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Oxide Ceramics — Erosion Resistant Materials

C. R. Dimond

Morgan Roctec Ltd, Bewdley Road, Stourport-on-Severn, Worcestershire
DY13 8QR, UK

1. INTRODUCTION

‘Wear’ defined as the removal of material, is a subject which is known and experienced by everyone. It impacts strongly on the domestic economy as well as industrial and governmental economies. In spite of this the subject receives little scientific attention and the level of knowledge available, when compared with other scientific disciplines, is low.

Very often wear is accepted as a natural consequence of use; ‘a fact of life’ that cannot be stopped but that can be budgeted for and maintenance schedules written around so as to prevent ‘unexpected’ breakdowns. Although wear cannot be stopped, the rate of wear can be decreased substantially with the use of the ‘best’ wear resistant materials correctly installed.

Wear is normally sub-divided into sections to include abrasive, erosive, adhesive and fretting wear and it is erosive wear which is being considered in this paper. Erosive wear is caused by the impingement of high velocity particles which can be either solid or liquid. The velocity of impingement can range in practical examples from 20 m s\(^{-1}\) for conveying in lean phase pneumatic systems to in excess of 250 m s\(^{-1}\) for radome materials suffering from rain erosion.

One of the materials that has been successfully used to combat erosion and reduce the rate of wear of components in the field of material transportation is sintered alumina and the application of this group of materials only will be considered in this paper.
A recent market research report\(^1\) highlighted the lack of understanding of ceramics by professional engineers and four major concerns were raised:

(i) they are only suitable for high-tech applications and are therefore too expensive;
(ii) they are not impact resistant;
(iii) they cannot be fixed securely;
(iv) they can be used only to effect at high (or low) temperatures;

some of which are addressed in this paper.

2. MATERIAL SELECTION

The choice of class of material is very dependent on the angle of attack of the particles as the relationship between erosion loss and angle of attack is different for different classes of material. For example, with brittle materials the erosion loss increases as the angle of attack increases whereas for ductile materials there is maximum erosion at an impact angle of about 30°.

In many applications concerning particle flow, the actual angle of impact is not known and in practical situations where the conveyed inhomogeneous material has a range of particle sizes and densities, then the angle of impact varies. In most pipe conveying systems impact, and therefore wear, takes place on the outside of the pipe generally at about three or four distinct points around the bend angle, each one covering about 30–60° of the circumference of the pipe. When wear does take place and particularly with ceramic materials, steps can be created thereby increasing the angle of impact. An example of step formed in a 380 mm diameter pulverised coal conveying pipe is shown in Fig. 1. Such changes in local surface profile mean that predicting life of linings is fraught with difficulty and is certainly not an exact science. Despite these obvious complexities, laboratory testing of materials, under a range of conditions, is a worthwhile exercise, not only for comparing materials of one class but also for comparing materials from different classes — although the latter results require substantial analysis before conclusions are drawn.

It is also necessary to take full account of in-service plant trials and use this information to complement the laboratory results so that test methods related to particular applications can be formulated.