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Temperature evolution at fatigue crack tip area after laser shock peening

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Abstract

In this work a thermodynamic peculiarities of fatigue crack propagation at titanium alloy Ti64 after laser shock peening were studied. The plane samples were weakened by notch to initiate fatigue crack. An area around notch was processed by laser shock peening. This made it possible to create a compress residual stress up to 1 mm depth. The infrared thermography method was used to analyze a temperature field at crack tip. An increase in heat dissipation during fatigue crack propagation after laser shock peening was found.

1. Introduction

The creation of new structural materials and their operation under various conditions require the development of existing and the creation of new methods for predicting the durability and strength of structures. At present time, a laser shock peening (LSP) technique for hardening metals and alloys is being actively developed [1]. During LSP an elastic-plastic wave changes surface layer and creates the compress residual stress that make it possible to use this phenomena for increase life time of materials and engineering construction. To date, non-destructive testing methods are widely used by various scientific groups to assess the condition of materials and structures [2, 3].

In this work, the energy approach [4-6] to describe a material state under deformation. The main assumption of this idea is that, from a physical point of view, the energy balance at the crack tip area plays a decisive role in the propagation of a fatigue crack is used to study an effect of laser shock peening on fatigue crack propagation. The main goal of this work is determining of dissipative features samples after laser shock peening during at fatigue crack propagation based on infrared thermography [7-9].

2. Experimental conditions and results

A series of plate samples made from titanium alloy Ti64 were tested. Samples had stress concentrator. The area around the stress concentrator was machined by laser shock peening technique. During fatigue tests the samples were subjected to cyclic uniaxial loading with constant stress amplitude. The crack length in the course of the experiment was measured by the potential drop method. For measure the temperature field at the crack tip the method of infrared thermography based on FLIR SC5000 camera was used.

The temperature field was recorded in blocks of 10 seconds for different crack lengths. For analysis of temperature fields the mean value of process zone and changes at each measurement were used. Figure 1 illustrates dependence between crack length and increase of temperature at crack tip during infrared measurement. After 10 mm the sharp increase is observed for both clear and LSP samples. There is not effect by laser shock peening.

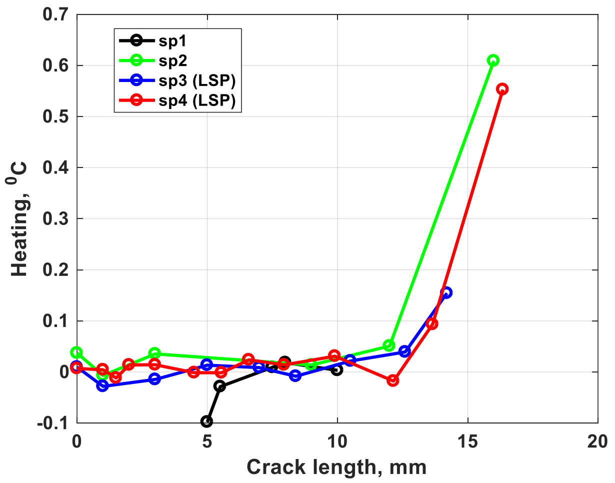

Fig. 1. *Increase of temperature in blocks measurement of infrared data.*

But LSP samples demonstrate higher heating, figure 2, during slowly crack propagation then clear samples. The dependence between crack rate and its length is presented in figure 3.

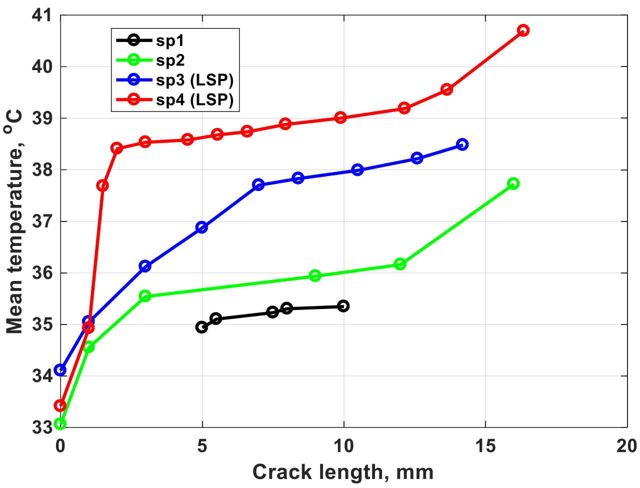

Fig. 2. *Dependence between temperature at crack tip and crack length*

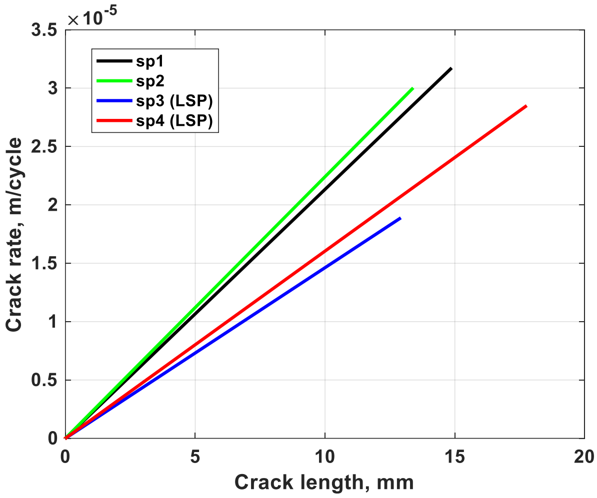

Fig. 3. *Dependence between crack length and its rate*

The trends of average temperature of treated and untreated samples approximately coincide, but the temperature value itself is significantly higher in treated samples at the same crack lengths as in untreated samples.

3. Conclusion

The influence of the laser shock peening process on the thermal dissipation during fatigue crack propagation in the titanium alloy Ti64 samples has been investigated. It is shown that the post-LSP samples do not exhibit any particular characteristic in the heat dissipation pattern. The temperature value of the treated specimens is higher for the same crack length. This increase in heat dissipation is probably caused by plastic deformation in surface layer caused by laser shock peening process.

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