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Gear Manufacturers
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Technical Resources

09FTM11

AGMA Technical Paper

Unique Design Constraints for Molded Plastic Transmissions

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[The statements and opinions contained herein are those of the author and should not be construed as an official action or opinion of the American Gear Manufacturers Association.]

Abstract

Any transmission design requires meticulous attention to detail including gear engineering, required performance, and manufacturing methodology. Plastic geared transmissions are no different in many ways than metal; however they do require a unique knowledge of the materials, the molding process, and special attributes that affect manufacture, performance, and life of the resulting transmission. In this paper we will discuss the design and manufacture of a particular plastic molded transmission with the purpose of describing design intent, manufacturing reality, inspection and testing results, and lessons learned. The selected transmission is a molded plastic gear pump.

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500 Montgomery Street, Suite 350
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September 2009

ISBN: 978-1-55589-964-6

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Background

A customer's pump failure prompted the need for a new design. The customer intended to build a plastic gear pump with commercially purchased pump gears and an in-house molded pump well. They chose the gears based on the manufacturer's recommendation. The resulting gears (see Figure 1) were 9 tooth, 24DP, 5° helical gears cut from Polyetheretherketone (PEEK). The pump housing was molded in Polycarbonate (PC) and then machined to the final internal dimensions (Figure 2). As a result, the customer's pumps were noisy, inefficient, and wore out quickly. The task at hand was to improve the performance of the pump.



Figure 1. Original gears



Figure 2. Pump housing

Initial review

The intended application of this gear pump is to circulate water at a flow rate of up to 1 liter per minute with at least 50 psi under varying temperature conditions. The gear pump's application as a disposable product is short-term, but must be able to maintain its performance characteristics for 72 hours with minimal noise and efficiency change. An initial review of the design history revealed a few problems.

Material concerns were immediately apparent. PEEK is an excellent semi-crystalline thermoplastic gear material with high strength, good wear characteristics, and non-hygroscopic properties (does not absorb water and swell). Typically, due to the material properties and price, PEEK is considered for more demanding applications with high loads and temperatures. Polycarbonate is an amorphous resin which is non-hygroscopic, but is not particularly good in wear conditions. These two materials are not a good match for this application. With a goal of minimizing development time, it was decided to continue with these materials and merely optimize the current design. This decision resulted in the need for inserted bearings and bushings to minimize wear.

Besides material considerations, the overall design of the pump resulted in stacked tolerances and difficult manufacturing techniques. The polycarbonate pump well was glued inside another case, with its cover then glued and screwed to the case. A separate molded seal was included to ensure against leakage (Figure 3). This resulted in high tolerance stack-ups and glued interfaces.

Inspection of the purchased gears proved them to be of inferior quality due to cutting errors during manufacturing. Because of the inferior manufacture of the existing gears, it was decided to improve them first, then decide on further modifications based on the results.