THERMASPRAY

Solid Particle Erosion Article

INTRODUCTION

Erosion of materials and components caused by the impact of solid particles can be a life limiting phenomenon for the operation of systems in erosive environments. Solid particle impact erosion has been receiving increasing attention in recent years because of the research and development of coal conversion plants with their need for movement and flow of solid particles into various equipment in these plants. The impact of these particles on moving blades, valve constrictions, pipe joints, and bends, and other surfaces have resulted in severe erosion. Solid particle erosion has been a concern for aerospace systems for many years including sand erosion on helicopter blades and jet engine blades and vanes. In the power generating industry, draft fan blades are exposed to fly ash erosion which severely limits the life of these blades [1].

EROSION AND ITS EFFECTS

Removal of material by solid particle impingement is perhaps the most pervasive of the erosion processes due to the growing utilization of coal in fine particulate form in power generating plants, other combustion product particulates in flue gases in these plants, solid particle impact in jet engines and on helicopter rotor blades, and even in large scale turbines due to spall and subsequent impact of solid oxide particles on downstream blades and surfaces.

Erosion is caused when a gas or liquid carries entrained solid particles that impinge on a surface with velocity. When the angle of impact is small, the wear producing mechanism is closely analogous to abrasion (Figure 1) [4].

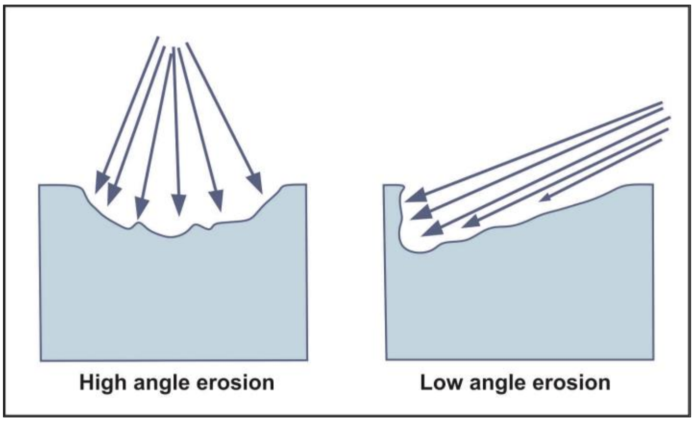


Figure 1: Angle of particle impact determines type of wear mechanism

Thermaspray (PTY) Ltd

Tel: +27 11 316 6520
Fax: +27 11 316 7527
Email: info@thermaspray.co.za
Website: www.thermaspray.co.za

Physical Address:
3 Axle Drive
Cnr Axle Drive & Hammer Rd
Clayville, Extension 11
Olifantsfontein
South Africa

Postal Address:
PO Box 1152
Olifantsfontein
1665

During erosion material is displaced by plastic flow or dislodged by brittle failure (Figure 1). During flight a particle carries momentum and kinetic energy, which can be dissipated during impact, due to its interaction with a target surface. Different models have been proposed that allow estimations of the stresses that a moving particle will impose on a target. The particle will also be subject to stresses and therefore it can undergo damage. It has been experimentally observed that, during the impact the target can be locally scratched, extruded, melted and cracked in different ways. The imposed surface damage will vary with the target material, erodent particle, impact angle, erosion time, particle velocity, temperature and atmosphere among others. Erosion rate, defined as the material loss per unit of erodent mass or volume, *vs.* impact angle, is used to distinguish the two main groups of erosion processes: ductile and brittle (figure 2). During the ductile erosion process (impact at lower angles), ductile materials, like most metals at room temperature, the surface damage develops predominantly by plastic deformation (figures 1 and 2). Among them include cutting, extrusion, adiabatic shear and forging. During the brittle erosion process (impact at higher angles), particle impact produces different types of cracks and chipping, with negligible plastic deformation as shown in figures 1 and 2. However, on a sub-micron scale, there is evidence of plastic deformation underneath the target surface. Other evidences suggest that erosion of materials combines ductile and brittle modes simultaneously, the ratio of them depending on impact angle and material properties [2,3].

