Basics, Components, Systems, and Perspectives

## **List of Chapters**

1	Hist	orical Review		5.3	Open 5.3.1		itive Processes ycle of the Perfect Engine
	<b>ston</b> I 2.1	nition and Classification of Reciprocating Engines Definitions Potentials for Classification 2.2.1 Combustion Processes			5.5.1	5.3.1.1 5.3.1.2	Elements of Calculation Work of the Perfect Engine Effectiveness of the Perfect Engine Exergy Loss in the Perfect
		<ul><li>2.2.2 Fuel</li><li>2.2.3 Working Cycles</li><li>2.2.4 Mixture Generation</li><li>2.2.5 Gas Exchange Control</li><li>2.2.6 Supercharging</li></ul>			5.3.2	Approxi Cycle 5.3.2.1	Cycle mation of the Real Working  Models to Determine
		<ul><li>2.2.7 Configuration</li><li>2.2.8 Ignition</li><li>2.2.9 Cooling</li></ul>		5.4 5.5		/ Balance	Combustion Behavior  in the Engine Equation
		<ul><li>2.2.10 Load Adjustment</li><li>2.2.11 Applications</li><li>2.2.12 Speed and Output Graduations</li></ul>	6	Crar 6.1	nk Geal	<b>rs</b> shaft Driv	ve
3	<b>Cha</b> 3.1	racteristics Piston Displacement and Bore-to-Stroke			6.1.2	Forces Drive	and Function Acting on the Crankshaft
		Ratio Compression Ratio Rotational Speed and Piston Speed			6.1.3 6.1.4		tial Force Characteristic and Tangential Force Forces
	3.4 3.5 3.6	Torque and Power Fuel Consumption Gas Work and Mean Pressure				6.1.4.1 6.1.4.2	Cylinder Crank Gears
	3.7 3.8 3.9	Efficiency Air Throughput and Cylinder Charge Air-Fuel Ratio				6.1.4.3	Cylinder V Crank Gear Inertial Forces and Inertial
4	Мар	os Os				6.1.4.4	Torque in Multicylinder Crank Gears Example
	4.1 4.2 4.3 4.4	Emission Maps Ignition and Injection Maps			6.1.5		alancing
5		Exhaust Gas Temperature Maps  rmodynamic Fundamentals				6.1.5.2	Crank Gears
	5.1 5.2	Cyclical Processes Comparative Processes 5.2.1 Simple Model Processes		6.2	6.1.6 6.1.7 Rotation 6.2.1	Internal Throw a onal Osci Fundam	and Firing Sequences Illations
		<ul><li>5.2.1.1 Constant Volume Cycle</li><li>5.2.1.2 Constant Pressure Cycle</li><li>5.2.1.3 Seiliger Process</li><li>5.2.1.4 Comparison of the Cyclical</li></ul>			6.2.2 6.2.3	Reducti Natural Natural	on of the Machine System Frequencies and Modes of Vibration
		Processes 5.2.2 Energy Losses			6.2.4 6.2.5		Forces And Exciter Work es to Reduce Crankshaft ons

