High Technology Hobs

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Today's high technology hobs are visibly different from their predecessors. Gear hobs have taken on a different appearance and function with present day technology and tool and material development. This article shows the newer products being offered today and the reasons for investigating their potential for use in today's modern gear hobbers, where cost reduction and higher productivity are wanted.

Even after some 150 years since the first hob patent was granted, gear hobbing continues to be the favored process for the production of many different types of gears, and no alternate method of making gears has yet appeared. At this time hobs appear to be one of the basic elements in gear manufacturing, like a wheel or lever, and so far, seem to be irreplaceable.

Hobbing is used for making a large variety of gears, including the smaller fine pitch gears used in instruments, timers, clocks and gages, where some pinions are as small as .050" in diameter and have pitches as fine as 150 diametral pitch (DP). On the large side there are gears that range beyond 20' in diameter and have pitches coarser than 1 diametral pitch. Such large gears are used in bridges, stamping and forging presses, drag lines, and mining and processing machinery. Between these two ends of the gearing spectrum lie the masses of gears that are used in the intermediate sizes and pitches. Here is where the demand for huge quantities of gears exists, and this is the most likely zone of opportunity for advancements in both machine tools for cutting the gears and in those gear cutting tools called hobs. While developments in the machine tools have moved at a substantial pace, the same has not been totally true of gear hobs, where even small changes in tool material metallurgy or tool processing were only accepted after a substantial period of trial and evaluation. Today hobs and machines are more closely linked together in the gear cutting process than ever before, and machine and tool builders have an opportunity to integrate the gear making system utilizing both machine advances and the latest improvements in the cutting tool field.

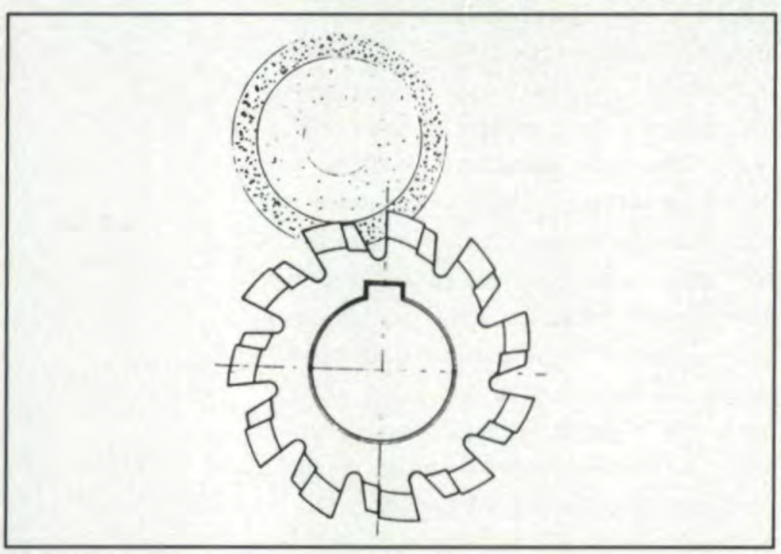

Fig. 1 - Conventional hob form grinding. (Courtesy FHUSA-Fabricacion de Herramientas y Utensilios.)

Five specific areas relating to possible improvements in cutting tool performance can be addressed. These are tool materials, tool coatings, tool accuracy, tool construction, and tool design.

Tool Materials

Almost all hobs are made from one of a large family of high-speed steels composed of iron plus some 17% to 27% of other metals - molybdenum, tungsten, vanadium, cobalt, and chrome. Usually selection is made on the basis of suitability to the material being cut, its treatment, and configuration. Some consideration must be given to all the factors involved and allowances made for tool material toughness, brittleness, wear, grindability, and cost. For coated tools the tool material is really a substrate for the coating, and usually the higher alloy super high-speed steels are most beneficial. Some gear materials are relatively free machining and only require the standard tool steels for the best economy.