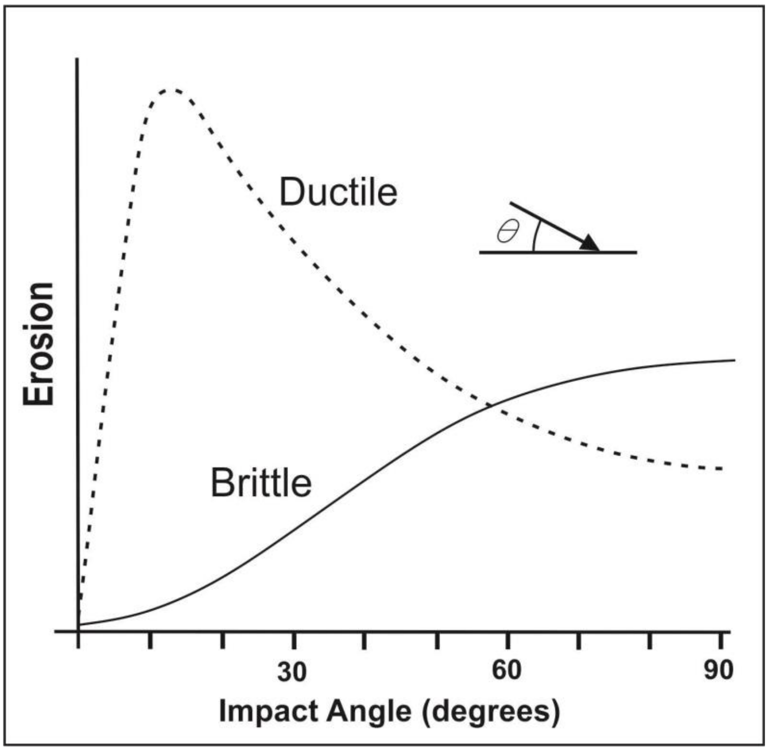


Figure 2: Erosion rates of ductile and brittle materials at various impact angles [3].

Thermaspray (PTY) Ltd

Tel: +27 11 316 6520
Fax: +27 11 316 7527
Email: info@thermaspray.co.za
Website: www.thermaspray.co.za

Physical Address:
3 Axle Drive
Cnr Axle Drive & Hammer Rd
Clayville, Extension 11
Olifantsfontein
South Africa

Postal Address:
PO Box 1152
Olifantsfontein
1665

JOINT VENTURE:

EROSION AND THERMAL COATINGS

Attempts are being made to reduce the damage caused by erosion by using thermal spray coatings. Thermal spraying allows the production of overlay protective coatings of a great variety of materials, almost without limitations as to its components, phases and constituents on a range of substrates. Wear and corrosion resistant coatings account for significant utilization of thermal spray processes. Besides being a means to evaluate the coating tribological performance, erosion testing allows also an assessment of the coating toughness and adhesion. Nevertheless, the erosion behaviour of thermal sprayed coatings is not clearly understood in the South African industry. There are certain factors that have to be taken into consideration when considering a coating for an application where erosion damage can be present [2]:

- Angle of impact < 45° - coating should be harder and more abrasion resistant
- Angle of impact > 45° - coating should be softer and tougher
- High service temperatures – coating should have high hot hardness and oxidation resistance
- When the carrier is a liquid – corrosion resistance of the coating should also be considered

EXPERIMENTAL

Thermaspray (Pty) Ltd has pioneered the way forward in terms of coating quality and the development of new coatings for specific applications. With this in mind Thermaspray (Pty) Ltd have designed and built a customized erosion rig according to the ASTM standard G76-13 for the erosion testing of thermal coatings by solid particle impingement. These tests were conducted in conjunction with client requirements in the South African industry. The rig is situated at Thermaspray's workshop in Olifantsfontein. Coatings were applied onto aluminium substrates (as per the customer requirement) which were sprayed according to standard Thermal Spray Coating Procedures. The samples were approximately 40mm x 40mm x 10mm. The erodent used was fused alumina. All tests were conducted at room temperature. Erosion results are based on mass loss calculated.

