Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 206 (2017) 222–227

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Industrial Engineering, ICIE 2017

Main Regularities of Elastic-Plastic Deformation and Brittle Failure in Micro Volumes of Abrasive Materials under Micro Pressure

O.I. Pushkarev[a], P.U. Bochkarev[b], I.V. Bashkirtseva[a] *

[a]*Volzhsky Polytechnic Institute (branch) Volgograd State Technical University, 42a, Engelsa Street, Volzhsky 404121, Russia*
[b]*Yuri Gagarin State Technical University of Saratov, 77, Politechnicheskaya street, Saratov 410054, Russia*

Abstract

There the results of the investigations of surface strength and fracture toughness of abrasive and other highly rigid materials using the method of micro pressure that provides high degree of localization of the application of an external force action, are presented.
The basic regularities of elastic-plastic deformation and brittle failure in the process of microindentation were determined for all the investigated materials. Based on the studies we also identified the power and energy conditions of elastic-plastic deformation and brittle failure in the process of microindentation of highly rigid and brittle materials. It was found, that in the 1st stage of the deterioration process the specific work of fracture and the stress intensity factor are directly proportional to the size of the stress concentrator, i.e. the imprint diagonal. Therefore the stress intensity factor, that is widely used in mechanics and micromechanics of materials, can be valid only when it is defined in terms of sustainable growth of cracks in the 2nd stage of brittle fracture of the investigated material.
According to test results we obtained the main characteristics of strength and fracture toughness of a number of abrasive materials used in industry and research organizations.

Peer-review under responsibility of the scientific committee of the International Conference on Industrial Engineering

Keywords: method of micro pressure; brittle fracture; micro volumes; origin; critical stress; the relative elastic deformation.

1. Introduction

In recent years serious attention is paid for the issues of surface strength and fracture toughness of the abrasive and other highly rigid materials, including their investigation by the method of micro pressure, that provides a high

* Corresponding author. Tel.: +7-902-364-0353; fax: +7-844-327-5732.
E-mail address: niovisteh@yandex.ru

1877-7058 © 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the scientific committee of the International Conference on Industrial Engineering.
10.1016/j.proeng.2017.10.464

degree of localization of the application of external force impact [1]. This method also makes it possible to study the processes of nucleation and development of cracks, leading eventually to brittle fracture of materials [2].

2. Theoretical part

In the process of microindentation of abrasive materials there are some interconnected processes of elastic-plastic deformation of the material – the formation of the imprint of the size *d* (diagonal of imprint), and brittle fracture of some of its micro volumes – the formation of zone *D* of fragile damageability, including all sorts of discontinuities (cracks, chips) (Fig. 1) in the area of this imprint. The dimensions of this zone are determined by brittle and strength properties of the test material and the test conditions (load *P* applied to the indenter, the indentation angle, indenter geometry) [3].

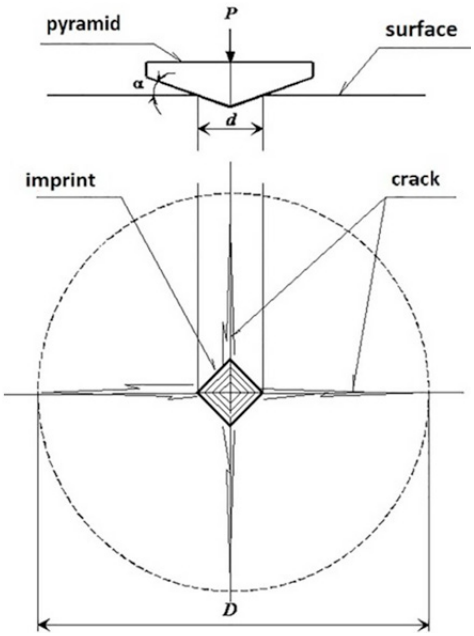

Fig. 1. The indentation's scheme indentation of pyramidal indenter into the test surface of highly rigid materials (*d* – diagonal of imprint; *D* – length of the crack, *α* - angle indentation).

The process of microindentation of highly rigid and brittle materials can not be adequately described with the help of a well-known law of indentation P=f(d), as it is usually done for plastic materials, because in this case ignored the brittle fracture of material in the imprint area is ignored. Therefore there is a necessity of simultaneous study of the process of crack's growth with c increasing the load on the indenter P=f(d).

To set the low indentation in the process of microindentation of highly rigid and brittle materials with the help of the developed device [4-17] testing in a wide range of loads on the indenter by the method of indentation of diamond triangular and square pyramids in the surface of the test solid was implemented. It let us investigate objects of very small sizes (less than 0,5 ÷ 1 mm), including coatings and thin films of almost any material hardness. A wide range of materials (abrasives, rocks, instrumental hard metals, glass, ceramics and piezoelectric ceramics, semiconductors, ferrites), including ultra-hard (diamond, cubic boron nitride) was investigated. The basic regularities of elastic-plastic deformation and brittle fracture at microindentation (correlation coefficient 0,95) were established.

The process of elastic-plastic deformation in the process of the micro indentation of a diamond pyramid id described by a formula.