Dry Gear Hobbing

How modern machine controls, drives and motors play a part in this emerging new technology.

E. Peter Kovar

Question:

We are contemplating purchasing a hobbing machine with dry hobbing capabilities. What do we need to know about the special system requirements for this technology?

Answer:

If you are cutting small gears in high-volume production, you should consider the dry hobbing option. Dry hobbing offers many advantages and very few disadvantages over conventional hobbing. Currently only certain sized gears justify the cost of cutting with this method. The decision is based on the pitch rating of the gears, which influences the cost of the tools. Dry cutting technology is generally used for smaller automotive sized gears. Larger pitch gears are not manufactured in sufficient quantities to justify the use of carbide hobs.

As additional dry hobbing machines of various sizes are introduced by the manufacturers and the cost of the tools goes down, the dry hobbing method will gain wider acceptance in the industry. (See *Gear Technology*, November/December 1994, "Gear Hobbing Without Coolant," for a basic introduction to this technology.)

There are two points that I would like to make regarding this new technology. The first one is that although the advance in CNC technology was not the only catalyst in the development of the dry hobbing technique, it is one of the keys to the functionality of this technology. Dry hobbing would not have been possible without the recent developments in CNC systems and motors. The second point is that dry hobbing is very fast, so fast that the CNC cannot correct inherent machinery problems (as it can in slower traditional methods). Therefore the dry hobbing machine needs to be very well designed.

Hand in hand with electronics, two other forces accelerated the development of dry hobbing technology. One was the introduction of better carbide tool materials. Significant increases in tool life have been achieved over the last few years. Further advances in carbide and ceramic tool technology, along with reductions in the cost of these tools, will increase the appeal of dry hobbing even more.

The second accelerating factor was the total redesign of the dry cutting machines themselves for accuracy, thermal stability and fast chip removal. The machines also needed to be built to more exacting tolerances. Machines cutting at these ultra-fast speeds need to be more accurate.

The integration of the hob and table kinematics of these fast machines tests the limits of modern CNC controls. Currently, CNC systems can correct kinematic errors in the magnitude of 160 Hz, depending on the inertia ratio between the servo motors and the machine elements to be controlled. The critical area is the angular link between the tool and the workpiece (the mechanical element in the hob head and the table). Errors in the kinematics of the machine cannot always be compensated for by the controls at such high speeds. These errors need to be eliminated in the design of the machines themselves.

Why Bother?

Dramatic new concepts are usually met with resistance. The poet Alexander Pope said, "Be not the first by whom the new are tried . . . " Most of us tend to agree, especially when the new involves big capital expenditures and the abandonment of old, comfortable ways of doing things. However, dry hobbing technology has been proven in tests to be faster, less expensive and more environmentally friendly than conventional hobbing for many high speed applications and, therefore, should be given serious consideration by gear application engineers.

The dry hobbing process was developed primarily for economic reasons. New cutting tool technologies using

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high-speed carbide cutters and ceramic tools, along with the higher speeds of modern machines, made the dry cutting process possible. One dry hobbing machine can replace two to six conventional machines, depending upon the hardness of the steel being cut.

One tremendous side benefit of this technology is environmental friendliness. Not only are coolant purchases and disposal costs eliminated, but there is also the added benefit of cleaner air on the production floor. Some of the chief proponents of this technology are the operators themselves, who can work in a cleaner environment when dry cutting. Shop personnel, floors and equipment are not covered with coolant at the end of the day. There is also a reduced fire hazard since flammable oils are no longer needed. Bacteria and corrosion from water-soluble coolants are also eliminated. A final benefit of dry hobbing is the simplification of the process, as parts do not require washing.

Ceramic or Carbide?

The cost-effectiveness of ceramic hobs is still subject to debate, especially since currently no domestic manufacturer makes these hobs. Most of the testing and research being done by the domestic automotive industry is now focused on carbide hobs (although Fiat-Italy, and ZF in Europe are testing ceramic hob capabilities). At the moment, ceramic hobs are very expensive, more sensitive to correct setup and calibration than carbide hobs and difficult to sharpen. However, new coatings are being tested that may significantly increase their performance.