Thermaspray (PTY) Ltd

Tel: +27 11 316 6520
Fax: +27 11 316 7527
Email: info@thermaspray.co.za
Website: www.thermaspray.co.za

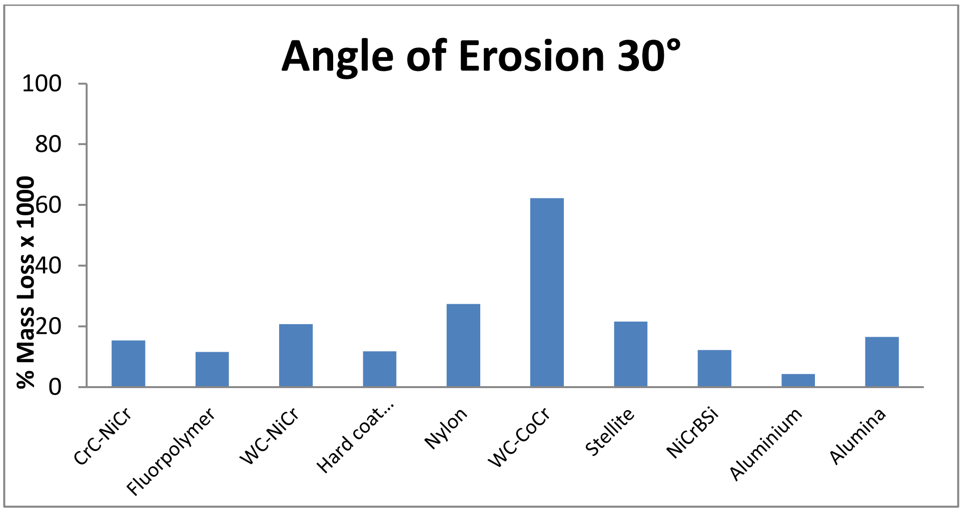
Physical Address:
3 Axle Drive
Cnr Axle Drive & Hammer Rd
Clayville, Extension 11
Olifantsfontein
South Africa

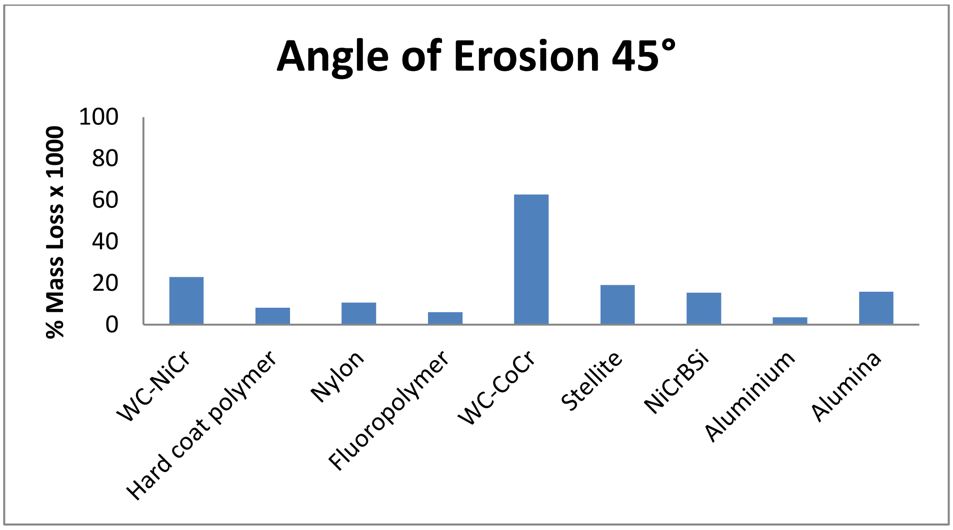
Postal Address:
PO Box 1152
Olifantsfontein
1665

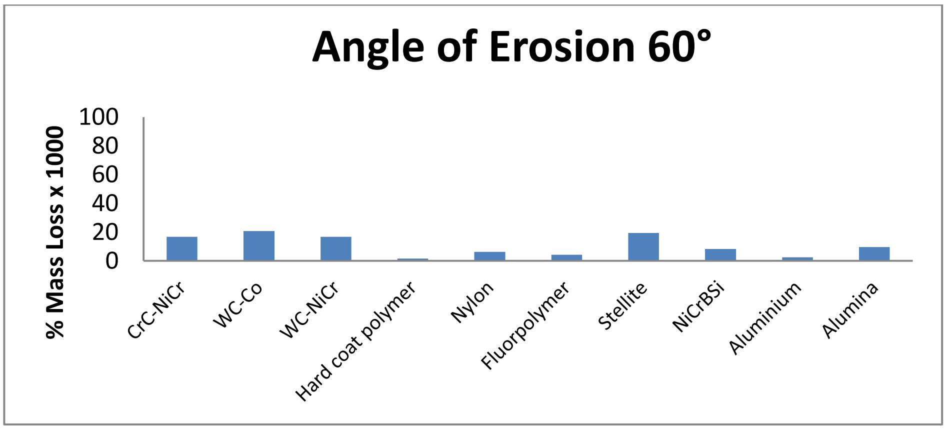
JOINT VENTURE:

