Wear 271 (2011) 2080–2088

Contents lists available at ScienceDirect

Wear

journal homepage: www.elsevier.com/locate/wear

Dependence of the rolling contact fatigue of HVOF-sprayed WC–17%Co hardmetal coatings on substrate hardness

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ARTICLE INFO

Article history:
Received 14 September 2010
Received in revised form 11 January 2011
Accepted 12 January 2011

Keywords:
Thermal spray coating
HVOF coating
WC–Co
Durability
Rolling contact fatigue

ABSTRACT

The continual demand for higher load-bearing capacity and improved performance and reliability of gears and other components increases the role of high endurable Hertz pressures and low friction. Coatings prepared by high velocity oxy-fuel spraying (HVOF), one of the most important thermal spray processes, have the potential to serve as a technical solution for highly loaded components such as gears. In this work the rolling contact fatigue (RCF) behaviour of HVOF-sprayed WC–17%Co coatings was investigated on roller specimens with coating thicknesses of 600 μm and 100 μm deposited on 16 MnCr 5 steel substrates in the unhardened, quenched and tempered, and case-hardened states with hardness values of 190 HB, 400 HB and 58–62 HRc, respectively. The endurable Hertz pressures of the coated specimens were benchmarked against uncoated case-hardened 16 MnCr 5 steel. The failed coatings and coating damages before failure were thoroughly studied by optical and SEM microscopy. The highest durability was realised for a coating thickness of 600 μm through the use of the quenched and tempered substrate (about 130% of the benchmark). Coatings on these substrates showed a minimal amount of micropits and no other damage such as large cracks after testing. It can be assumed that differences in specimen preparation by grit blasting prior to spraying and different substrate strengths were responsible for the different results for the coated unhardened, quenched and tempered, and case-hardened substrates. The durability for a coating thickness of 600 μm was higher than for a coating thickness of 100 μm when unhardened and case-hardened substrates were used. Further improvements in the rolling contact fatigue behaviour could be achieved by optimisation of the combination of coating thickness and substrate strength and by use of other WC-based coatings.

1. Introduction

Thermal spray processes represent an important and rapidly growing group of surface modification technologies which are of particularly great importance for wear-resistant coatings [1]. Application of thermally sprayed hardmetal coatings as structural components has been hindered in the past due to their insufficient mechanical properties under contact loading. According to a short introduction to thermal spray processes given elsewhere, with the broad introduction of high velocity oxy-fuel spraying (HVOF) into industrial practice about 15–20 years ago a process for preparation of high-quality hardmetal coatings became available, enabling the development of new applications including surface modification of structural components [1,2]. At the same time, application of HVOF spraying opens up the opportunity to realise the functionality of hardmetals on the surfaces of parts which cannot be produced by sintering.

Among the commercially available compositions, in a comparative study by Nieminen et al. [3] on rolling contact fatigue (RCF) tests performed about 15 years ago, the best results were obtained for HVOF-sprayed WC–17%Co coatings deposited on quenched and tempered steel with a hardness of 32–37 HRc. This coating composition was also the best performer among several hardmetal coating compositions in a multi-stage testing and selection process consisting of an oscillating sliding wear test, a rolling contact fatigue test (twin-disk tribometer) and a back-to-back gear test for dry-running gears [4,5]. In particular, for the WC–17%Co coating in the rolling contact fatigue test (twin-disk tribometer) under self-mated, dry running conditions no failure up to a Hertz pressure of 1385 MPa and 30% slip ratio was observed [5]. The results of the gear tests showed that significant progress can be expected from further improvement of the coating properties as well as from constructive solutions for gearwheels which are more suitable for the application of thermal spray processes [4].

Only a few other RCF studies with other hardmetal coatings have been reported thus far in the literature. A systematic damage and failure analysis for WC–12%Co and WC–15%Co coatings deposited by different spray processes was performed by Ahmed

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0043-1648/$ – see front matter © 2011 Published by Elsevier B.V.
doi:10.1016/j.wear.2011.01.061