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WEAR EVALUATION OF AN AISI 1020 STEEL COATED WITH PEEK[1]

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Abstract

PEEK (Poly-ether-ether-ketone) coatings have been attracted interest from some industry sectors due to its good wear resistance. In this study the wear resistance of a AISI 1020 steel coated with PEEK it was compared with that the AISI 52100 steel quenched and tempered to a hardness of 60HRc. The wear tests were performed in a fixed-ball micro-wear machine, using three different loads in the dry condition and using a lubricant. It was found that the PEEK coating presented a better wear performance than the AISI 52100 steel in dry condition and a wear performance close to the lubricated AISI 52100 steel while the PEEK layer maintains its integrity. In the case of the lubricated tests, the AISI 52100 steel provided the best performance among the samples tested.
Key words: PEEK (Poly-ether-ether-ketone); Coating; Wear.

AVALIAÇÃO DO DESGASTE DO AÇO AISI 1020 RECOBERTO COM PEEK

Resumo

Revestimentos de PEEK (Poly-ether-ether-ketone) tem atraído interesse de alguns setores da indústria devido a sua boa resistência ao desgaste. Nesse estudo, foi comparado a resistência ao desgaste de um aço AISI 1020 revestido com PEEK com um aço AISI 52100 temperado e revenido, para uma dureza de 60 HRc. Os testes de desgaste foram realizados numa máquina de micro-desgaste de esfera fixa, usando três cargas diferentes, na condição seco e com uso de lubrificante. Constatou-se que o revestimento de PEEK apresentou um desempenho melhor que o aço AISI 52100 na condição seco e um desempenho próximo ao desgaste do aço AISI 52100 na condição com lubrificação, enquanto a camada de PEEK mantém sua integridade. O aço AISI 52100 com lubrificação apresentou os melhores resultados dentre as amostras testadas.
Palavras-chave: PEEK (Poly-ether-ether-ketone); Revestimento; Desgaste.

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1 INTRODUCTION

Reduction in friction and wear resistance are the challenges of industrial applications. In order to improve the surface tribological performance, polymeric coatings have been developed. PEEK (Poly-ether-ether-ketone) can be manufactured using a variety of techniques such as injection molding and other common techniques to process thermoplastic polymers,[1] such as high velocity oxygen fuel (HVOF) and Flame spraying (FS).[1,2,3] The use of bulk PEEK has been limited due to its high cost.[4] However, recent work has indicated that PEEK is a promising alternative when used as thin coating for metallic alloys.[4] PEEK is a semi crystalline material and many of its properties are due to the degree of crystallinity of the final product. PEEK is an advanced engineering thermoplastic polymer with excellent mechanical properties, thermal stability, good chemical and electrical properties, impact resistance and low wear rate and coefficient of friction, and is becoming one of the most attractive polymer materials being used more and more as bearing and sliding material in industrial applications.

The applied load and sliding velocity are of great significance to the tribological behavior and wear mechanism.[5] In many industrial situations when the sliding contact occurs between metallic surfaces, lubrication is required. This is not the case with polymer-metal sliding contacts, due to the self-lubricating characteristics of the polymers. A low coefficient of friction coupled with high wear resistance may be obtained in polymer-metal systems without the use of an external lubricant.[6]

The objective of this study was to evaluate the wear properties of a PEEK coated AISI 1020 steel, comparing it with the AISI 52100 steel quenched and tempered, with and without the use of a lubricant; using a fixed-ball micro-wear machine.

2 MATERIALS AND METHODS

2.1 PEEK Coating Preparation

AISI 1020 steel samples were coated with a PEEK layer by spray painting. Subsequently the samples were heated to a temperature of 120°C and later on at 398°C during 15 minutes to promote the curing of the layer.

2.2 Preparation of AISI 52100 Steel

Samples of AISI 52100 steel were heated at 870°C, quenched in oil and tempered at 200°C for a final hardness of 60HRc.

