International Journal of Automotive Technology, Vol. 8, No. 6, pp. 723−730 (2007)

1229−9138/2007/037−07

MEASUREMENT AND CHARACTERIZATION OF FRICTION IN AUTOMOTIVE DRIVESHAFT JOINTS

C.-H. LEE*

Department of Mechanical Engineering, Inha University, Incheon 402-751, Korea

(Received 25 January 2007; Revised 6 September 2007)

ABSTRACT−The typical design of automotive driveshafts generally utilizes Constant Velocity (CV) joints as a solution to NVH. CV joints are an integral part of vehicles and significantly affect steering, suspension, and vehicle vibration comfort levels. Thus, CV joints have been favored over universal joints due to the constant velocity torque transfer and plunging capability. Although CV joints are common in vehicle applications, current research works on modeling CV joint friction and assumes constant empirical friction coefficient values. However, such models are long known to be inaccurate, especially under dynamic conditions, which is the case for CV joints. In this paper, an instrumented advanced CV joint friction apparatus was developed to measure the internal friction behavior of CV joints using actual tripod-type joint assemblies. The setup is capable of measuring key performance of friction under different realistic operating conditions of oscillatory speeds, torque and joint installation angles. The apparatus incorporates a custom-installed tri-axial force sensor inside of the joint to measure the internal CV joint forces (including friction). Using the designed test setup, the intrinsic interfacial parameters of CV joints were investigated in order to understand their contact and friction mechanisms. The results provide a better understanding of CV joint friction characteristics in developing improved automotive driveshafts.

KEY WORDS : Automotive driveshaft; Constant Velocity joints; Friction test; Automotive tribology

1. INTRODUCTION

It is well known that the Constant Velocity (CV) joint is the standard design for the automotive driveshaft joint due to its superior performance in eliminating uneven rotating torque compared to universal joints (Hooke's and Cardan joints are also used interchangeably). This is achieved through their self-centering properties (Schmelz *et al*., 1992; Wagner, 1979). Typically, each driveshaft is comprised of two types of CV joints, fixed and plunging types connected by a solid shaft. Current research is emphasized on a class of CV joints called tripod joints, which have been favored especially for automatic transmission vehicles. This is due to their noise and vibration advantages offering lower plunging resistance, compared to ball-type joints.

Although CV joints are common in vehicles, there are certain aspects of their internal friction dynamic that is not fully understood or modeled. These effects are not generally predictable and repeatable, thus causing uncertainty in performance reliability predictions.

A typical vehicle problem associated with CV joints is the so-called "take off shudder," which generally occurs when the vehicle moves (starts) abruptly. This problem is primarily related to the internal friction in the CV joint, which consequently generates an axial force know as Generated Axial Force (GAF). The other problem accounting for vehicle vibration is "idle boom". As the plunging joint is directly connected to the gearbox, whereby the engine excites, there is a transfer of vibration to driveshafts, even when the vehicle is stationary.

To avoid such potential problems, extensive testing with all new vehicle models is usually undertaken leading to longer development periods. Better understanding of the non-linear dynamic interfacial friction behavior of CV joints can provide powerful design tools and lead to the development of basic CV joint friction models. Because of the importance of CV joints as well as their complexity, a specialized CV joint apparatus has been presented in the literature to measure different aspects of CV joint behavior. For example, Philpott *et al*. (1996) developed a tester and implemented a two-phase surface fitting regression algorithm to quantify the race track wear in CV joints. Bierman (1999) designed an apparatus to accurately measure the efficiency of CV joints by recording power and heat losses. Kernizan *et al*. (2002) developed a tester to assess the performance of grease by measuring the temperature increase in CV joints. Jia *et al*.

**Corresponding author.* e-mail: chulhee@inha.ac.kr