



THE INFLUENCE OF INJECTION ANGLE, PARTICLE DIAMETER AND PLASMA GAS FLOW ON A NiCrAlY PARTICLE IN THE PLASMA SPRAYING PROCESS

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Abstract: This paper presents how the particle diameter, the gas flow and the position of the powder injector angle affects the behavior of a NiCrAlY particle with some simulations made with "Jet&Poudre" software.

Key words: NiCrAlY, powder injector angle influence, particle diameter, gas flow, plasma spraying process.

1. INTRODUCTION

Plasma spraying process consists of injecting solid particles into a high temperature and high velocity gas jet, in which the particles are being melted and sprayed on parts surfaces, the schematic process being shown in figure 1.

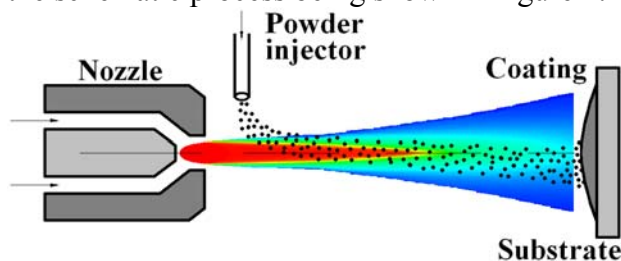


Fig. 1 Schematic of the plasma spraying process

There are a lot of parameters that can influence the quality of the sprayed coatings, the nozzle parameters, the parameters from the particle plasma jet interaction, and the parameters of the particle impact on the substrate. Maybe the most important parameters, to obtain an efficient and a high quality coating in a plasma spray process are the injection angle of the particles, the particle diameter and the plasma gas flow.

In the following paper will be presented the influence of the parameters mentioned above on a NiCrAlY particle in the plasma spraying process. The advanced copper alloys are a candidate for combustion chamber liners and

nozzles in reusable launch vehicles. Many of the properties of these alloys have been shown to be superior to the conventional copper alloys.

2. INJECTION ANGLE INFLUENCE

To see how the injection angle can influence the behavior of the NiCrAlY particle there were made a few simulations using "Jet&Poudre" software. The NiCrAlY particle was injected under seven different injection angles, as shown in figure 2.

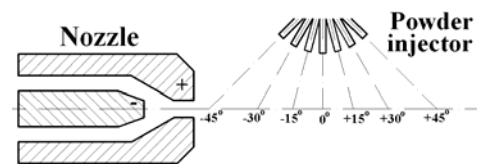


Fig. 2 Different powder injection angles

In this simulations were followed the temperature of the particle, the velocity, the molten ratio and the radial position of the particle.

In the simulations were used the following parameters, the spraying distance 12 cm, and the used gas is H₂-Ar 75%. The flow rate, at 300 K is 26 m/s.

The temperature of the plasma jet at the nozzle exit is 11841 K. The diameter of the injected NiCrAlY particle is 55μm.

The simulation boundary conditions are presented in figure 3.

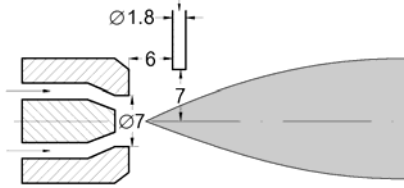


Fig. 3 Powder injector position used in the simulation

After the simulation, the results were presented in charts. The temperature of the particles injected under the seven injection angles are presented in figure 4.

