Journal of Korean Institute of surface Engineering
Vol. 29, No. 6, Dec., 1996

WEAR PROPERTY OF PLASMA-SPRAYED COATING LAYERA IN Cr_2O_3

J. M. Pakr*, S. W. Lee*, Byong Kee Kim, Dong Won Lee****

**Department of Materials Engineering, Sun Moon University, 336-840*
***Korean Institute of Machery and Materials, Department of Materials Processing, 66 Sangnam-dogn, Changwon, Kyungnam, Korea*

ABSTRACT

Wear property of plasma spray coating in Cr_2O_3 powder manufatured of spray dry method on the aluminum substrate was inspected for the application of piston-ring of automotive enginel. The plama spray coatings were varied with feed rate and particle size. Used the ball-on disc type tribometer, wear volume, friction, surface rougness were investigated. The delamination of the coating layer were observed with SEM. Also the cross-section of wear track were investigated, using optical microscopy. As a result of experiment, wear mechanism was addressed in the various coating process.

INTRODUCTION

The recent advance in the mechanical industry requires the development of materials. These materials have mixed characteristics of ceramics and metals which are necessary for the use of the automotive, the aviation, the fiber industry. For production of these materials plasma thermal spray coating technology could be protential by materials which have characteristics of the mechanical, thermal, chemical, properties such as resistance to abrasion, thermal, corrosion.[1, 2]

But, it is difficult that the development of material have good properties. In the plasma thermal spray coating technology, cheramics are melted at the high temperature and accelerated on substrate the thick film and is form. In comparison with other technology, for example, PVD, CVD, Sputtering, plasma spray coating technology has highly comparable in cost and reduces the difficulty in coating complex shaped components. While it is very quick in the forming thick film and has no limitation of the usable powders, that is, metals, ceramics, plastics, and shape and size of substrate. Recently, the next generation industry aims at the improvement of defect, fracture, wear, failure that exist to the aviation, automotive, fiber component and so on. Therefore, using by plasma thermal spray coating technology, after inorganic system powder Cr_2O_3 which formed by spray-drying coated on the aluminum substrate, we estimated the microsturcutre with the various condition as well as wear-mechanical property.

EXPERIMENTAL METHOD

Plasma spray coating machine made by METCO Co. was MBN gun that gernerates 40Kw and operating gas are Ar and H_2. Before spraying, grit blasting treatment with alumina grit was performed for the purpose of development adhesion of particle and substrate and removal of impurity on substrate surface. And surviving grit removed with compressed air The spray condition is listed in Table. 1

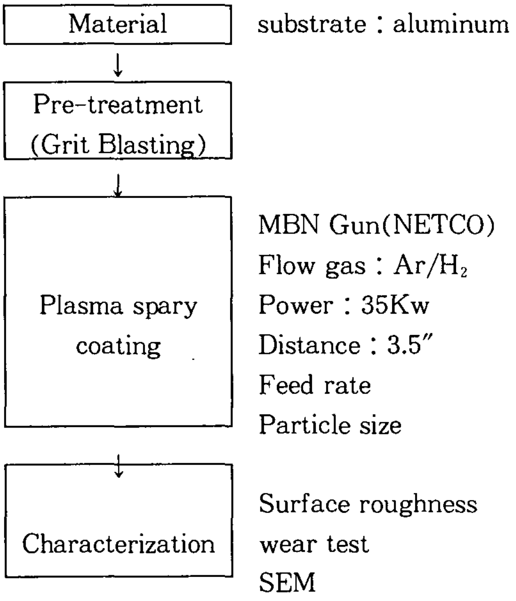


Fig. 1. Flow chart of experimental process.

