

Image processing by morphological covariance applied to the identification of wear damage in UHMWPE

Vanessa Kapps^{1)*}, Marcia M. Maru¹⁾, André V. Alvarenga¹⁾, Charles B. Prado¹⁾ and Carlos A. Achete¹⁾

¹⁾National Institute of Metrology, Quality and Technology, INMETRO, Brazil.

*Corresponding author: vanessakapps@gmail.com

In this work, the technique of digital image processing by morphological covariance was applied to a set of images obtained by optical microscopy of surfaces of polymeric samples after tests of friction and wear under various conditions of contact pressure and sliding speed. It was possible to evaluate and distinguish one of the main wear mechanisms in polymers, delamination, that was associated with the critical test condition.

Keywords: UHMWPE, wear mechanism, texture analysis, morphological covariance

1. Introduction

In the last decades, the increasing advance of digital technology, associated with the development of new algorithms for digital image processing, has allowed applications that permeate in several branches of human activity, such as in identification of artifacts in biomedicine. The image processing tools are based on the fact that the morphological operations can handle with the image data by preserving the principal characteristics of the object [1]. In the field of tribology, the development of methods for evaluating the performance of materials and parts represents a great challenge in the area, but important criteria for experimental evaluation, such as the quantitative analysis of the wear surface morphology, is less taken into account [2-3]. Image processing techniques based on mathematical morphology characterization can add reliability to the results of image analysis. In this work, morphological covariance tool was applied to a set of images obtained by optical microscopy of surfaces of polymeric samples after sliding friction tests under various conditions of pressure and speed, in order to identify the existence of correlation of a mathematical quantifiable entity to the wear morphology. With the results obtained, it was possible to evaluate and distinguish one of the main wear mechanisms in polymers, delamination, associated with the critical test condition.

2. Methods

The wear behavior by delamination was investigated for ultra-high molecular weight polyethylene (UHMWPE, GUR 1020), used in components of joint orthopedic prostheses. The friction tests were performed in dry reciprocating sliding mode at room temperature, in a steel ball-on-polymeric plate configuration, with variations in contact pressure and sliding speed (34 MPa-1 Hz, 50MPa-1Hz, 34MPa-5Hz). The resulting wear mechanisms in the polymeric specimens were observed under optical microscope (Carl Zeiss, AxioTec, 5x objective). In these images, digital image processing by mathematical morphology tool was applied using the GNU Octave software (version 5.2.0), and a method of texture analysis by morphological covariance. Power spectra, and Fourier transform (FFT), were analyzed to search for textures related with the specific damage levels and types observed in the surface.

3. Results and Discussion

Figure 1 shows the identification of the texture period by morphological covariance, measured by volume of the image eroded by a pair of points in the horizontal direction, and the corresponding images (257 × 581 pixels). The optical images evidenced that the deformation level left in the polymer depended on de friction condition. The mathematical processing of the images has revealed that the surfaces were in fact worn out, associated with the smoothing of the covariance peaks corresponding to the pristine surface. The delamination related morphology, represented by the deformation appearing orthogonal to the friction direction, is more evident in Fig.1d. In this case, some specific covariance peaks in the short range comes to appear in the power spectral density graph. The use of the digital image processing with morphological covariance is shown to be an interesting tool for the determination of the level and the type of wear damage occurring in the polymeric material.

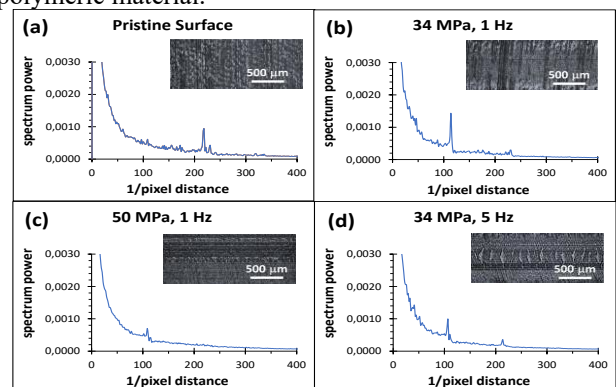


Figure 1: Power spectral density graphs and the respective images

4. References

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