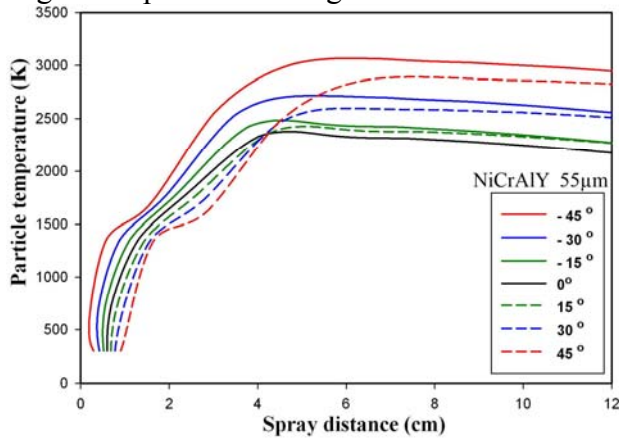


Fig. 4 Particle temperature along spraying distance

We can see that the highest values for the particle temperature are obtained when the particle is injected under -45 degrees or upstream injection. A high temperature of the particles can provide better molten ratio and of course better coatings.

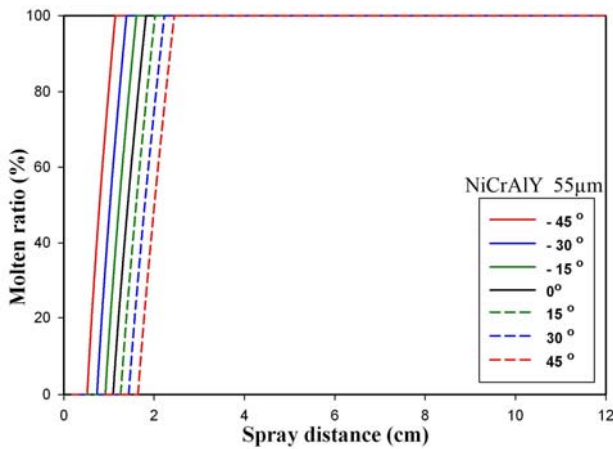


Fig. 5 Molten ratio along spraying distance

The molten ratio of the NiCrAlY particle under different injection angles is presented in figure 5.

Again we can see a better molten ratio for the particle that was injected under -45 degree.

The velocities of the particles under the seven injection angles are shown in figure 6.

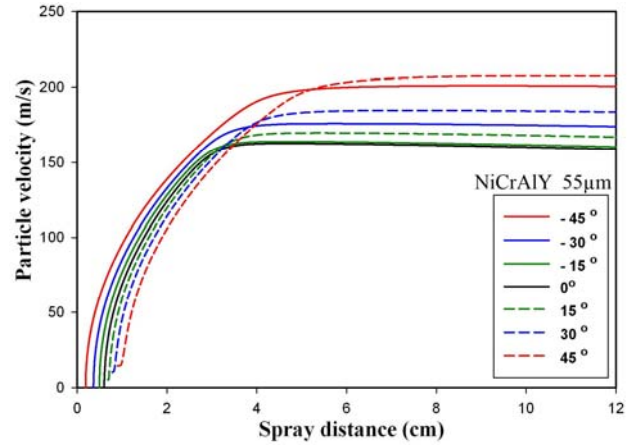


Fig. 6 Particle velocity along spraying distance

Here we can see a change. The particle injected under -45 degrees has a better velocity from the beginning, but from the middle of the plasma jet, the particle with the highest velocity is the particle injected under 45 degrees. The better the velocities of the particles are, the denser and the better the quality of the coating is.

The radial position of the particle in the plasma jet is presented in figure 7.

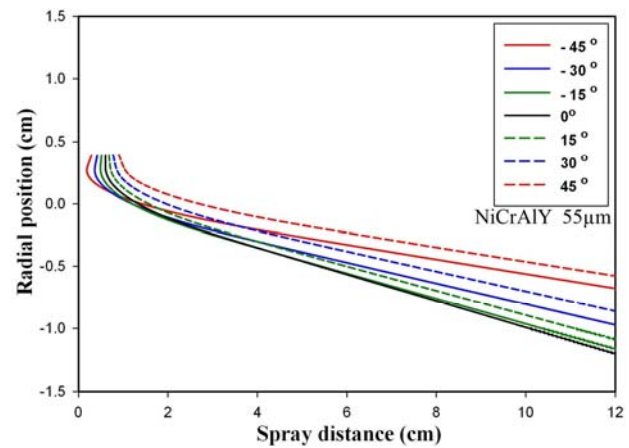


Fig. 7 Radial position along spraying distance

The radial position of the particles has to be close to the center of the plasma jet, because there the temperature is higher, and the particles can melt. From the center of the plasma jet to the periphery, the temperature decreases. In figure 7 we can see that the better radial position is for the particle injected less than 45 degree.