6.2.6 Two-Mass Flywheels

7	Engi	ine Cor	nponents	•			7.4.5.1	Die Casting
	7.1			ins / Wristpin Circlips			7.4.5.2	Die Casting
		7.1.1	Pistons				7.4.5.3	Lost-Foam Process
			7.1.1.1	Requirements and			7.4.5.4	Sand Casting
				Functions			7.4.5.5	Squeeze Casting
			7.1.1.2		7.5	Cylind		equeeze euemig
			7.1.1.3		7.0	7.5.1		Designs
			7.1.1.4			7.0.1		Monolithic Design
			7.1.1.4	Running Play			7.5.1.2	
			7.1.1.5	Piston Masses			7.5.1.3	Bonding Technology
				Operating Temperatures		7.5.2		ng Cylinder Running
				Piston Cooling		1.5.2	Surface	
				Piston Designs			7.5.2.1	Machining Processes
				Piston Manufacture		7.5.3		Cooling
						7.5.5		
			7.1.1.10	Protection of Running			7.5.3.1	Water Cooling
			7 1 1 11	Surfaces/Surfaces	7.6	Oil Da	7.5.3.2	Air Cooling
		710		Piston Materials	7.6	Oil Pa		Danima
		7.1.2	Wristpin		77	7.6.1	Oil Pan	
				Functions	7.7		case Vent	
				Designs		7.7.1		tional Crankcase Ventilation
			7.1.2.3			7.7.2		Crankcase Ventilation (PVC)
			7.4.0.4	Dimensioning			System	D 1 1 1 0 1
			7.1.2.4	Materials		7.7.3		-Regulated Crankcase
		7.1.3		Snap Rings			Ventilati	on
	7.2		ecting Roc		7.8		ler Head	
		7.2.1		of the Connecting Rod		7.8.1		esign for the Cylinder Head
			Loading	<b>-</b>			7.8.1.1	Layout of the Basic
			Conrod	Bolts				Geometry
		7.2.4					7.8.1.2	Determining the
			7.2.4.1	Conrod Ratio				Manufacturing Processes
		7.2.5		Manufacture			7.8.1.3	Layout of the Gas
				Manufacturing the Blank				Exchange Components
			7.2.5.2	Machining			7.8.1.4	Variable Valve Control
		7.2.6		Materials		7.8.2		Head Engineering
	7.3	Piston					7.8.2.1	Laying out the Rough
		7.3.1	Embodir					Dimensions
				Compression Rings			7.8.2.2	
				Oil Control Rings				Port Design
		7.3.2		mbinations			7.8.2.3	Valve Train Design
		7.3.3	Characte	erizing Features			7.8.2.4	Cooling Concepts
		7.3.4	Manufac	cturing			7.8.2.5	Lubricating Oil
			7.3.4.1	Shaping				Management
			7.3.4.2	Wear-Protection Layers			7.8.2.6	<b>Engineering Design Details</b>
			7.3.4.3	Surface Treatments			7.8.2.7	Engineering in
			7.3.4.4	Contact Surface Shapes				Construction Steps
				for Piston Rings			7.8.2.8	Using CAD in Engineering
			7.3.4.5	Materials for Piston Rings			7.8.2.9	Computer-Assisted Design
		7.3.5	Loading	, Damage, Wear, Friction		7.8.3		Process
	7.4		Block	, ,			7.8.3.1	Sand Casting
		7.4.1		ents and Functions			7.8.3.2	Die Casting
		7.4.2	•	Block Design			7.8.3.3	Lost-Foam Process (Full
				Types of Engine Blocks				Mold Process)
		7.4.3		ng Acoustic Properties			7.8.3.4	Pressure Die-Casting
		7.4.4		ng Engine Block Mass				Process
		7.4.5		Processes for Engine Blocks		7.8.4	Model a	and Mold Construction

	7.8.5	Machinii 7.8.5.1	ng and Quality Assurance Mass-Production	7 11	Valves		Sprockets
		7.0.3.1	Manufacture	7.11			s and Explanation of Terms
		7.8.5.2	Prototype Manufacturing		7.11.1	and Con	
			Quality Assurance for		7 11 2		Valves and Manufacturing
		1.0.3.3	Cylinder Heads		1.11.2	Techniqu	
	7.8.6	Shanos	Implemented for Cylinder				Monometallic Valves
	7.0.0	Heads	implemented for Cylinder				Bimetallic Valves
		7.8.6.1	Cylinder Heads for				Hollow Valve
		7.0.0.1	Gasoline Engines		7 11 3	Embodir	
		7.8.6.2	Cylinder Heads for Diesel		7.11.0		Valve Head
		7.0.0.2	Engines				Valve Seat
		7.8.6.3	Special Cylinder Head				Valve Stem
			Designs		7.11.4	Valve Ma	
	7.8.7	Perspec	tives in Cylinder Head				Heat Treatment
		Technolo					Surface Finishing
7.9	Cranks		- 37		7.11.5		Valve Designs
	7.9.1		n in the Vehicle			7.11.5.1	Exhaust Control Valves
		7.9.1.1	The Crankshaft in the		7.11.6	Valve Ke	
			Reciprocating Piston				Tasks and Functioning
			Engine				Manufacturing Techniques
		7.9.1.2	Requirements		7.11.7		tation Devices
	7.9.2	Manufac	cturing and Properties			7.11.7.1	Function
		7.9.2.1	Process and Materials			7.11.7.2	Designs and Functioning
		7.9.2.2	Materials Properties for			Springs	
			Crankshafts	7.13		Seat Inser	
	7.9.3		ight Engineering and Future			Introduct	
		Trends			7.13.2		s Made on Valve Seat Inserts
		7.9.3.1	Hollow Cast Crankshafts			7.13.2.1	Loading on Valve Seat
		7.9.3.2	ADI Austempered Ductile				Inserts
		7000	Iron			7.13.2.2	Materials and Their
		7.9.3.3	Increasing Component			7.40.00	Properties
			Strength through				Geometry and Tolerances
7 10	Value 7	Fuein Cen	Postcasting Treatment			7.13.2.4	Cylinder Head Geometry
7.10		Frain Com		7 1 1	\/alva /	Outdoo.	and Assembly
	7.10.1	Valve Tra		7.14	Valve (		manta for Valva Cuidas
			Direct Drive Valve Trains		7.14.1		nents for Valve Guides
			Indirect Drive Valve Trains Hydraulic Valve Play		71/0		Loading on Valve Guides and Properties
		1.10.1.3	Compensation		1.14.2		Materials
		7 10 1 /	Mechanical Valve Play				Materials Properties
		7.10.1.	Adjustment		7 14 3		y of the Valve Guide
		7 10 1 5	Future Trends				in the Cylinder Head
	7 10 2		sioning Systems, Idler and	7 15	Oil Pui		in the Cymider riedd
	7.10.2		on Pulleys	7.10			v of Oil Pump Systems
			Introduction		7.10.1		Internal Gear Pump
			Automatic Belt Tensioning				External Gear Pump
			System for Synchronous				Vane Pumps
			Belt Drives				Benefits and Drawbacks of
		7.10.2.3	Idler and Deflection Pulleys				Individual Pump Systems
			for Synchronous Belt Drives		7.15.2	Regulation	on Principles ,
		7.10.2.4	Prospects for the Future				Direct Regulation
	7.10.3		ensioning and Guide Systems				Indirect Regulation
		7.10.3.1	Introduction				Regulation in the Clean Oil
		7.10.3.2	Chain Tensioning Element				Stream
		7.10.3.3	Tensioning and Guide Rails				

