

High Efficiency Gear Hobbing

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American Gear Manufacturers Association



TECHNICAL PAPER



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ABSTRACT:

This paper discusses the design advances of disposable gear cutting tools, specifically those which have produced the non-resharpenable Wafer™ hob, the application of the tools, and the benefits derived from applying these tools in gear manufacturing. The concurrent development of hobbing machines capable of efficiently applying these tool designs is also detailed.

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HIGH EFFICIENCY GEAR HOBBING

A New Approach To Hob Design & Gear Hobbing

Over a period of several years a range of gear cutting tools, specifically hobs and shaper cutters, has been developed using non-traditional design parameters.

For clarity it should be stated that traditional designs were developed in favor of minimum per piece tool cost with adequate

the diameter of the hob if sharpenability is to be maintained.

While an increase in tool diameter would not be detrimental in other machining operations, such as sawing or milling, the result in hobbing is a reduction in productivity in direct proportion to the increase in hob diameter.

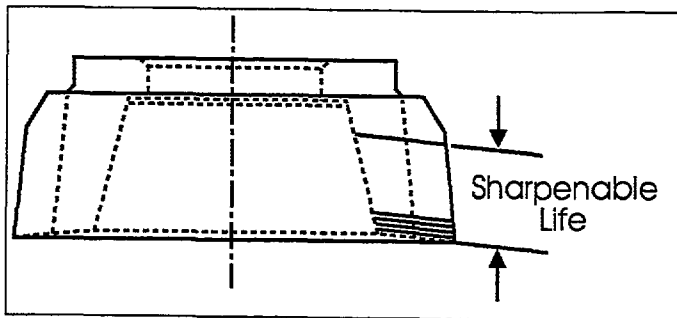


Figure 1. Sharpenable Life of a Shaper Cutter.

productivity and part quality.

When these parameters are applied to a shaper cutter design the result is a cutter which is severely compromised in respect to accuracy of the profile, which will produce correct profile geometry at only one point in its sharpenable life, and in its cutting geometry where relief angles are reduced to a minimum to lessen this effect (**Figures 1 thru 3**).

In the case of a hob, there is little or no direct effect on profile quality due to the tool being sharpened "to life". The indirect effect on accuracy of designing to a minimum number of gashes in order to maintain a high degree of sharpenability is, however, very clear.

The tooth profile of the hobbled part is generated by a number of flats, one per hob gash. Reduction in the number of gashes has a direct effect on the quality of the entire profile but is particularly noticeable in the trochoid area at the root of the tooth (**Figures 4a-4d**).

Increasing the number of gashes within traditional design parameters must increase

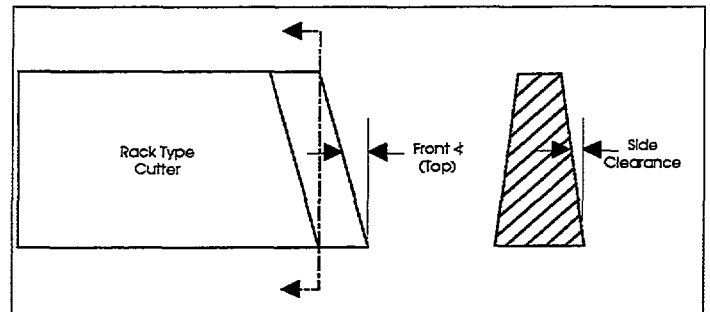


Figure 2. Rack Type Cutter.

It was with the idea of reducing the per piece tool cost that the Wafer™ shaper cutter concept was introduced in the 1980's. The idea of a low cost, disposable tool was obviously very appealing and, of course, is the "normal" design for turning and milling tools today.

In execution, the Wafer™ shaper cutter could not be economical based solely on the parameter of tool cost per Wafer™ compared with the tool cost of a solid cutter sharpened a number of times. On that basis alone a disposable tool or blade (**Figure 5**) would have to have a price equal to or lower than that of a standard cutter divided by the number of available sharpenings. Typically, this would amount to perhaps one twentieth of the cost of a solid cutter. Taking into account the accuracy requirements and the limitations of manufacturing methods this is simply not feasible.

