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Decreasing Fuel Consumption and Exhaust Gas Emissions in Transportation

Sensing, Control and Reduction of Emissions

Springer

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Preface

Since 1998, the introduction of the first Directive with On-Board Measurement in the EU, many parameters in transport have changed. Both the population of the world and the demand for transportation have been continuously increasing. Transport has become the basic foundation of the economy in all countries. In the course of this process, the environment and the climate have been changing in a remarkable way and in turn have influenced transport.

Environmental legislation with Directives such as 98/69/EU, 99/96/EU, and finally 582/2011/EC with amendments, is already reducing emissions of individual vehicles. However, the number of motor vehicles, ships, and airplanes is rapidly rising, especially in fast developing countries. Parallel to this, the amount of oil products consumed and the mass of pollutants emitted are intensively increasing.

A new, sustainable path is required, which focuses on reasonable mass transport at a reasonable price, short travel times with optimal connections, positive impacts in safety, and improvements in sustainability. Good examples are needed worldwide.

Transportation could be improved with the introduction of carbon taxes, higher fuel efficiency standards and the use of new kinds of fuels. It is not enough to produce biogenic and synthetic fuels, although they can be optimally used in road vehicles, airplanes and ships, because they have their own additional problems. On the one side, their utilization lowers the consumption of fossil fuels, but on the other side, their exaggerated use could contribute to the destruction of agriculture and the landscape.

Transport burns most of the petroleum of the world and emits the most air pollution, including unburned hydrocarbons, carbon monoxide, nitrous oxides, and particles. It is the fastest growing consumption and emission sector on Earth. This leads to significant environmental and health problems especially in large cities and is a major contributor to global warming because of emissions of carbon dioxide. New urban infrastructure needs to primarily foster environmentally friendly modes and better management of transportation.

Vehicles, airplanes and ships are becoming more and more efficient, i.e., lighter and more intelligent, with improved aerodynamics, optimized design, and higher

performance. But can technology reduce fuel consumption and emissions effectively?

While technological development has created many problems, such as climate change and loss of resources, at the same time it is part of the solution. The higher demand for transportation could be fulfilled with the assistance of new technologies, new materials and highly intelligent hardware and software systems. Additionally, navigation and active communication systems can optimally and safely regulate the increasing traffic.

The higher comfort level and safety of new vehicles, airplanes and ships also contributes to more sustainability in transportation. However, improved infrastructure is often combined with increased traffic density and higher emissions. That is the reason why research and technological development have to survey alternative technologies and pilot projects to provide sustainable urban development and improve the potentials of mass transportation.

Regarding fuel consumption and emission characteristics, regulations have been intensively expanded in the last 20 years. Energy use and emissions vary greatly between several modes of transportation. Electrification and energy efficiency of transport must be increased in the next decades. However, the introduction of new technology will not happen suddenly but only gradually.

Less than optimal measures to order intensive fuel saving could cause major economic losses. Fuel substitution in transportation has high investment costs in comparison to other sectors of the economy. Therefore, besides technology, a sustainable strategy requires the increased use of renewable energy resources, worldwide intelligent navigation measures, common international regulations, and voluntary agreements between governments, civil, and international organizations limiting fuel consumption and exhaust gas emissions.

The topic of this book is the comprehensive consideration of all aspects of intelligent fuel consumption and exhaust gas emissions in transportation. It can be recommended as a source for the stimulation of further discussions to anyone interested in the field of sustainable transportation.

Lüneburg, winter 2011 Prof. Dr. Wolfgang Ruck

Acknowledgments

Three years ago, 2008, my first book concerning On-Board Measurement was published by the Expert Verlag in Renningen, Germany. In that book the basic fundamentals of direct measurement technology (OBM) were described. Since that time, the legislation and the technology have been intensively developed. It seems to be necessary, to continue the work. The next logical stage of On-Board Measurement is Self Diagnosis (SD) which is the centre of consideration in this book.

This is the result of three and a half years of work. Special thanks go to the researchers and teachers, scientists and professors of Leuphana University Lüneburg for the invaluable advice and support regarding sustainable transportation.

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Hamburg, winter 2011 Prof. Dr.-Ing. habil. Michael Palocz-Andresen

Contents

Abbreviations

AAC	Alaska Marine Vessel Visible Emission Standard
ACNS	Airborne computer-based navigation system
AFDS	Autopilot Flight Director System
ADC	Analogue-digital converter
AFL	Airplane flight log
AFP	Alloy ferritic-pearlitic
AIP	Aeronautical information publication
AIS	Automatic identification system
ALU	Arithmetic logic unit
AMOC	Area Meteorological and Oceanographic Coordinator
APU	Auxiliary power unit
ARO	Air Traffic Services Reporting Office
ASTM	American Society for Testing and Material
AT	Auto throttle system
ATC	Air traffic control
ATM	Air traffic management
ATS	Air traffic service
BEV	Battery driven electric motor vehicle
BPR	Bypass pressure ratio
BSFC	Best specific fuel consumption
BTL	Biomass to liquid
CAA	Civil Aviation Authority
CAC	Charging air cooling
CAD	Computer-aided dispatch
CAEP	Committee on Aviation Environmental Protection
CAFÉ	Corporate average fuel economy
CAI	Controlled auto ignition
CAN	Controller area network
CARB	Californian Air Resources Board
CCNR	Central Commission for Navigation on the Rhine
CDA	Continuous descent approach