		7.15.2.4	Two-Stage or Multistage Regulation			7.18.2.2	Auxiliary Component Drive System
		7.15.2.5	Two-Stage Regulation				Application Examples
			Pump	7.19	Bearin	gs in Inte	rnal Combustion Engines
		7.15.2.6	Regulated Internal Gear			Fundam	
			Pump				Radial Bearing
		7 15 2 7	Regulated External Gear				Axial Bearing
		7.10.2.7	Pump		7 10 2		ing and Dimensioning
		7 15 2 9	Regulated Vane Pump		1.13.2	Engine E	
	7 1 5 0						
	7.15.3		ing Basics				Loading
		7.15.3.1	Crankshaft Pump			7.19.2.2	Bearing Journal
			Sump Pump				Displacement Path
		7.15.3.3	Key Oil Pump Values Taken			7.19.2.3	Elastohydrodynamic
			from Practice				Calculation
		7.15.3.4	Comparison between			7.19.2.4	Major Dimensions:
			Crankshaft and Sump				Diameter, Width
			Pumps			7.19.2.5	Oil Feed Geometry
		7.15.3.5	Cavitation and Noise				Precision Dimensions
			Emissions		7.19.3	Bearing	Materials
	7.15.4	Calculati					Bearing Metals
			Numerical Simulation of				Overlays
			Flow — CFD		7 19 4		Bearings — Structure,
		7 15 4 2	One-Dimensional				earing Capacity, Use
		7.10.4.2	Simulation of Flow Grids				Solid Bearings
7 16	Camsh	aft	omidiation of Flow ands				Two-Material Bearing
7.10			t Functions			7.10.4.2	Three-Material Bearing
			in Configurations			7.13.4.3	Miba <sup>™</sup> Grooved Bearings
			e of a Camshaft				Sputter Bearing
			gies and Materials		7 10 5	Bearing	
	7.10.4		Cast Camshaft		7.19.5		
							Progress of Damage
			Assembled Camshaft		7 10 0		Types of Bearing Damage
			Steel Camshaft	7.00			ts for the Future
		7.16.4.4	Materials Properties and	7.20		Systems	de un accede a de la Adrida de la A
	7 40 5	<b>.</b>	Recommended Matches		7.20.1		dynamics in Air Intake
			on of Mass			Systems	
	7.16.6		nfluencing Camshaft			Acoustic	
		Loading		7.21		g Systems	
			g Cam Profiles		7.21.1		Head Sealing Systems
			cs Calculation			7.21.1.1	Ferrolastic Elastomer Head
		•	s Calculations				Gaskets
	7.16.10	)Camshaf	t Shifter Systems			7.21.1.2	Metal-Elastomer Head
7.17	Chain	Drive					Gaskets
	7.17.1	Chain De	esigns			7.21.1.3	Metaloflex® Layered Metal
	7.17.2	Typical C	Chain Values				Head Gaskets
		Sprocket				7.21.1.4	Prospects for the Future
			uide Elements		7.21.2	Special S	
7.18	Belt Dr	ives					Functional Description of
	7.18.1	Belt Drive	es Used to Drive Camshafts				the Flat Seal
			Synchronous Belt Drive			7.21.2.2	Elastomer Seals
			Synchronous Belt Drive				Metal-Elastomer Seals
			System				Special Metaloseal®
		7.18 1 3	Synchronous Belt Dynamics				Gaskets
			Application Examples			72125	Prospects for the Future
	7 18 2		V-Belt Drive to Power		7 21 3		er Sealing Systems
	10.2	Auxiliary			2 1 . 0		Elastomer Seals
			Micro-V <sup>®</sup> Drive Belts				Metal-Elastomer Gaskets
							sta. E.astorrior Gashots