2.3 Micro-wear Tests

The micro-wear tests were carried out in fixed-ball equipment in which a AISI 52100 (100Cr6) steel ball with diameter of 1" (25.4mm) rotates in contact with a flat sample under loads of 665, 1349 and 1826g. The sphere hardness was 63±3HRc. The rotation speed and load were 300rpm and 6.65, 13.59 and 18.26N, respectively. Consecutive wear scars were produced for test times of 5, 10, 15, and 20min in order to obtain the volume loss curve. The removed volumes (V) of each wear crater were calculated according to the following equation:[7,8]

$$V \approx \frac{\pi \cdot b^4}{64 \cdot R}\text{, for } b << R \qquad (1)$$

where b is the scar diameter and R the sphere radius.

Figure 1 shows a scheme of the micro-wear machine (Fig. 1a) and the procedure to measure the scar diameter (Fig. 1b) and calculate the volume lost according to Eq. 1.

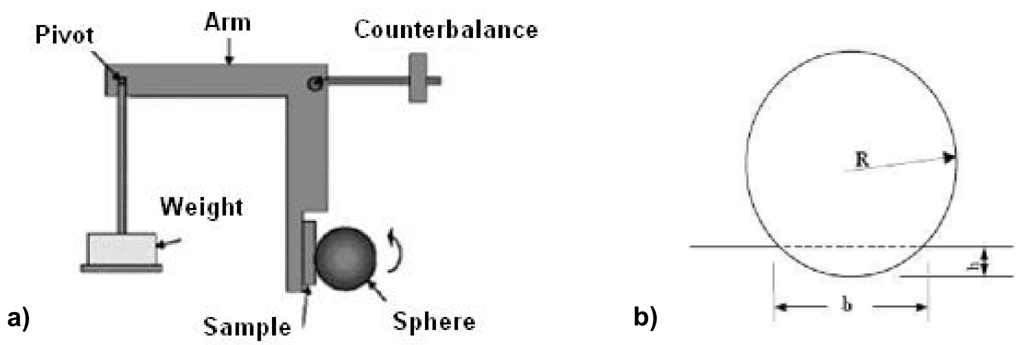

Figure 1. Scheme of the equipment used in the micro-wear tests and a wear scar.

The wear tests were performed on the following samples: AISI 1020 coated with PEEK, AISI 52100 steel quenched and tempered in the dry and lubricated condition. The lubricated wear was carried out using an SAE 20W-50 lubricant oil dripped between the sample and the sphere every 30s.

3 RESULTS AND DISCUSSION

In Figure 2 are plotted the volume lost curves for the AISI 52100 in dry (Fig. 2a) and lubricated (Fig. 2b) conditions and the AISI 1020 coated with PEEK (Fig. 2c). Figure 2d plots the wear rates against load to observe the increase of the wear rates with the increase of the applied load.

For all testing conditions, the volume lost increased as the distance and load were increased. The use of an oil lubricant diminishes the wear volume in about 100 times (Fig. 2a and b). Comparing the PEEK coating and the dry tests on AISI 52100 its verified that PEEK is a very efficient coating until the disruption of the layer. After that the substrate's wear process is accelerated. The same is observed when comparing the PEEK coating and the lubricated tests carried out on AISI 52100 steel.

Fig. 2d makes clear that the wear rate of the PEEK coating increased rapidly with the raise of the load. For 6.65N the PEEK's wear rate is the same level to that observed for the lubricated AISI 52100. However, for 13.59 and 18.26N the wear rate of the PEEK coating is higher than that of the dry test of the steel sample AISI 52100.

The lubricated tests on AISI 52100 resulted in constant wear rates, even after the load was increased from 6.65 to 18.26N. Thus, PEEK is an efficient coating material to

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avoid high wear rates and loss of mass, although the tests showed that the applied layer does not support high loads (13.59 and 18.26N).