Tool Coatings

A development with perhaps even more impact has been the use of the metallic compound titanium nitride (TiN) as a thin coating on hobs. The result in suitable applications can extend tool life by two to three times compared to an uncoated tool, which is a major improvement. This is attributed to the extremely high hardness, above 8O RC, and the dissimilar nature of the coating relative to the material being cut. The coating is resistant to high temperature and corrosion, welding, seizing, and, therefore, wear. The gains offered by the coating can be taken several ways, but by strategizing the operating parameters of speed and feed, the real advantage is to minimize the cost per gear as registered by a gear cutting cost analysis. TiN is not the only coating possible, and there are many that may yet be developed and offered. Titanium carbonitriding (TiCN) is one that is showing real promise for even greater cost reduction and is being actively used today.

Tool Accuracy

Tool accuracy may not directly influence cutting tool performance, but can yield benefits further down the processing line. Gear hobbing is strictly linked geometrically, gear to hob, in the cutting process. Inaccuracies in the cutting process, whether caused by the original hob quality or induced later in mounting or resharpening, have a way of being discovered later in the finished gears. Subsequent secondary finishing operations on the gear, such as shaving or rolling, may not remove all traces of hob runout, wobble, thread spacing, or profile errors. Since one of the major objectives today is to keep the hob in the machine as long as possible, then consistency of the hob across its entire length becomes imperative, since the hob will be shifted in use across its entire face width, and no significant variations in the gears cut can be allowed. On the multiple-start hobs that are frequently used, thread spacing also becomes critical, and most of these super hobs have unique tolerances specified that

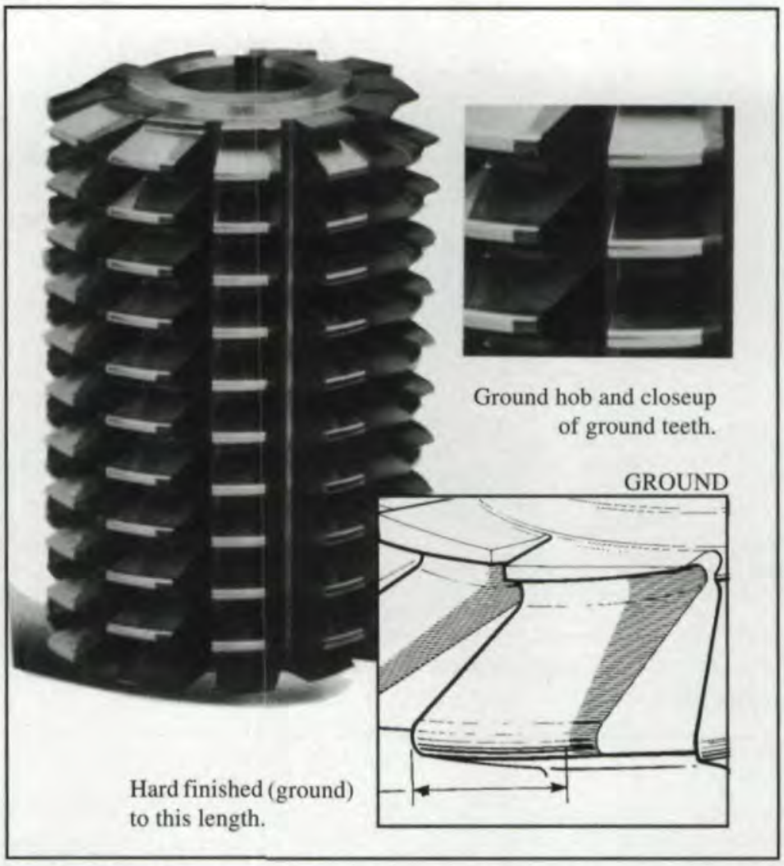

Fig. 2 - Star Cutter's conventionally ground form hob. (Courtesy Star Cutter Company.)

are nonexistent in the usual trade standards.