	,		•	, ,	•					
	7.22	Thread 7.22.1 7.22.2 7.22.3	Developr 7.21.4.1 7.21.4.2 led Conne High-Str Quality F Threader 7.22.3.1 7.22.3.2 7.22.3.3 7.22.3.6 7.22.3.7 Threader Magnesi Screw Ti 7.22.5.1 7.22.5.2	Modules ment Methods Finite Element Analy Simulation in the Laboratory — Testing Functions and Service ectors at the Engine ength Threaded Conrectors dequirements deficitions Connectors Head Bolt Main Bearing Cap Bearing Cap Bearing Cap Bolt Conrod Bolt Belt Pulley Bolt Flywheel Bolt Camshaft Bearing Components deficitions in um Components ghtening Process Torque-Controlled Tightening Rotation-Angle Contrightening Tightening	ce Life nectors  Solt Cap Bolt crews	9.4 9.5 9.6	9.4.1 9.4.2 9.4.3 9.4.4 Influence	ary Cond Run-In S Combus Oil Visco Tempera Engine Coe of Frich Behavions S Already Breakdo Engine F 9.6.2.1 9.6.2.2 9.6.2.3 Valve Tir Gear) Auxiliarie 9.6.4.1 9.6.4.2 9.6.4.3	State of the Internal tion Engine posity sture Influence Operating Point tion on the Fuel Consumper of Internal Combustion Built with the England Power Unit Crankshaft Conrod Bearing and Pist Group Mass Balancing ming (Valve Train and Times Oil Pump Coolant Pump Alternator Fuel Injection Pump Air Conditioning	stor
	•	7.23.1	st Manifol Manifold	Development Proces	SS	40 Ober		9.6.4.7	Compressor Radiator Fan Power Steering Pump	
		7.23.2	7.23.2.1 7.23.2.2 7.23.2.3	s as Individual Comp Cast Manifold Tube Manifold Single-Wall, Half-Sh Manifold Manifolds with Air G Insulation (AGI Mani	ell	<b>10 Char</b> 10.1	Gas Ex Engine 10.1.1 10.1.2 10.1.3	s Valve Ge Compon Kinemat Valve Ge Valve Ge		
	-	7.23.3	7.23.3.1	ifold as a Submodule Integrated Manifold Catalytic Converter Integrated Manifold Turbochanger	e and		Calcula The Ch	Four-Streating Cha	of Gas Exchange Devices oke Engines rge Cycles ele in Two-Stroke Engines jing	
	7.24		l Mechan	Components sms for Two-Stroke	Cycle	10.4	10.3.3 Variabl	Scaveng e Valve A	hange Organs jing Air Supply ctuation ft Timing Devices	
8	8.1	8.1.1 8.1.2	gical Prin Friction Wear					10.4.1.1	Overview of the Functio Principles of Camshaft Timing Devices The Effects of Camshaft	t
	8	8.2.1 8.2.2	ation Syst Lubricati Compon						Timing Devices on Engil Camshaft Adjusters for Production Engines Reflections about Cams	
9	9.2 I	Parame Friction	n States	suring Friction				the Valve	Adjusters with Stepped Variation of Stroke or Opening Time Variable Valve Actuation	)

Basics, Components, Systems, and Perspectives

, , , , , , , , , , , , , , , , , , ,	, , , , , , , , , , , , , , , , , , , ,			
10.4.3 10.4.3 10.4.3 10.5.1 10.5.1 Introd 10.5.1 Introd 10.5.2 Desig Strok 10.5.3 Optio Cycle 10.5.3 10.5.3 10.5.3 10.5.3 10.5.3 10.5.4 10.5.4 10.5.5 Demo Single 10.5.5	e Valve ns for Influencing the Charge 3.1 Dynamic Supercharging in Induction Engines (Pulse Charge) 3.2 Supporting and Recharging Supercharged Engines 3.3 Throttle-Free Load Control 3.4 EGR Control 3.5 Hot Charging Supercharged Engines 3.7 Cylinder Shutoff type for Engine Tests 4.1 Parameters and Design 4.2 Implemented Prototype Instration of Function in E-Cylinder Engines 5.1 Increasing Air Expenditure by Dynamic Supercharging 5.2 Increasing Torque by Dynamic Supercharging 5.3 Required Air Stroke Valve Operating Times in	12.4	12.3.1 12.3.2 12.3.3 12.3.4 12.3.5 12.3.6 12.3.7 Mixture Injectio 12.4.1 12.4.2 Mixture 12.5.1 12.5.2	Intake Manifold Injection Systems Systems for Direct Injection 12.4.2.1 Air-Supported Direct Injection 12.4.2.2 High-Pressure Injection 12.4.2.3 Injected Fuel Metering Formation in Diesel Engines Injection Systems — An Overview Systems with Injection-Synchronous Pressure Generation 12.5.2.1 Individual Pump Systems with a Line 12.5.2.2 Inline Fuel Injection Pump 12.5.2.3 Distributor Injection Pump 12.5.2.4 Pump Nozzle System Systems with a Central Pressure Reservoir 12.5.3.1 High-Pressure Pump
	Operating Times in Dynamic Supercharging 5.4 Hot Charging nary and Outlook			12.5.3.1 High-Pressure Pump 12.5.3.2 Rail and Lines 12.5.3.3 Injectors 12.5.3.4 Injection Nozzle
11 Supercharging of 11.1 Mechanical S 11.2 Exhaust Gas 11.3 Intercooling 11.4 Interaction of	Internal Combustion Engine Supercharging Turbocharging  f Engine and Compressor			12.5.3.5 Electronics 12.5.3.6 Developmental Trends Injection Nozzles and Nozzle-Holde Assemblies Adapting the Injection System to the Engine
Comp 11.4.2 Mech	Stroke Engine in the pressor Map anical Supercharging ust Gas Turbocharging navior	<b>13 Ignit</b> 13.1	Spark-1 13.1.1	Ignition Engine Introduction to Ignition Requirements of the Ignition Systen
11.6 Additional Mo	easures for Supercharged bustion Engines gines		13.1.3	Minimum Ignition Energy Fundamentals of Spark Ignition 13.1.4.1 Phases of the Spark 13.1.4.2 Energy Transmission
12 Mixture Formatio 12.1 Internal Mixtu 12.2 External Mixt			13.1.6	Efficiency Coil Ignition System (Inductive) Other Ignition Systems Summary and Outlook

