CURE KINETICS OF EPON 828 CURED WITH TETA

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ABSTRACT

The curing reaction of diglycidyl ether of bisphenol A (DGEBA) with triethylene tetra amine (TETA) were studied with a differential scanning calorimeter (Perkin-Elmer DSC 6) under dynamic and isothermal conditions in the range 50-80 °C .A computerized data acquisition system was used to collect and process rate and integral heat of reaction data during reaction.

A mathematical kinetics model describing the reaction is proposed, the rate constants were determined at different temperature, and the heat of reaction was found to be 24.5-25 kcal/kmol. Good agreement between mathematical kinetics model and experimental data was found.

KEYWORDS

Cure kinetic, epoxy resin, DSC.

دراسه تفاعل Epon 828 مع TETA

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الخلاصة

تم في هذا البحث دراسة تفاعل أ نضاج Diglycidyl Eether of Bisphenol A (DGEBA) مع Tri Ethylene Tetra Amine (TETA) باستخدام جهاز المسح التفاضلي (DSC) نوع (Perkin- Elmer DSC 6) تحت ظروف درجات الحرارة الثابته و المتغيره من (50-80 °C) .

تم استخدام الحاسوب لجمع البيانات و تحليلها.

أقترح نموذج رياضي لوصف التفاعل و حساب ثوابت معدلات التفاعل للدرجات الحراريه المختلفه و كانت حرارة التفاعل (24.5-25 kcal/kmol).

لقد وجد آن هنالك تطابق بين النموذج الرياضي المقترح و النتائج المختبريه.

Eng. & Technology, Vol.25, No.7,2007

Mathematical Model of Autoclave Curing of Epoxy Resin Based Composite Materials

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Received on: 5/5/2005
Accepted on: 7/9/2005

Abstract

Polymer matrix composites using thermosetting resins as the matrix are increasingly finding use in several applications. Process modeling describing the governing curing has played an important role, in improving the fundamental understanding and development of composite fabrication techniques. In present work, the thermokinetic involved in the autoclave curing of fiber-reinforced epoxy has been studied by means of a computer program, using the transient heat conduction equation coupled with kinetic equation, and the initial and boundary conditions. In the analysis the cure assembly is assumed to consist of a tool plate, composite laminate. The temperature distribution and the degree of reaction are obtained as a function of position and time.

Keywords: Mathematical model, curing, epoxy resin

الموديل الرياضي لعملية إنضاج متراكبات الأيبوكسي في جهاز الاوتوكليف

الخلاصة

يشهد استخدام المواد المتراكبة الايبوكسية تطورا كبيرا. ويلعب الموديل الرياضي لعملية الإنضاج دورا كبيرا في فهم هذه العملية وتحسينها وتطويرها.
تم أيجاد مود يل رياضي يقوم بحساب درجات الحرارة و درجة الإنضاج كدالة من الزمن و الموضع ويشمل هذا الموديل على حل معادلة الطاقة (un steady state energy equation) مع إضافة حدود تمثل الحرارة المتولدة (generated heat) نتيجة تصلب الايبوكسي . ويعتمد الموديل الرئيسي على موديل ديناميكية التفاعل الأيبوكسي والذي تم دراسته باستخدام جهاز المسح التفاضلي .

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Eng.&Tech.Vol.26,No4,2008

Study the Adhesion Force of Tubular Shaped Fiber Reinforced Composites

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Received on:11/4/2006
Accepted on:5/12/2007

Abstract

In the present work tubular –shaped fiber reinforced composites were manufactured by using two types of resin epoxy (EP) and unsaturated polyester (UP),each was separately reinforced with glass, carbon and kevlar-49 fibers (filament and woven roving), hybrid reinforcement composites of these fibers were also prepared. The adhesion force test of the prepared specimens was carried out. These adhesion forces exhibited a peak value at a percent of hardener/resin (H/R)= 3% for UP matrix with all type of fiber arrangements while 30% was obtained for EP matrix .Such behavior was declined with increase in temperatures. Glass transition temperatures were determined from these measurements, and found to be 90°C for EP–glass and 83 °C for UP –glass composites.

