T5.5 Case study Problem- Based Learning (PBL)

Title of Case Study / Problem-based learning case

Cold Spray Additive Manufacturing (CSAM) Powder Recycling and Reuse

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Cold Spray Additive Manufacturing Powder Recycling | MTC Case Study

Background:

Cold spray technology was originally developed as a coating technology rather than a specific AM method. The significant benefit of moving this into the AM field relates to the rapid production of parts which is directly applicable for the defence and aerospace applications. One of the main benefits includes the ad-hoc and rapid application of the technology when needed.

Cold spray functions using supersonic velocity for the adhesion of the powder to create the part. The general process includes feeding powder, in this case copper, into a heated gas stream. The gas then expands through a de Laval nozzle which accelerates the particle to supersonic velocity and through plastic deformation there is solid-state bonding which therefore creates the substrate. Key benefits include the ability to use copper in comparison to PBF-LB; the reflectivity is not an issue for this method.

However, with this method certain limitations include the adhesion of the powder particles; not all particles adhere to the substrate. Often the powder which does not adhere is not commonly reused and as copper powders can frequently be up to £200 per kilogram, not reusing this powder can be a major concern.

- Material: copper powder
- Method: cold spray additive manufacturing (CSAM)
- Motivator: building in sustainability from an environmental and cost perspective when using CSAM technology for the powder which did not adhere during the first build of a product.

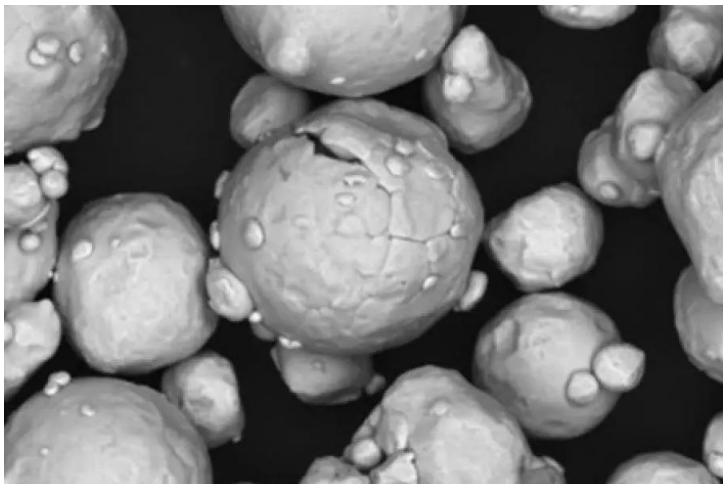
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Illustration of the case study