3. PARTICLE DIAMETER INFLUENCE

The success of plasma spray depositing layers depends on the ability of placing the particles in the plasma jet so that the particles to melt without being vaporized and designed with an optimum speed to impact the substrate. Fine particles are difficult to be injected and require high speed of transportation gas that will cool the plasma jet. This difficulty appears at very fine powders that due to the pinch effect of the plasma may not enter the hot zone of the plasma jet, reaching the periphery of the jet, they are not rendered sufficiently before the impact with the substrate. Larger particles will have a lower speed and can be partially melted during their dwell time. Size distribution is very important in the plasma jet spraying, the optimal distribution is between 30 and 100 μm .

For the particle diameter, in the simulation was followed the radial position of the particles. The boundary conditions for the simulations are the same. There were used 3 different NiCrAlY particle sizes, 45 μm , 55 μm and 60 μm . The results for this simulation are presented in figure 8.

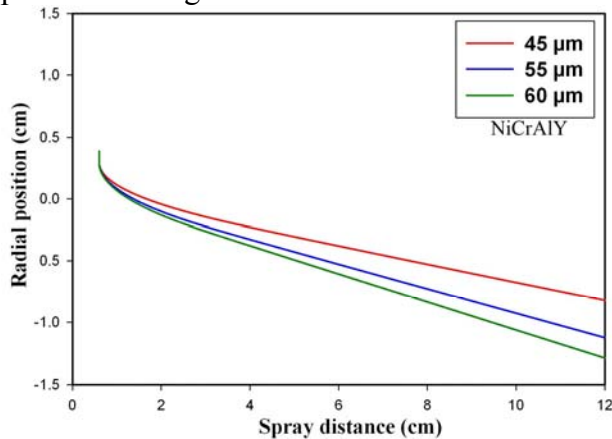


Fig. 8 Radial position for different particle diameters along spraying distance

We can see that the 45 μm has a better trajectory, or radial position in the plasma jet, because it spends a longer time in the hot spot of the plasma. However, being a little smaller that is with 55 μm particle, it could vaporize under the overheating of the particle. The 60 μm particle trajectory is not crossing the hot spot of the plasma, and having a larger diameter, it could not melt. In conclusion we can say that for a NiCrAlY particle, the optimum diameter of the particles is the 55 μm diameter.

4. GAS FLOW INFLUENCE

The gas flow is maybe one of the most important parameter in the plasma spraying process, because it provides momentum and heat transfer to the injected particles.

To see the gas flow influence, for this simulation was used a 55 μm NiCrAlY particle diameter, injected in the plasma jet under vertical injection with 3 different gas flow speeds, 40 SLM, 55 SLM and 70 SLM (SLM = Standard Liter per Minute). For the gas flow simulation were monitored the temperature, the velocity and the radial position of the injected particle under the 3 different gas flows.

The temperature of the particle is given in the chart from figure 9.