Table. 1. Coating conditions

Feed rate(g/min)	Particles size(㎛)
30	below 75
	38～75
	15～45
Particles size(㎛)	Feed rate(g/min)
below 75㎛	30
	50
	70
	80

Wear test machine which is capable of temperature control from RT to 800℃ was utilized. The sliding friction which caused by reciprocating ball onto the disc specimens was measured. Once torque, generated by friction between testing adn fixed specimens, transmitted to transducer. Computer calculated friction coefficient. In this study, wear test was carried out at room temperature. The applied forced load was 10N, the reciprocal speed was 1Hz, the reciprocal distance was 12.2㎜ and the performing time was 1hr. Wear volume obtained by measuring the area of morphology of worn area using roughness tester. It was calculated by multifying the worn area and the sliding distance.

After wear test, Ry was calculated by maximum value minus minimum value with surface roughness tester and cut off value was 0.8.

The stacking behavior of Cr_2O_3 powder on the subtrate was observed by SEM. The spray coated layer, wear track, and cross-section of the worn area were investigated. In cross-section view, we cut the coated layer with diamond cutter at a low speed in oder not to drop the layer, and polish it.

RESULT AND DISCUSSION

Wear test result

We measured the wear volume with the various feed rates and particle sizes. The applied load was 10N and the sliding speed was 1Hz. Fig. 2 and 3 showed the wear volume as a function of the particle size and feed rate. The results with change of the particle size fixed by feed rate as follows : 15～45, to 0.1747㎜^{3}, 38～75㎛ to 0.3653㎜^{3}, below 75㎛ to 0.3176㎜^{3}. The particle size with 38～75㎛ showed maximum wear volume. And the result with the change of the feed rate as fol

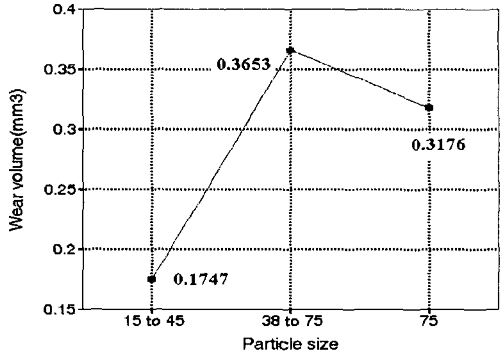


Fig. 2. Variation of the wear volume at various particle size.

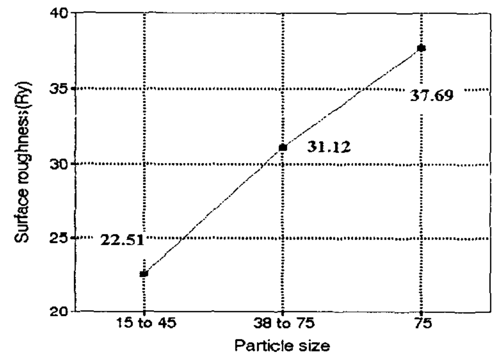


Fig. 3. Variation of the wear volume at various feed rate.

lows: 30g/min to 0.3176mm^3, 50g/min to 1. 1417mm^3, 70g/min to 0.3172mm^3 80g/min to 0. 2574mm^3. The feed rate with 50g/min showed maximum wear volume in comparison with otehr conditions.

Surface roughness test result

Fig. 4 and 5 showed surface roughness with the change of the particle size and feed rate. In Figure 4, the bigger particle size and the higher surface roughness. According to feed rate, the surface roughness of the coated layers decreases from 30g/min to 70g/min, but increases from 70g/min to 80g/min as shown in Figure 5.

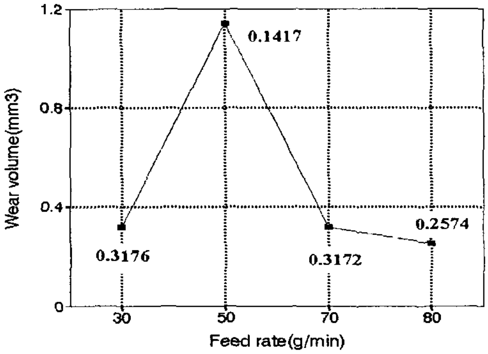


Fig. 4. Variation of the surface roughness at various particle size.