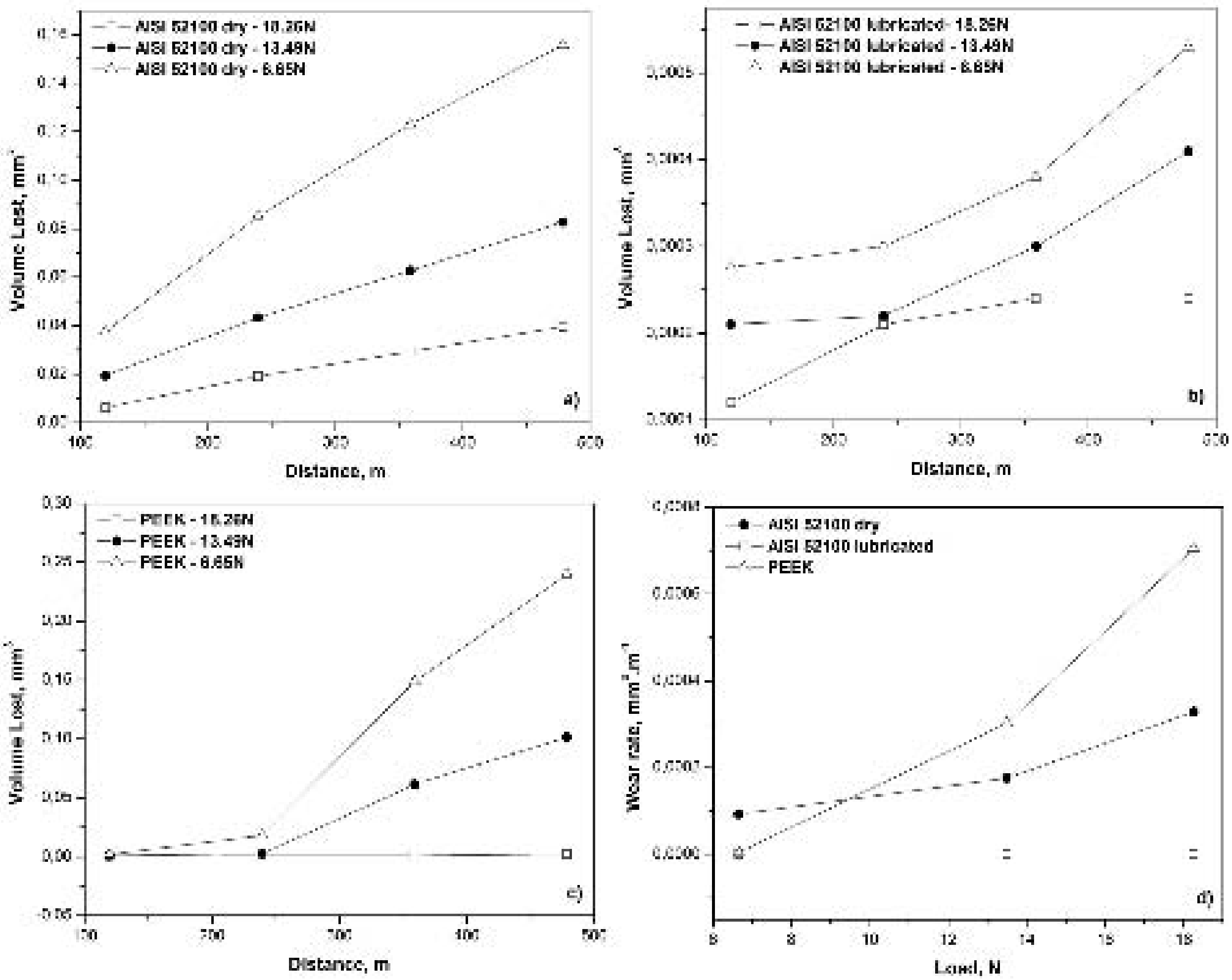

Figure 2. Volume loss curves of the: (a) AISI 52100 dry; (b) AISI 52100 with lubricant; (c) PEEK and (d) wear rates versus loads.

Figure 3 shows the wear scars obtained after 5min of wear testing with load of 18.26N for dry AISI 52100 (Fig. 3a), lubricated AISI 52100 (Fig. 3b) and PEEK (Fig. 3c).

