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Rapid Assessment of Wear-Resistant Tool Coatings

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Abstract—The operation of a cutting wedge is studied in order to improve coating application on tools. A method of investigating the coating characteristics in plant conditions is outlined. The mechanisms of coating failure in cutting are established. The blunting of tools in the course of operation is analyzed. Coating application is optimized.

Keywords: wear-resistant coatings, cutting tools, tool wear, coating defects, coating failure

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Cutting is the main technique for shaping machine parts. It is a very complex process, with considerable deformation of the metal removed. At the tool's contact areas, the normal (σ_N) and tangential (τ_F) stresses may be thousands of MPa [1]. The heat released in chip deformation is such that the temperature in the cutting wedge may exceed 700–800°C, while the temperature gradients are very high (Fig. 1a).

In the section with constant contact (L_{const}) at 200–500°C, adhesive bonds arise between the tool and workpiece (Fig. 1b). At high cutting speeds, when the temperature is more than 700°C, their atoms may diffuse in opposite directions. In the section with discontinuous contact (L_{dis}), the surface layers of the tool are vigorously oxidized. That intensifies tool wear. To combat wear, the properties of tool materials must be constantly improved [1]. However, the scope for the improvement of uniform hard tools was exhausted in the 1980s. Interest turned to surface hardening. The most common approach is the application of wear-resistant coatings based on the carbides and nitrides of transition metals (TiN, TiC, ZrN, CrN, NbC, TaC, etc.) [2, 3].

Various multilayer coatings have been developed for different cutting conditions. At the same time, cutting processes have been improved. The efficiency of cutting may be enhanced by optimizing the cutting conditions—for example, by reducing the cutting

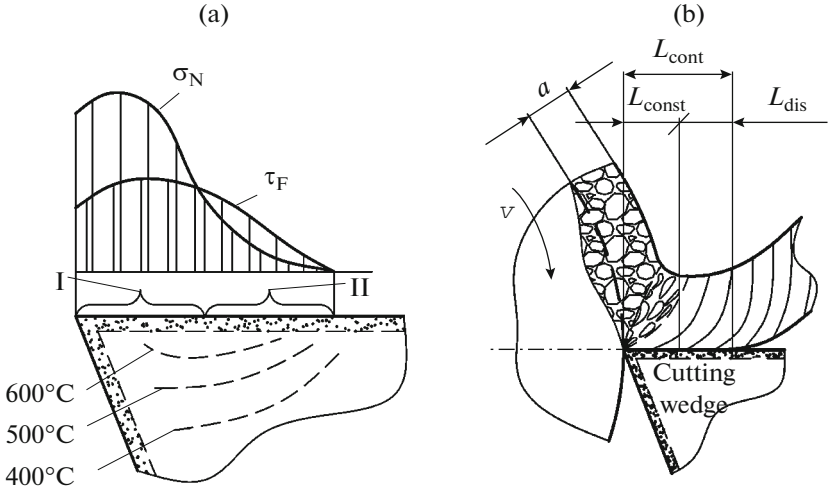

Fig. 1. Operating conditions of wear-resistant coatings (a) and cutting process (b): (I) adhesion and diffusion zone; (II) oxidation zone.