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The Influence Of Bonding Mode and Wire Setting On The Stresses Of Metal Matrix Composite Reinforced with Continuous wire

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Abstract

This paper deals with the influence of bonding mode and the setting of the reinforcement between matrix and reinforcement for metal matrix composite on the induced stresse and also on the value of the reinforcing A charpy specimen with notch was used as a specimen test for comparison . Analytical model was built via ANSYS 8.1 software with a nonlinear solution based on the elastic –plastic behavior for both phases (matrix and reinforcement).Five miscellaneous cases for bonding mode and the setting of the reinforcement (wire with 1 mm diameter) were used .The results exhibit the eloquent perfect bonding on the value of reinforcing and also the setting (semi-circle) of the reinforcement in the matrix which gave the best reinforcing.

الخلاصة

تناول هذا البحث دراسة تاث ي اسلوب الالتصاق ووضعية مادة التقوية ب ا ادة الاساس ومادة التقوية ادة متراكبةعلى الاجهادات ا تولدة وكذلك مقدارالتقوية داخل ا ادة ا تراكبة اعتماد عينة جار القياسية ذات ا ز لاختبار الصدمة كعينة اختبار. بناء ذا الغرض الا وذج التحليلي باستخدام برنامج ANSYS 8.1 ا تطور وباسلوب ا ل الغ خطي مع اعتماد سلوك ا ادة ا رن اللدن لكلا الطورين (مادة التقوية وا ادة الاساس). استخدام س حالات متنوعة لاسلوب الالتصاق ووضعية مادة التقوية (سلك يف بقطر 1ملم)وقد اظهرت النتائج التاث البالغ لاسلوب اللصق ا ثا على مقدار التقوية كذلك وضعية الدائرة الناقصة ادة التقوية (السلك) داخل ا ادة الاساس حيث اعطت افضل تقوية.

Keywords: Metal matrix composites , fiber, ansys.

Introduction

The strength of the composite and its behavior depends upon many factors(1), one of them, is the bonding strength between the matrix and the reinforcement that has great effect on specifying the mechanical characteristics of it and the orientation of the fiber in the matrix(2) also on the volume fraction of the reinforcement(3). The metal matrix composite is one of the most important types of the composite materials, which is use in different applications and depends strongly on the bonding forces between the matrix and the reinforcement (the interface nature) besides the

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properties of the reinforcement materials.

This paper deals with the effect of bonding forces between the matrix and the reinforcement and geometric setting on the stresses in the metal matrix composite and its location besides its values.

The Simulation Work:

A simulation technique is used via finite element method to build a 3D model for three point bending test specimen according to ASTM –E23 (Fig, 1) where [a brick 45] 3D element is used for the original and for the composites models, Fig.(2)also have been specified the locations of the applying load and constrained points of the specimens. The original model (without fibers) was used for comparison with composite models.

3D models for three point bending test composite specimens were built with continuous wire at different locations and in different geometric setting of metal reinforcement.
One, wire was used at different locations and sets, the aim of this variation and layout is to find out the nature and values of the induced stresses.
After building of these models was complete, the nature of the bonding strength between the wires (reinforcement materials) and the matrix was placed and classified into two modes: perfect bonding strength, not strong bonding strength. The first modes represented by very high bonding forces where is no slip will occur between the reinforcement and the matrix [(4)]we suppose here a perfect bonding is present: the two materials (matrix and the reinforcement) have the same strain (ISO –strain)

$$\varepsilon_c = \varepsilon_f = \varepsilon_m \qquad (5)$$

The composite material obeys the rule of mixture. And the other mode of the bonding is the not strong bonding where a slipping will occur between the reinforcement and the matrix at loading depending upon the shear stresses parallel to the fiber surface, in this case the composite material not obey the rule of averages.
Both modes were used when constructing models of metal matrix composites specimens reinforced with metal fibers, first mode (perfect bonding) was used via merging the volume of the matrix and the volume of the reinforcement material (fibers) by the command *overlap* and with the uses mesh just for one time. The second mode (poor bonding) or the imperfect bonding, 3D *contact* technique was used to describe the relation bonding between the matrix and the reinforcement with introduing the friction coefficient and the maximum interfacial shear stress, with ability to change these parameters with respect to the nature of bonding.