Basics, Components, Systems, and Perspectives

13.2	Spark	Pluas	15 Combustion Systems
. 0.2		Demands on Spark Plugs	15.1 Combustion Systems for Diesel Engines
		Design	15.1.1 Diesel Combustion
		Heat Range	15.1.2 Diesel Four-Stroke Combustion
		Required Voltage for Ignition	Systems
		Ignition Characteristic (and Mixture	15.1.2.1 Methods using Indirect
		Ignition)	Fuel Injection (IDI)
	13.2.6		15.1.2.2 Direct Fuel Injection
		Application	Method (DI)
13.3		Engines	15.1.2.3 Comparison of Combustion
		Autoignition and Combustion	Systems
	13.3.2	Diesel Engine Cold Starts	15.1.2.4 Special Methods and
		13.3.2.1 Important Influential	Features
		Parameters	15.2 Spark-Injection Engines
		13.3.2.2 Start Evaluation Criteria	15.2.1 Combustion Processes in Port Fuel
	13.3.3	Components for Supporting Cold	Injection (PFI) Engines
		Starts	15.2.2 Combustion Process of Direct
		13.3.3.1 Glow Plug Systems	Injection Spark Ignition (DISI) Engines
		13.3.3.2 Heating Flange	15.3 Two-Stroke Diesel Engines
	13.3.4	Outlook	15.4 Two-Stroke SI Engines
		13.3.4.1 Combined Systems	16 Electronics and Mechanics for Engine
		13.3.4.2 Measurement of Ionic	Management and Transmission Shift Control
		Current	16.1 Environmental Demands
		13.3.4.3 Regulated Glow Plug	16.2 Stand-Alone Products (Separate Devices)
		Systems	16.3 Connecting Approaches
14 Com	bustion	1	16.4 Integrated Products (MTM = Mechatronic
	Princip		Transmission Module)
	14.1.1		16.5 Electronic Design, Structures, and
		Oxidation of Hydrocarbons	Components
14.2		ustion in SI Engines	16.5.1 Basic Structure
	14.2.1	Mixture Formation	16.5.2 Electronic Components
		14.2.1.1 Intake Manifold Injection	16.5.2.1 IC Knocking Input Filter
		14.2.1.2 Direct Injection	Component
		Ignition	16.5.2.2 Driver Stage Component
	14.2.3	Combustion Process	16.5.2.3 Microcontroller
		14.2.3.1 Flame Propagation	16.5.2.4 Voltage Regulator
		14.2.3.2 Mean Pressure and Fuel	16.6 Electronics in the Electronic Control Unit
		Consumption	16.6.1 General Description
		14.2.3.3 Cyclical Fluctuations	16.6.2 Signal Conditioning
1/10	Combi	14.2.3.4 Engine Knock	16.6.4 Signal Output
14.3		ustion in Diesel Engines Mixture Formation	16.6.4 Signal Output 16.6.5 Power Supply
	14.5.1	14.3.1.1 Phenomenology	16.6.6 CAN Bus Interface
		14.3.1.2 Fuel Jet Propagation	16.6.7 Electronics for Transmission ECUs
	14 3 2	Autoignition	16.7 Software Structures
		Combustion Process	16.7.1 Task of the Software In Controlling
		14.3.3.1 Phenomenological	Engines
		Description	16.7.2 Demands on the Software
		14.3.3.2 Equivalent Combustion	16.7.3 The Layer Approach to Software
		Curves	16.7.4 The Software Development Process
14.4	Heat Ti	ransfer	16.8 Torque-Based Functional Structure for
		Heat Transfer Model	Engine Management
	14.4.2	Determination of Heat Transfer	16.8.1 Model-Based Functions Using the
		Coefficients	Example of Intake Manifold Charging

