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focus: making automotive parts

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Alternative FORM

Rolling worm forms: overview and advantages.

A worm is a thread form produced on a cylindrical shaft that meshes with a helical gear. Combined, they can produce a significant speed reduction in a single stage.

Worm gears often are used for applications in which the power source runs at high speed and the output is at low speed and high torque. A unique characteristic of worm gears is that the worm can easily turn the gear but the gear cannot turn the worm. This locking feature is desirable in applications that involve lifting or pulling, such as winches, cranes and conveyors.

Worm forms also are incorporated into many automotive components, including high-performance slip differentials, windshield wiper systems, power mirrors and seats, and retractable running boards.

Advantages of Rolling

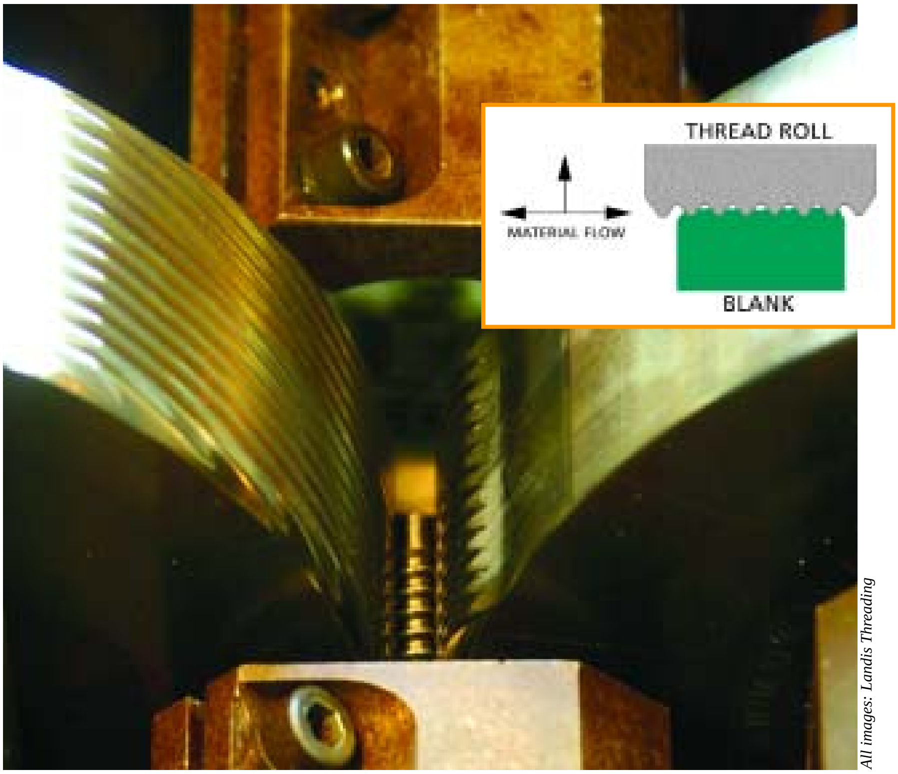
The traditional way of producing worms is by cutting or grinding. An often overlooked technique is rolling. In this process, the worm's spiral groove is cold-formed by specially designed, hardened dies that penetrate a round blank. The force required to accomplish this is sufficient to permanently displace the workpiece material, which flows both axially and radially.

Rolling offers these advantages:

Longer life. Although rolling equipment costs more than metalcutting machines, dies usually last much longer than cutting tools. A set of dies can produce anywhere from several thousand worms to as many as 500,000, depending on their geometry and the process. Moreover, the dimensional tolerances of the finished parts remain more uniform during the life of the dies.

Higher strength. Rolled worms are stronger than their cut or ground counterparts, because those parts are severed, not cold-formed. Rolling produces a metallurgical change in the finished product. The material near the worm's surface workhardens, becoming harder than the original blank. The increased hardness can be as much as 10 HRC.

Greater wear-resistance. Workhardening also makes rolled worms more wear-resistant. When dies penetrate the blank, the rolling action rearranges the grains and creates residual



All images: Landis Threading

Rolled worm forms are more wear-resistant than cut worms. Inset: When a blank is formed into a worm, material flows radially and axially.

compressive stresses, which raise the worm's resistance to tensile loads. Tensile strength can be increased about 10 percent, and fatigue strength can be improved by as much as 50 to 75 percent.

