

Thermal IR Signature Study and Analysis of Exhaust Emission of Diesel Engine Vehicles

-Doctor of Philosophy

A Thesis submitted by
Ajay Jain

in partial fulfillment of the requirements for the award of the degree of
Doctor of Philosophy



॥ त्वं ज्ञानमयो विज्ञानमयोऽसि ॥

Indian Institute of Technology Jodhpur
Department of Mechanical Engineering
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Declaration

I hereby declare that the work presented in this Thesis titled “*Thermal IR Signature Study and Analysis of Exhaust Emission of Diesel Engine Vehicles*” – Doctor of Philosophy submitted to the Indian Institute of Technology Jodhpur in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy, is a bonafide record of the research work carried out under the supervision of Associate Professor Dr B. Ravindra, IITJ. The contents of this thesis in full or in parts, have not been submitted to, and will not be submitted by me to, any other Institute or University in India or abroad for the award of any degree or diploma.



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Certificate

This is to certify that the thesis titled "*Thermal IR Signature Study and Analysis of Exhaust Emission of Diesel Engine Vehicles*" by *Ajay Jain* (PG201281001) to the Indian Institute of Technology Jodhpur for the award of the degree of *Doctor of Philosophy* is a bonafide record of the research work done by him under my supervision. To the best of my knowledge, the contents of this report, in full or in parts, have not been submitted to any other Institute or University for the award of any degree or diploma.



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“Dedication”

This dissertation is dedicated

to

My wife Archana Jain

and

**my children
Ashna Jain & Aman Jain**

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List of Symbols

Symbol	Description
A_p	Projected area
A_s	Area on the surface of the Sphere
N	Avogadro's Number
C_o	Radiation speed of propagation
C_R	Thermal contrast ratio
E	Emissive Power or Radiant Power
E_λ	Spectral emissive Power
$\gamma(\lambda)$	Extinction or attenuation coefficient
$k(\lambda)$	Radiation absorption coefficient
$\sigma(\lambda)$	Scattering coefficient
G	Irradiation
I_e	Radiant blackbody Intensity
I_λ	Spectral radiant Intensity
μm	Micrometer
J	Radiosity
k	Boltzman constant
L	Radiance or total intensity
p	Photon momentum
α	Absorptivity
ρ	Reflectivity
τ	Transmissivity
h	Planck's constant
λ	Radiation wavelength
sr	Steradian
s or Sec	Second
ν_f	Frequency of radiation
ϵ	Emissivity
$\emptyset$	Radiant Flux

List of Abbreviations

Abbreviation	Full form
BS	Bharat Stage
CI engine	Compression Ignition Engine
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
CPCB	Central Pollution Control Board
DCOAS(P&S)	Deputy Chief of Army Staff (Production & Supply)
DLJ	Defence Laboratory Jodhpur
DPSU	Defence Public Sector Unit
DTDG	Deception Technology Development Group
Dte	Directorate
EGR	Exhaust Gas Recirculation
EM	Electromagnetic
ESC	Exhaust emission steady state cycle
ETC	Exhaust emission transit cycle
FTIR	Fourier Transform Infrared
FOV	Field of View
GS	General Staff(Army)
HITRAN	High resolution Transmission molecular absorption database
H ₂ O	Water
HC	Hydrocarbons
HDVs	Heavy Duty Vehicles
HHTI	Hand Held Thermal Imager
IDC	Indian Driving Cycle
IFOV	Instantaneous Field of View
IITJ	Indian Institute of Technology Jodhpur
InSb	Indium Antimonide
IR	Infrared
LNC	Lean NO _x Catalyst
LNT	Lean NO _x Traps
LORROS	Long Range Reconnaissance and Observing System
LWIR	Long Wave Infrared
MCT	Mercury Cadmium Telluride
MW	Microwave
MWIR	Mid Wave Infrared
MIDC	Modified Indian Driving Cycle
NIR	Near Infrared
N ₂	Nitrogen
NH ₃	Ammonia
N ₂ O	Nitrous Oxide
NO ₂	Nitrogen dioxide
NO _x	Oxides of nitrogen (include NO, NO ₂)
O ₂	Oxygen
O ₃	Oxone
OFB	Ordnance Factory Board
PEMS	Portable emission measurement system
ppm	Parts per million
RH	Relative Humidity
SCR	Selective Catalytic Reduction
SEMS	Smart emission measurement system
SO ₂	Sulphur dioxide
SO-in-C	Signal Officer in Chief
SWIR	Short Wave infrared
TIR	Thermal Infrared
UV	Ultraviolet
VLWIR	Very long wave infrared
VOC	Volatile organic compound

