Recent Advancement In Gear-type Oil Pumps

Helical, Asymmetrical Gear Teeth

Pumps that use external/external involute spur gears have been, and continue to be, very popular. That is because they can strike a very good balance between overall performance and cost. However, with the increasing expectations of engineers, as well as vehicle owners, concerning operating efficiency and NVH (Noise, Vibration and Harshness…), certain, fundamental characteristics of oil pumps that use external/external involute spur gears must be addressed.

Volumetric Efficiency

A major source of leakage within a gear-type oil pump is the clearance between the tips of the gears' teeth and the radial surfaces of the pockets where the pumps reside. At very low ambient temperatures, there must be enough radial clearance to accommodate the various manufacturing tolerances and any differences in thermal expansion between the gears and the pump body/housing. As the oil heats, it becomes thinner and the rate of internal leakage increases dramatically. If the gears are made from steel, cast iron or sintered steel and the pump body/housing is made from aluminum, then the radial clearance will increase, thereby allowing even more oil to leak past the tips of the gears' teeth.

Flow Ripple

All positive displacement pumps have a signature. For a given rate of flow and pressure, a gear-type pump that uses gears having a small number of teeth (say, 7…), will exhibit a signature that has a relatively low frequency and a high amplitude, whereas a version of that pump which uses a large number of teeth (say, 20…), will exhibit a signature that has a relatively high frequency and a low amplitude.

The resulting flow ripple can, and oftentimes does, create a pressure ripple. In extreme cases, the pressure ripple is actually a series of sharp spikes, which can excite the pressure regulating valve, the oil filter, the oil cooler and/or high pressure lines. The greater the nominal pressure, the greater the spikes and the more severe the excitation.

Contact Stresses

Depending upon the application, the material that is chosen for the gears is based upon several physical and mechanical properties. Strength (tensile strength…), toughness (impact strength…), hardness and wear resistance all come to mind. However, the rolling of each tooth's flank along its mate's flank causes contact stresses that must be taken into account as well.

A Single Solution

The use of asymmetrical gears for transmitting power was popularized by Alex Kapelevich. (www.akgears.com) Recently, the Melling Tool Company introduced a line of gear-type pumps which use helical, asymmetrical involute gears. (www.melling.com) Also known as "shark tooth" gears, they are optimized for use in pumping applications by combining the best attributes of asymmetrical gears and helical gears.

The designs of asymmetrical gears are not constrained by standard pitches/modules or pressure angles. As such, those parameters can be optimized to yield a gear that has the most favorable tooth count, the longest

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line of contact and the lowest contact stresses. In cases where the gears will be used in a pump, the width of the tooth tips, which form important sealing lands, can be maximized.

Helical teeth allow the pumping chambers, which are formed by the unmeshing and the meshing of those teeth, to open and close gradually. On the inlet side of the pump, the gradual unmeshing of the teeth enhances filling and delays the onset of cavitation. On the discharge side of the pump, the gradual meshing of the teeth minimizes the flow ripple and its associated pressure ripple.

The combination of smoother mechanical action, reduced contact stresses, enhanced filling and smoother discharge, make the use of helical, asymmetrical gears a smart choice when NVH and/or durability are of concern. This is especially true in hybrid and electrically-power vehicles, where there is very little in the way of background noise to mask the sounds that emanate from the pump.

The advantages of helical, asymmetrical gears become more pronounced as pressure increases, making them ideal candidates for use in power hydraulics.

Helical, asymmetrical gears can be manufactured using conventional techniques, such as hobbing, shaping, milling and grinding. They can also be molded using the powdered metal process and injection molding. That being the case, it is virtually guaranteed that a manufacturing process can be found that will yield the required physical and mechanical properties for a particular application at a reasonable cost.

Design Assistance

I have extensive experience in designing pumps that use helical, asymmetrical gears. If you believe that you have an application that would benefit by using these kinds of gears, then contact me directly at marcdesign@comcast.net for a free consultation.

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