Fortunately there are other factors involved which override this unfavorable cost ratio.

Such a cutter, freed from the constraints

of the need to sharpen, can be designed to optimum generating geometry; i.e., profile and size, and cutting geometry; i.e., clearance and rake angles.

The small amount of material in the Wafer™ itself allows for the use of premium tool steels and the absence of the need to resharpen allows for optimizing of coating type and thickness.

When the convenience factor is taken into account through the elimination of changes in size and stroke settings on the shaping machines and the elimination of resharpening and recoating, the concept becomes attractive.

Experience has proven that such tools

feed.

There is an obvious limit to such an approach. In fact, in some high production applications, particularly automotive manufacture, this limit was reached or exceeded in recent years.

In some extreme cases the forces applied to the workpiece were greater than can be effectively resisted by the available clamping area in the workpiece and the tooling. In other cases the feed marks are too deep for economical finishing by normal methods and the effect in the trochoid and tip areas is unacceptable (see **Figure 6**).

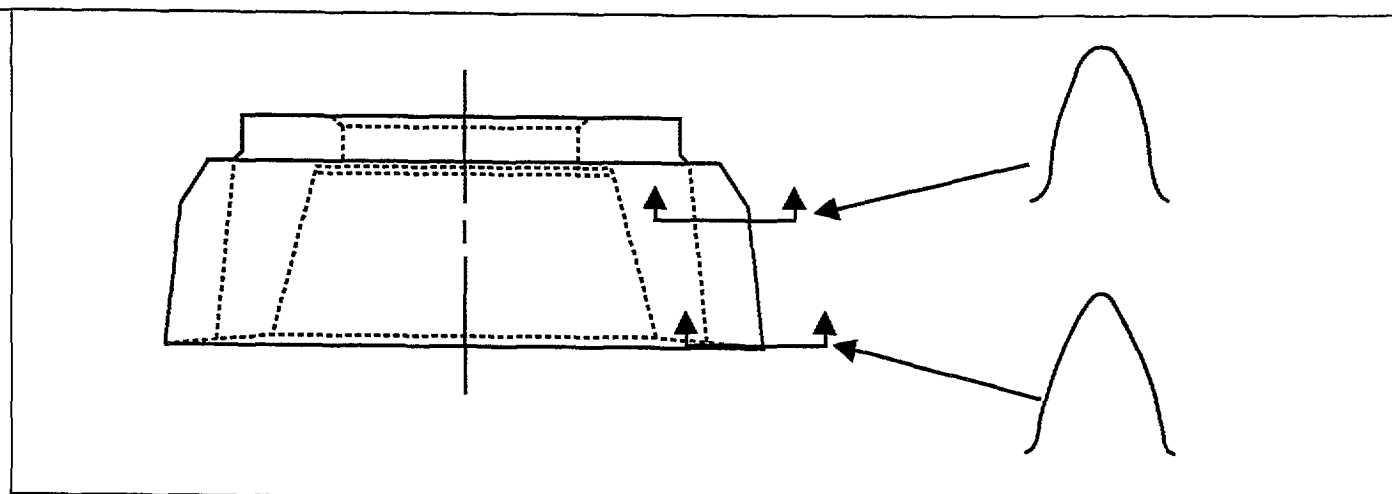


Figure 3. *Disc Type Shaper Cutter.*

allow machines to be run at higher stroking rates, cutting many more pieces per tool change with significant reduction in tool change costs and downtime (See **Table 1** for hob example).

Hobbing Limitations

Until now, improvements in gear hobbing productivity have resulted solely from the application of "brute force". Increasingly heavier, more rigid machines with greater horsepower and the application of multiple thread hobs with teeth or segments of heavy cross section (inserted blade hobs) to withstand the heavy loads applied from ever-increasing feed rates has been the general direction.