16.9 Functions

**Electrical Machine** 

Basics, Components, Systems, and Perspectives

**17** 

		λ Regulat				17.7.4	Series D	evelopment	
		Antijerk F		10 (	Sens	orc			
			/alve Control						
	16.9.4	Knocking	, Control				rature Se	nsors	
	16.9.5	"On-Boar	rd" Diagnosis (OBD)				Sensors		
			Self-Diagnosis Tasks	•	18.3	Exhaus	st Gas Se	ensors	
			Monitoring the Catalytic			18.3.1	Lambda	Sensors	
			Converter			18.3.2	NO <sub>x</sub> Sen	sors	
	1696	Safety Ar	pproaches	-	18.4	Pressu	re Sensoi	rs	
	10.5.0	Calciy Ap	pproacties					Pressure Sensors	
The	Powert	rain				. •		Piezoresistive	
		rain Archi	tecture					Measurement Principle	
			le's Longitudinal Dynamics				18/119	Capacitive Measuremen	+
							10.4.1.2		IL
		ission Typ				10.40	Madiuma	Principle	
			Signal Processing Level					Pressure Sensors	
17.5			ınagement			18.4.3		essure Sensors	
	17.5.1	Functions					18.4.3.1	Technical Boundary	
			Overview					Conditions	
		17.5.1.2	Driving or Gearshift				18.4.3.2	Signal Transmission	
			Strategy				18.4.3.3	Measuring Precision	
		17.5.1.3	Automatic Transmissions	•	18.5	Air Mas	ss Sensoi	rs	
			with Planetary Gears and			18.5.1	Compari	ison of Air Mass-Controlle	ed
			Torque Converter					ke Manifold Pressure-	
		17.5.1.4	Automated Stick-Shift					ed Systems	
			Transmissions			18.5.2		ng Principles	
		17515	Continuously Variable					Anemometer	
		11.0.1.0	Transmissions (CVT)					ary Air Mass Sensors (SAI	E)
176	Intogra	tod Powo	rtrain Management (IPM®)		126		Sensors	ary Air Mass Ochsors (OA)	' '
					10.0			Speed Sensors	
17.7			tarter-Motor/Alternator (ISG)					Speed Sensors	
	17.7.1		ystem Overview			10.0.2	Active S	erisors	
		17.7.1.1	Torque Structure in a Motor	10	Λctu	ators			
		47740	Vehicle				for Charo	ge Controllers	
		17.7.1.2	Starter-Motor/Alternator		19.1			tic Drives	
			Structure						
		17.7.1.3	Description of the Starter-			19.1.2	Electric I		
			Motor/Alternator's Most					Stepping Motor	
			Important Modes of Use					DC Motor	
	17.7.2	Converte	rs (Powertrain Management					Torque Motor	
		and Volta	ige Converters)		19.2		e Valve A		
		17.7.2.1	Requirements Made on the					ction in SI Engines	
			Electronics from a System			19.2.2	Key Fund	ction in Diesel Engines ar	nd
			Viewpoint				in Quality	y-Controlled SI Engines	
		17722	Function Groups and				(Direct In	njection)	
			Design Criteria			19.2.3	Addition	al Functions	
		17.7.2.3					19.2.3.1	Idle-Speed Control of S	l
			Classification of the					Engines	
		17.7.2.4	Converter's Power				19.2.3.2	Position Signal	
								Dashpot Function	
		47705	Electronics					Cruise Control Function	
	1770		DC/DC Converters			1021		y Wire"/E-Gas	
	17.7.3	Electrical							
			Design Criteria					Pressure Control	
			Simulation Tools		100			Prethrottle Actuators	
			Thermal Simulation		19.3		nd Tumbl		1
		17.7.3.4	Mechanical Strengths			19.3.1		te Actuators (Swirl/Tumb	ıe
		17.7.3.5	Requirements Made on the				Actuator	,	
			Flectrical Machine	-	19.4	Exhaus	st Gas Re	circulation Valves	