Material savings. Because rolling is a chipless process, smaller-diameter blanks can be used than when cutting. This can yield significant material savings for long production runs.

Speed. Grinding, though capable of producing highly accurate worms, is a relatively slow process compared to rolling. And, grinding accuracies are not required for every application.

Rolling Considerations

Several factors must be considered before instituting a worm-rolling program. Other than the equipment needed, the most important of these is material selection.

Generally, a material-elongation factor of 12 percent is considered acceptable for rolling fine-pitch worms. However, as the pitch becomes coarser and the form deeper, the elongation factor must be increased. In one case where a coarse-pitch worm was being rolled by the in-feed method, the material had to be annealed so that elongation was approximately 27 percent. This allowed the worm to be rolled in one pass.

Fine-pitch worms have been rolled successfully in materials as hard as 32 HRC, with acceptable die life. Coarser-pitch worms may require use of a material with a much lower hardness, perhaps as low as 160 HB.

Microstructure and chemistry play roles in whether a rolling operation is or isn't successful. Sulfur and lead are added to steels to improve their machinability. But these additives prove detrimental when rolling. To ensure good rollability, it is recommended that the sulfur content not exceed 0.13 percent and the lead content be less than 0.1 percent.

Materials with good rollability have a specific flow pattern, which can be seen by acid etching a sample of the rolled worm. In materials that lend themselves to rolling, the grains will have been reoriented. The grains of materials that are poor candidates for rolling are merely relocated.

In general, worm-rolling materials are limited to the carbon and alloy types of steel. Only fine-pitch worms are rolled in stainless steels, aluminum, brass and bronze.

Steels that are good candidates for worm rolling are 1137, 1132, 1120, 1117 and the following series: 1300, 3100, 4000, 4100, 4300 and 8600.

An important design consideration is the pressure angle. While it is practical to roll worms in which the pressure angle is 14½°, there are good reasons to choose a higher angle, such as 20°, 22½° or 25°. Among them are greater ease of rolling and lower rolling forces, improved flow pattern and finish, better control of end feeding, straightness and concentricity, and longer die life.

Worms with higher pressure angles have narrower roots and crest areas. The correspondingly narrow crest on the dies allows them to penetrate the blank easier, meaning lower rolling force is required.

The design and size of the blank can have a measurable impact on the success of the rolling process. When designing a worm for rolling, the minimum active length of thread must be determined. Only the number of full threads required to mate with the worm gear, or worm wheel, should be specified.

To maximize die life, it is important to maintain control of the blank diameter. When an oversize blank is used, excessive forces are exerted on the die teeth, causing premature failures. The proper blank diameter should be established through test rolling.

Blanks must be as straight and round as possible to prevent any tapering or out-of-roundness on the rolled workpiece. The blank should also be free of scale and oxide, which can cause the die to suffer abrasive wear.

Finally, interested manufacturers should consult a qualified engineer, one who has worm-rolling experience. He or she can determine the suitability of the process, help resolve technical issues and get a manufacturer "on a roll" as quickly as possible.

Rolling out safer vehicles

Auto manufacturers are confronted with increasingly rigorous governmental safety standards. One such standard requires that the armatures of motors used for power seats maintain integrity during crash tests.

One common source of armature failure has been the teeth on a small gear driven by the worm form. Increasing tooth thickness improved crash integrity, but also created challenges when manufacturing the worm form. The change to thicker teeth on the worm wheel necessitated thinning the teeth on the shaft worm, a feat not easily accomplished via rolling.

Engineers at Landis Threading Systems used its segmental dies for the job. They proved to be the only practical method for producing the small-diameter, coarse-pitch worm.

The reason is due to the dies' proprietary design. The beginning of the rise, or throat area, is ground with a tooth profile that is narrow and shallow, then it progressively gets wider and deeper until it reaches the full thread section. This design feature allows the die to roll thinned-tooth, small-diameter worms to full depth.

—B. Shook

About the Author

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