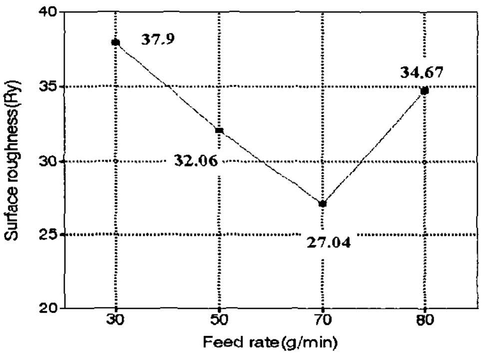


Fig. 5. Variation of the surface roughness at various feed rate.

The main factors which govern, the characterization of microstructure of the plasma spray coated layer were varied from property of the powder, are current, the gun distance, the flow rate, a type of gas and so on. The plasma sprayed powders have a different shape, density, particle distributon, flux, stability. in order to transfer powder smoothly into plasma jet, a sphere powder is adjusted because flowablility of powder is good. The particle size is controlled in order for high density coating, A exceedingly fine powder was heated but oxidation or evaporation easily and made agglomeration, then generated problem of powder injection. But, in case of coarse powder was caused by incompletyl molten particle, and generated a crack of coated layer or increased more pore. Therefore, sprayed powder more than minimum 5 ㎛ and less than 100㎛. In case of the powders used bewteen 10㎛ and 44㎛. The more feed rate(30, 50, 70, 80g/min), the more thickness of coated layer. As the feed rate increased, the thickness of the coated layer increment of powder supplying quantity per unit hour, however, in case of high feed rate, incompletly molten particle presented at the coated layer because lots of powder into the fixed plasma spray energy are supplied so that it is highly probability to increase porosity into coated layer.

Observation of SEM micrographs

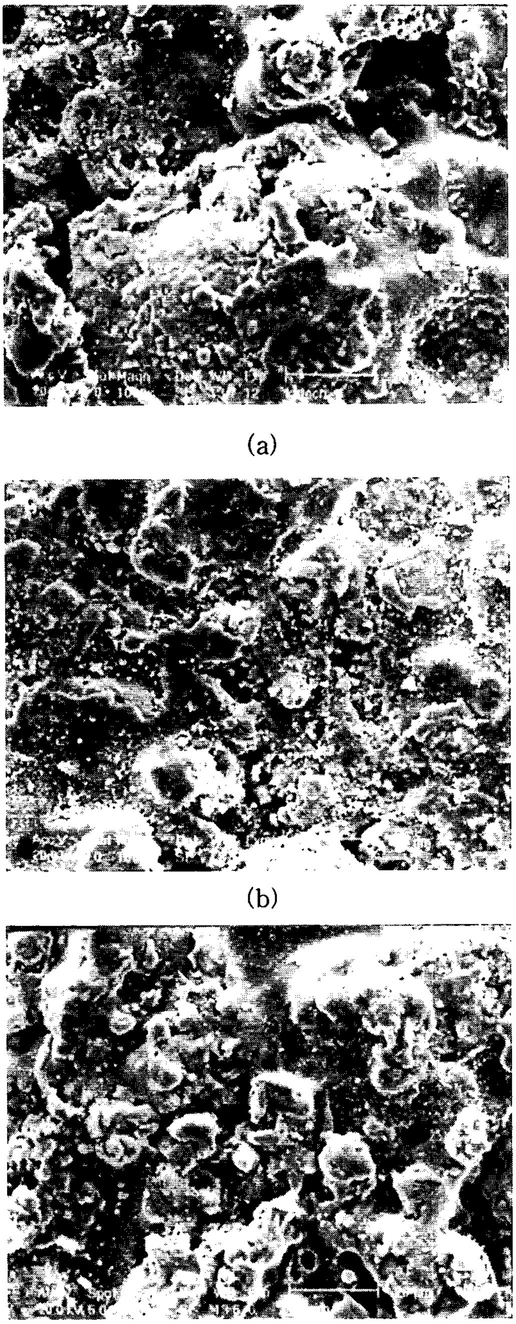
Fig. 6. showed SEM micrographs of the surface layers coated with various particle sizes. Various sizes of spherical particles and the melted splats were illustrates. Specially, in the layer coated with 75㎛ powder, 30g/min feed rate there are spherical particles sticking onto the coated layer and few melted splats. The surface roughness in coincident with increasing the size of Cr_2O_3 powder. Fig. 7. illustrated that spherical particles are squeezed during wear testing and surface roughness is high but wear volume is low. And, we understood that the melted splats were delaminated such as "chipping effect" during wear test.