The executed models

1-Marix only (Fig.(1))
2- One wire with the same length of the specimen of matrix.Fig,(3)
3-One wire was used as an arc at an angle of 7^0 with the horizontal line . Fig.(4).

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4- One wire was used as an arc with an angle 10^0 with the horizontal line .fig.(5).

5- One wire was used as semi-circle .Fig.(6)

Matrix and Reinforcement Materials:

Aluminum and its alloys are very attractive materials to act as matrix in MMC, among the aluminum –based alloys, aluminum –silicon alloys are very convenient to produce MMC by applying the liquid metallurgy technique .In this work we introduce the essential mechanical properties of this alloy as an input data, like modulus of elasticity, poisons ratio ,while the reinforcement material was stainless steel fiber with big diameter (1mm) and used for its basic properties (modulus of elasticity, Poissons ratio) .

Results and Discussion:

Table(3), illustrates the whole results including the stresses and the displacement at the notch of the specimens:

A nonlinear solution was used and an elastic-plastic with linear work hardening was assumed for the matrix and the reinforcement. According to these results we can see that the matrix has a plastic behavior and this is valid for the second and third cases that the stress at the notch was higher than the yield stress and that is an indication which the crack will nucleate at the notch .from the third case (Fig.(9)), the deflection at the notch was more than at first and the second cases that means, the wire in this case (reinforced by slip) acts as a void not as a reinforcement in spite of a friction coefficient being equal to 0.6(µ)and the interfacial shear stress was a 20MPa (poor bonding). A comparison between the second case (one straight wire along the specimen) with perfect bonding with the matrix and the third case (reinforcement by slip)(using contact technique)shoes that the second case(Fig.(8)) is more positive with the reinforcing by slip at the same value of the interfacial shear stress and friction coefficient .Now when using the wire as an arc Fig.(5,10) with length shorter than the specimen .the stress value of the at notch decreases ,that means a reinforce erreat the takes place and also the deflection of the specimen decreases too.

The fifth case (Fig. (4,11)) which is used here the wire is used as an arc with its ends coinciding with the ends of the specimen (perfect bonding assumed), the deflection is approximately the same compared with later one.

The last case (Fig.(6,12)) in which the wire is placed in the specimen as a semi-circle ,the stress at the notch decreases more than in all cases above ,this placement may represent the best setting for reinforcing specimens under three point bending test or for specimens that suffer flexure stresses. Note that in all cases the reinforcement (wire) sustained the higher stresses

Conclusions:

1- The perfect or by slip reinforcing mode has a large effect on the reinforcing values

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2- The geometric setting in the specimen (composite) has a large effect on the reinforcing value.

3- Limiting the ends of the continuous fibers has appositive effect on the reinforcing.

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Table(1) Mechanical properties of the metal fibers

UTS N/mm^2	Proof stress N/mm^2	Elongation %
660	440	30

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Table(2) Mechanical properties Matrix

Yield Strength N/mm^2	Tensile Strength N/mm^2	Elongation %
100	120	3

Table(3)The relation between the reinforcing type and stresses and displacement that are induced in the specimens (*. Stress at the notch)

No: of case	***Reinforcing type***	***Stress MPa***	***Displacement mm.***	**Fig. No:**
1	Matrix only	124.578*	0.0806	7
2	Perfect: straight continuous wire.	*126.211*	0.0886	8
3	By slip	*127.9**	0.0926	9
4	Arc ;by slip	*93.151*	0.0656	10
5	continuous arc ;perfect bonding	*104.41*	0.0663	11
6	Semicircle: perfect bonding	94.014* 347.286	0.0557	12

