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Technical Resources

09FTM08

## AGMA Technical Paper

# Load Sharing Analysis of High Contact Ratio Spur Gears in Military Tracked Vehicle Application

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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

Military tracked vehicles demand a very compact transmission to meet mobility requirements. A compact transmission with low operating noise and vibration is desirable in military tracked vehicles to reduce weight and improve power to weight ratio. It is also necessary to increase the rating of existing transmissions in military tracked vehicles, like prime movers, to accommodate the additional weight required for ballistic protection. Hence, it was decided to apply high contact ratio (HCR) spur gearing concept which will reduce noise, vibration and enhance load carrying capacity, for a 35 ton tracked vehicle final drive. In HCR gearing, the load is shared by a minimum two pairs of teeth as in helical gears. It was decided to analyze the load sharing of the normal contact ratio (NCR) gearing used in sun-planet mesh of the existing final drive, and also, to analyze the load sharing of HCR gearing which will be used to replace the NCR gears without any change in the existing final drive assembly except sun, planet and annulus gears. This paper deals with analysis of load sharing percentage between teeth in mesh for different load conditions throughout the profile for both sun and planet gears of NCR/HCR gearing using finite element analysis (FEA). Also, the paper reveals the variation of bending stress, contact stress and deflection along the profile of both NCR/HCR gearing.

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American Gear Manufacturers Association  
500 Montgomery Street, Suite 350  
Alexandria, Virginia, 22314

September 2009

ISBN: 978-1-55589-961-5

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## Introduction

Contact ratio is defined as the average number of teeth pairs in contact under static conditions and without errors and tooth profile modifications. A majority of the current gearboxes for tracked vehicle applications have contact ratios ranging from 1.3 to 1.6. Then, the number of tooth engagements is either one or two. The term High Contact Ratio (HCR) applies to gearing that have at least two tooth pairs in contact all times i.e., contact ratio of two or more. As the percentage change in mesh stiffness for HCR meshes is lower than the percentage change in mesh stiffness for Normal Contact Ratio

(NCR) meshes, one can expect high quality HCR gear meshes to have lower mesh induced vibration and noise than NCR gear meshes. A high powered compact transmission [1] is essential to enhance the mobility of military tracked vehicles. This requirement is partially met by improvements applied to NCR gearing. Literature survey indicated that HCR gearing was designed [2] and successfully used in helicopter transmission [3], to improve further the power to weight ratio of the transmission. In HCR gears, since a greater number of teeth share the load [4], the concept appears to be simple and has wide potential applicability, it has not been applied to military tracked vehicle transmissions.