Fig. 8 shows the SEM micrographs of the unworned part and the worn part which were made at various feed rate. Here, we can observe more spherical particles rather than the melted splat. When plasma spray coating carried out the melted particles melted by high temperature and formed splat shape onto substrate. But we observed that parts of them which incompletly melted were laid on the splat shape particles. The coated layers with the condition of the particle size is 75㎛ and feed rate 50g/min has more splash-splat and surface roughness is relating lower but wear volume is high becuase of more void. Fig. 9 illustrated that the similar morphologies during sliding of the surface coated at different feed rate.

Observationg of optical microscope of the cross-section

Fig. 10 and 11 show photographs of the cross-section of the worn area at various particle size and feed rate. The size of spraying coating particle governs to the interface adhesion and the splats binding shapes. The smaller particle size, the better interface. The feed rates of powder changes the stacking shape and the adhesion between the splats and aluminum substrate. At 30g/min it shows the poor interface ad porosity.

Fig. 12. shows the mechanism that particles are stacked onto substrate. In these Figures, particles into the plasma assumed sphere shape, but actually, the shape of the particles into plasma vary but especially were divided into two types, that is, Splash-splat and disc-splat. splash-splats adversely affect adhesion for three reasons[3]. Firstly, they result in voids at the coating-substrate interface, since the spaces separating the individual splashes are often too small for the second layer of splats to penetrate. Therefore, disc-type particles have less pore than splash-splat because of squueezing between particls.

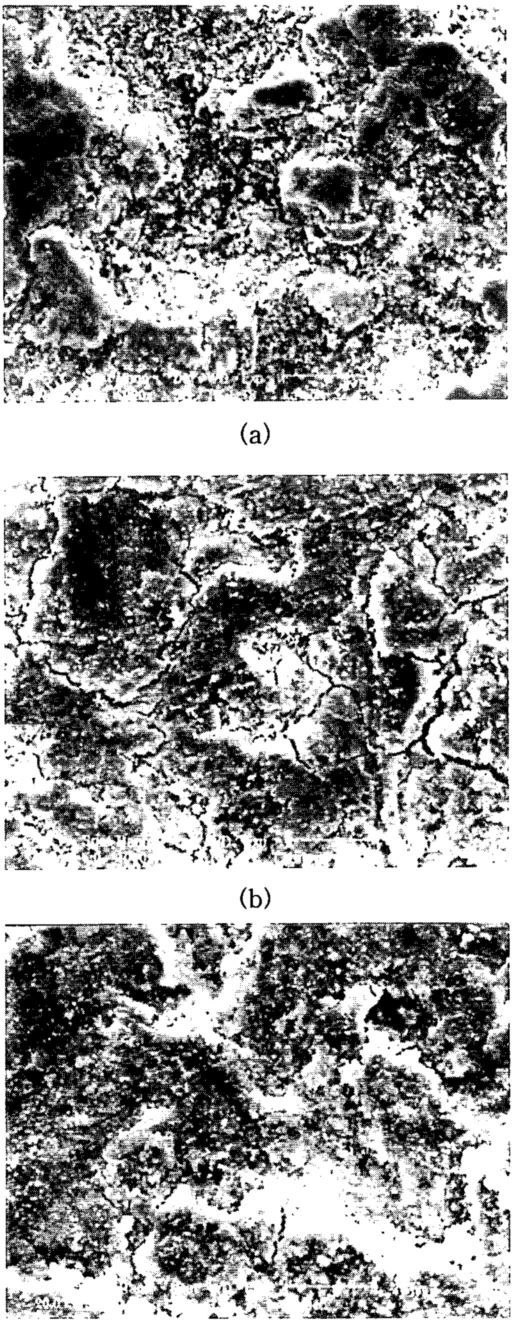


(a)