In fact, apart from cutting speed increases resulting from improved tool steels and coatings, all machine and tool design developments have been in the area of increased effective

An Approach to Higher Efficiency

Obviously, given the limitations of applied feed, every possible means to increase the speed must be considered if appreciable gains in productivity are to be achieved.

Given that the best available tool materials and coatings for a specific application are to be used there are two opportunities for the tool designer to increase productivity. These areas are the overall dimensions of the hob (diameter and length) and the cutting tooth geometry (particularly in respect to clearance angles).

It is necessary to understand the limitations of the traditional design approach and the compromises required to achieve traditional concepts of value in this tool.

Because the hob continuously advances

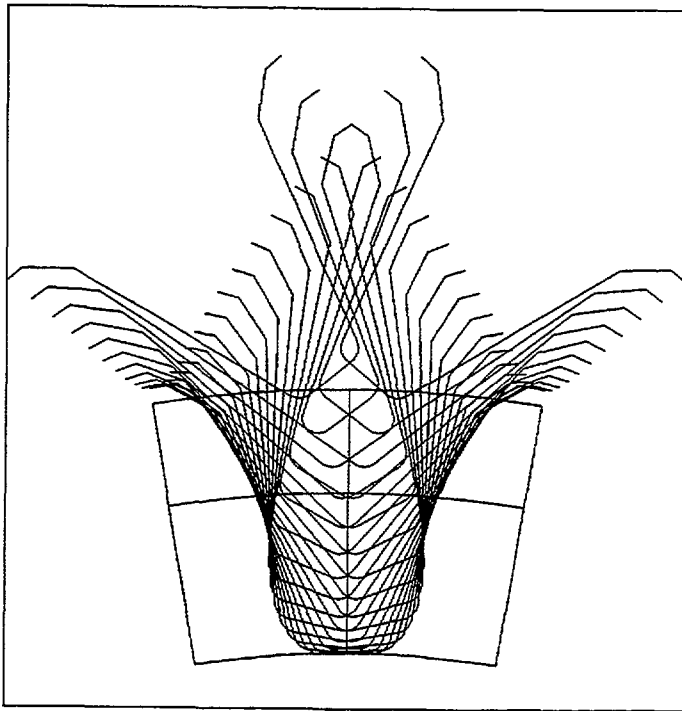


Figure 4a. Two thread hob with 12 gashes cutting a 19 tooth gear.

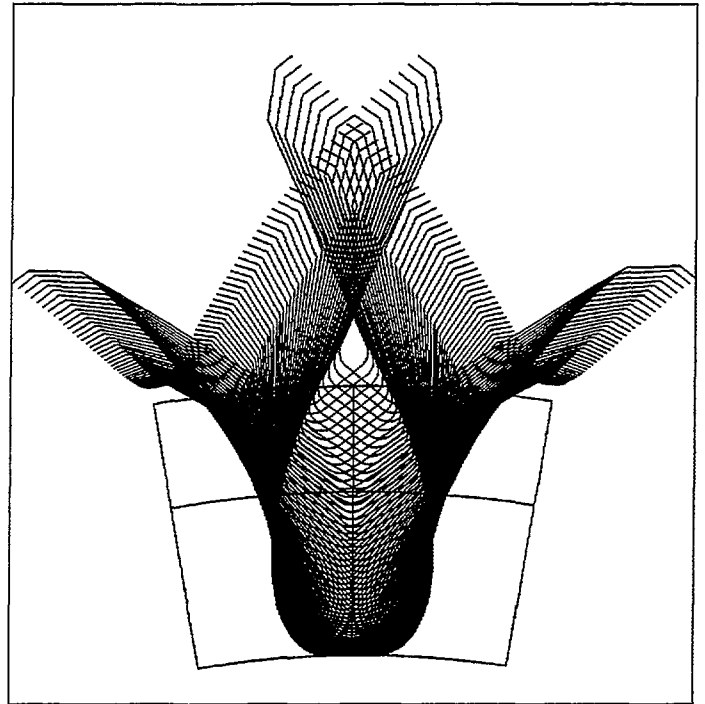


Figure 4c. Single thread hob with 24 gashes cutting 19 teeth.