Hob Construction

The original solid or monoblock hob, which is the most frequently used construction, does have some limitations on its utility. This is especially so with those hobs that are ground on form to improve tool surfaces and increase total hob accuracy. Fig. 1 shows the small restricted size of a grinding wheel required to grind the hob flank as far back as possible. The wheel must eventually leave the flank being ground and be lifted out to start the grinding cycle on the next hob flute. A portion of the hob tooth length is then not useable because of a change of geometry in that area. Sometimes a sacrifice or compromise is made to reduce the clearance on the tool to let the wheel move further toward the next flute extending the ground length, but reduced clearance generally means increased wear. In the end, one cannot get full utilization of the available tool material.

Fig. 2 shows a traditionally ground solid Star Cutter hob and the unusable area is shown. Fig. 3 is an example of a new development by Star Cutter, a hob that is finished by a skiving process, and as with grinding, the operation is performed with the hob in the hardened state.

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Fig. 3 - Skived finish hob made by Star Cutter. (Courtesy Star Cutter Company.)

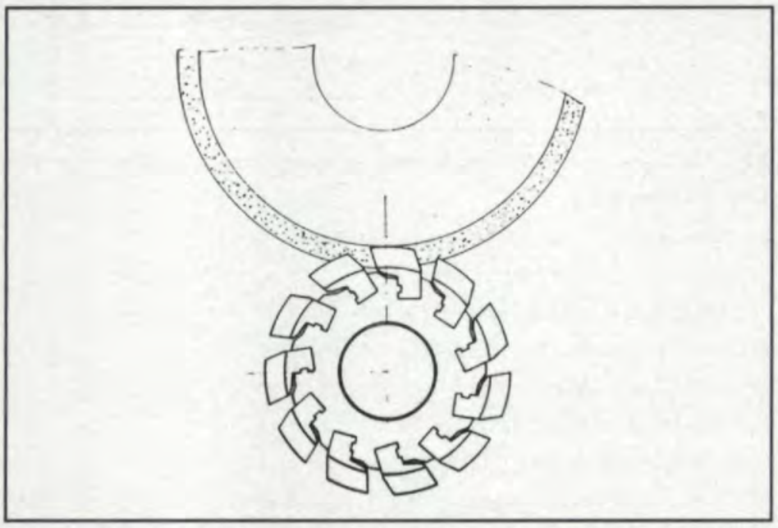

Fig. 4 - Segement hob blades in form grinding. (Courtesy FHUSA-Fabricacion de Herramientas y Utensilios.)

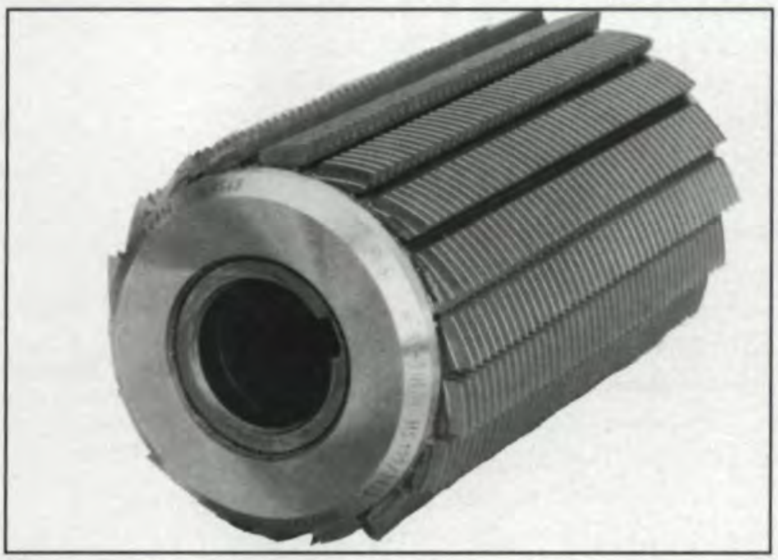

Fig. 5 - A FHUSA segmental hob. (Courtesy FHUSA-Fabricacion de Herramientas y Utensilios.)

The form on the hob is finished almost all the way back to the next flute and can be fully used, yielding the maximum resharpening. The skived surface has a super finish, good accuracy, and is suitable for coating with TiN and TiCN. It is limited to approximately 17.5°pressure angle and higher.