Keywords: **Adhesion force, tubular shaped, composites**

Tikrit Journal of Eng. Sciences/Vol.15/No.4/December 2008, (27-44)

STUDY THE CREEP OF TUBULAR SHAPED FIBER REINFORCED COMPOSITES

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ABSTRACT

In present work tubular –shaped fiber reinforced composites were manufactured by using two types of resins (Epoxy and unsaturated polyester) and separately reinforced with glass, carbon and kevlar-49 fibers (filament and woven roving), hybrid reinforcement composites of these fibers were also prepared. The fibers were wet wound on a mandrel using a purposely designed winding machine, developed by modifying an ordinary lathe, in winding angle of 55° for filament. A creep test was made of either the full tube or specimens taken from it. Creep was found to increase upon reinforcement in accordance to the rule of mixture and mainly decided by the type of single or hybridized fibers. The creep behavior, showed that the observed strain tends to appear much faster at higher temperature as compared with that exhibited at room temperate. The creep rate also found to be depending on fiber type, matrix type, and the fiber /matrix bonding. The creep energy calculated from experimental observations was found to exhibit highest value for hybridized reinforcement.

KEYWORDS

Creep, tubular shaped, composites

Eng, & Tech. Vol. 26,No.8 2008

Diffusion of various liquids to tubular shaped fiber reinforced composites

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Abstract

In present work tubular –shaped fiber reinforced composites were manufactured by using two types of resins (Epoxy and unsaturated polyester) and separately reinforced with glass, carbon and kevlar-49 fibers (filament and woven roving), hybrid reinforcement composites of these fibers were also prepared. The fibers were wet wound on a mandrel using a purposely designed winding machine, developed by modifying an ordinary lathe, in winding angle of 55° for filament. Various liquids were allowed to diffuse into the composite samples, where all composite samples were immersed in water, HCl (0.5N, IN) and NaOH (0.5N, 1N). The exhibited behaviors were mainly explained in accordance to Fick's –law. However, there were few case of anomalous behavior observed.

The observed difference in diffusion rate for acidic and basic solutions may be explained in terms of different permeability of OH- and H+ ions in the composite samples. This permeability was also found to be affected by the debonding process which might be initiated by the liquid penetration. Diffusion coefficients were also deduced and their relatively higher values are indicative for some damage mechanism taking place in the composite and not the pure matrix. UP composite exhibited higher values than EP composite which suggest that higher damage has taken place in UP-composite.

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Study Diffusion of Water to Carbon Fiber /Epoxy Composite

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Received on: 31/3/2008
Accepted on:26/6/2008

Abstract

In present work moisture diffusion properties of the woven fabric carbon/epoxy laminates were determined using weight gain, experiments over a temperature range of 30 ^{0}C to 60 ^{0}C. The laminate–shaped fiber reinforced composites were manufactured by using epoxy resin (Epon 828) cured with TETA (tri ethylene tetra amine) reinforced with carbon fiber. The prepared Composite samples were immersed in water for several weeks and moisture content was measured. The diffusivity of the composite was found to obey the Arrhenius relation over the entire range of temperature. Analytical solution to Fick's law is done by build up computer program in Matlab. Good agreement between experiment data and analytical solution of Fick's Law.

Keywords : Composite, Diffusion, Laminate, Activation Energy.

دراسة انتشاريه الماء لمواد متراكبة من الياف الكاربون والايبوكسي

الخلاصة

في البحث الحالي تم دراسة عملية انتشار الماء في مواد متراكبة. تم تصنيعها من راتنج الايبوكسي(أيبون828) المقسى بالمصلد(TETA) و المسلح بالالياف الكاربونية. تم غمر النماذج في الماء لعده اسابيع وبدرجات حراره تتروح من 30 – 60 درجه سيليزية. فسر السلوك الذي أظهرته عمليه الانتشار في النماذج حسب قانون فك (Ficks-law) . تم حل معادله (Ficks-law) باستخدام برنامج حاسبه وجد هنالك تطابق بين الدراسه النظريه والتحليليه .

