TENSILE BEHAVIOR OF TEMPERED AA5050/Al_2O_3 METAL MATRIX COMPOSITES USING RVE MODELS: EXPERIMENTAL VALIDATION

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Abstract

The present work was aimed to calculate the influence of H32, H34, H36 and H38 temperaments on the tensile behavior of the AA5050/Al_2O_3 metal matrix composites. The results obtained from the finite element analysis were verified with those of experimentation. The tensile strength and von Mises stress was greatly improved with the temperament, H38.

Keywords: *AA5050, Al_2O_3, H32, H34, H36, H38, tensile behavior, finite element analysis.*

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1. INTRODUCTION

Alumina Al_2O_3 is found as the mineral corundum. It provides superior abrasion, high temperature and chemical resistance, and is also electrically insulating. This material has an excellent cost-to-part life performance record. Purity Applications include wear- and heat-resistant liners, mechanical and pump seals, nozzles, semiconductor equipment components, insulators, etc. AA5050 is famous for its very good corrosion resistance and good workability properties. It is commonly used in the manufacture of refrigerator trim and coiled tubes. The fracture of particle reinforced metal matrix composites is dependent on the particle strength and particle/matrix interface strength. The toughness decrease slightly with decreasing particle size, the effect of particle size is less because decreasing particle results in a lower inter-particle spacing [1-8].

The present work was focused on the effects of temperaments such as H32, H34, H36 and H38 on the properties of alumina (Al_2O_3) reinforced AA5050 composites. The results obtained the finite element analysis (FEA) were validated with those of experimentation.

2. MATERIALS AND METHODOLOGY

The matrix material used in the present work was AA5050 alloy. The reinforcement material was Al2O3 at 30% volume fraction of the composites with average size 100nm. The matrix alloys and composites were prepared by stir casting process [2, 3].

In this research, a cubical RVE was implemented to analyze the tensile behavior AA5050/Al_2O_3 nanocomposites. The loading on the RVE was defined as symmetric displacement, which provided equal displacements at both ends of the RVE. The large strain PLANE183 element was used in the matrix and the interphase regions in all the models. In order to model the adhesion between the interphase and the particle, a COMBIN14 spring-damper element was used. The stiffness of this element was taken as unity for perfect adhesion which could determine the interfacial strength for the interface region. It is equally important to set the strain rates of the finite element models based on the experimental tensile tests' setups to converge an exact nonlinear solution. Therefore, the rate of displacement in the RVEs was set to be 0.1 (1/min). The discretization of the RVE cell is shown in figure 1.

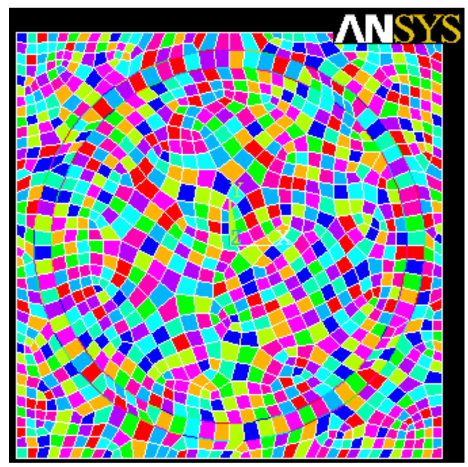

Figure 1: Discretization of RVE model.

The AA5050 alloys were tempered for H32, H34, H36 and H38 as follows:

- H32 - heat treated at 345°C, held at temperature at 150°C.
- H34 - heat treated at 345°C, held at temperature at 100°C.
- H36 - heat treated at 345°C, held at temperature at -80°C.
- H38 - heat treated at 345°C, held at temperature at -30°C.

3. RESULTS AND DISCUSSION

For the temperament H32, the tensile strength of AA5050/Al_2O_3 composite specimens had low tensile strength, whereas it was high for the temperament H38 (figure 2). The experimental values are lower than those obtained from finite element analysis.

The effect of temperaments on the tensile strain is shown in figure 3. The trend is same as that of the tensile strength. The increasing order of the Young's modulus is H32 < H34 < H36 < H38 as shown in figure 4. The increasing order was observed experimentally. But, the variation of the Young's modulus was negligible as observed from the FEA results.

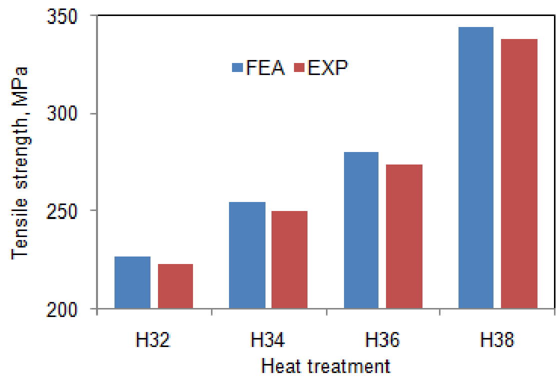

Figure 2: Effect of heat treatment on tensile strength.

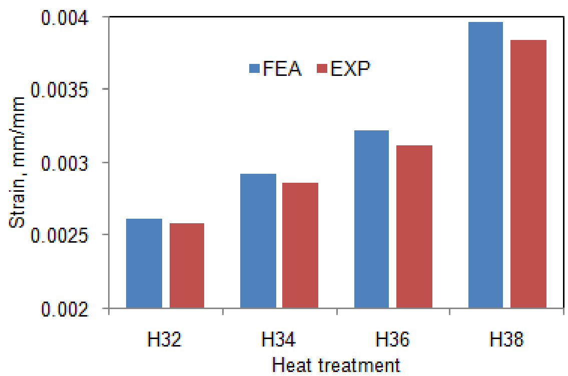

Figure 3: Effect of heat treatment on tensile strain.

