Article by Dr. Stuart C. Salmon, the Father of Creepfeed Grinding

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GRINDING IS ONE OPERATION WHERE today's technologies are impacting what used to be considered a finishing process and adding the flexibility to do more operations over a variety of processes.

In order to take advantage of what is becoming available in grinding technology and to justify its purchase, it is critical to know the actual cost of manufacturing a part. Competitive companies are no longer purchasing grinding machines to replace worn out grinders to perform the same operation. They are evaluating manufacturing methods and adopting new practices to achieve higher quality parts at lower piece part costs.

A creep-feed grinding operation, for example, could replace a number of milling and broaching operations. Apart from the improvement in workpiece quality, the abrasive machining process will off-set the cost of capital equipment, consumable tools, resharpening, inspection and inventory of cutters, fixture cost, tool changeover and part handling times, and post-process deburring/finishing operations.

New bond systems.

Superabrasives, particularly CBN (cubic boron nitride), appeared in the late 1960s. Great strides have been made since then to improve bond systems and techniques to eliminate or at least better control wheel trueing and dressing operations. Resin bond diamond and CBN wheels, which require a certain amount of finesse to prepare for grinding, are facing strong competition in the new vitrified and electroplated wheels.

Vitrified bond superabrasive wheels are similar to the vitrified bond conventional abrasive, aluminum oxide and silicon carbide wheels. Wheel preparation is simplified, in that traditional wheel trueing methods, like crush form dressing and single point diamond dressing, can be applied to true and form the wheel periphery. However, all vitrified superabrasive wheels are not so easy to use, as a certain amount of peripheral wheel conditioning (sticking with an aluminum oxide stick) may be required prior to grinding.

The vitrified bond superabrasive wheels available today provide better chip clearance and better cutting fluid application over resin and metal bond wheels. Vitrified superabrasive wheels are particularly suited to, and are finding the most application in, ID (internal diameter) grinding where the wheel wear and redressing time associated with conventional wheels drastically affects the productivity and precision of the process.

Resin and metal bond superabrasive wheels can have very strong grain retention properties, yet to achieve that strength, they are very closed in structure and therefore limit the efficiency of the process.

New abrasives.
Not all grinding will be with superabrasives in the future. Particularly when batch quantities are low and a variety of form profiles are required, economic justification can be made for the use of conventional grinding wheels. The advent of ceramic abrasives, like Cubitron by The 3M Company (St. Paul, MN) and SG (Seeded-Gel) Abrasive by Norton (Worcester, MA), has greatly enhanced the wear characteristic of the grains so that they stay sharp and cool cutting, extending the life of coated abrasive media (in the case of Cubitron), and extending the time between wheel dressings (as with Norton's SG abrasive).

Conventional aluminum oxide is fused from bauxite. After crushing in a ball mill, the result is a very random shape grain with a very brittle structure. This is in contrast with the very dense and hard structure of the SG abrasive. However, a balance has to be struck between the properties of the SG grain and the "fracturability" and ease of bonding of the conventional fused alumina. This is why SG wheels are being produced with a variety of percentage mix of both the SG and alumina grain.

An exciting aspect in the manufacturing process of the SG abrasive is that the shape and aspect ratio of the grains can be controlled. Perhaps we might one day see a grinding wheel made of grains which are the same size and shape as well as oriented in the wheel to perform at maximum efficiency.

Machining the materials of tomorrow.
Ceramic materials are the greatest challenge to the machining industry today. Grinding, using diamond grinding wheels, is the only economically viable method for the precision machining of ceramic materials in their sintered state. Ceramic materials are generally very hard and prone to edge chipping. The mechanism for machining ceramics is different from machining metals.

Ceramic materials are machined in a manner which resembles the chipping of ice from a driveway. The surface is pitted with craters the size of which depends on the size of the grain being used. The diamonds on the grinding wheel periphery act more like a series of hammer blows to the surface rather than as cutting edges causing chips to form.

Work that is being conducted on laboratory research machines in Japan has shown that, with very small infeeds and a very rigid machine, ceramic materials can be machined within their plastic regime. This yields excellent structural surfaces with high surface integrity.

Abrasive machine tool design.
High precision and the ability to produce consistently high quality workpieces in state-of-the-art materials is a technological challenge. To perform this economically is another challenge and is directly related to the employment of the latest technology.

Lawrence Livermore National Laboratories (Livermore, CA) is synonymous with ultra-precision machining. Its search for an ultra-precision grinding machine took it to Italy where it was able to commission the most accurate creep-feed grinding machine ever built. Cimat-Camut produced the Gamma 625 machine. Standing on a giant block of stone and in an environmentally controlled room, this machine surpassed the expected values of slideway straightness, squareness, positioning and stiffness expected by the engineers at Lawrence Livermore.

Flexibility and versatility have been built into the Ceratech T-25 grinding machine by Mazak (Florence, KY). This fully CNC machine has been specifically designed for machining ceramics. It has automatic wheel changing capability from a magazine of wheel heads, wheel position sensing and an unusual method for trueing metal bond diamond grinding wheels. The CNC control is used to turn the inverse shape of the grinding wheel profile in a graphite electrode, on the machine. That electrode is then used to EDM the profile into the metal bond diamond grinding wheel. This concept allows virtually any shape to be formed into the grinding wheel in as short a time as it takes to turn the electrode.

Equipment is changing.

Advanced Science and Technology has developed a machine that looks nothing like a grinding machine, but the advantages easily outweigh its peculiar appearance. Basically, it has a stationary wheelhead concept, but supported equally from both sides of the grinding wheel. The wheelhead does not move; it is isolated and de-coupled from the workpiece manipulation system so that minimal process vibration is transmitted through the structure, providing more stability for high-speed grinding operations. The dynamic stiffness of the system will approach 10,000,000 lbs/in. How the workpiece is presented to the grinding wheel is what makes the machine a plane, cylindrical, or contour grinder.

A new era.

Electroplated superabrasive grinding wheels are taking us into high-speed grinding. High speed refers to the peripheral wheel speed. Conventional wheel speeds range from about 2,000 to 7,000 sfm. High speed grinding is in the range of 20,000-50,000 sfm. At these speeds, stock removal capability increases, wheel life may be extended and part surface integrity can be improved. The electroplated grinding wheel is a metal hub with a single layer of superabrasive plated to an accurately machine rim. The wheel needs no dressing, only trueing on the machine spindle. As the electroplated wheel is basically a metal disc, it can withstand very high rotational speeds without bursting.

Competitive advantage.

These new abrasives technologies should be viewed as a significant element in an approach to strategic manufacturing. Advancing abrasives technology, plus grinding machine tool development and refinement, can be coupled to provide a serious competitive advantage in material removal operations. The enlightened grinding practitioner will keep a close eye on both machine tool and abrasives technology to turn their rapid advancement to individual and corporate advantage.