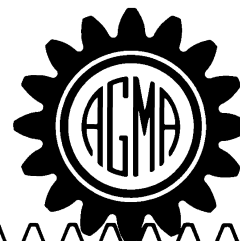


Opportunities to Replace Wrought Gears with High Performance PM Gears in Automotive Applications

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TECHNICAL PAPER

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Introduction

Powder metallurgy enables cost effective production of parts with complex geometries such as gears. The amount of waste material is often negligible as a consequence of the minimal necessity to machine the parts and the use of ecologically harmful cutting fluids is avoided.

The growth of the PM market has a long history and we have not seen significant downturns in this growth. In order to continue this growth it is important to maintain the PM strong points, i.e. the net shape capability while performance is improved. In order to expand the PM market new applications could be won by combining the inherent advantages of PM while performance is increased by surface densification.

Gear rolling is a well-known technology for improving the shape and surface finish of solid steel gears [1,2,3,4]. When applied on PM gears, rolling also enhances the fatigue properties since the density and hence the strength in the highly loaded regions, i.e. the surface regions, increases to full density [2, 3, 5, 6, 7]. This technique was first developed more than 20 years ago, but has not reached widespread use due to several reasons. The difficulty in obtaining good densification and good gear quality simultaneously has limited the applicability and cost effectiveness of the process. Also the long developing times have hindered the utilization of the surface densified gears. Improvements in rolling machines and increase in knowledge and experience have significantly changed the situation [7]. Several parts producers have after significant and committed development work started to offer surface densified components to the market [5, 8, 9]. Another factor limiting the use of surface densification technology has been the continuous market growth. In fact as long as the requirements from the more demanding applications could be met using existing

technologies the driving force for developing surface densification technology was limited.

This paper aims at pointing out some possibilities in using the combination of powder metallurgy and surface densification. It will be demonstrated that the performance of two surface densified gears can be adequate for highly loaded applications. The gear quality is also presented and discussed.

Gears studies

The gears examined in this study are the fifth gear used in a manual gearbox in a passenger car and the planetary gear in the reduction unit in a heavy truck gearbox. The two gears are shown in Figure 1.



Figure 1a. Fifth gear of a manual transmission in a Volvo passenger car.



Figure 1b. Planetary gear of a reduction unit in a Scania heavy truck gearbox.

Typical data of the gears are presented in table 1. In this study both gears were manufactured by combining the PM process route with gear rolling. The helical gear was redesigned in order to facilitate testing in a pitting test rig. The clutch gear was removed, the diameter of the bore was enlarged and a keyway was introduced.