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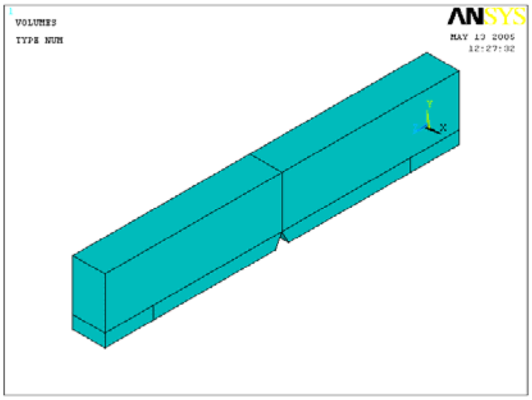

Fig.(1) Charpy specimen

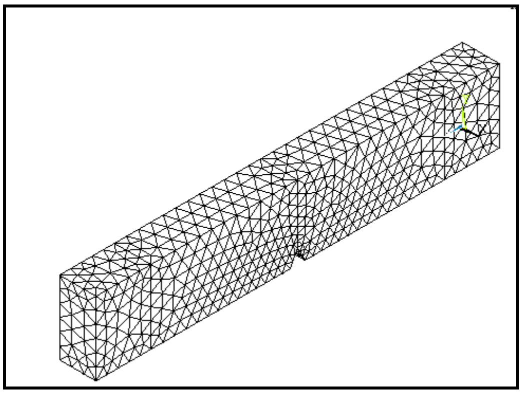

Fig.(2)Finite element model

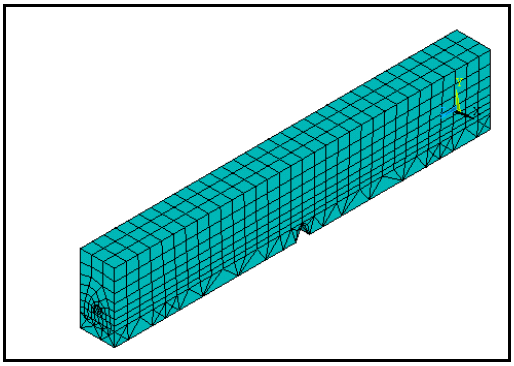

Fig.(3).Finite element model for specimen reinforced with one wire

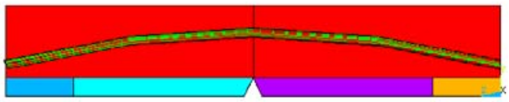

Fig.(4) .One wire was used as an arc with an angle 7^0 with the horizontal line

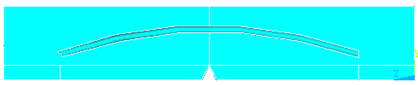

Fig.(5) .One wire was used as an arc with an angle 10^0 with the horizontal line

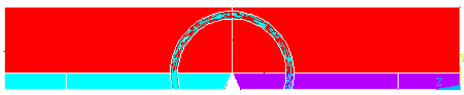

Fig.(6). One wire was used as semi-circle .

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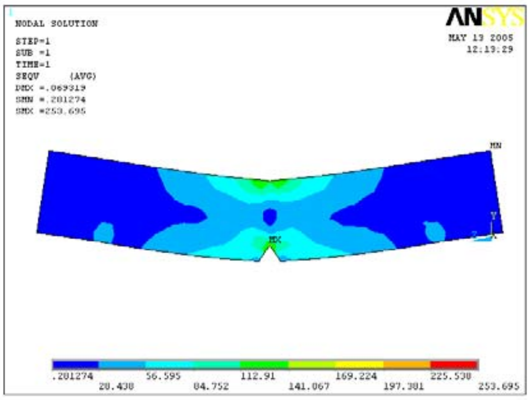