	19.5			ssions Compo Purge Valves	onents			21.5.2.1	Three-Way Catalytic Converter
			Evaporat	ive Emissions Tank Diagnos				21.5.2.2	Oxygen Storage Mechanism
				Pressure					Cold Start Strategies
			19.5.2.2	Tank Diagnos	stics with		04.5.0		Deactivation and Its Effect
				Vacuum			21.5.3		Converter Approaches for rn Engines
20	Cool	ling of I	nternal C	ombustion E	ngines				Options for NO <sub>x</sub> Reduction
		Genera							in Lean Exhaust Gas
				Cooling Syst				21.5.3.2	The NO <sub>x</sub> Storage Catalytic
	20.3	Tools	ies for Ca	lculation and	Simulation			01 5 0 0	Converter
	20.4		Coolina S	Subsystems				21.5.3.3	System with a Precatalytic Converter and NO <sub>x</sub>
			Coolant (	Cooling					Adsorber
					tection Media		21.5.4	Metal Ca	talytic Converter Substrates
			Intercooli	ng Gas Cooling		21.6			ent in Diesel Engines
			Oil Coolir				21.6.1		kidation Catalytic Converters
				Fan Drives				21.0.1.1	Pollutants in Diesel Exhaust
			g Modules					21.6.1.2	Characteristics of Diesel
	20.6	Overall	Engine C	ooling Syster	n				Oxidation Catalytic
21	Exha	aust Em	issions					04 0 4 0	Converters
			Regulation	S				21.6.1.3	Deactivating the Catalyst Surface
			Europe					21.6.1.4	Evaluating Diesel Oxidation
			California	ı, USA					Catalytic Converters
		21.1.3		zing Exhaust I	-mission		21.6.2		orbers for Diesel Passenger
			Regulation					Cars	Operation Depart of
	21.2			ust Emissions				21.0.2.1	Operating Range of Storage Catalytic
		21.2.1			for Certifying				Converters
		21 2 2	Automob	iles g Technology	for Engine				Desulfurization
		21.2.2	Developn		TOT ETIGINE		04.0.0		Regeneration Methods
	21.3		nts and T	heir Origin			21.6.3	Particle F	-liters Particle Definitions and
		21.3.1		ection Engine				21.0.0.1	Particle Properties
			21.3.1.1	Restricted Ex Emission Con					Goals of Particle Filtration
			21.3.1.2	Unrestricted				21.6.3.3	Requirements for Filter
				Components					Media and Technical Solutions
		21.3.2	Diesel En		da a cont			21.6.3.4	Deposition and Adhesion
			21.3.2.1	Restricted Ex Components					Regeneration and Periodic
			21.3.2.2	Unrestricted				04 0 0 0	Cleaning
				Emission Co				21.6.3.6	Regeneration Emissions and Secondary Emissions
	21.4		ing Polluta					21.6.3.7	Pressure Loss
		21.4.1		elated Measu Spark-Injection					Installation Area and
				Diesel Engine					System Integration
	21.5	Exhaus		atment for Sp				21.6.3.9	Damage Mechanisms,
		Engine	S	-	_			21.6.3.10	Experience Quality Criteria
		21.5.1		Converter De Reactions	sign and				Performance Test, Type
		21.5.2		Converter Ap	proaches for			04.00:-	Test, OBD, Field Control
				netric Engines				21.6.3.12	Catalytic Soot Filter

	21.6.3.13 Partic	cle Measuring		22.2.9		ils for Two-Stroke En Two-Stroke Performa	
22 Operation 22.1 Fue						Classes	
	1.1 Diesel Fuel					Two-Stroke Test Met	noas
22.		J Eugl Componente	22.3	Coolar			
		el Fuel Components			Frost Pro		
		Composition				n Protection	
	22.1.1.2 Chara			22.3.3	Specifica	ations	
	Prope						
		ives for Diesel Fuel				ng Fluids	
		native Diesel Fuels	23.1	Air Filt			_
22.	1.2 Gasoline	_		23.1.1		ortance of Air Filtratior	n for
		line Components and				Combustion Engines	
		position				es in Engine Intake Air	
	22.1.2.2 Chara	acteristics and		23.1.3	Data for	Assessment of Air-Filt	er
	Prope	erties			Media		
	22.1.2.3 Alterr	native Gasolines		23.1.4	Measurir	ng Methods and Evalu	ation
22.2 Lul	oricants			23.1.5	Requirer	nents Made on Moder	'n
22.	2.1 Types of Lubric	cants			Air-Filter	Systems	
	2.2 Task of Lubrica			23.1.6	Design C	Criteria for Engine-Air I	ilter
22.	2.3 Types of Lubric	cation			Elements		
	2.4 Lubrication Red			23.1.7	Filter Ho		
	2.5 Viscosity/Visco					Design of Filter Hous	inas
		nce of Temperature	23.2	Fuel Fi			
		scosity				Fuel Filters	
		nce of the Pressure				uel Filters	
		e Viscosity				ormance Data of Fuel	Filters
		nce of Shear Speed	23.3		-Oil Filtra		1 111010
		scosity	20.0			d Filtration	
22	2.6 Basic Liquids	SCOSITY				v Oil Filters	
22.	22.2.6.1 Miner	ral Basic Oils				Efficiency and Filter	
				20.0.0	Fineness	<del>-</del>	
20	2.7 Additives for Li	netic Basic Liquid		00 0 4			
22.				23.3.4	Буразз ч	Oil Filtration	
	22.2.7.1 V.I. In		24 Calc	ulation	and Sim	ulation	
	22.2.7.2 Deter					oration Calculation	
		ersants	27.1			res and Methods	
		xidants and Corrosion				Examples of Applicat	ions
	Inhibi					alculations	.10113
	22.2.7.4 Friction		24.2		Calculation		
		cers (EP/AW	24.2			d Quasidimensional Me	thode
	Addit	,				mensional Flow Calcu	
	22.2.7.5 Foam						
22.		Four-Stroke Engines		24.2.3	Selected	I Examples of Applicat	.1011
		Viscosity Classes for	25 Com	hustio	n Diagno	stics	
		ne Oils		Discus	_		
		e-Grade Engine Oil		Indicat			
	22.2.8.3 Multio		20.2		•	ng Systems	
	22.2.8.4 Fuel I				Quality (		
	22.2.8.5 Break					g: Prospects	
	22.2.8.6 Gas E		25.2	Visuali:		g. 1 103pects	
	22.2.8.7 Meth	anol Engine Oils	20.0			s and Discussion	
		ogen Engine Oils				is and Discussion ition Methods for Real	
		rmance Classes		20.3.2			
	22.2.8.10 Evalu	ating Used Oil				Operation The Regions Dreporti	00 Cf
	22.2.8.11 Racin				23.3.2. l	The Radiant Properti	
	22.2.8.12 Wank					Gas, Gasoline, and D	nesei
		•				Flames	