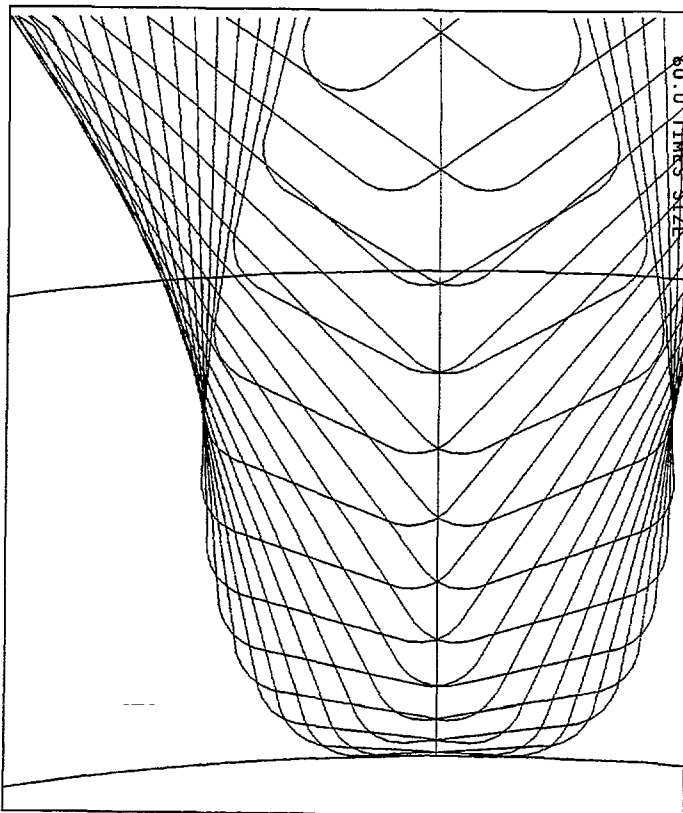


Figure 4b. Trochoid area of 19 tooth gear cut with a two thread hob with 12 gashes.

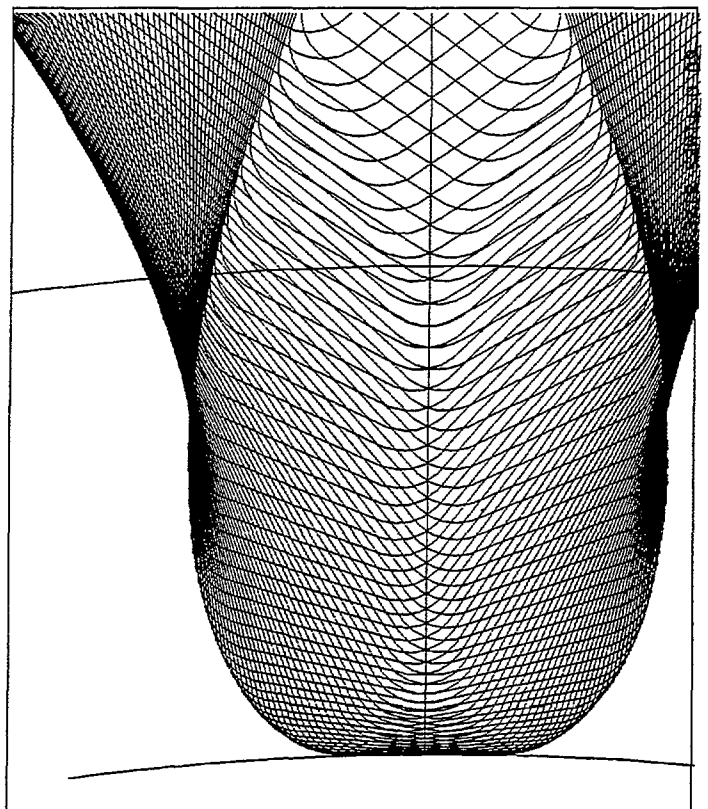


Figure 4d. Trochoid area of 19 tooth gear cut with a single thread hob with 24 gashes.