Virgin Powder



'Pancake' shaped powder

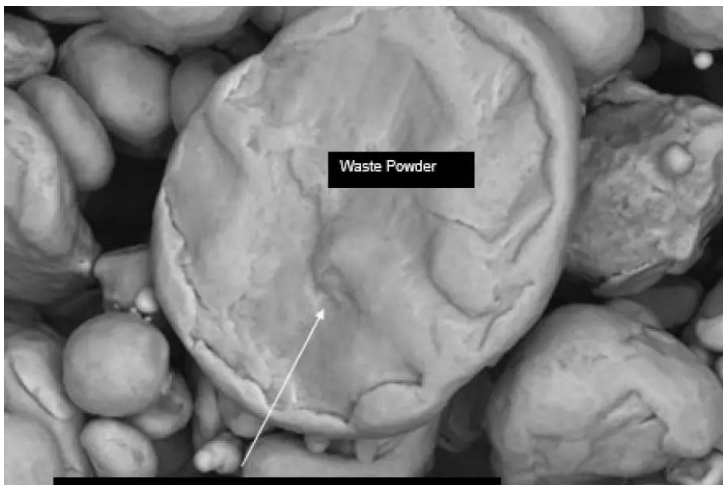


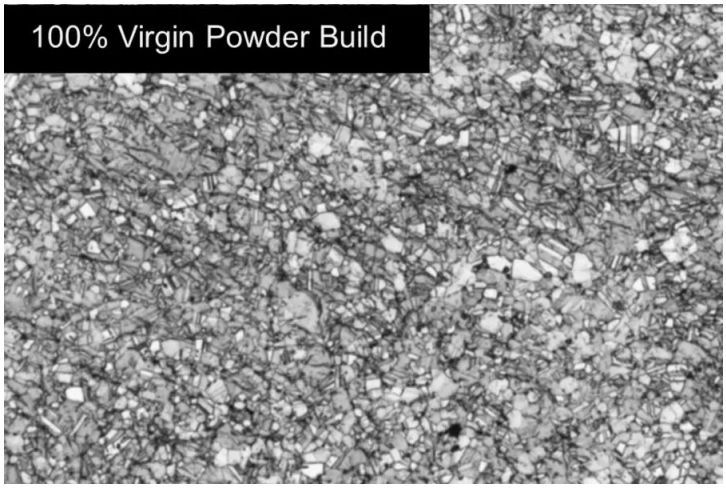
Figure 1. The difference between the virgin powder and the powder which did not adhere to the substrate during the CSAM process. (Manufacturing Technology Centre, 2026)

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100% virgin powder build



50% waste powder build

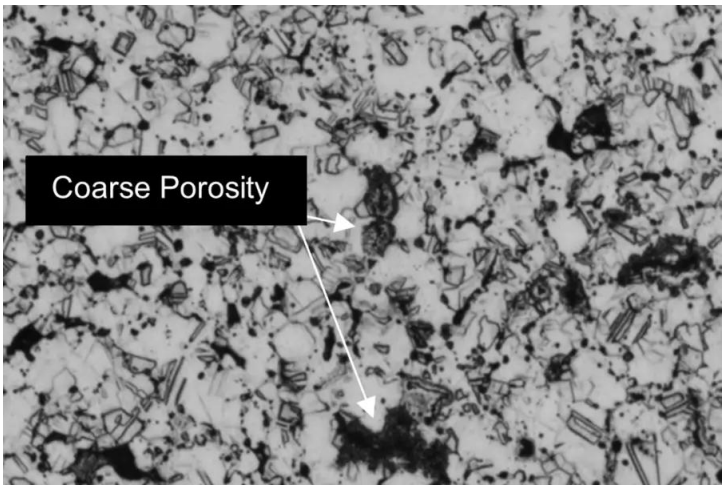


Figure 2. SEM Imaging of the two different powder types demonstrating the different coarse particle levels of each powder. (Manufacturing Technology Centre, 2026)

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Technical challenge

Main technical challenges:

- A lack of adhesion during the CSAM process
  - This creates a large amount of powder which is not directly reuseable.
  - A costly amount of waste especially for higher quality powders.
- Degradation of powder morphology
  - The powder which did not adhere has more coarse particles, not as spherical and pancaked shaped.
  - Often causes inconsistency in the feeding of the powder into the flow system.
  - Impacts the flowability of the powder.
- Powder contamination
  - Any waste powder will contain contaminants from the machine.
  - The powder will have debris.
  - This impacts the final part quality.
- Work Hardening of particles
  - As the unused powder did not adhere, they have undergone impact deformation which increased the hardness of the powder.
  - This impacts the bonding efficiency is being reused.

Questions posed:

1. How to overcome the debris and contaminants in the waste powder?
2. How to demonstrate the recycled powder is suitable for use?
3. How do we address the flowability due to the coarse particles in the waste powder?

Detailed solution/ process

The initial steps taken to condition the waste powder include ensuring the powder met the required particle size distribution (PSD) for Cold Spray Additive Manufacturing (CSAM) on the xSPEE3D system. This was done via a sieving step was carried out using an AS200 Tap and a RETSCH 75 µm mesh.

The sieving step using an AS200 Tap and a RETSCH 75 µm mesh, effectively removed large contaminants and maintained the powder within specification, with only 10 grams of waste lost during the sieving stage. For CSAM applications, the contaminants which are generated after the initial use are often ‘pancaked’ shaped as shown in Figure 1 and therefore they are often larger than the mesh size stated. For this specific application, the 10 grams of waste has indicated initially the minimal large contaminates within the powder. No other processing stages were applied to help remove contaminants.

