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RESEARCH

Edoardo Rossi

Investigation of Innovative Water Injection Strategies for Gasoline Engines by Means of a 3D-CFD Virtual Engine Test Bench

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„No bird soars too high, if he soars with his own wings“
William Blake

Preface

This work was realized during my tenure as a research associate at the Institute of Automotive Engineering (IFS) of the University of Stuttgart under the supervision of Prof. Dr.-Ing. M. Bargende.

I would like to thank Prof. Dr.-Ing. M. Bargende for the opportunity he provided me to complete this work and for the scientific support and supervision during these years. My gratitude goes also to Prof. F. Millo from Politecnico di Torino, who accepted to join the doctoral committee after being for me an excellent professor and advisor during my master studies in Turin. Furthermore, I would like to thank Prof. Dr.-Ing. A. Casal Kulzer for the technical supervision of the project from which this work is inspired.

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Last but not least, I want to dedicate this work to my mum Valentina, my dad Giuseppe, my sister Michela and my dear Enrica. This work is the result of these though years of distance, and none of this would have been possible without your love, patience and unconditional support. I hope to have made you proud.

Stuttgart Edoardo Rossi

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Abbreviations

CO_2	Carbon dioxide
T_3	Exhaust gas temperature before turbine
ε	Compression ratio
p_3	Exhaust gas pressure before turbine
$p_{2.2}$	Intake pressure before cylinder
0D	Zero-dimensional
1D	One-dimensional
3D	Three-dimensional
a.FTDC	after firing top dead center
ASOI	After Start of Injection
b.FTDC	before firing top dead center
CA	Crank angle
CFD	Computational fluid dynamics
CNG	Compressed Natural Gas
CO	Carbon monoxide
CPU	Central processing unit
DEI	Direct water-in-fuel emulsion injection
DI	Direct injection
DNS	Direct numerical simulaion
DOI	Duration of injection
DWI	Direct water injection
ECU	Electronic control unit
EGR	Exhaust gas recirculation or residual burned gas
EIVC	Early intake valve closure
EOI	End of injection
EVO	Exhaust Valve Opening

FKFS	Forschungsinstitut für Kraftfahrwesen und Fahrzeugmotoren Stuttgart
FTDC	Firing top dead center
FVV	Forschungsvereinigung Verbrennungskraftmaschinen
GDI	Gasoline Direct Injection
GHG	Green House Gases
HC	Unburned hydrocarbon
HCCI	Homogeneous charge compression ignition
HLB	Hydrophilic-Lipophilic Balance
HOV	Heat of vaporization
ICE	Internal combustion engines
IDT	Ignition Delay Time
IFS	Institut für Fahrzeugtechnik Stuttgart
IMEP	Indicated mean effective pressure
IP	Ignition point
ISFC	Indicated specific fuel consumption
IVC	Intake valve closure
IWI	Indirect water injection
LES	Large eddy simulation
LFS	Laminar Flame Speed
LHV	Lower Heating Value
MFB10-90	Combustion duration corresponding to 10-90% burned mass fraction
MFB50	50% Burned mass fraction
MTBE	Methyl Tertiary-Butyl Ether
MTG	Methanol-to-Gasoline
NOx	Oxides of nitrogen
PDA	Phase Doppler Anemometry
PDPA	Phase Doppler Particle Analyzer
PFI	Port fuel injection