Inserted blade hobs are another way to address the accuracy and utility problems. When the blades are made for these hobs, they are ground while in a tipped-down position, and a set of blades is presented to the grinding wheel as a worm thread surface. As seen in Fig. 4, the grinding wheel is five to 10 times larger in diameter than that used on a solid hob, and no cam jump is involved. Very smooth flank finish and good accuracy is achieved. When the blades are mounted into the body in the cutting position tipped up, the tool clearance angles are usually higher than solid hobs and are conducive to longer tool life. The entire length of the hob tooth is consumable in the sharpening cycle, and the blades can be coated with TiN. An example is shown in Fig. 5 of a multiple-start hob made by FHUSA in Barcelona, Spain.

Hob Design

In hob design there are many variables that can be studied. The simple dimension of hob face width can be important when trying to increase machine up-time. Doubling the hob length will double time between hob sharpenings, minimizing machine down-time, machine reset, and setup proofing. Fig. 6 is an extra length hob with a reduced diameter made by Pfauter-Maag Cutting Tools. For comparison a conventional hob is shown behind it.

Hob diameter is another variable that can be used to advantage. A smaller hob diameter permits higher hob rotational speed, while keeping the surface speed the same. In turn this reduces approach time and allows faster part indexing, both of which reduce gear cutting time.

Another factor which reduces part cutting time is the use of multiple-start hobs. Since the gear being cut and the hob are locked together in the hob starts/gear teeth ratio, a two-start hob will increase the indexing or turning rate to twice that of a single start. Three starts will increase it three times, and so on. The net result is a significant reduction in the time it takes to cut a gear.

The surface of a hobbed gear flank is composed of a pattern of facets; feed scallops in the longitudinal direction, and generating flats in the lateral direction. The feed scallops are controlled by the feed rate, and the generating flats are a function of the flutes and starts in the hob. Since gears with larger numbers of teeth require fewer generating flats, and those with fewer teeth need more, the flutes must be chosen carefully. One must depart from the tradition of using standard fluting, which yields a somewhat large number of resharpenings, and balance the flutes, generating flats, and sharpening life to give the best results on the gear cost analysis sheet.

Optimized Designs

The design of high-production hobs today requires much more planning and data to arrive at a final specification. Part data, processing method; (i.e., finishing, pre-shave, pre-roll, or pre-grind), gear material and its physical properties, targeted part production rates, gear machine capacities and capabilities, loading and unloading methods, tool change timing, number of sharpenings desired, along with generating flats and scallops permissible, and chip load per cutting edge are used to develop the hob design and specification. The optimization will be in the tool material, tool coating, hob diameter and length, number of starts. and number of flutes.

Fig. 7 shows a hob based on the above concept made by Pfauter-Maag Cutting Tools. This Opti-Gash™ hob has several resharpenings planned into it. If the sharpenings are reduced to zero, the hob becomes a single-use, disposable hob. In this case the hob diameter is an additional variable, and it is made as small as possible to permit higher hob spindle speeds.

The Wafer™ hob, shown in Fig. 8 is a disposable or throw-away hob by Pfauter-Maag Cutting Tools. After it is dulled, it is retired and not resharpened. The hob tooth is just thick enough to support the cutting load, and the hob may be of an integral arbor type to facilitate the smallest diameter and maintain rigidity. These tools are coated by the Tinite™ process for further life enhancement.

Fette Tool Systems offers its version of a high-output hob, the Gash-master,™ shown in Fig. 9. It is available in 8.5 DP or finer, is TiN coated, and is a single-use, non-resharpenable hob. As many as 48 flutes can be used. Fette also offers a heavy duty hob which will have eight to 10 sharpenings designed into it. The hob is de-

Fig. 6 - Extra-length hob with conventional hob in back from Pfauter-Maag Cutting Tools. (Courtesy Pfauter-Maag Cutting Tools.)

Fig. 7 - Opti-Gash™ produced by Pfauter-Maag Cutting Tools. (Courtesy Pfauter-Maag Cutting Tools.)

