

Cutting Worm Gears with Standard Gear Hobs

William L. Janninck

We make a lot of single-start worm and worm gear sets, and it always seems as though we're buying another special hob. We also do a lot of spur gear cutting, and the spur gear hobs and the worm gear hobs look alike, so we wonder why we cannot use the standard hobs for cutting worm gears too. Can we do this?

Bill Janninck replies: Yes, you can. We will explain how in a moment, but we would suggest you first look into the catalog worm gear

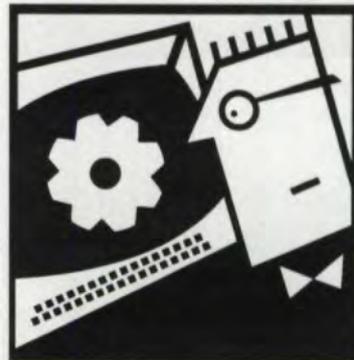
Since the hand of the worm and the hand of the hob must be the same, you have a better chance of finding a stock hob for a right-handed application, because more right-handed stock hobs are available.

hobs carried in stock and try to use them as well as your own supply of worm gear hobs whenever possible.

There are some differences between worm gear hobs and spur gear hobs which must be taken into consideration when using a spur gear hob to cut a worm gear.

Single-start worms, as well as those with multiple starts, can be of right- or left-hand configuration. Since it is imperative that the hand of the worm and the hand of the hob be the same, the chances of finding a stock hob are better for right-handed applications because there are many more right-handed standard stock hobs available than left-handed ones.

Worm gear designers traditionally have used standardized axial pitch dimensions for both the worm and gear, usually using fractional inches. The worm may have, for example, 1/2" or .5000 axial pitch, and the mating gear, for the typical right angle or 90° axis angle, will have a .5000 transverse circular pitch. This does make it easier to establish gear and worm specifications, including center distance, but there is no reason that the design cannot start with specifications located in the normal plane and based on the normal diametral pitch or normal circular pitch. A 10DP gear hob, for example,



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When a stock hob is used as the basis for your design, you must develop worm specs based on the hob dimensions and complete the rest of the design based on the worm.

has a normal circular pitch of .31416, and the design would have to be developed around this normal plane data, a different approach from the usual procedure.

In a traditional design, the worm and gear set are fully specified with gear ratio, lead angle and worm and gear dimensions. Then a hob is procured to suit the worm specifications. When an in-hand stock gear hob is used as the basis, you must develop worm specifications based on the hob dimensions and then complete the rest of the design based on that worm.

A sample case might offer the best explanation. A standard 2-3/4" diameter gear hob would be marked:

10NDP 20NPA 1-RH LA 2° 16'
.2157 WD

The normal circular pitch $NCP = \pi/NDP = .31416$. The actual outside diameter of the hob measured is 2.730. The hob pitch diameter would be $2.730 - 2 \times .1157 = 2.499$. (.1157 is the standard hob addendum for .2157 whole depth.)

The suggested hob diameter oversize between the worm and hob, which will give about 30% gear face contact, is $0.10 \times .31416 (NCP) + .050$ and is .081. Worm pitch diameter is then set at $2.499 - .081 = 2.418$, and the worm outside diameter is

$2.418 + 2 \times .100 = 2.618$. (.100 is the standard addendum for .2157WD). The sine of the worm lead angle is $NCP/(2.418 \times \pi)$, so the worm lead angle = 2°, 22'. The worm lead and axial pitch are $NCP/(\cosine \text{ worm lead angle}) = .3144$. The worm normal pressure angle is the same as the hob and is 20°. The worm thread thickness at the pitch line is one half of the normal circular pitch, minus some allowance for backlash. The whole depth of the worm is as marked on the hob and is .2157. This provides enough data so that a worm can be made that is suitable to the above gear hob.

As with a regular worm gear hob, this hob can be used to cut any number of teeth on the gear from 16 up, without causing natural undercut. In our sample case, if we need a 40-tooth worm gear, its pitch diameter is $(40 \times .3144)/\pi = 4.003$. The throat diameter would be $4.003 + 2 \times .100 = 4.203$. The center distance would be the sum of worm and gear pitch radii — in this case, 3.210.

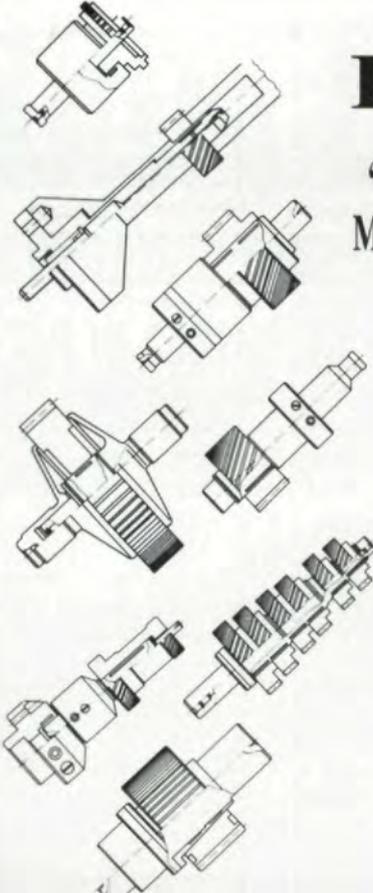
If the center distance for the set must match some existing or preset dimension, it may be possible to spread or close the dimension and then cut the worm gear oversize or undersize to suit. There is no simple formula to calculate how much to allow, but on our 40-tooth example the center distance could be varied approximately $\pm .157 \times NCP$; that is, from 3.161 to 3.259.

There is some further flexibility in the amount the center distance can be altered, and for our 40-tooth gear, if the centers are closed by $.314 \times NCP$, the worm gear pitch diameter will coincide with the gear throat diameter, resulting in what the trade calls an all-recess-action worm gear set. Unless you are familiar with this design of worm gearing, going to this extreme is not recommended.

Another detail to be resolved is that most all worm gear hobs are

made in a topping configuration so the throat radius is swept out or machined during the tooth hobbing operation. Most spur gear hobs are non-topping, meaning that they do not cut or touch the gear outside diameter. In preparing a gear blank then, the throat diameter and the sweep radius will have to be machined as a turning operation.

We have had success using this procedure in a number of situations. One case was with the replacement of a gear set on an emergency basis for an important section of a production machine. The steel worm was salvageable, but the bronze gear was completely worn away, resulting in tooth breakage. The worm gear had a long lead time for an original equipment replacement, the machine was foreign-built and the gear set was dimensioned in met-



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Most spur gear hobs do not cut the gear outside diameter; therefore, when preparing a worm gear using such a hob, the throat diameter and the sweep radius will have to be machined as a turning operation.

rics. A common replacement set, including both worm and gear, were made using an available stock gear hob, meeting the required ratio and center distance. ■

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