To address any problems in terms of the flowability of the powder due to a high concentration of coarse particles, a series of blending techniques were employed to restore flowability in the reclaimed powder. Therefore, the blending process (incorporating virgin powder and our processed powder) helped in terms of creating powder with a more equally distributed PSD which aids the flowability.

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To understand the behaviour of recycled powder, initial trials using a blend of 75% waste powder and 25% “old” powder were trialled, but this blend failed to achieve adequate flow. However, a 50:50 blend ratio proved successful, enabling consistent flow and allowing the powder to be used in the cold-spray print.

However, during the deposition process of CSAM, it was noted the 50:50 blend ratio provided inconsistencies during the build process; throughout the powder, work-hardened copper particles which had not been previously removed, impacted the deposition efficiency of the process. Overall, it caused the build to be quite unpredictable, with a significant amount of variation due to the incorporation of waste powder.

To further validate this approach of recycling CSAM powder, the printed parts from the 50:50 blend were then mechanically tested. This highlighted the 50% waste powder blend had lower mechanical properties than the original virgin powder blend. Key parameters included ductility which was recorded at 19% for virgin powder build and 4% for the waste 50:50 blend, probably resulting from the coarse porosities present in the part.

This approach provided the opportunity to evaluate both mechanical and metallurgical properties of the printed components, demonstrating the potential viability of reusing waste powder through controlled blending for components where the geometry is the focus and not the mechanical performance of the part. To help further validate the ability to use recycled powder, future work is recommended to investigate vacuum drying or any other specific conditioning techniques to remove moisture present within the powders to help address flowability and the challenges in deposition efficiency found during printing.

1 Bibliography

Manufacturing Technology Centre. (2026). *Cold Spray Additive Manufacturing (CSAM) powder recycling and reuse*. Retrieved from https://www.the-mtc.org/insights/cold-spray-additive-manufacturing-csam-powder-recycling-and-reuse

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Competence unit coverage:

	AILEEN competence units	Covered CU
AW_01	Welding: Advanced Metallic Materials in Aerospace and Defence Sectors	
AW_02	Welding: Advanced Welding Processes and Equipment in Aerospace and Defence Sectors	
AW_03	Welding: Advanced Welding Applications in Aerospace and Defence Sectors	
AW_04	Welding: Introduction to brazing technology Knowledge for quality brazed joints	
AW_05	Welding: Fundamentals of Industrial Brazing: Main Processes, Quality Standards & Applications	
AI_01	Inspection: Non-Destructive Testing (NDT) in Additive Manufacturing for metals and polymers	
AI_02	Inspection: Metrology in Additive Manufacturing for metals and polymers	
AI_03	Inspection: Inspection of AM parts. Material Quality	X
AAM_01	AM: Qualification, Certification and Standards for AM in A&D	X
AAM_02	AM: Quality Assurance & Quality Control for AM in Aerospace & Defence	X
AAM_02/3	AM: Design of AM parts for A&D (2 courses - for DED & PBF)	X
AD_01	Digital: Introduction to Digital Technologies in Advanced Manufacturing	
AD_02	Digital: Data Acquisition and Analysis	
AD_03	Digital: Industrial Internet of Things (IIoT) and Advantages in Advanced	
AD_04	Digital: Artificial Intelligence and Advantages in Advanced	
AD_05	Digital: Automation and Advantages in Advanced Manufacturing	
AD_06	Digital: Potentials of Advanced Simulation and Modelling in Advanced	
AD_07	Digital: Potentials of Digital Twins and Smart Factory Automation in Advanced Manufacturing	
AD_08	Digital: Unlocking the Potential of 3D Models Beyond Technical Drawings in the Aerospace and Defence Sector	
AG_02	Green: Sustainable Design and Environmental Compliance in Aerospace and Defence	

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