TIPS FOR TOUGHER MOLDED PLASTIC GEARS

Plastics are quickly becoming a contender for some power gearing applications, and the lessons learned in development will apply to other engineering design challenges.

By Rod Kleiss

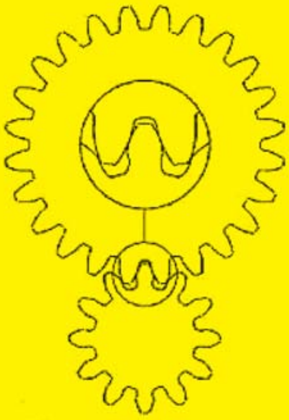
Molded plastic gearing is rapidly becoming a real contender in moderate power gearing applications. Custom gear design, precision molding equipment, and new formulations of engineering thermoplastics are offering real breakthroughs in performance. With proper processing, material control, and precision inspection, molded gears can lead the way for improved performance at lower cost with plastics.

Molded gearing requires special attention in the areas of unique part and cavity design, precision molding, and inspection. Rarely do molded gears have the cosmetic appearance requirements of other plastic parts, but they are often required to transfer relatively large torques or precise rotary position in less than perfect environmental conditions.

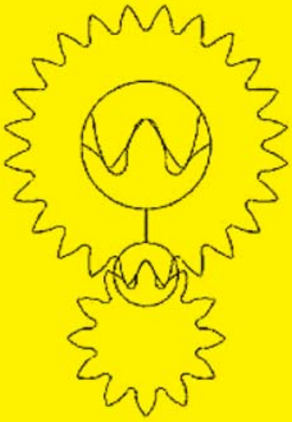
The first step in achieving a performance enabled molded gear transmission is through design. It is a very common and basic mistake to assume that standard gears as found in catalogs are suitable for a molded application. Standard gears have evolved for simple steel gear requirements. Their tolerances have been set with the expectation that these gears will be cut with hobbing machines.

Thermoplastics are much weaker than steel. In general, custom design is used to help increase the load carrying capacity of the gear set. At the same time, tolerances for a molded gear will need to be greater than for cut gears. Longer, bigger teeth will help in that regard as well. Figure 1 shows a standard gear mesh next to a specially

FIGURE 1:



STANDARD GEAR SET



MODIFIED GEAR SET

designed molded set. Even visually, the apparent improvement in strength is obvious.

Once the gears are designed the gear cavity must be developed. It is critical to understand and be able to measure the actual shrinkage characteristics of the plastic material for a gearing application. Simple look and feel estimates and inspections will almost never result in a correctly sized gear. At the very least there are four distinct shrink rates for molded gears, as shown in Figure 2. Estimates for these shrinkages are made; the cavity is constructed and placed in the precision tool.

In general, gear tooling will be of the three-plate design with excellent temperature control and insulated mounting plates. Spur cavities can be cut with extreme accuracy by wire Electrical Discharge Machining (EDM). This tool with this first estimated shrink cavity will then be set up and molded with a process intended to maximize accuracy and properties of the selected material. No concern should be given at this first trial to actually mold a gear to size. Size will be determined completely by the

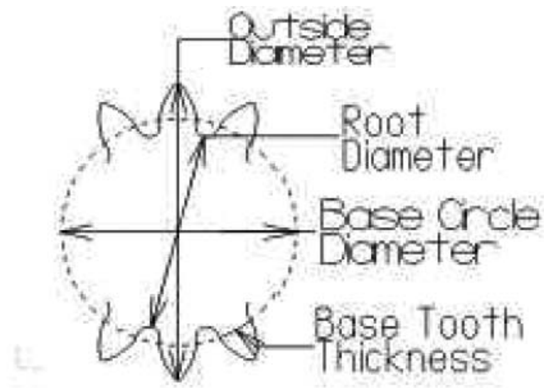


FIGURE 2: SHRINK RATES

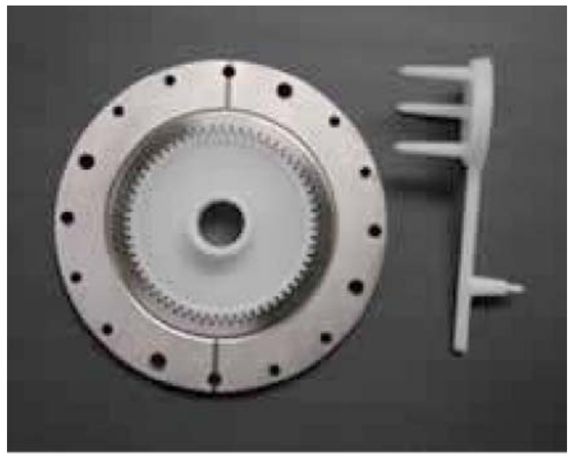


FIGURE 3: TYPICAL GEAR CAVITY

cavity design. Process will control material properties and dimensional repeatability. Once a stable, repeatable process is established, the molded gear can be measured and a final cavity cut for nominal molded part dimensions.

In the design of a good gear mold, it is always a good idea to make the gear cavity easily replaceable. Invariably this cavity will need to be resized at least once. Usually it is more cost effective to make two cavities right away so that resizing will not take so much time. A typical gear cavity is shown in Figure 3, with its cold runner next to it.

We should discuss the actual molding of plastic gears just a little bit. Our experience at Kleiss Gears is that the molded gear should be filled to maximize its weight. Gates should be large, and melt material should be injected hot to decrease viscosity and increase flow. The material vendor recommendations for process parameters are a good place to start, followed by varying the control conditions to determine the effect of minor changes on flow, pack, and part stability. To do this, it requires state-of-the-art molding machines with continuous monitoring of temperatures, speeds, and pressures. Just as one cannot bake a soufflé on a campfire, one cannot mold a precision gear on a generic molding machine.

Materials have come a long way in this pursuit of a better-molded gear. Historically, unfilled acetal and nylon have been the materials of choice for molded gears, and they are both quite good. Both materials exhibit large shrinkage coefficients from the mold to the part, but their behavior and stability in gearing applications are excellent. Provisions must be made for thermal expansion and water absorption, but that is straightforward to do in the early design work. Using filler in gears is not such an easy decision when trying to improve strength. Filler will nearly always result in knit lines, which affect accuracy and strength. Filler will also introduce abrasive into the gear, which will affect life and wear. Whenever possible, unfilled materials should be chosen. Acetal has the most forgiving and easiest processing advantages. Nylon can withstand higher temperatures with greater strength.

Some of the new high temperature nylons on the market are showing excellent promise in even higher temperature regimes. Unfilled polyetheretherketone (PEEK) has also shown great promise as an excellent gear material. It is much stronger than the traditional unfilled plastics, and I believe it may indeed be able to replace steel in some power gearing applications with all of the advantages of plastic material, yet with strength approaching that of steel.

The future for molded plastic gears is very positive. The advances being made today will yield better, more cost-effective products tomorrow. The lessons we learn with gears can also be applied to other challenging engineering tasks. As with every technical challenge, the ingredients to success with molded gears are design, implementation, and verification.

ABOUT THE AUTHOR:

Rod Kleiss is president of Kleiss Gears, Inc. He can be reached at (715) 463-5995 or kleiss@kleissgears.com. Go online to [www.kleissgears.com]. This article was originally published in *My Plastics Journal*.