# Correlations between In-flight Particles, Splats and Coating Microstructures of Ni20Cr Thermally Sprayed by Flame and Arc Spray Processes

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**Abstract**

*Correlations between in-flight particle, splat and coating microstructure of thermally sprayed Ni20Cr were investigated. Flame spray and arc spray systems were employed for spraying Ni20Cr powder and Ni20Cr wire, respectively. The results showed that the arc spray process produced a broader size distribution for both in-flight particles and splats compared to flame process. Flower-like splat morphology was obtained from the arc spray whereas a pancake-like splat was obtained by flame spray. Ni20Cr coating sprayed by arc process had a denser microstructure, lower porosity and better adhesion at the interface.*

**Keywords : arc spray, flame spray, coating, in-flight particle, splat**

## 1. Introduction

Flame spray and arc spray have been widely used for producing various coatings for industrial applications. Ni20Cr is one of the most commonly used alloys for thermal spraying that are available in both powder and wire forms[1,2]. Spray process have been found to have a great influence on coating properties and microstructure [3]. Since in-flight particles and splats are the fundamental elements of coating formation, this work has focused on the correlation of the in-flight particle, splat and coating microstructure produced by the two different spray systems.

## 2. Experimental

### 2.1. Preparation of In-flight Particles, Splats and Coatings

Ni20Cr powders were sprayed by a flame spray system (MEC powderjet) and compared with Ni20Cr wire sprayed by an arc spray system (MEC Arcjet) using spray parameters shown in Table 1. In-flight particles were collected by spraying through a stainless steel filter into distilled water. Splats were collected by spraying onto a polished stainless steel substrate.

**Table 1. Spray parameters for flame spray and arc spray**

| Flame spray | | Arc spray | |
|---|---|---|---|
| Spray distance (mm) | 205 | Spray distance (mm) | 175 |
| Powder feed rate (g/min) | 75 | Voltage (V) | 31 |
| Oxygen flow (scfh) | 45 | Current (A) | 200 |
| Acetylene flow (scfh) | 55 | Air pressure (kPa) | 520 |

### 2.2. Coating Characterization

Coatings surface roughness measurements were performed with a Roughness Checker (Surtronic3+). The morphology and microstructure of the powder, in-flight particle and coating were characterized by an optical microscope (ZIEEZ, AXIO) and scanning electron microscope (SEM). An image analysis technique was used to determine the porosity and oxide content from polished coating cross-sections. Coating hardness was measured by a Vickers microhardness tester (Galileo Microscan OD). Pin-on-disk tester was used for sliding wear test using a tungsten carbide tip with a 100 g load at a 0.1 $m.s^{-1}$ disk velocity.

## 3. Results and Discussion

Flame spray process; the pre-sprayed Ni20Cr powder particles have a typically spherical shape with some elongated-shape, as shown in Fig.1(a). The morphology of splats as shown in Fig.1(c) were mainly pancake-shaped. This indicates that the molten or semi-molten particles are well spread out on impact giving an average size of splats 4.3 times larger than the in-flight particles.

Arc spray process; The average size of the arc sprayed in-flight particles is about 24 percent smaller than that from flame spraying. Figure 1f shows the splat morphology which was principally a flower shape implying that fully molten particles impacted on the substrate. Therefore, good adhesion of coating and substrate with a dense lamella structure was obtained, as shown in Fig.1(g).

The Ni20Cr arc sprayed coating showed an approximately 2 times lower sliding wear rate than the flame sprayed coating, as expected. This is in accordance with the microstructure and properties previously discussed, including porosity, oxide and hardness.

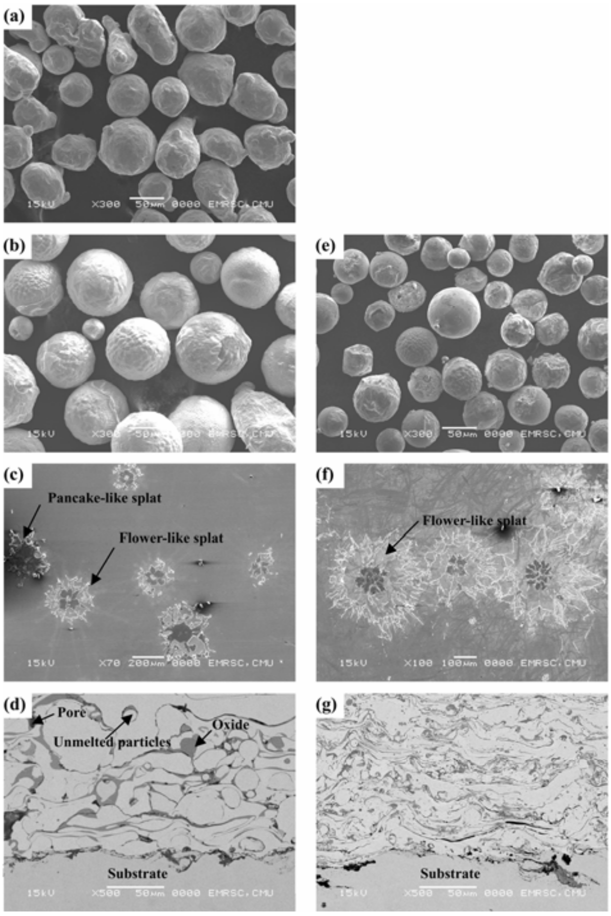


**Fig. 1. SEM micrographs showing morphology and microstructure of Ni20Cr powder flame spraying, FS (a-d) and Ni20Cr wire arc spraying, AS (e-g).**
**(a) pre-sprayed powders (b) FS-in-flight particles (c) FS-splats (d) FS-Ni20Cr coating (e) AS-in-flight particles (f) AS-splats (g) AS-coating**

## 4. Conclusions

The flame spray process gave a narrower size distribution for both the in-flight particles and the splats, while the arc spray showed a broad size distribution, particularly for the splat sizes. In addition, a flower-shaped splat was obtained from the arc spray, while the flame spray gave a pancake shape. The splat/in-flight particle size ratio from the arc spray was higher than that of the flame spray as a result of the higher temperature and higher particle velocity in arc spraying. The smaller in-flight particles, thinner splats, lower porosity and higher oxide content were obtained from arc spraying, which agreed well with the higher hardness and wear resistance of the coating obtained.

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## 5. References

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