(b)

(c)

Fig. 6. SEM micrographs of the unworn area at various particle size: (a) 15 to 45μm (b) 38 to 75μm (c) 75μm

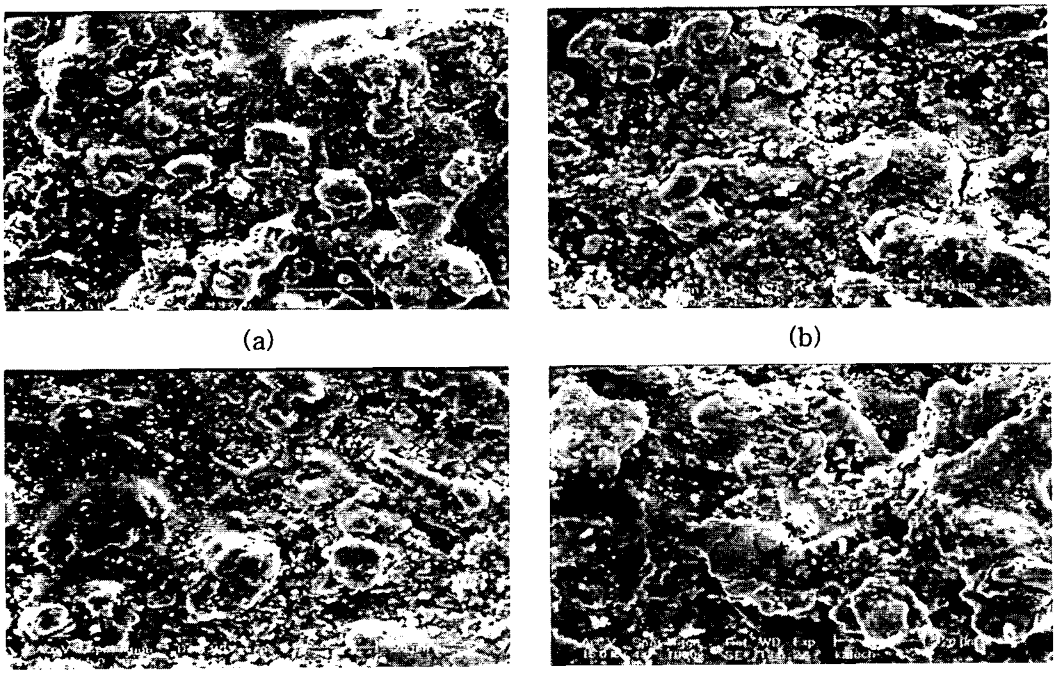


(a)

(b)

(c)

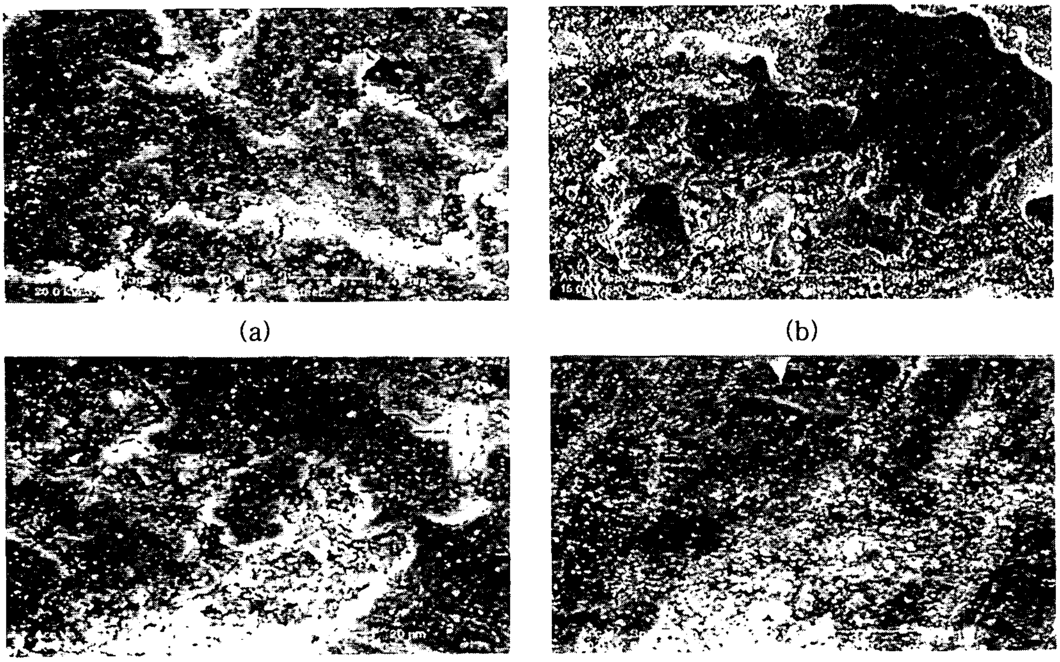
Fig. 7. SEM micrographs of the worn area at various particle size: (a) 15 to 45μm (b) 38 to 75μm (c) 75μm



