Application of Directed Metal Deposition (DMD) for Manufacturing and Remanufacturing of Nickel Alloys Components

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Introduction

Nickel based superalloys have excellent high temperature mechanical and physical properties. They exhibit great thermal fatigue and oxidation resistance and are frequently used in applications where they are exposed to temperature range of 540˚C to 1000˚C [1]. Nickel Alloys are also known to have excellent corrosion resistant properties [2]. When using subtractive manufacturing techniques, engineers are often unable to use these alloys due to cost and availability restrictions. This article explores the use of an additive manufacturing technique called Direct Metal Deposition (DMD) to manufacture and remanufacture nickel alloy components. Since additive manufacturing creates near-net shape components, the necessity to use material removal techniques is minimized and the overall manufacturing cost can be greatly reduced [2]. This technique can also be coupled with conventional manufacturing processes to reduce the cost of the overall component. Furthermore, this technique is very well suited for large components. This article uses three case studies to examine this technique in more detail and compares its merits and limitation to conventional and other additive manufacturing/welding techniques.

Background

The success of DMD technique lies in the design of it powder, shielding gas and laser delivery nozzle shown in Figure 1a. Powdered metal is channeled into a cone such that its tip intersects with the substrate. A high powered laser beam is delivered through the axis of the cone to provide the energy to melt and fuse the powdered metal to the substrate. A curtain of shielding gas is created around the metal which protects the melt pool from atmospheric gases [3, 4].

During deposition, the laser creates a melt pool on the substrate. The addition of powdered metal to the melt pool increases its volume and creates a bead. By moving the nozzle relative the substrate intricate patterns can be created. By stacking these patterns on top of one another, 3D shapes can be formed [5]. Changes in cooling rates due to variation in part geometry and part temperature profile can influence the thickness of the layer being deposited. To counter this effect, companies like DM3D Technology™ use closed loop systems. Figure 1b shows an example of one such system where three Charge-Coupled Device (CCD) cameras monitor the height of the melt pool in real time and adjust the process parameters to maintain a constant layer thickness [3, 4]. Temperature of the melt pool can be controlled and monitored by the use of pyrometers [6].

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