CDU	Control display unit
CDL	Configuration deviation list
CEV	Combustion engine vehicle
CFC	Carbon fibre composite
CFD	Computational fluid dynamics
CLD	Chemo luminescence detector
CM	Condition monitoring
CN	Cetane number
CNG	Compressed natural gas
CNS	Communication, navigation and surveillance
COP	Compliance of production
CPU	Central Processor Unit
CRT	Cathode ray tube
CSR	Common structural rules
CVS	Constant volume sampling
DAC	Digital-analogue converter
DGPS	Digital global positioning system
DME	Distance measuring equipment
DOC	Direct operation cost
DPNR	Diesel particulate NO_x reduction
DWT	Deadweight tonnage
EASA	European Aviation Safety Agency
EC	European Commission
ECAC	European Civil Aviation Conference, Regional body of ICAO for European regions
ECD	Electronic chart display
ECDIS	Electronic chart display and information system
EDC	Electronic diesel control
EEC	European Economic Community
EEDI	Energy efficiency design index
EEP	Engine enhancement package
EEPROM	Electrically erasable programmable read-only memory
EFIS	Electronic flight instrument system
EGAS	Electronic accelerator gas
EGT	Exhaust gas temperature
EPROM	Electronic programmable read only memory
ERAA	European Regions Airline Association
ETC	Exhaust turbo charger
ETP	Equal-time point
ETSO	European technical standard orders
ETOPS	Extended-range twin-engine operation performance standards
EU-OPS	European operation performance standard
FAA	Federal Aviation Administration
FADEC	Full authority digital engine control
FAME	Fatty acid methyl ester

FAR	Federal aviation regulation
FBP	Final boiling point
FC	Fuel cell
FCC	Flight Control Computer
FCY	Flight cycles
FID	Flame ionisation detector
FEW	Fuel–water emulsion
FHEV	Full hybrid engine vehicles
FM	Field monitoring
FMS	Flight management system
FTIR	Fourier transformation infra red
FTP	Federal test procedure
FAB	Functional airspace block
GAMA	General Aviation Manufacturers Association
GC	Green card
GDP	Gross Domestic Product
GHG	Green house gases
GMDSS	Global maritime distress and safety system
GPS	Global positioning system
GPU	Ground power unit
GSM	Global system for mobile telecommunication
GT	Gross tonnage
GTL	Gas to liquid
GVWR	Gross vehicle weight rating
HCCI	Homogenously charged compression ignition
HCO	Heavy cycle oil
HDDE	Heavy commercial diesel engine
HDT	Heavy commercial truck
HDV	Heavy commercial vehicle
HDC	Highway driving cycle
HFO	Heavy fuel oil
HSLA	High strength low alloy
HWFET	Highway fuel economy cycle
IACS	International Association of Classification Societies
IATA	International Air Transport Association
IC	International convention
ICAO	International Civil Aviation Organization
ICCT	International Council on Clean Transportation
ICT	Information and Communication Technology
IFO	Intermediate fuel oil
IFR	Instrument flight rules
ILO	International Labour Organization
IM	Inspection and maintenance
IMC	Instrument meteorological condition
IMO	International Maritime Organization

IOSA	International operation safety audit
IRS	Inertial reference system
ISA	International standard atmosphere
ISM	International Safety Management
JAA	Joint Airworthiness Authority
JAA-OPS	Joint Airworthiness Authority-Operation Performance Standard
JAR	Joint airworthiness requirement
JTSO	Joint technical standard order
LCD	Liquid crystal display
LDT	Light duty truck
LDV	Light duty vehicle
LF	Low frequency
LNG	Liquid natural gas
MARPOL	International convention for the prevention of maritime pollution from ships
MDF	Marine destillate fuel
MDO	Marine diesel oil
MEL	Minimum equipment list
MEPC	Marine Environment Protection Committee
MF	Medium frequency
MGO	Marine gas oil
MMI	Man–machine interface
MOT	Ministry of Transport
MP	Maintenance Program
MSC	Maritime Safety Committee
MSG	Maintenance Steering Group
MSI	Maritime safety information
MTOW	Maximum takeoff weight
NAA	National aviation authority
NEDC	New European Driving Cycle
NOTAM	Notices to airman
OAT	Outside air temperature
OBD	On-Board diagnosis
OBM	On-Board measurement
OC	On condition
OCA	Oceanic control area
OFCA	Operational fuel consumption analysis
OPR	Overall pressure ratio
PCM	Phase changing material
PHEV	Plug-in hybrid engine vehicle
PO	Peak oil
PROM	Electronic Programmable Read-Only Memory
RAM	Random access memory
RBM	Risk-based Maintenance
RCM	Reliability centered maintenance

RMF	Residual marine fuel
RNP	Required navigation performance
SAFC	Solid acid fuel cell
SC	Start control cycle
SCR	Selective catalytic reduction
SD	Self Diagnosis
SFC	Specific fuel consumption
SI	International System of Units (Système International d'Unités)
SN	Smoke number
SMS	Short message service
SOLAS	Safety of life at sea
SRAS	Shipboard routing assistance system
TA	Type approval
TC	Type certification
TMC	Traffic message channel
TEU	Twenty equivalent units (20 feet container)
Tier	Emission Standard in the USA
TOC	Top of climb
TSFC	Thrust specific fuel consumption
TSO	Technical standing order
TST	Total seaborne trade
TST	Type sample test
TÜV	Technischer Überwachungsverein
UDDS	Urban dynamometer driving schedule
UHB	Ultra high bypass
UNFCCC	United Nations Framework Connection on Climate Change
VFR	Visual flight rules
VHF	Very high frequency
VLA	Very large airplane
VTG	Variable turbine geometry
WAFS	World area forecast system
WHSC	World harmonized stationary cycle
WHTC	World harmonized transient cycle