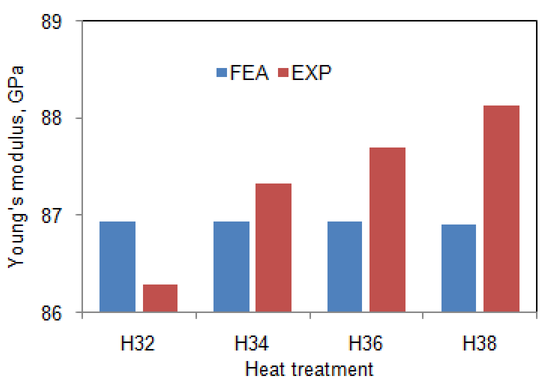

Figure 4: Effect of heat treatment on Young's modulus.

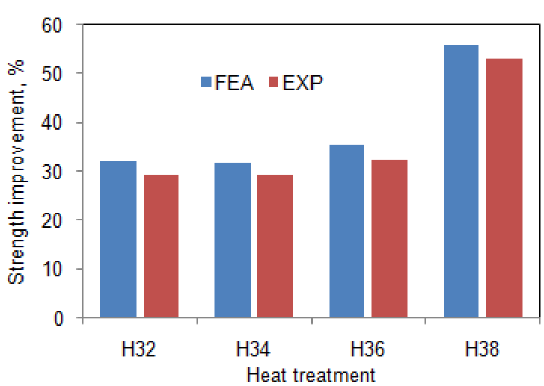

Figure 5: Effect of heat treatment on improvement of strength.

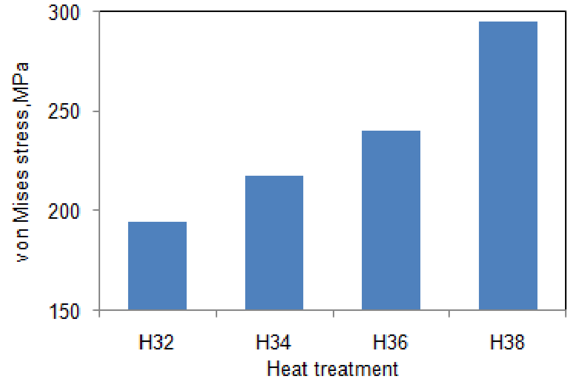

Figure 6: Effect of heat treatment on von Mises stress.

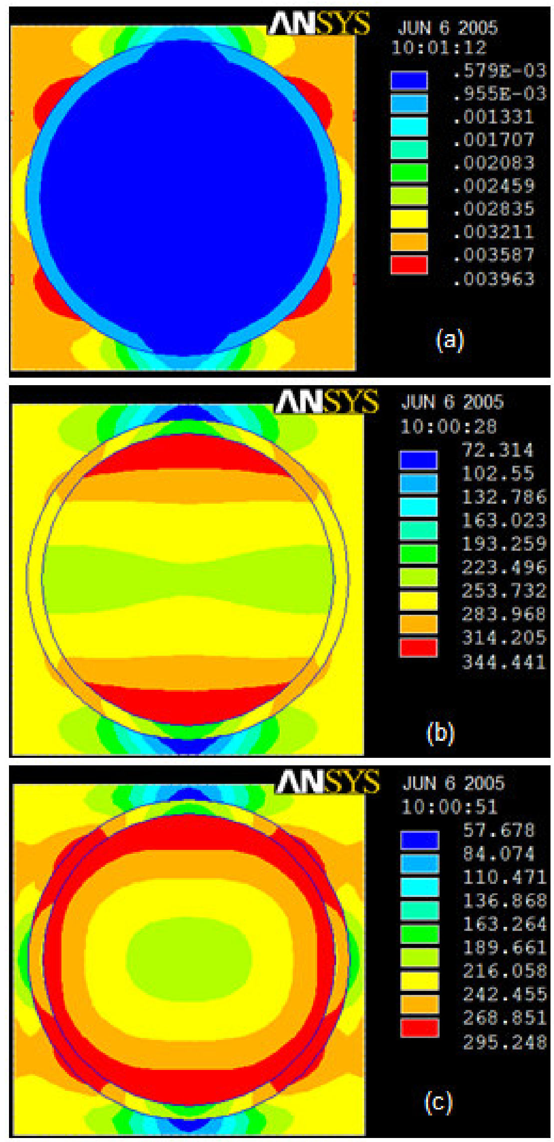

Figure 7: FEA results for heat treatment, T6 (a) tensile strain, (b) tensile strength and (c) von Mises stress.

The strength improvement in the metal matrix composite is computed as follows:

$$\% \text{ strength improvement (FEA)} = \left(\frac{\sigma_{ufea} - \sigma_{um}}{\sigma_{um}}\right) \times 100 \qquad (1)$$

$$\% \text{ strength improvement (Exp)} = \left(\frac{\sigma_{uexp} - \sigma_{um}}{\sigma_{um}}\right) \times 100 \qquad (2)$$

where, σ_{ufea}, σ_{ufea} *and* σ_{um} are, respectively, the tensile strength obtained FEA, the tensile strength obtained experimentation and the tensile strength of the matrix.

The improvement of tensile strength was high on account of Al_2O_3 reinforcement particle inclusion and heat treatment (figure 5). The improvement in the tensile strength for the temperaments H32, H34 and H36 was nearly the same (about 32%). But, the improvement in the tensile strength for temperament H38 was almost 50%. The von Mises stress was found to be high with temperament H38 and it was low with temperament, H32 (figure 6). The FEA results for temperament H38 condition are shown in figure 7.

4. CONCLUSION

The results obtained from FEA procedure were in good agreements with the experimental results. The strength improvement was highly significant with temperament, H38 for AA5050/Al_2O_3 metal matrix composites.

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