Fuel Economy Impacts of Manual, Conventional Cruise Control, and Predictive Eco-Cruise Control Driving

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ABSTRACT
The paper presents the results of a field experiment that was designed to compare manual driving, conventional cruise control (CCC) driving, and Eco-cruise control (ECC) driving with regard to fuel economy. The field experiment was conducted on five test vehicles along a section of Interstate 81 that was comprised of ±4% uphill and downhill grade sections. Using an Onboard Diagnostic II reader, instantaneous fuel consumption rates and other driving parameters were collected with and without the CCC system enabled. The collected data were compared with regard to fuel economy, throttle control, and travel time. The results demonstrate that CCC enhances vehicle fuel economy by 3.3 percent on average relative to manual driving, however this difference was not found to be statistically significant at a 5 percent significance level. The results demonstrate that CCC driving is more efficient on downhill versus uphill sections. In addition, the study demonstrates that an ECC system can produce fuel savings ranging between 8 and 16 percent with increases in travel times ranging between 3 and 6 percent. These benefits appear to be largest for heavier vehicles (SUVs).

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1. INTRODUCTION

This section quantifies the fuel efficiency impacts of using a conventional cruise control (CCC) system relative to manual driving based on field driving tests. CCC (or autocruise) is a device or system that is frequently used while driving, especially on highways, as it automatically controls the speed of a vehicle as set by the driver. Consequently, using CCC reduces the driver's fatigue and improves comfort. As fuel prices change significantly, the fuel savings that result from the use of CCC have recently attracted attention. From a fuel-saving perspective, CCC use is recommended as one of the eco-driving tips by many organizations.

CCC was invented in 1945 by Ralph Teetor, and the system was initially installed into the Chrysler Imperial in 1958 [1]. Automotive electronic CCC, which is an electrical version of the CCC, uses digital memory and was invented by Daniel Aaron Wisner in 1968. An extensive adaptation of CCC was achieved following development by Motorola, Inc. of an integrated circuit. Most cars currently manufactured in the United States are fitted with a CCC system that uses a specific control algorithm that depends on the manufacturer.

As mentioned earlier, it is widely known that the use of CCC on highways can save gas. However, it is difficult to find literature that proves CCC's effectiveness in a quantitative manner with regard to fuel savings even though this idea seems to be accepted by the public. One study conducted by Edmunds.com concluded that an average fuel economy saving of 7 percent could be achieved from the use of CCC [2]. However, it is not clear how the effectiveness will vary if the system is used on uphill or downhill sections. It is recommended that CCC be disabled on hilly terrain because the system tries to maintain even speeds on steep hills, thus resulting in high fuel consumption levels [3]. The literature indicates that experienced drivers can manually drive in a more fuel-efficient manner than by enabling CCC driving [4]. Consequently, there is a need to test the effectiveness of using CCC in a systematic fashion based on field driving tests. Specifically, the objectives of this study are to test:1) if CCC driving can significantly save fuel compared to manual driving, and 2) whether fuel savings remain constant when driving on uphill and downhill sections of a roadway. In addition, the third objective is to compare the operation of a predictive ECC system to manual and CCC driving.

2. INTRODUCTION

2.1. Collection of Field Data

Experiments were conducted on a section of Interstate 81 between mile markers 118 and 132 in order to collect fuel consumption rates under actual driving conditions. The test section was selected because it comprises various uphill and downhill sections and thus provides a suitable environment to test different engine load conditions under manual and CCC driving scenarios. Specifically, the northbound and the southbound directions can be considered a 1.3% downhill and a 1.3% uphill section, respectively, as the difference in altitude between the start and end points of the section is approximately 280 m across 22.4 km (14 miles). However, the roadway grade on the section varies between ± 4%. There are two 4% uphill sections that have an additional truck-climbing lane.

Six light-duty vehicles were tested, including four passenger cars and two sport utility vehicles (SUVs). These vehicles included: a 2001 SAAB 95, a 2006 Mercedes