

Catching up to Creep-Feed Grinding

Creep-feed grinding (CFG) is undoubtedly the fastest growing abrasive-technology process in the US, along with the use of superabrasives. To machine materials of the future---ceramics, cermets, monocrystal ceramics, whisker-reinforced metals, nonmetals, etc---grinding will be the only process available. CFG will be the only economical solution for ceramics. Conventional milling, broaching, planing, and turning---even in their most up-to-date forms---will not be able to cut tomorrow's materials. Grinding will be the only way for cutting tool technology to catch up to material science.

Unfortunately, the US machine tool industry has not kept abreast of this evolving technology and has lost market share to off-shore competition. US industry, until recently, has depended on foreign machine tool builders to produce creep-feed grinding machines and modern grinding systems. US builders have had to play catch-up, with few companies fully embracing the new technology, because of the significant investment commitment required---both financially and technically in the machine-tool designs suitable for creep-feed and superabrasive grinding.

CFG is a high-precision, high stock-removal abrasive process. Even the most difficult-to-machine materials can be machined relatively burr-free with excellent surface integrity. Metallics are being machined at rates much faster than milling and in the hardened state. The savings are not just the result of fast stock removal. Add to this the elimination of costly deburring operations, straightening after heat treatment, inventorying of raw material and consumable tooling, risk of thermal or metallurgical damage to part surfaces, or the need for expensive near-net-shape technologies. This is why CFG is the choice of the aerospace industry.

New machine requirements

CFG has been in use for almost 30 years. The 1990's will be an opportune time to reassess the CFG process and develop a completely new concept in machine-tool design, a new generation addressing these present and future industry needs:

Higher speeds: Industry recognizes the need for higher peripheral wheel speeds, particularly with superabrasives. This expertise lies predominately in Europe, and US safety standards for use of high wheel speeds lag those in Europe. Major high-speed advantages are being lost here due to inadequate machine designs and lack of initiative to improve wheel-safety standards.

Higher precision: Precision is directly affected by machine-tool design. Although CNCs and pseudo-adaptive controls allow poor machine designs to perform somewhat satisfactorily, the only path to an advanced, more precise machine is through its basic design.

A significant contributor is the epoxy/concrete machine base, such as the Granitan patent held by Studer in Switzerland. US builders are relying heavily on the Swiss for machine-base technology, as well as its fabrication and manufacture.

Wheel technology: The latest abrasive technologies require superior machine tools from the standpoint of thermal and vibrational stability, as well as truing and dressing methods. Whether the raw grains are manufactured by GE or DeBeers, the majority of superabrasive wheels are made by foreign sources. The latest grinding wheel technologies are vitrified superabrasive wheels and high induced-porosity conventional wheels. Japan leads the way in superabrasive wheel technology, followed closely by the Europeans. Domestic wheels have improved dramatically in recent years with some wheel specifications equal to European. Although the dollar decline has made foreign products less attractive, European wheel vendors remain highly competitive.

Materials technology: Machining the latest materials-high-temperature alloys, ceramics, and nonmetals-requires machine tools with high stiffness and superior control and resolution. As this technology accelerates, it is leaving behind those grinding machines that have been on the shop floor for years and are now either technically or economically unable to machine these latest materials.

Continuous-dress capability: Continuous-dress creep-feed grinding (CDCF) is an additional need for US industry, beyond CNC creep-feed and CNC surface grinding. Other than companies such as Brown & Sharpe, Roberts, and Gallmeyer & Livingston in the US; CFG and CDCF machine-tool expertise lies in Europe with companies such as Elb, Maegerle, and Hauni-Blohm. The Japanese are closely following the creep-feed process with Niigata and Okamoto offering machines capable of CFG and ceramic grinding.

Controls and automation

Control systems need to be developed to perform complex multi-axis contouring of shapes on CFG machines. Very high resolution is required. Contouring has opened a new market for CFG, but needs the development of user-friendly controls. For CFG to machine a wide variety of materials and profiles, it will need machines designed for faster and easier setups and economical small-lot production. Today's just-in-time concepts are completely different from those for the CFG machines of even a short time ago.

Even in Europe, makers of CFG machines still rely on the traditional surface-grinder approach to their machine designs; i.e., a century-old concept of manual operation. A major disadvantage of CFG today is that cut time is such a small portion of floor-to-floor time.

Automation of part loading/unloading, and wheel and dresser changing is of paramount importance. A newer surface grinder concept is needed that is uncompromising in capitalizing on the potential of the creep-feed process. The move is away from dedicated automated grinding cells (ably suited for producing turbine blades in high volume) to

more flexible systems that allow economical production of medium to small batches of a wide variety of workpiece shapes and materials.

Machineability research

Research in creep-feed machineability is presently being conducted in the US, and accelerated to encompass wider fields of materials, grinding wheels, dressing systems, and cutting fluids. With so little CFG expertise in the US, the process desperately needs a source of definitive machineability data, and users need confidence in what is very much a foreign process-in both senses of the word.

Process adaptive control is not presently a reality for CFG. Although machining to a predetermined algorithm is possible, true adaptive control is beyond the realm of present-day technologies.

Opportunity knocks

With these industry needs, there is enormous potential for the US machine-tool industry to build a new generation of CFG equipment. With little to be gained from equaling the competition, the effort should be to surpass it. A new approach would not only offer a competitive alternative, but boost export sales. This calls for a cooperation between user and machine builder, and input from independent sources to keep the design universal and not particular to one industry or application.

A concept I have long proposed for a whole new generation of grinding machines is based on bringing the part to the wheel, instead of the wheel to the part. This, after all, is how our ancestors sharpened their knives and tools: they held them against a stable, spinning wheel. They never attempted to do it the other way around!

My approach incorporates a wheelhead and dressing system more rigid and vibrationally stable than any existing production machine. Theoretical stiffness is in the order of 6 million lb/in. The principle of this patented design is a stationary, dual-supported grinding wheel. A special hydrostatic bearing allows the wheel and dresser to be changed easily, automatically, and accurately without sacrificing the mechanical stiffness of the system. The result is a single grinding machine capable of flat, form, contour, cam, and OD cylindrical grinding. This concept of versatility, stiffness, and stability would take abrasive machining into the next generation.

By Dr Stuart C. Salmon
President
Advanced Mfg Science & Technology
Cincinnati, OH