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Phase boundary texturing influence on laminated compound durability under local thermal effect

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Abstract

Destruction process modeling has been conducted for a laminated material under a local pointed thermal effect. Temperature field dependence on the coating surface texturing parameters has been studied. A mathematical model of the load distribution in the laminated material with wavy coating surface texturing under thermal effect is presented.

Keywords: Mathematical modeling, laminated compound, phase boundary texturing, thermal influence, destruction process.

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1. Introduction

Fixed connection durability under external local pointed effect (striking pointed thermal impacts) is of a particular interest nowadays. Therefore, scientists face an urgent task to develop the new coating types and increase the resistance of already known and used laminated compounds. And there is no doubt that destruction process modeling remains an extremely topical issue.

The obtained modeling results provide the new research level, including controlled formation of the laminated material with specified composition and phase boundary texture.

Phase boundary texturing enables maximum adhesion of the laminated coating to the metal surface.

During the model development the textured phase boundary generatrix of the laminated coating material feasible to be described by a two-dimensional sinusoidal dependence was considered.

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The textured generatrix surface of the laminated non-metallic inorganic nanostructured coating is supposed to be described by the following equation[1]:

$$Z = a\cos(mx)\cdot b\sin(ny) + z_0, \qquad (1)$$

where:

- a – X-axis texturing amplitude;
- b – Y-axis texturing amplitude;
- m – X-axis pitch;
- n – Y-axis pitch;
- z_0 – average thickness of the coating.

2. Influence of the coating surface generatrix texturing on the nature of temperature distribution

Let us now calculate the temperature field[2] at the wavy coating generatrix in non-dimensional values for T/I coordinates from the wavy generatrix equation:

$$T = \frac{I}{(2(at\pi)^{0.5})^{3}}\exp[-(x)^2 + 2a\sin(mx)\sin(my) + (Z_0)^2 + \frac{(y)^2}{4at}]. \qquad (2)$$

The calculations were performed for the following parameters: $Z = z_0 = 2\cdot10^{-5}$ m – the distance from the generatrix midpoint to the surface, $I = 0.02$ – thermal effect source intensity, $\alpha = 0.2\cdot10^{-5}$ m^2/s – thermal diffusivity coefficient, $a = 5\cdot10^{-6}$ m – the amplitude value of the wavy surface, $m = 1\cdot10^{6}$ m^{-1} – the distance between the peaks of the wavy generatrix, $\tau = 100$ s – operation time. The interval from the local thermal impact point is ± 60 μm along the X-axis and Y-axis (Fig. 1).

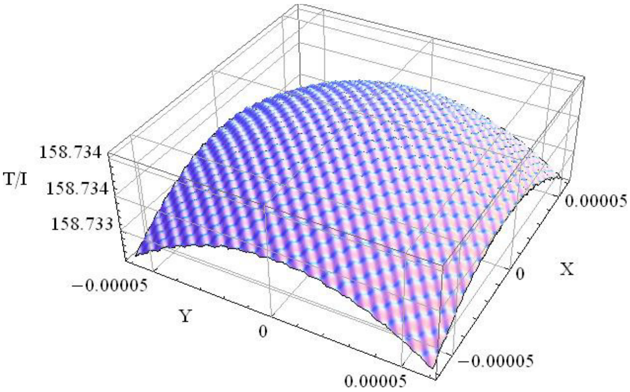

Fig. 1. Temperature field dependence in T/I coordinates at the textured wavy coating surface generatrix with $2\cdot10^{-5}$ m coating thickness along the X-axis and Y-axis in the range from -60 to 60 μm.

It may be seen from the obtained dependence that the temperature value at the textured wavy generatrix decreases from the impact point unevenly with the increasing distance along the X-axis and Y-axis, but with some texture. The wavy temperature change against the background of smooth decrease at the X-axis and Y-axis deviations from the thermal impact point is notable.