Nomenclature

c	The concentration (mole/liter)
C_p	Specific heat (J/g °C)
D	Diffusion coefficient (cm^2/sec)
E_d	Activation energy, kj/mole
h	Thickness of lam
inate, mm	
K	Thermal conductivity (kcal/h °C)
M	Mass percentage of water absorbed (%)
R	Gas constant, j/mol K
t	Time (s)
T	Temperature, ^{o}C

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Electrical And Thermal Properties Of Epoxy Resin Filled With Carbon Black

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Received on:2 /12 /2008
Accepted on:4 /6 /2009

Abstract

Thermal and electrical conductivity of an insulating polymer can be achieved by dispersing conducting particles (e.g., metal, carbon black) in the polymer. The resulting materials are referred to as conducting polymer composites. Electrical and thermal properties of epoxy-carbon black composites were studied in this work. The weight fraction of the carbon blacks ranged from 0.0 up to 20 wt % with the epoxy resin. By discharging a high voltage through the composite it was found that the resistivity of the composite decreased. Epoxy-carbon black composites show significant differences from the neat epoxy resin measured in the frequency range. Conductivity percolation threshold was found when carbon blacks is added in the range of 1 and 2 wt%. It was found that the epoxy/ carbon black composites have better thermal properties than the neat epoxy.

Keywords: Thermal conductivity, electrical conductivity, carbon black, epoxy

دراسة الخواص الحرارية والكهربائية لراتنج الايبوكسي المدعم بمسحوق الكاربون

الخلاصة

يمكن تحقيق التوصيل الحراري والكهربائي للبوليمرات العازله وذلك باستخدام دقائق مثل المعادن والكاربون الاسود . حيث يشار للمواد الناتجه بالمواد المتراكبه الموصله ذات الاساس البوليمري . في هذا البحث تم دراسه خواص التوصيل الحراري والكهربائي لراتنج الايبوكسي المدعم بأسود الكاربون بنسب مئويه وزنيه تتراوح من 0 الى 20 % .وجد عند امرار فولتيه عاليه خلال النماذج المدعمة حدوث انخفاض واضح في المقاومه النوعيه مقارنه بنماذج الايبوكسي غير المدعمه بأسود الكاربون . لوحظ حدوث ظاهرة (percolation threshold) عند النسب الوزنيه لاسود الكاربون من 1-2% . ووجد تحسن في خواص التوصيل الحراري لمتراكبات الايبوكسي المدعم باسود الكاربون مقارنه بالايبوكسي غير المدعم

Nomenclature

A	Across sectional area (mm^2)	t	Temperature (°K)
CB	Carbon black	v	Volume fraction of filler (%)
d	Thickness of the sample (mm)	v_c	Critical volume fraction
DC	Direct current	ΔV	Critical volume fraction
K	Thermal conductivity (W/ m-K)	**Greek Letters**	
I	Current (ampere)	σ	Electrical conductivity (s/cm)
R	Electrical resistivity (Ω. Cm)		

Mathematical Model For Autoclave Curing Of Unsaturated Polyester Based Composite Materials

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Abstract

Heat transfer process involved in the autoclave curing of fiber-reinforced thermosetting composites is investigated numerically. A model for the prediction of the temperature and the extent of the reaction across the laminate thickness during curing process in the autoclave of unsaturated polyester based composite has been developed. The governing equation for one dimensional heat transfer, and accounting for the heat generation due to the exothermic cure reaction in the composites had been used. It was found that the temperature at the central of the laminate increases up to the external imposed temperature, because of the thermal conductivity of the resin and fiber. The heat generated by the exothermic reaction of the resin is not adequately removed; the increase in the temperature at the center increases the resins rate reaction, which in turn generates more heat.

Key words: Mathematical model, Autoclave, Curing, Composite, Unsaturated poly ester.

نمذجة رياضية للانضاج بالاوتوكليف لراتنج البولي استر لمواد متراكبة

الخلاصة

تم دراسة عملية انتقال الحرارة في جهاز الاتوكليف لإنضاج المواد المتراكبة باستخدام راتنج البولي أستر الغير المشبع حيث تم أيجاد نموذج رياضي يقوم بحساب درجات الحرارة و درجة الإنضاج كدالة من الزمن و الموضع لعمليه إنضاج البولي استر غير المشبع في جهاز الاوتوكليف ويشمل هذا النموذج على حل معادلة الطاقة (unsteady state energy equation) مع إضافة حدود تمثل الحرارة المتولدة (generated heat) نتيجة تصلب البولي أستر غير المشبع. لقد وجد ان درجه الحرارة في منتصف طبقات المادة المتراكبة تزداد حتى تصل إلى درجه حرارة الإنضاج . ونتيجة للحرارة المتولدة من تفاعل الإنضاج الباعث للحرارة ,و لكون الموصلية الحرارية للراتنج والليف واطئة ولايمكن إزالة الحرارة بصوره جيده لذلك سوف ترتفع الحرارة في منتصف الطبقات والذي سوف يولد المزيد من الحرارة .