(a) (b)

(c) (d)

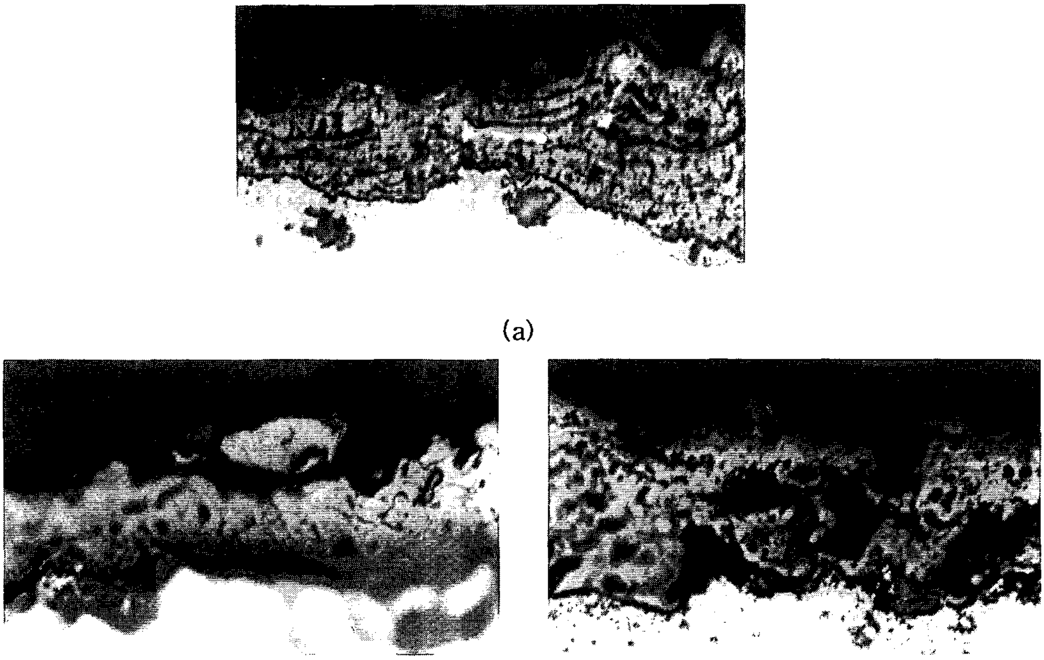
Fig. 8. SEM micrographs of the unworn area of the spray coated Cr_2O_3 layers at various feed rate: (a) 30g/min (b) 50g/min (c) 70g/min (d) 80g/min



(a) (b)

(c) (d)