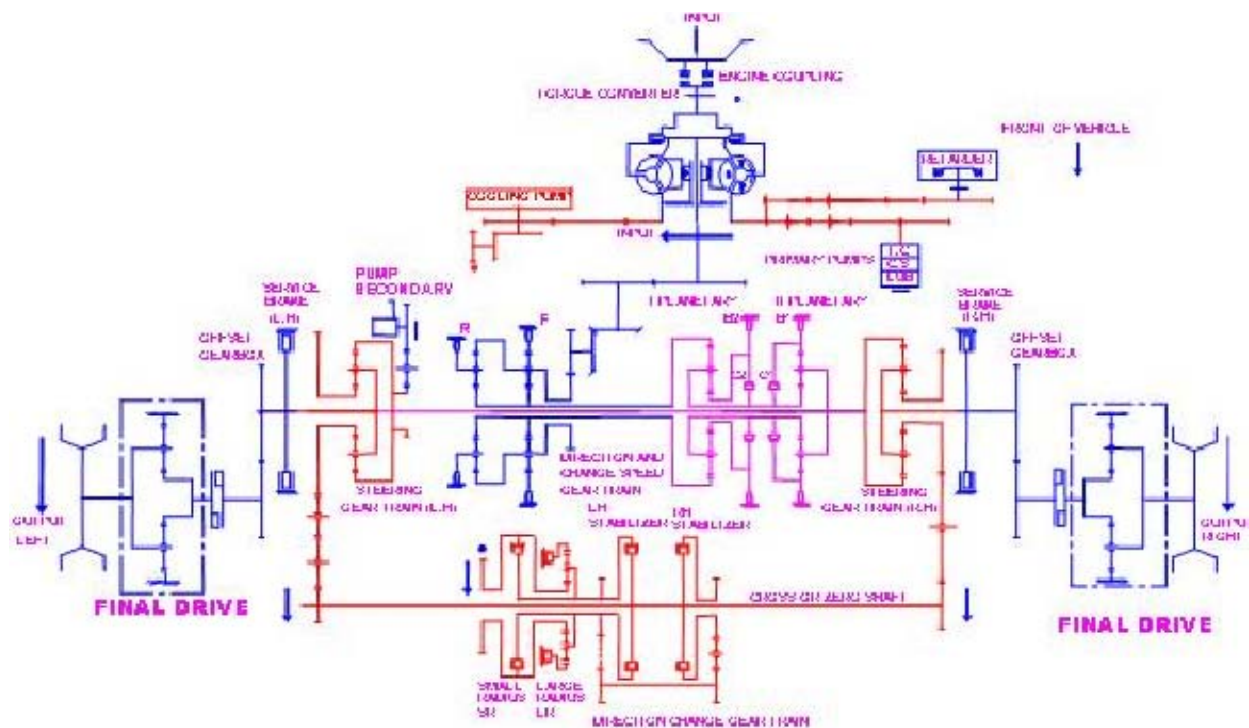


Figure 1. Mechanical schematic of 800 hp automatic transmission

A detailed study of the existing final drive planetary gear assembly as shown in Figure 1 of a 35 ton military tracked vehicle was carried out to apply the HCR concept. The final drive is an independent unit which has been isolated for separate testing to apply the concept of HCR. This paper provides an approach to arrive at the HCR gears for the final drive of a tracked vehicle, a detailed analysis of load sharing percentage of teeth in mesh throughout the profile for both sun and planet gears of NCR/HCR gearing using finite element analysis (FEA). Bending stress, contact stress and deflection of gear teeth were calculated.

An attempt has also been made to prove the new concept of HCR gearing using ANSYS software [5].

### Evolution of design for HCR final drive

The mechanical schematic of the entire transmission is shown in Figure 1. NCR gearing was

originally used through the transmission and final drive. The HCR gearing concept is applied to the final drive of the 800 hp automatic transmission.

The final drive is located outside the main transmission and is fixed to the vehicle hull. It serves as an additional reduction unit in multiplying the driving and braking torque for the tracks. The final drive as shown in Figure 2 consists of three gear elements namely sun gear (23 teeth), planet gear (22 teeth) and annulus gear (69 teeth) of module 4 mm with contact ratio of 1.343. The transmission LH and RH outputs are connected via toothed sliding couplings to the sun gears of the LH and RH final drives respectively. The annulus gears of the two final drives are fixed and they provide the reaction torque. The output power from the LH and RH final drives is taken from the planet carriers, which are connected to the LH and RH sprockets driving the tracks.

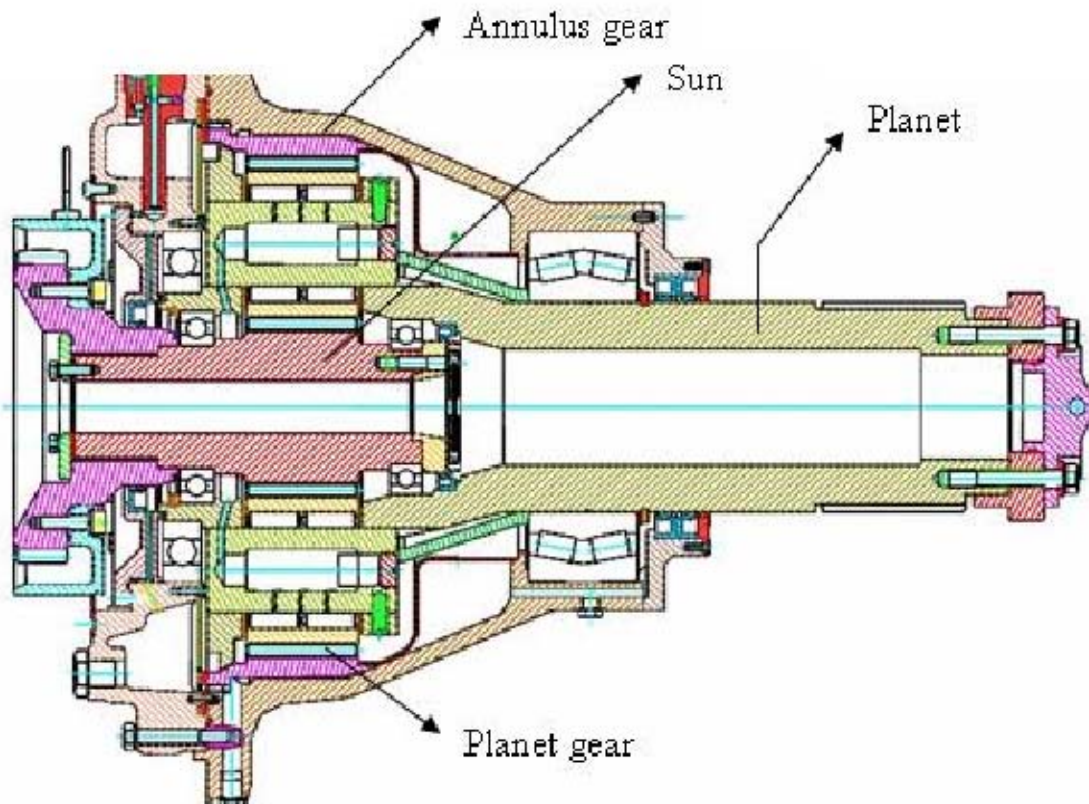


Figure 2. Cross section of final drive