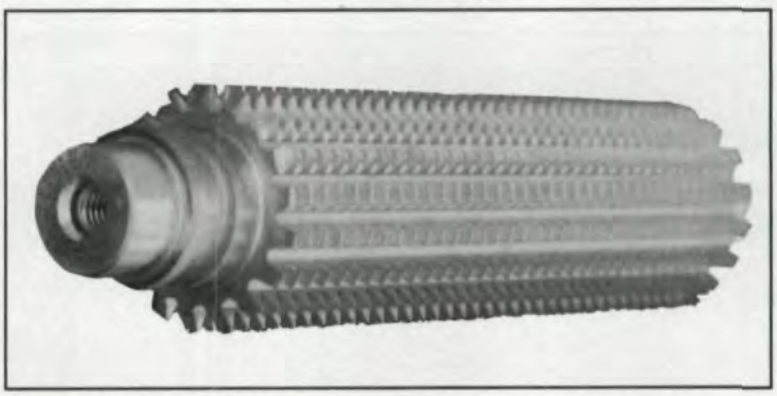

Fig. 8 - The Wafer™ hob offered by Pfauter-Maag Cutting Tools. (Courtesy Pfauter-Maag Cutting Tools.)

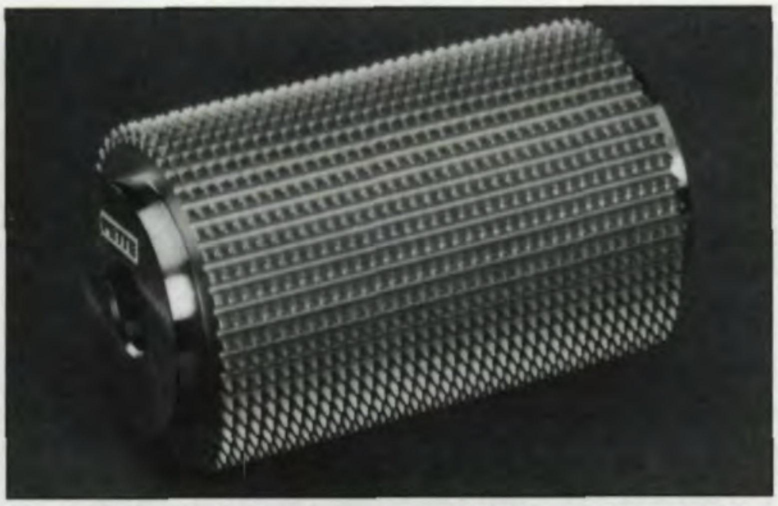

Fig. 9 - Gash-Master™ hob manufactured by Fette Tool Systems, Inc. (Courtesy Fette Tool Systems.)