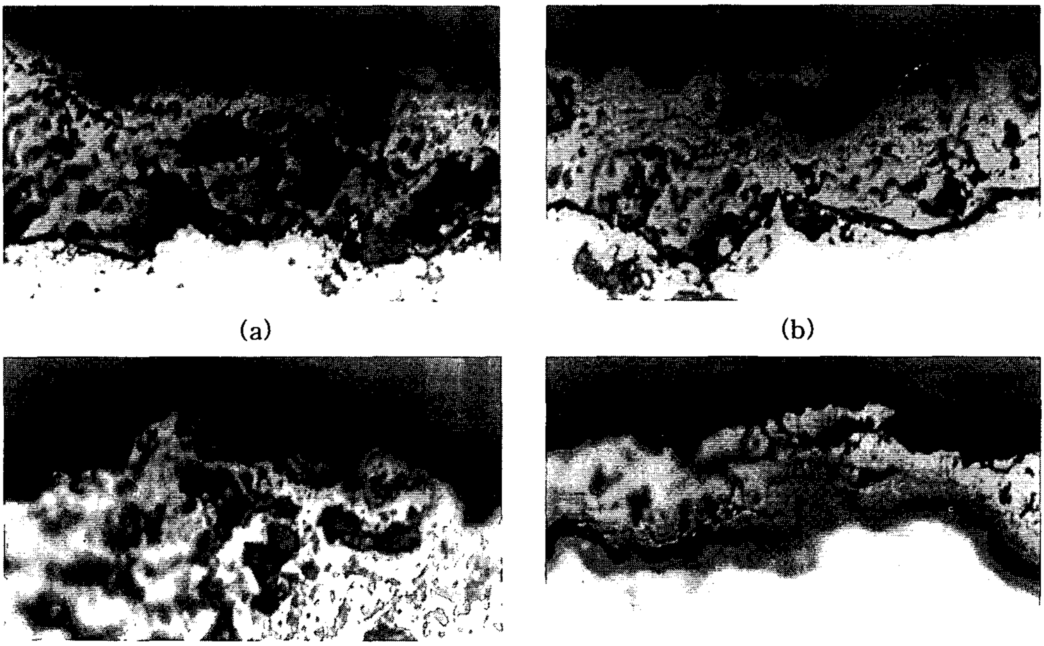
Fig. 9. SEM micrographs of the wear track of the plasma spray coating layers at various feed rate (a) 30g/min (b) 50g/min (c) 70g/min (d) 80g/min



(a)

(b) (c)

Fig. 10. Photographs of cross-section of worn area at various particle size:
(a) 15 to 45μm (b) 38 to 75μm (c) 75μm



(a) (b)

(c) (d)

Fig. 11. Photographs of cross-section of worn ared at various feed rate:
(a) 30g/min (b) 50g/min (c) 70g/min (d) 80g/min

These microstructure affects the interface bondings and tribological properties on the contact state.

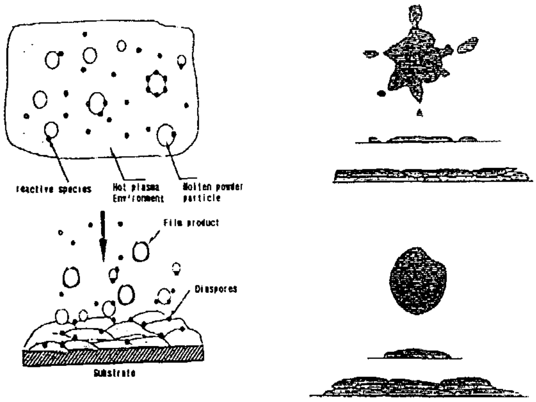


Fig. 12. Schematic diagram of powder deposition.

Ⅳ. CONCLUSION

When the plasma spray particle size of Cr_2O_3 increases, surface roughness increases, but wear volume is regradlness of particle size different from particle shape into plasma. Splash-splats involve much more extensive flow and flattering of the droplets on impact than disc-splats, so that they are thinner and cool more rapidly. Consequently, there is less time for chemical bonding, resulting in interior adhesion with splash-splats. The result of the experiment made a conclusion that wear volume and surface roughness of Cr_2O_3 plasma spray coated on aluminum depend significantly on the feed rates and partilcles size of Cr_2O_3 powder. It seems that wear mechanism is combinated be delamination and abrasion.

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