Additive Manufacturing

Carbide End Mills for Additive Manufacturing Applications

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In recent manufacturing trade fairs, many machine builders from around the world are exhibiting new state-of-the-art machinery engineered for additive manufacturing. Although initially used mostly as a prototyping solution in the manufacturing sector, increasing digitalization and government initiatives are driving manufacturers to further accelerate the development of advanced additive manufacturing solutions.

What is Additive Manufacturing?

Unlike conventional processing, where an object is formed by removing excessive materials, additive manufacturing deposits material layer upon layer to form a three-dimensional object. Various substances can be employed for the layering material, such as metal powder, thermoplastics, ceramics, composites, glass and more. Additive manufacturing is agonistic to part complexity and can manufacture unique geometries that would be impossible or unrealistic by using traditional manufacturing methods. Coupled with today’s high connectivity production environment, additive manufacturing is radically revolutionizing the way products are produced by allowing companies to manufacture end products with similar scale and strength to injection-molded parts. In addition, additive manufacturing allows shorter delivery time, lower cost, higher quality parts, and generates minimal waste as compared to conventional manufacturing techniques. Due to these advantages, the adoption of additive manufacturing platforms has greatly accelerated across industries worldwide.

Types of Additive Manufacturing

As illustrated in Figure 1, there are two key categories of additive manufacturing based on material – metal and resin. For this article, we will only focus on metal additive manufacturing. Various metals and metal alloys can be used in additive manufacturing, such as stainless steel, titanium, precious metals and more. Within metal additive manufacturing, there are two main deposit methods – directed energy deposition (DED) and powder bed fusion (PBF). Furthermore, machines used for metal additive manufacturing can be classified into two categories – those that are used solely for deposition; and hybrid machines equipped with capabilities to deposit, heat treat, coat and metal cutting. Major machine builders in Japan have begun the production and sales of hybrid metal additive manufacturing machines. In response to new market demand, OSG Corporation has recently launched a new end mill series engineered for these hybrid machines, especially for the DED method.

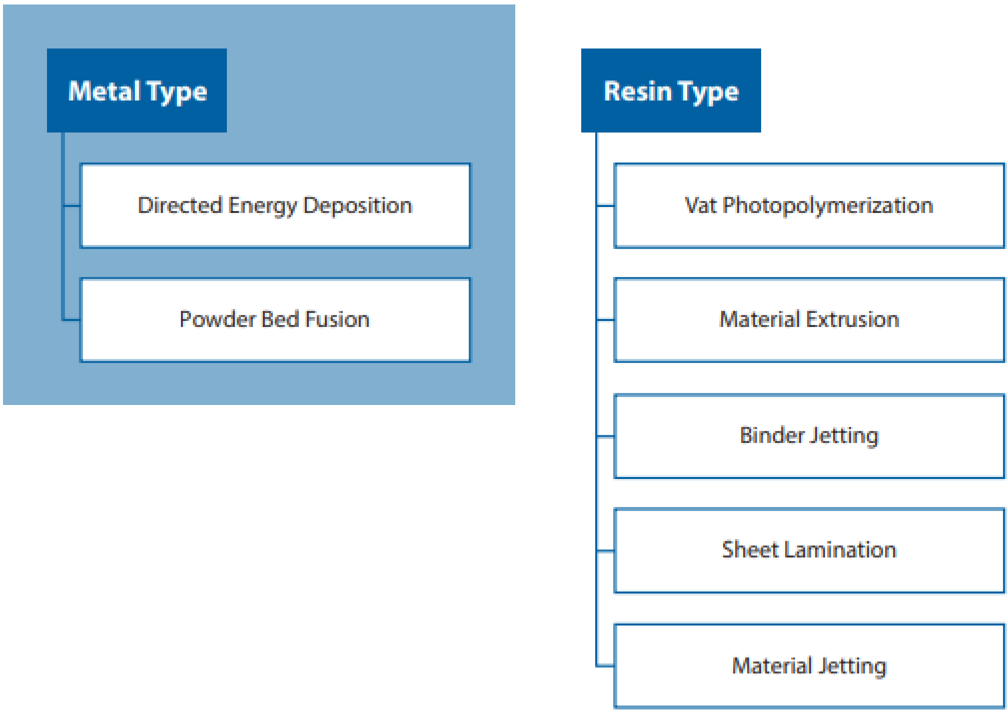

Figure 1. Types of additive manufacturing and deposit methods

As shown in Figure 2, although the DED method offers many advantages, its deposit accuracy is inferior to PBF. This shortcoming has a large effect on secondary operations, especially on the cutting process where cutting tools are used to complete the product. Figure 3 depicts deposited SKD11 (60 HRC) by the DED method. As shown in the photograph, a step difference of over 1 mm can be observed after the deposition. In the cutting process, a change in machining allowance of unevenness exceeding 1 mm greatly affects tool life and is a major cause of tool life reduction.

