Abstract

Investigation of thermal signatures of vehicles is of immense importance for civilian and military applications. In military scenario, deception device or decoy with thermal signature similar to that of the original vehicle is used to create false signature of the vehicle with an aim to fool the adversary on the presence of the original vehicle. Collection of important information pertaining to type of ground vehicles available in enemy territory is an essential requirement of defence forces. Thermal signature of diesel exhaust emission will also help in detection and identification of engine characteristics as well as taking preventive measure for vehicles maintenance. This is more applicable in field conditions, where standard conditions and test equipment are not readily available.

Considering the importance of thermal signature of military assets in national security, acquisition, visualisation and analysis of thermal signature of exhaust emissions of diesel engine using Infrared imaging technique have been selected for present research work. Two representative diesel engine based ground vehicles have been chosen for this study. Measurement on exhaust emission of these vehicles has been carried out using portable gas analyser under idling and accelerating conditions of these vehicles. Analysis of the acquired data is presented in the thesis. Subsequently, thermal signatures of exhaust emission of the two vehicles in TIR (3-5 μm and 8-14 μm) bands of EM spectrum have been acquired. Analysis of the TIR signatures of the two vehicles has been made.

Analysis of thermal signature variation of diesel exhaust emission has been carried out during idle and accelerating engine running condition of static vehicles. Also attempt was made to measure exhaust emission compositions such as CO, HC, NO & NO_2 of the two vehicles using a portable gas analyzer.

In the present study, thermal signature feature extraction was also carried out from thermal IR images. Spectral radiance computation of exhaust gas species has also been carried out using high transmission (HITRAN) molecular absorption database, which has provided useful information for determining thermal signature of vehicle. Moreover, analysis of vehicle exhaust emission data (particularly NOx) has been carried out in field condition for determining the concentration variation of exhaust gases emission with respect to time during acceleration and deceleration of vehicles.

It is concluded that results of the investigation of thermal signatures of the two vehicles can be extended to military vehicles and will be useful for developing effective deception devices for creating false impression of their presence in field conditions. Infrared imaging techniques for visualization of exhaust emission gas species is a promising methodology to get information about the nature of ground vehicles present in the enemy's territory. While the thermal signature carries useful information to identify the operating condition of the vehicle, it is insufficient to completely characterize the chemical composition of the exhaust gases. This thesis work has resulted in the following peer reviewed publications.

(i) Ajay Jain., Amit Sharma., S.L Borana., B. Ravindra., and J.P, Mangalhara., "Study and Analysis of Exhaust Emission of Diesel Vehicles using Thermal IR Imager", Defence Science Journal (Peer-reviewed international journal of DRDO), Vol 68, No.6 , November 2018, pp. 533-539 (DOI: 10.14429/DSJ.68.12701@2018, DESIDOC)

(ii) Ajay Jain and B. Ravindra., "Experimental investigation of infrared thermal signature of exhaust emission of diesel engines" Conference proceedings of the 2nd National Aerospace Propulsion conference (NAPC-2018), Dec 17-19, 2018 (held at IIT Kharagpur);