GASOLINE ENGINE INTAKE MANIFOLD LEAKAGE DIAGNOSIS/PROGNOSIS USING HIDDEN MARKOV MODEL

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ABSTRACT. Leakages in the air intake system (AIS) of gasoline engine can deteriorate its performance causing poor fuel efficiency, air pollution and retarded driving performance. The diagnosis and prognosis of air leakage becomes inevitable in order to enhance reliability and improve fuel consumption. Currently, air leakages detection is hardly found in any of the available On Board Diagnostic version-II (OBD-II) scanners. In this paper, a challenging task of detecting manifold air leakage at early stage has been resolved by employing discrete Hidden Markov Model (HMM). Discrete HMM is an stochastic classifier that has been exploited for the first time to generate useful information about AIS condition based maintenance. The proposed fault diagnosis and prognosis (FDP) scheme can detect air leaks and consequently the severity of air leakage is explored to update the schedule of maintenance prior to any mishap. The validation of the proposed algorithm is carried out on 1.3L production vehicle engine. The experimental results demonstrate that HMM based FDP scheme accurately detects air leakage at early stage and informs about its approximate severity. The suggested scheme for leakage diagnosis is cheaper, does not require any extra hardware installations and it remains valid for all OBD-II compliant commercial vehicles.

1. Introduction. On-board condition monitoring of naturally aspirated automotive engines is an integral part of Electronic Control Unit (ECU) equipped vehicles. This is because of strict legislative regulations defined in OBD-II [1] and European On-Board Diagnostics. Automotive industry is constantly struggling to incorporate efficient on-board fault diagnosis methodologies to overcome these legal requirements. Besides such requirements, end-user satisfaction is also a major concern of automotive industry. Fault free, fuel efficient and environmental friendly vehicles are always preferred.

One of the main requirements of ODB-II for spark ignition (SI) engine is to monitor the health of its AIS. Any OBD-II compliant vehicle will be equipped with Manifold Air Pressure (MAP) or Manifold Air Flow (MAF), throttle position and angular speed sensor. These sensors provide useful information to monitor the health of air intake system and to diagnose/prognose malfunctioning of the components involved in AIS. The components are air filter, intake manifold, throttle valve and installed sensors. A brief discussion will give us an overview of the problems caused by AIS malfunctioning, its effect on engine performance and how the researchers attempted to resolve the problem.

1.1. Air intake system fault diagnosis/prognosis. Engine fuel efficiency depends on the Air to Fuel Ratio (AFR) of in-cylinder mixture that is required to be as close to its stoichiometric proportions as possible. The standard stoichiometric ratio can be maintained if AIS performance is ensured. Any malfunction in AIS will affect the amount