संयोजन का प्रतिरोधी होना चाहिए। कड़े कार्बन स्टील्स की मशीनिंग के दौरान भी सिरामिक अच्छे वीयर रेसिस्टेंस का प्रदर्शन करते हैं। इंडस्ट्रीज सामग्रियों में सुधार, नवीनतम प्रौद्योगिकी के साथ स्वतः बड़े पैमाने पर उत्पादन मशीनों का उपयोग कर विनिर्माण प्रक्रियाओं पर ध्यान केंद्रित कर रही हैं। इसलिए, बड़े पैमाने पर उत्पादन के लिए मौजूदा उपकरण को सुधारने या एक नया उपकरण विकसित करने की आवश्यकता है जो मौजूदा टूल का विकल्प हो सकता है। इस प्रकार के कम्पोजिट बनाने के लिए कई वाणिज्यिक प्रक्रियाएं उपलब्ध हैं। विनिर्माण विधियों में हैंड ले-अप एवं स्प्रे तकनीक, रेज़िंग ट्रांसफॉर्म मोल्डिंग, कम्प्रेसिंग मोल्डिंग, आटोक्लेव मोल्डिंग, इंजेक्शन मोल्डिंग, फिलामेंट वाइंडिंग, पलट्रेशन इत्यादि शामिल हैं। यह देखा गया कि सुदृढीकरण के अलावा बेहतर यांत्रिक गुणों जैसे कड़कपन और कठोरता का उत्पादन होता है। उच्च प्रदर्शन संरचनाओं के लिए कम्पोजिट विकसित किए गए थे और विकसित सामग्री को भी एबसरेसिव कटिंग के लिए भी इस्तेमाल किया जा सकता है।

यह लघु शोध प्रबंध उच्च प्रदर्शन संरचना और छत टाइल्स एप्लिकेशन के लिए धातु परत के साथ लेपित पॉलीस्टाइन पॉलिमर सामग्री की संभावना पर केंद्रित है। छत टाइल सिरामिक हो सकती है या सिरामिक पाउडर, पॉलिमर मिश्रित और अन्य सामग्रियों, जैसे सीमेंट और कंक्रीट का उपयोग करके मिश्रित सामग्री से निर्मित भी हो सकती है। छत टाइल के फायदे में हल्के वजन, कम परिवहन लागत, आसान निर्माण और स्थायित्व

शामिल है। भविष्य के अनुप्रयोगों के लिए सौर ऊर्जा शिंगल्स, अक्षय ऊर्जा उत्पादन के लिए पर्यावरण के अनुकूल एप्रोच की पूर्ति का वादा करते हैं। वे सामान्य रूप से छत (डामर) शिंगल्स की तरह दिखते हैं, जो कि ऊपर की पतली फिल्म के रूप में एक विशेष फोटोवोल्टेइक पदार्थ होते हैं, जिसमें सौर विकिरण (प्रकाश) को सीधे भवन की एस्थेटिक्स वैल्यू को बर्बाद किए बिना बिजली में परिवर्तित करने की क्षमता होती है।

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LIST OF ABBRIVIATIONS

RTM	Resin transfer moulding
VARTM	Vacuum assisted resin transfer moulding
MIM	Micro injecting moulding
MDI	Microcell Distribution Index
BRT	Barrel residence time
GFRC	Glass fiber reinforced composite
CFRC	Carbon fiber reinforced composite
MMC	Metal matrix composite
CMC	Ceramic matrix composite
PMC	Polymer matrix composite
GRP	Glass reinforced polymer
FRP	Fiber reinforced polymer
SEM	Scanning electron microscope
PVD	Physical vapor deposition
CVD	Chemical vapor deposition
DSC	Differential scanning calorimetry
TGA	Thermo gravimetric analysis
XRD	X-ray diffraction
TEM	Transmission electron microscopy
LCC	Life cycle cost

LCA	Life cycle analysis
SiC _p	Silicon carbide particles
MPa	Mega-Pascal
GPa	Giga- Pascal
PM	Powder Metallurgy
ENF	End Notched Flexure
DCB	Double Cantilever Beam
MMB	Mix Mode Bending