Basics, Components, Systems, and Perspectives

			25.3.2.2 Flame Spectroscopy 25.3.2.3 Flame Propagation in	27.2.1 Methods of Measuring Emitted Noise
			Premixed Charges with Supplied Ignition	27.2.2 Critical Evaluation of the Informational Value of the Emitted Noise Measuring
			25.3.2.4 Flame Propagation in Diffusion Combustion in a Diesel Engine	Method 27.2.3 Emitted Noise Limits, International Legislation; Future Trends
		25.3.3	Visualization of Combustion in Real	27.3 Sources of Emitted Noise
			Engine Operation by the Flame's Intrinsic Luminescence	27.4 Emitted Noise-Reduction Provisions 27.4.1 Provisions on the Engine
			25.3.3.1 Technical Exploitation:	27.4.2 Provisions on the Vehicle
			Flame Propagation	27.5 Engine Noise in the Vehicle Interior
		25.3.4	Visualization of Illuminated Processes	27.6 Acoustic Guidelines for the Engine Designer
			25.3.4.1 Visualization of Mixture	<ul><li>27.7 Measuring and Analytical Methods</li><li>27.8 Psychoacoustics</li></ul>
			Distribution	27.9 Sound Engineering
			25.3.4.2 Visualization of Velocity	27.10 Simulation Tools
		25.3.5	Fields Visualization: The Future	27.11 Antinoise Systems: Noise Reduction using Antinoise
26	Fuel	Consu	mption	28 Alternative Propulsion Systems
		Genera	al Influencing Factors	28.1 The Rationales for Alternatives
			Air Resistance	28.2 The Wankel Engine
			Weight	28.3 Electric Propulsion
			Wheel Resistance	28.4 Hybrid Propulsion System
	26.2		Fuel Consumption  Modifications	28.4.1 Storage Systems 28.5 The Stirling Engine
	20.2		Downsizing	28.6 Gas Turbines
			Diesel Engine	28.7 The Steam Motor
			Gasoline Engine	28.8 The Fuel Cell as a Vehicle Propulsion System
			26.2.3.1 The Lean-Burn Engine	28.8.1 The Structure of the PEM Fuel Cell
			Concept and Direct	28.8.2 Hydrogen as the Fuel
			Injection	28.8.3 Methanol as the Fuel
			26.2.3.2 Variable Valve Timing 26.2.3.3 Ignition	28.8.4 Gasoline Engine Fuel 28.8.5 The Fuel Cell in the Vehicle
		26.2.4	Cylinder Shutoff	28.8.6 Evaluation of the Fuel Cell vis-à-vis
			26.2.4.1 Concept for Reduction of	Other Propulsion Systems
			Fuel Consumption	28.9 Summary
		_	26.2.4.2 Consumption Benefits in the Part-Load Range	29 Outlook
	26.3		nission Ratios Selection of Direct Transmission	Index
			Selection of Overall Transmission	Alexander Bulliana
		20.0.2	Ratio in the Highest Gear	About the Editors
	26.4	Driver	Behavior	Color Section
	26.5		nissions	
		26.5.1	CO <sub>2</sub> Emissions and Fuel	
		06.5.0	Consumption The Influence of Engine Lies on CO	
		20.5.2	The Influence of Engine Use on CO <sub>2</sub>	

#### **27 Noise Emissions**

27.1 Basic Physical Principles and Terms

27.2 Legal Provisions Concerning Emitted Noise

26.5.3 The Trend in Global CO<sub>2</sub> Emissions