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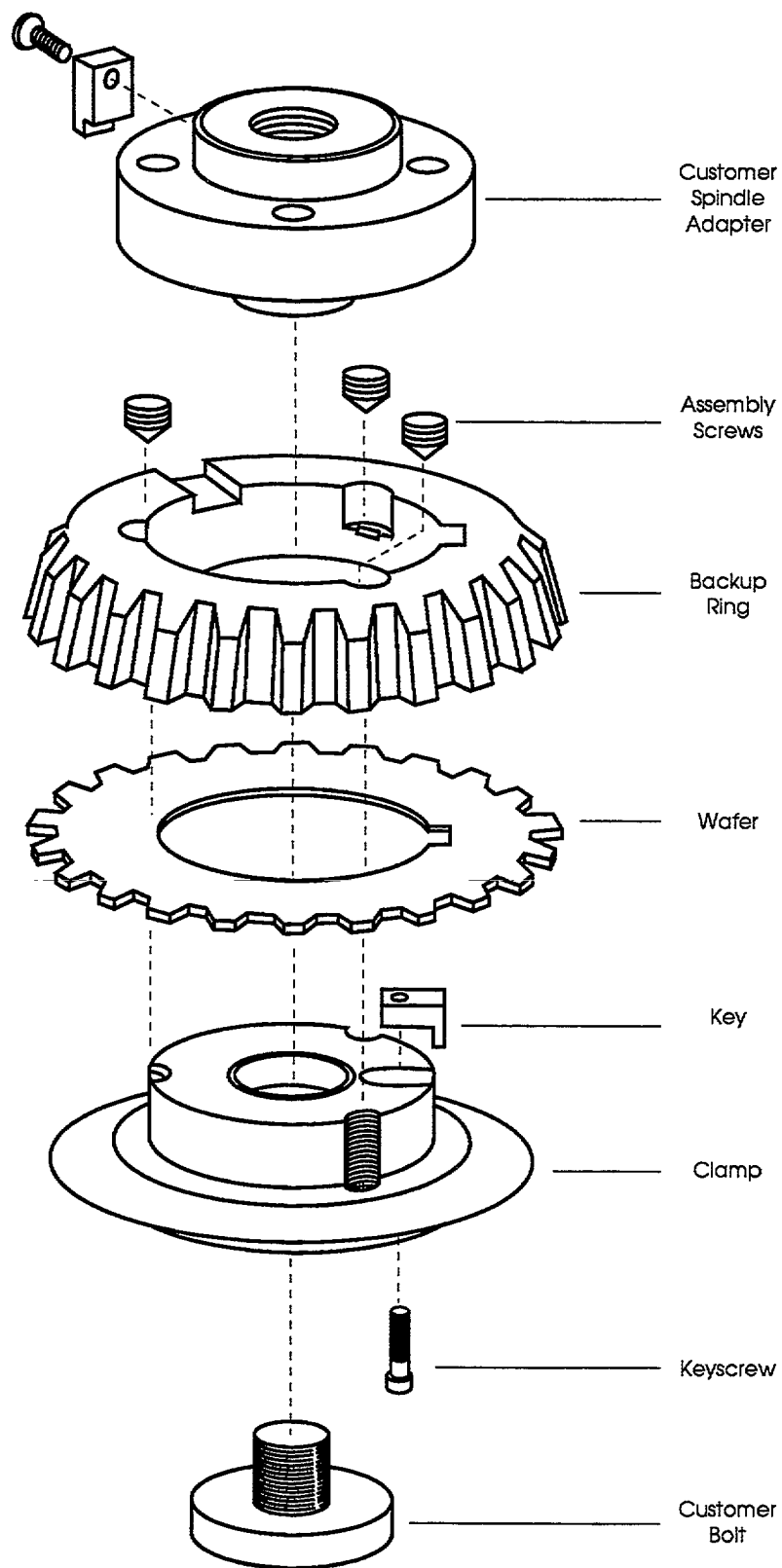


Figure 5. Exploded View of a Wafer™ Shaper Cutter Assembly.