RESULTS AND DISCUSSION

Below are erosion results for various materials at different angles of erosion:







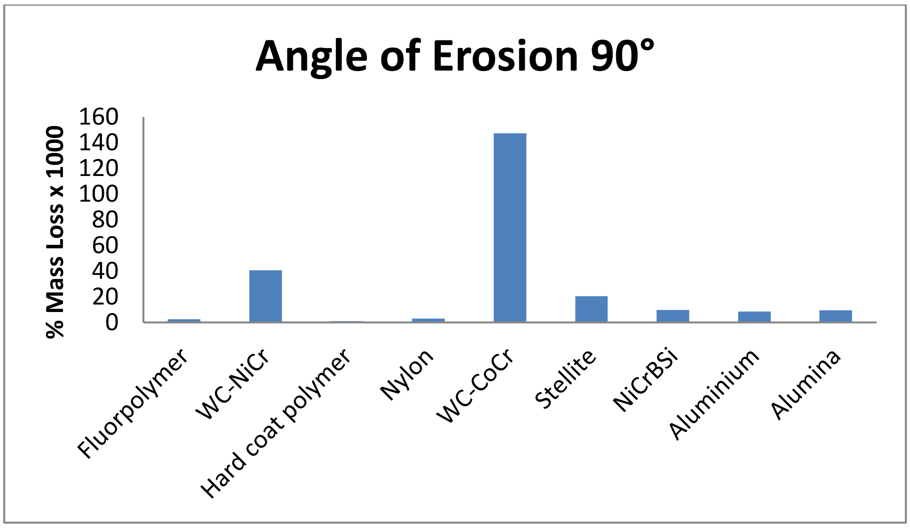
Thermaspray (PTY) Ltd

Tel: +27 11 316 6520
Fax: +27 11 316 7527
Email: info@thermaspray.co.za
Website: www.thermaspray.co.za

Physical Address:
3 Axle Drive
Cnr Axle Drive & Hammer Rd
Clayville, Extension 11
Olifantsfontein
South Africa

Postal Address:
PO Box 1152
Olifantsfontein
1665

JOINT VENTURE:



The results indicate that among the materials tested, the polymers, and the thermally sprayed aluminium showed the highest erosion resistance.

Erosion resistance is complex, combining the many variables to actually duplicate and recreate field environments is next to impossible in laboratory tests. Additional environmental factors such as thermal shock, erosion resistant material bond strength, as well as many other variables must be considered when choosing a coating.

CONCLUSION

The erosion wastage of thermal sprayed coatings is strongly affected by particle impact angle. However, material behaviour depends on mechanisms of material removal while hardness seems to be of minor importance. In order to choose the correct coating all environmental factors and variables should be taken into account.

REFERENCES

1. Priit Kulu, Irina Hussainova, Renno Veinthal., *Solid particle erosion of thermal spray coatings.* Wear 258 (2005) 488–496, Elsevier.
2. http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1516-14392004000100020 (22 September 2014)
3. Hutchings I. M., *Tribology: Friction and Wear of Engineering Materials*. London, Edward Arnold, 1992.
4. Thermaspray (Pty) Ltd internal documents

Thermaspray (PTY) Ltd

Tel: +27 11 316 6520
Fax: +27 11 316 7527
Email: info@thermaspray.co.za
Website: www.thermaspray.co.za

Physical Address:
3 Axle Drive
Cnr Axle Drive & Hammer Rd
Clayville, Extension 11
Olifantsfontein
South Africa

Postal Address:
PO Box 1152
Olifantsfontein
1665

JOINT VENTURE:
SURCOTEC SPECIALISED METAL COATINGS