Fig.(7).Matrix only

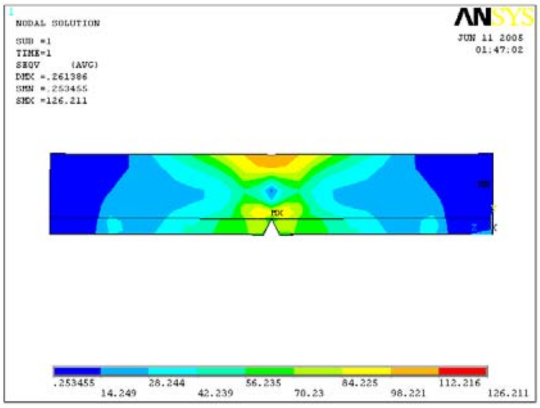

Fig.(8)Straight wire, perfect bonding

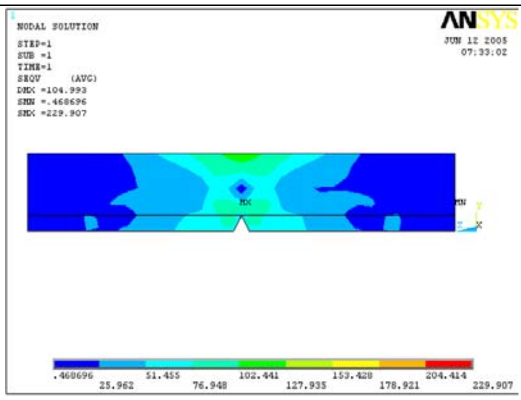

Fig.(9) Straight wire, reinforcing by slip(stresses)

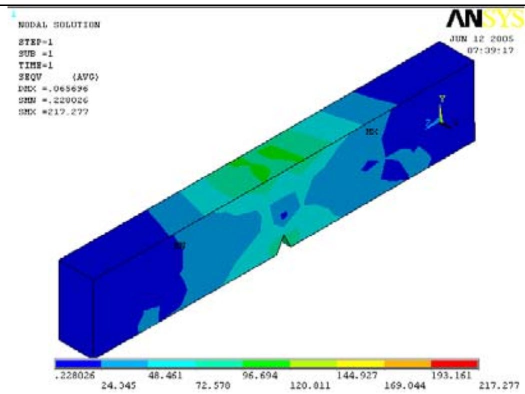

Fig.(10).Arc wire reinforcing by slip(stresses)

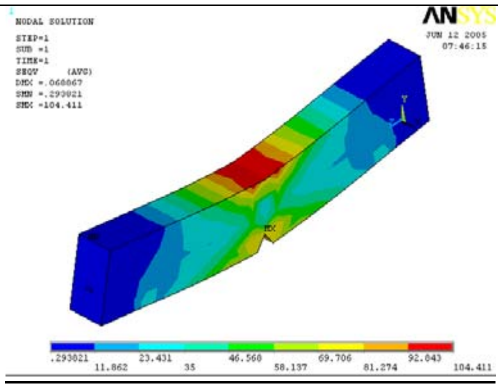

Fig.(11). Continuous arc, perfect bonding (stresses)

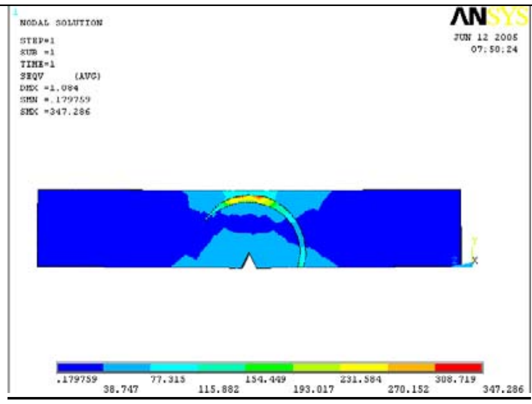

Fig.(12).Semi- circle wire ,perfect bonding(stresses)