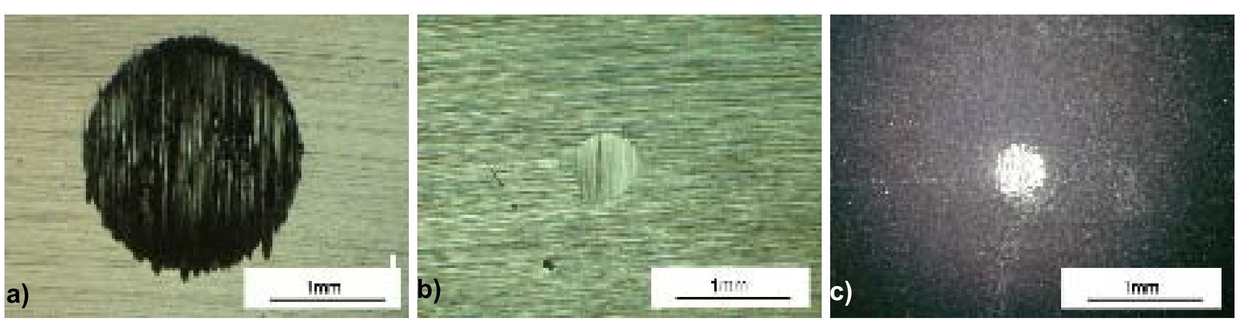

Figure 3. Crater formed at a load 18.26N and 5min of wear testing: a) dry AISI 52100; b) AISI 52100 with lubrication and c) PEEK.

The dry testing on AISI 52100 results in a larger wear scar similar to the scars in the lubricated test and PEEK coating.

Figure 4 presents wear scars after 15min of wear testing with load of 18.26N for dry test AISI 52100 (Fig. 4a), lubricated AISI 52100 (Fig. 4b) and PEEK (Fig. 4c).

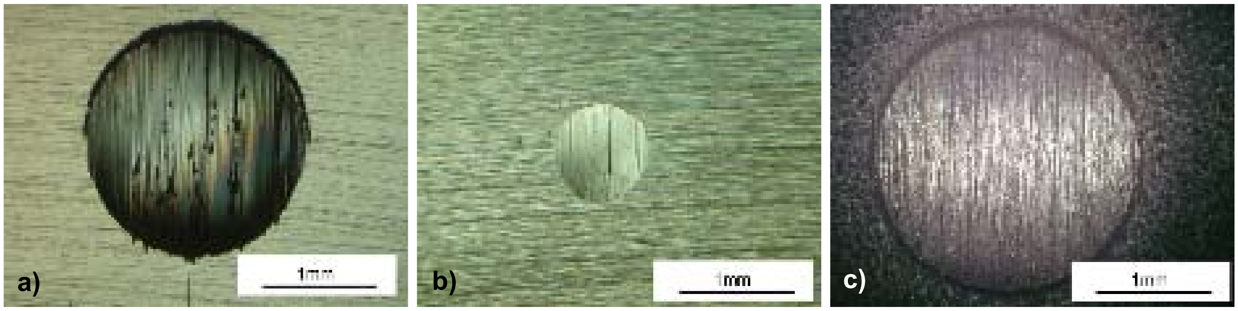

Figure 4. Crater formed at a load of 18.26N and 15 min of wear testing: a) dry AISI 52100; b) AISI 52100 with lubrication and c) PEEK.

Fig. 4c shows the disruption of the PEEK layer, promoting a great increase on wear. The debris particles act as abrasives, accelerating the wear process of the AISI 1020 steel substrate.

4 CONCLUSIONS

The samples coated with PEEK showed good wear performance in the dry test when compared with AISI 52100 steel for all loads, up to the moment that there is disruption of the PEEK layer. After that the wear process is accelerated.

The PEEK coating presented the same wear rate as the AISI 52100 steel in lubricated condition for load of 6.65N.

The steel coated with a PEEK yield an excellent wear resistance while the applied layer maintains its integrity. After the rupture of the layer, debris particles probably act as an abrasive, accelerating the substrate wear process.

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