Introduction

Ceramic-metal coatings are key for space application of lubricants and shielding of surfaces. The mechanism for forming these coatings via supersonic particle deposition is still not widely understood especially for the ceramic bonding mechanism. These Ceramic particles are key elements in a number of functionalized coatings. This project uses simulations to determine the bonding mechanism.



Method

Material impact was simulated using Finite Element Modelling.

$$\begin{aligned} \text{Johnson} &- \text{Cook} \\ \sigma_y &= (A + B\varepsilon^{p^n})(1 + Cln\dot{\varepsilon}^*)(1 - T^{*^n}) \\ \varepsilon^f &= \max \begin{pmatrix} \left[D_1 + D_2^{D_3}\sigma^* \right] \left[1 + D_4 ln\dot{\varepsilon}^* \right] \\ & \left[1 + D_5T^* \right], \text{EFMin} \end{aligned}$$

chnson Holmquist

$$\sigma^* = \sigma_i^* - D(\sigma_i^* - \sigma_f^*)$$

$$\sigma_i^* = a(p^* + t^*)^n (1 + Cln\dot{\varepsilon}^*)$$

$$\varepsilon_f^p = d_1(p^* + t^*)^{d_2}$$
urg 2: Simulation Seture

Figure 2: Simulation Setup fo particle and substrate for testing cold spray impact. Particle was either Al₂O₃ or Al metal and substrate was either Al or Steel



Understanding Deformation Mechanisms of Metal-Metal and Metal-Ceramic During Supersonic Particle Deposition Mechanical Engineering Department, University of Nevada, Reno Raven Maccione and Pradeep Menezes





Single Particle Results

Single particle impact was varied by velocity. Stress, Strain, and Pressure were measured

- Ceramic particles shattered above 400 m/s
- Bonding began at 400 m/s
- Al bonded around 600 m/s
- Steel bonded around 900 m/s

















Double Particle Results

Double particle impact was performed to study interaction of particles post impact.



Ceramic Materials need low speeds to remain intact relative to metals which need high speeds to achieve deposition energy.

- ceramics for metal bonding

Metal Particles deformed around Ceramic ones.

Ceramics below particles shattered around 400 m/s Metal particles below bonded around 600m/s

Conclusion

Ceramic particles shattered above 400 m/s. Metal particles bonded at around 600 m/s for aluminum and above 900m/s for steel Particles may need partial fracture for bonding Combining coatings would require the shattering of