EVALUATION OF THERMAL SPRAYED POLYMERS FOR TRIBOLOGICAL APPLICATIONS

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Introduction

Thermal spray processes have a broad application in both manufacturing and maintenance [1]. Thermal spray is a group of processes in which metallic and nonmetallic materials, finely divided, are deposited on a prepared substrate forming a sprayed deposit [2]. Polymer coatings have great potential to improve the performance of surfaces of light or heavy metals [3]. This work aims to study the properties of polymer coatings obtained by thermal spraying and to discuss the obtained results for tribological demand.

Experimental

Powders of PEEK-poly-ether-ether-ketone- (polymer Victrex ® PEEK ™), Polyamide 12 and Organic Polyamide were applied onto carbon steel substrates of 100 x 50 mm. Coatings were Flame Sprayed (Terodyn-2000 gun) fueled by acetylene gas and oxygen in a 2:1 ratio. Specimens were sandblasted to clean the surface and increase the roughness. The substrates were pre-heated to 230 ^{0} C before spraying. A 30 psi carrier gas pressure and a 85 mm distance were adopted. After spraying, the samples were cooled in three ways: fast, moderate and slow cooling for PEEK and fast cooling for Polyamide coatings. Bending test was conducted as well as ASTM C633 tensile adhesion test. Hardness tests were carried out by Shore D and Vickers measurements. Abrasive wear test was performed to evaluate the coating wear resistance.

Results and Discussion

The overall coatings characterization results are presented in Table 1.

Table 1. General characteristics of coatings

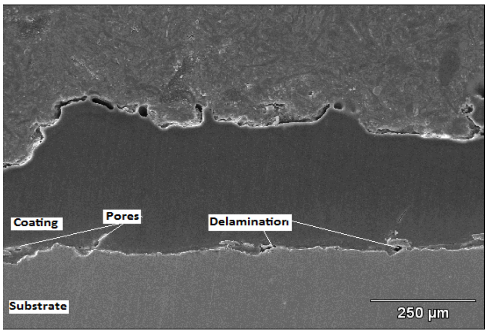
Coating	Peek Fast	Peek Mod	Peek Slo	Poly 12	Org Poly
Thickness (μm)	250	250	250	250	250
Roughness (μm)	0,39	0,42	0,39	0,39	0,45
Density (%)	> 98	> 98	> 98	> 98	> 98
Adhesion (MPa)	> 12	> 12	> 12	> 12	> 12

In bending test, fast cooled PEEK coating showed no cracks while for moderate and slow cooling some micro cracks can be observed. This difference is credited to the distinctive lamellar structures. PEEK coating with fast cooled has proved to be more ductile, decreasing in ductility for larger cooling times. This behavior can be explained due to polymer glass transition. Adhesion results show that the coatings have a real adhesion superior to 12 MPa which is essentially high mainly considering the thickness of the coatings. As discussed by some authors working with post treated PEEK blends, preheating is a necessary step in order to obtain good performance [4, 5]. Hardness results are presented in Tables 3 and 4. From the macrohardness results, the organic polyamide showed lower values compared to polyamide 12.

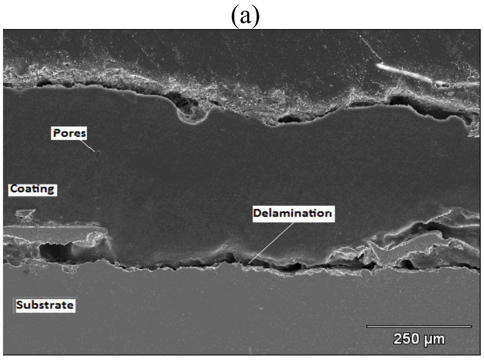
Table 6. Vickers microhardness results

Material		Microhardness (Hv)
	Fast	18.5 ± 0.2
PEEK	Moderate	20.0 ± 0.1
	Slow	20.9 ± 0.5
Polyamide 12		18.2 ± 0.5
Polyamide Organic		18. 5 ± 0.1

The results of microhardness increased gradually along with the difference in cooling for the PEEK coatings. Comparing the results of Vickers hardness with the bending test results, a difference between toughness and hardness may be noted. The PEEK coating with fast cooling had higher ductility but showed lower hardness. The one with moderate cooling has presented moderate ductility and hardness. For slow cooling, the ductility was lower than in the others opposing a higher hardness. Fig. 2 and 3 show images of scanning electron microscopy of typical obtained coatings. Note the presence of pores, delamination and the interface substrate / coating.



(a)



(b)

Fig. 2. Cross sectional SEM micrographs of a) PEEK and b) Polyamide coatings

The test results of three bodies abrasion (CETR tribometer) is shown in Fig. 4. It can be seen that the best results were for fast cooled PEEK coating which showed the lowest wear rate. It may be related to improvements in cristallinity even though it has the lowest hardness but also a better substrate interaction showing no cracks at the surface with means less process residual stresses. Some studies have focused on the evaluation of composite coatings that combine thermally sprayed ceramic or metallurgical primary layer and a polymer CVD/PVD deposited secondary layer. The former protects the metal

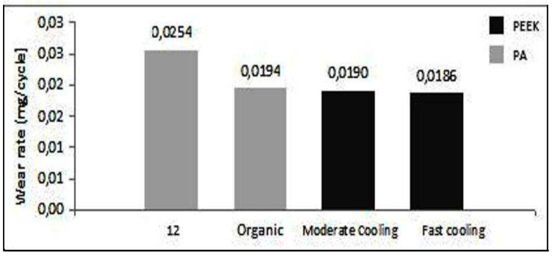


Fig. 4. Wear test results- CETR tribometer

substrate by providing compressive strength, hardness and wear resistance. The polymer top coating causes a low friction coefficient. Residual stresses are reduced by using a bond layer [5].

Conclusion

PEEK and polyamide polymers were applied by thermal spraying on carbon steel substrates. PEEK coatings were cooled in different cooling times and polyamide were varied in the nature of the resin. The results showed that all coatings presented different characteristics related to hardness, ductility but similar adhesion behavior. The obtained results give strong evidence that the use of flame sprayed polymer powders, mainly PEEK, with substrate preheating would have a good performance in wear applications

References

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