Deposit Method	Advantage	Disadvantage	Cutting Tool Requirement
Directed Energy Deposition	• High-speed deposition • Simultaneous deposition of multiple materials • Coating possible • Heat treatment possible • Large scale deposition possible	• Poor deposition accuracy • Complicated parameters	• Strong tool geometry for machining uneven, wavy surfaces • Enables large depth of cut to minimize air cut • Suitable for various work materials • Accommodates 3-axis and 5-axis machines
Powder Bed Fusion	• High deposition accuracy • Complex shape possible • Simple parameters	• Slow deposition speed • Single material deposition only • Limited deposition size (mostly small components)	• Optimal tool lineup for complex shapes • Optimal tool geometry for finishing • Optimal tool geometry and coating to prevent welding

Figure 2. Cutting tool requirement, advantages and disadvantages based on deposit method

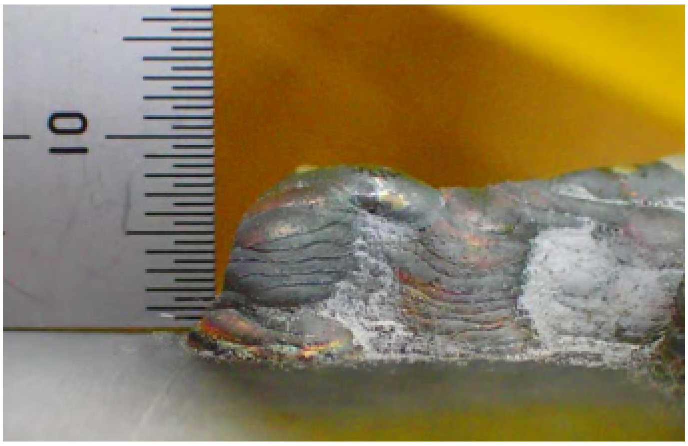

Figure 3. Photograph of deposit by the DED method in SKD11 (60 HRC)

To resolve this dilemma, OSG has developed the AM-EBT ball type carbide end mill (six sizes available from R3 to R10) and AM-CRE radius type carbide end mill (six sizes available from dia. 6 mm to 20 mm) that can achieve efficiency and long tool life in large depth-of-cut and high-hardness additive manufacturing work applications (Figure 4).

Features & Benefits of OSG's End Mills for Additive Manufacturing Applications

The AM-EBT ball type carbide end mill features a robust three-dimensional negative geometry optimized for large depth of cut. The AM-CRE radius type carbide end mill is available in 6-flute or 8-flute configuration. OSG's AM series end mills are recommended for materials in hardened steel, pre-hardened steel, stainless steel, heat-resistant alloy additive manufacturing applications and built-up welding parts.

Figure 4. From left, OSG ball end mill AM-EBT R6 and radius end mill AM-CRE dia. 12 x R2

The AM-EBT and AM-CRE are coated with OSG's original DUROREY coating. The super heat-resistant layer and ultra-fine periodic nano-layer structure of the DUROREY coating provides superior toughness while maintaining high heat resistance and abrasion resistance. The DUROREY coating also suppresses chipping in high hardness milling and enables long tool life even in the milling of built-up welding parts with large depth of cut.

The secondary process after metal additive manufacturing has very many similarities to the milling of built-up welding parts. For die and mold repair and correction applications, time-consuming air cutting is commonly employed. OSG's AM-EBT ball-type carbide end mill and AM-CRE radius-type carbide end mill are able to achieve high efficiency and long tool life for the roughing of additive manufacturing applications and mold overlay surfaces. These end mills have received a lot of positive feedback from manufacturers who have used them for trials and are able to successfully minimize air cutting and reduce machining time.

Today, the increasing demand for smaller, higher quality and more versatile end products are accelerating the development of additive manufacturing technologies. The global market for additive manufacturing is expected to experience significant growth in the coming years. The sales volume of additive manufacturing machines is steadily increasing, and business correlated to secondary processing is expected to increase correspondingly. OSG is positioned to readily respond to evolving needs through continuous research and development to help manufacturers further enhance flexibility, productivity and speed of digital manufacturing.

Previously Featured in OSG's ShapeIt magazine.