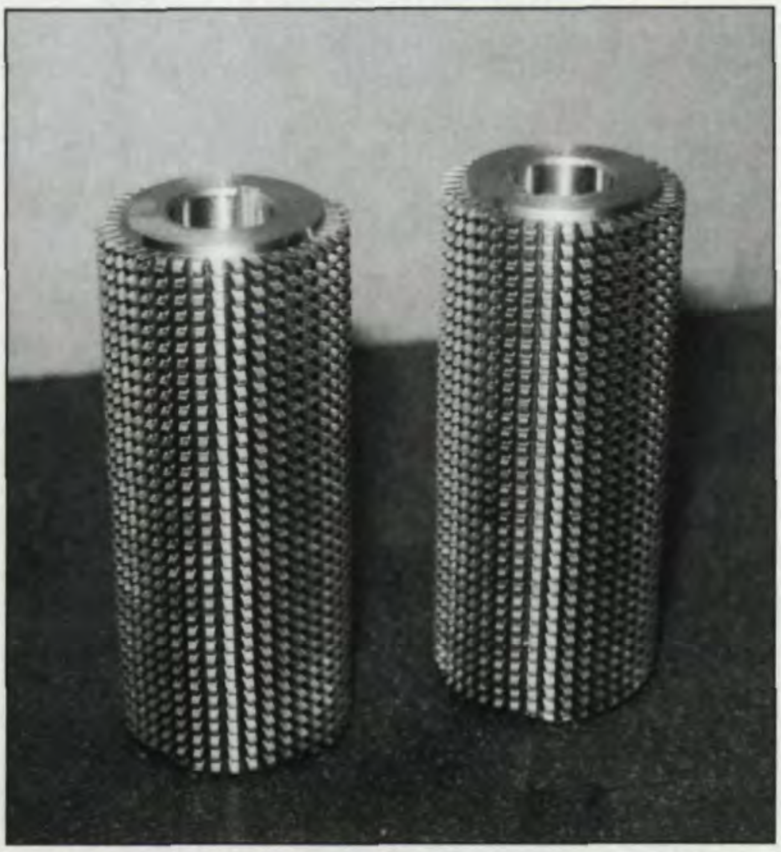

Fig. 10 - Illinite® Maintenance-Free hob made by ITW Components and Tools. (Courtesy ITW Components and Tools.)

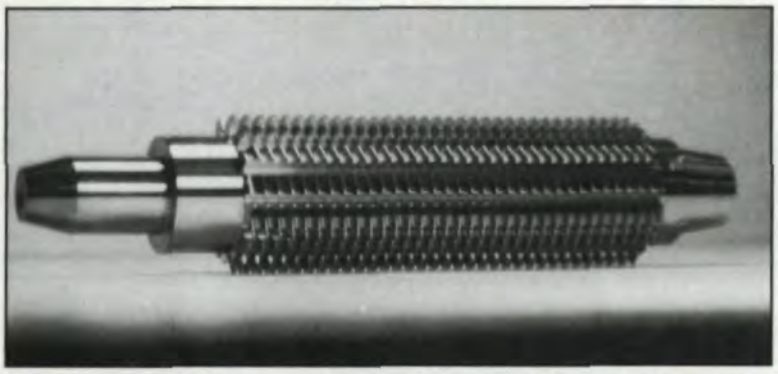

Fig. 11 - Star Cutter's small diameter hob with limited sharpenings. (Courtesy Star Cutter Company.)

signed with the same parameters and goals, but incurs the resharpening cycle.

ITW Components and Tools, an Illinois Tool Works Company, offers the Illinite® Maintenance-Free hob, a disposable hob with no resharpening, shown in Fig. 10. It is fully coated with a TiN or TiCN material and is constructed with a bore or as a solid integral unit.

Star Cutter offers its small diameter hob, a high-capacity hob, which is designed for a small number of resharpenings, with a solid integral drive shank or bore. It is shown in Fig. 11, and is fully coated with their Gold Star TiN.

There are some common general features regarding the super hobs, such as the Wafer,™ Gash-Master,™ and Illinite® Maintenance-Free designs. They have a long, useable face width, are as small on diameter as conditions allow, are coated, have many flutes, have multiple-starts, and are disposable and not resharpened. They always operate with a full coating on face and flank of the hob teeth and need no recoating. Their initial accuracy is intact for their duration, and no sharpening or qualification equipment or in-float inventory is needed.

The effectiveness of a super hob or any other hob can be measured by several factors. One is the number of pieces the hob can cut in its life, preferably measured by the lineal tooth inches cut. (This is the number of parts times the gear face width times the number of gear teeth. Some data for disposable hobs have reported 200,000 to 300,000 tooth-inches, and with the resharpenable hobs, even higher numbers.) Another measurement factor is the floor-to-floor time, and another is the cost of the tool. Probably none of these taken alone will represent the true picture, which is the net cost per piece. A complete gear cutting cost analysis, including tool cost, machine cost, setup and inspection cost, resharpening cost, recoating cost, tool inventory float cost, and perhaps a few additional factors, is needed to find the cost per piece.

Many times gears are cut under predetermined conditions with gear making and sharpening machinery already in place, and the Fette Heavy Duty and Star Small Diameter hobs, with limited sharpenings, could be more suitable for these circumstances. These "near" super hobs, because they are resharpenable, can produce more pieces per hob and might be the right choice when the manufacturing cost accounting is reviewed.■