APPLICATION OF IMPACT DYNAMICS TO ASSESSEMENT OF COMPOSITE EROSION RESISTANCE

Irina Hussainova/ Tallinn University of Technology
Klaus-Peter Schade/SIVUS GmbH, Chemnitz University of Technology

ABSTRACT
Surface damage or material removal during particle – target collision is the result of material response to the contact stresses. Energy dissipation under two bodies collision may be estimated by means of the coefficient of velocity restitution and friction. Approach of impact dynamic and experimental study of dynamic coefficients has been applied to clarify the composite material behaviour under conditions of solid particle erosion. It has been shown that the level of energy dissipation during application and value of dynamic coefficient of friction can be a good guide for material selection for the use in conditions of dynamic loading.

Keywords: Ceramic-Metal Composites; Erosion; Dynamic Coefficients; Energy dissipation

INTRODUCTION
Ceramic-metal composites have many attractive mechanical properties which make them the candidate material for a variety of wear applications. However, erosion behavior of cerments by solid particles is rather complex due to its relation to many factors including particle velocity, collision angles, temperature etc., and energy transmitted to the surface.

The behaviour of non-homogeneous materials cannot be evaluated by only measured mechanical characteristics or by complex of the bulk properties [1]. Erosion rate and/or energy absorbed is not just proportional to the incident kinetic energy of the particle but includes a substantial component attributed to the energy dissipation by frictional deformation and heating at erodent – material interface and, further, this part of the absorbed energy depends strongly on the coefficient of dynamic friction rather than on material hardness.

EXPERIMENTAL, RESULTS AND DISCUSSION
Among composites the WC – 23vol%Co hard metals and CrC2 – 7vol%Ni cerments of the similar hardness (HV 10) value of about 1400 and carbide grains sizes of about 1.5 – 3.0 µm were chosen for testing. Impact variables have been measured by video camera using argon – ion laser for illuminating of a working area (Figure 1).

The disk accelerator allows a precise evaluation of the collision variables. A centrifugal force drives particles through the channels of the accelerating disk that is set in rotation by a circulating belt. Therefore, the particles outlet has a fixed spatial position and a negligible rotation. The particle velocity before impact was 10 and 30 m/s and the collision angle was from 15 up to 85. The 125-µm glass beads were used as the impacting particles.

Based on well-known approach of solid spherical particle impacting a massive flat surface [2] and taken into account the equality of initial rotation to 0, the coefficients of velocity restitution \( k \) and the dynamic friction \( f \) can be calculated as follows:

\[
\begin{align*}
    k &= \frac{v_{re}}{v_{ei}}, \quad f = \frac{v_{ci} - v_{ei}}{v_{ei} (1 + k v_{ci})}. \\
    \text{The boundary conditions for the sliding impact can be written as}
\end{align*}
\]

\[
f_s \leq \frac{2}{7} \frac{1}{1 + k \tan \alpha}.
\]

The energy loss expressed in non-dimensional form can be re-written for the conditions presented in this study as following:

\[
    K^* = (1 - k)^2 \sin^2 \alpha + \frac{2}{7} f_s \left(2 - \frac{f}{f_s}\right) \cos^2 \alpha, \quad (1).
\]
By setting the ratio \( f/f_c \) equalled zero, the first term in equation (1) is recognized as the fraction of the energy loss due to the normal inelasticity alone. The second term corresponds to the fraction of the energy loss due to the tangential effect. Thus, equation (1) becomes:

\[
K^* = K^*_n + K^*_t
\]

Here \( K^*_t \) depends on \( k \) through \( f_c \). Either of the two terms of the normalised energy loss is plotted in Fig. 2.

This reveals that the energy loss at the smaller impact angles is due almost exclusively to the tangential forces. Both compressive and tangential losses have the same order of magnitude at the angle of about 60°. The compressive effects dominate at the angles approaching to normal one.

Energy loss due inelasticity is insufficient because material hardness exceeds particle’s hardness and relatively soft but brittle particle are not able to cause remarkable plastic flow in a hard target. In the case of elastic impact the energy absorbed at oblique impact angles includes a substantial component attributed to the energy dissipation by frictional effects at the particle – target interface and the component of the energy transmitted to the surface depends strongly on the impact angle through the coefficient of dynamic friction. A large portion of the incident energy is dissipated via elastic-plastic deformation and heating in the near surface regions. Figure 3 shows the normalized energy absorbed by two composites.

![Figure 2. Effect of impact angle on the normal and tangential part of the normalized energy loss in the case of WC-23vol%Co composite](image)

![Figure 3. Effect of impact angle on energy absorbed.](image)

The initial stage of material damage can be studied by means of the presented technique and a scanning electron microscope. Single impact craters produced by glass sphere into the surface of WC-Co and Cr3C2-Ni cerments are presented in Fig. 4. The isolated impact sites reveal different mechanisms of material failure for different composites. As compared with the relatively ductile WC-Co, impact site of Cr3C2-based cermet shows much more brittle-like response.

**CONCLUSIONS**

The magnitude of the energy absorbed during each impact is a function of impact angle and frictional effects play the most important role in the energy release under conditions of two-body interaction. To apply the expression and study the impact wear dependence on energy absorbed by a surface, two coefficients have to be estimated. Those are the classical coefficient of velocity restitution, \( k \), and the dynamic friction coefficient, \( f \). The method and test equipment proposed above allow estimating coefficients experimentally and energy absorbed gives evidence on two bodies interaction process. Moreover, tests allow simulation single or multi – impacts of controlled energy. The initial stages of the erosion damage can be examined.

**ACKNOWLEDGMENTS**

The authors would like to express their gratitude to M.S. O. Volobujeva for her nice assistance in the SEM micrographs obtaining; Ph.D. J. Pirso for supplying with the test specimens and the DAAD Foundation, Germany, for funding a fellowship for this study. This research was supported by the Estonian Science Foundation under grant No. 6163.

**REFERENCES**