What's Involved?

Dry hobbing is much more complicated than simply "turning off the coolant." In addition to the cutting tool, three design factors must be considered. The machine itself needs to carry away hot chips efficiently so the geometry of the workpiece is not affected. Also, the machine's chip chute must not inhibit the chips. The chute design is therefore much steeper than that of a conventional machine (see Fig. 1).

The machine design must ensure thermal stability, since there is no coolant in the machine bed to carry away the generated heat. Dry hobbing machines are designed with special internal ribbing for thermal stability. They are generally quite heavy and incorporate special steep walls around the table. The machines also include an integrated chip conveyor to keep the heat of the chips from accumulating in the machine and to maximize the speed at which the chips are removed from the machine for disposal. In some cases, the manufacturers of the machines are using special vibration panels underneath the workpiece to accelerate chip removal. Finally, the machine must be capable of high cutting speeds. The machine's CNC-controlled, integrated automation must support the shorter machining cycles of these machines.

The feeds and speeds of the machine, along with the number of starts in the cutting tool, need to be optimized to obtain a chip thickness that can carry the heat away from the part. The machine must be capable of a minimum hob speed of 3,000 rpm and a table speed of at least 500 rpm. Engineers carefully select the appropriate motor sizes for these machines in order to ensure that sufficient torque is available to cut the proper chip depth efficiently. As new carbide compounds are developed, the hob and table speeds will be pushed even higher.

Machines for dry hobbing need to incorporate modern, preferably digitally controlled motors capable of supporting the dynamics in this high-speed application. The speed of the application also puts a demand on the synchronization of the hob and table rotations controlled by the CNC.

Without today's electronic technology, dry hobbing methods would not be cost-competitive. The machines and controls must be capable of achieving at least a 3,000 rpm hob speed for long periods of time without overheating. The selection of the controls and motor capacity is critical.

Another area controlled by the CNC in the past is temperature compensation. The thermostability of the conventional machine was not a critical area of concern for machine designers. Most gear machine manufacturers were able to compensate for inherent machine temperature instability with special coolant routing or by using the CNC to perform electronic compensation, although neither method was very reliable. Dry cutting requires that the machines have an inherent thermostability, and, therefore, the machine does not need electronic compensation devices.

Most of the heat generated in the dry hobbing process (as much as 80%) is carried away with the chips. Gears generally come out of the machine in the temperature range of 105–115°F. Machines that heat gears only to 115° generally do not require thermal compensation devices.

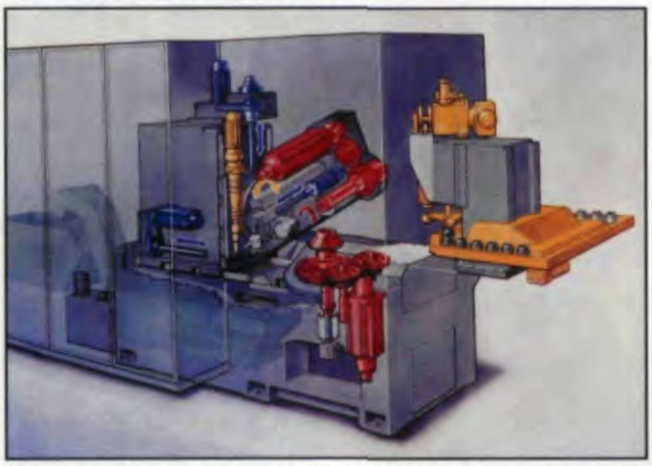

Fig. 1 — Concept hobbing machine for dry hobbing. Courtesy of Liebherr America. Used with permission.

Conclusion

Modern controls, drives and motors have set the pace for technological advances and a better environment. Dry hobbing technology is a giant step toward lowering the total long term costs of gear manufacturing and oil disposal. ✪

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