Nomenclature

A	Pre-exponential factor,
C_f	Specific heat, J/g °C Specific heat, J/ °C
E	Activation energy, Kj/mole
h	Thickness of laminate, mm
H_r	Total heat of reaction, j/g
K	Reaction rate constant, s^{-1}
K	Thermal conductivity, Kcal/h °C
m&n	Empirical exponents in the cure kinetic model
p	Intercept in Eq. (15)
q	The heat generated by the curing resin, j/g sec

IMPROVE THE PERFORMANCE OF EPOXY RESIN AND POLY (VINYL BUTYRAL) AS AN ALUMINUM METAL ADHESION+

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Abstract:

The present work is mainly concerned with study the performance of epoxy resin which blended with poly (vinyl butyral) in order to be used as adhesive for aluminum metal. A different weight ratios of poly (vinyl butyral) was blended with epoxy resin (10-90 wt %) and these blends were cured at different conditions; time (10-60) minutes and temperature (100-200 C^0), different mechanical properties (shear stress, elongation and peeling stress) were carried out on the prepared samples.

Box – Wilson design method was adopted to find useful relationships between the three variables [(weight ratios and curing conditions (time & temperature)] with mechanical properties shear stress, elongation and peeling stress , it was found that the best adhesive properties of the prepared sample (i.e. best mechanical properties) obtained with the weight ratio of (40) wt% epoxy resin and (60) wt% poly (vinyl butyral) while the best curing condition obtained at a temperature of 160 C^0 for (30) min.

المستخلص :

البحث الحالي يدرس تحسين أداء راتنج الايبوكسي بعد خلطه مع بولي فنيل بيوترال وذلك لاستعماله لاغراض لصق معدن الالمنيوم ، تم أستخدام نسب وزنية مختلفة من راتنج الايبوكسي مع بولي فنيل بيوترال تتراوح بين (10–90 %) كنسبة وزنية وهذة المخاليط تم انضاجها في ضروف مختلفة من درجات حرارة وزمن حيث تم استخدام درجات حرارة إنضاج تتراوح بين (100–200) درجة سيليزية وزمن انضاج يتراوح بين (10–60) دقيقة ، بعد ذلك تم قياس الخواص الميكانيكية (جهد القص ، الاستطالة وجهد التقشر) للنماذج المحضرة.

تم أستخدم تقنية Box – Wilson design من اجل ايجاد علاقات تربط المتغيرات الثلاثة (النسب الوزنية المختلفة ، درجة حرارة انضاج وزمن إنضاج) مع فحص الخواص الميكانيكية المختلفة وهي جهد القص ، الاستطالة وجهد التقشر ، حيث وجد أن احسن خواص لصق والمتمثلة بافضل خواص ميكانيكية تم الحصول عليها عند النسبة الوزنية 40% من راتنج الايبوكسي و60% من بولي فنيل بيوترال بينما احسن درجة حرارة إنضاج كانت هي 160 درجة سيليزية وعند زمن إنضاج قدره 30 دقيقة.

+ Received on 30/5/2007 , Accepted on 17/1/2008

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Accepted to appear at Diyala journal of engineering sciences (2010)

MODELING OF THE CURE OF EPOXY BASED COMPOSITE, HEATED AT CONSTANT TEMPERATURE IN CYLINDERICAL MOULD

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ABSTRACT

The heat transfer process involved in the curing of fiber-reinforced thermosetting composites is investigated numerically. This composite is made of woven fiber and resin and placed in a cylindrical mould. The governing equation for one dimensional heat transfer, and accounting for the heat generation due to the exothermic cure reaction in the composites had been used. A finite element method is developed to solve the mathematical model problems for composites manufacturing.
The solution of the complete mathematical system gives, both, the temperature and the degree of reaction as functions of time and position. It was found that the temperature at the central of the sample increases up to the external imposed temperature, because of the thermal conductivity of the resin and fiber. The heat generated by the exothermic reaction of the resin is not adequately removed; the increase in the temperature at the center increases the resins rate reaction, which in turn generates more heat.

Keywords : Mathematical model, curing, epoxy resin, cylindrical mould