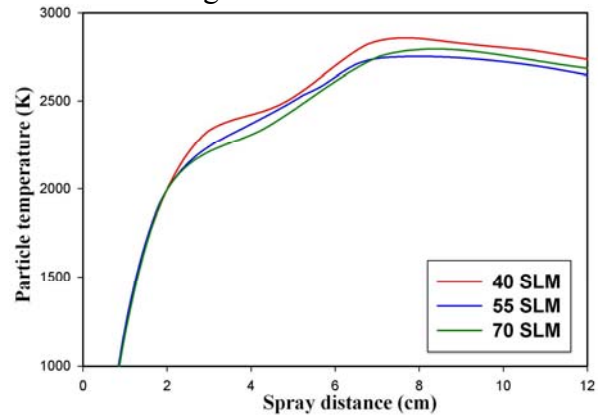


Fig. 9 Particle temperatures for different gas flows

From figure 9, it is obvious that the highest value of the temperature is for the particle injected under 40 SLM gas flow. This is because the gas flow being smaller, the particle dwell time (the time that particle spends in the plasma jet) is higher, and it reaches higher values of temperature. The velocities of the different gas flows are shown in figure 10.

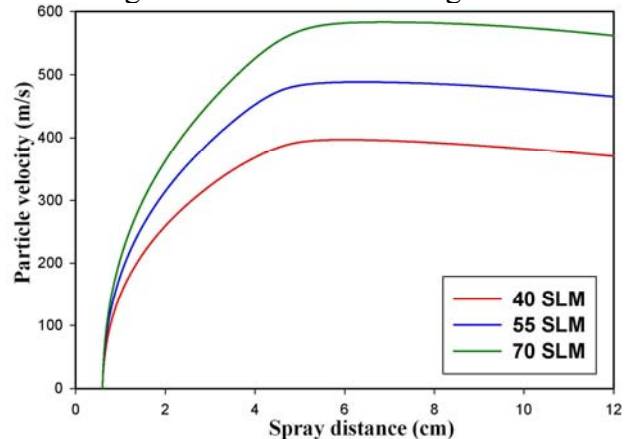


Fig. 10 Particle velocities for different gas flows

We can see that we have a higher velocity for the particle injected under 70 SLM flow speed. Higher gas flows, provides higher velocities. It is known that high velocities generate better and denser coatings, but it can also generate unmelted particles because of the short dwell time of particles.

The radial position of the particles with different gas flows are shown in figure 11.

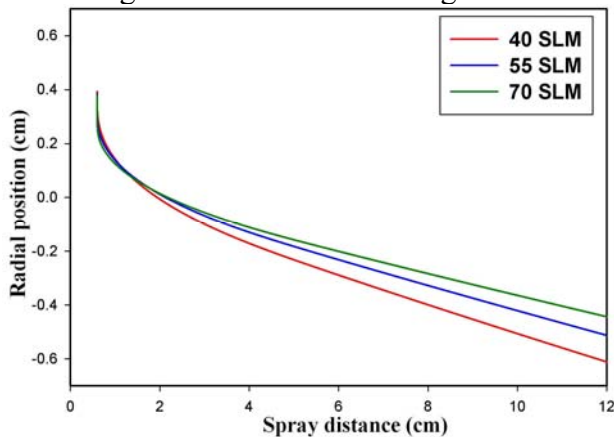


Fig. 11 Radial position of particle for different gas flows

We can see that the radial position of the particles improves with the increasing of the gas flow.

5. CONCLUSIONS

In conclusion we can say that for the injection angle influence we get better values when the NiCrAlY particle is injected upstream or counter flow of the jet. For the particle diameter influence, the temperature and velocity of particle decreases with the increase of particle diameter. Smaller particles can vaporize and larger particles may not melt.

Finally for the gas flow influence we can say that higher gas flows generate better velocities

and radial positions for the particles but also increases the dwell time of particles thing that generates lower temperature and melting ratio.

6. REFERENCES

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Influența unghiului de injecție, a diametrului particulei și a debitului de curgere a gazului plasmagen asupra unei particule de NiCrAlY în procesul de pulverizare cu jet de plasmă

Lucrarea de față prezintă o serie de simulări realizate cu softul "Jet&Poudres" pentru a determina modul în care poziția unghiului de injecție a pulberilor, diametrul particulelor și debitul de curgere a gazului plasmagen poate afecta procesul de pulverizare și comportamentul particulelor de NiCrAlY.

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