

Table of Contents

Preface to the Second English Edition	ix
Preface to the First English Edition	xi
Chapter 1 - Introduction	1
Chapter 2 - The Engine.....	9
2.1 Properties and peculiarities.....	9
2.2 Operating conditions.....	11
2.2.1 Engine concepts	11
2.2.2 Engine power output and power reduction.....	14
2.3 Operational behavior of engines	20
Chapter 3 - Failure—Definitions and Concepts	41
Chapter 4 - Causes of Failure	47
4.1 Wear and tear	47
4.2 Technical defects (product defects)	49
4.2.1 Design flaws (planning flaws)	49
4.2.2 Materials defects	52
4.2.3 Manufacturing defects.....	53
4.3 Operating errors.....	53
4.3.1 Overloading.....	53
4.3.2 Changing operating conditions.....	54
4.3.3 Operating errors	55
4.4 Humans as the cause of failures	59
Chapter 5 - Explanation of Failures.....	61
5.1 Type of failure	61
5.1.1 Failures from mechanical loading.....	61
5.1.2 Overload failure.....	62
5.1.3 Fatigue fractures	65
5.1.4 Thermal damage.....	71
5.1.5 Failure through corrosion in aqueous media	73
5.1.6 Failure through tribological loading.....	76
5.2 Failure analysis	86
5.2.1 On-site inspection.....	86
5.2.2 Securing damaged parts.....	86

5.2.3	Determining damage-relevant data of a machine installation	87
5.2.4	Course of events	88
5.2.5	Exact description of damage.....	90
Chapter 6 - Engine Failures	91	
6.1	Overview.....	91
6.2	Crank train failures.....	99
6.2.1	Pistons	99
6.2.2	Piston rings.....	178
6.2.3	Connecting rods.....	190
6.2.4	Crankshafts.....	203
6.2.5	Crank train bearings	215
6.2.6	Engine oil	275
6.3	Crankcase and ancillary components	284
6.3.1	Crankcase.....	284
6.3.2	Crankcase damage and failure	287
6.3.3	Cylinders, cylinder liners, and cylinder jackets	291
6.3.4	Cylinder damage	299
6.3.5	Cavitation	305
6.3.6	Cylinder heads	309
6.3.7	Cylinder head damage	312
6.4	Valve train.....	318
6.4.1	Valve springs	322
6.4.2	Valves	325
6.4.3	Camshaft and cam followers	342
6.4.4	Timing belts, chains, and gears.....	347
6.5	Fuel injection and ignition systems.....	369
6.5.1	Diesel engine mixture formation and combustion	369
6.5.2	Fuel injection systems	381
6.5.3	Fuel injection system damage.....	392
6.5.4	Glow plugs	405
6.5.5	Otto-cycle engine ignition and combustion.....	412
6.6	Filters	427
6.6.1	Fundamentals of filtration.....	427
6.6.2	Air filters	432
6.6.3	Oil filters	440
6.6.4	Fuel filters	451
6.7	Heat exchangers and heat transfer devices.....	454
6.7.1	Shell and tube heat exchangers	459
6.7.2	Heat exchanger damage	463

6.8	Turbochargers.....	477
6.8.1	Turbocharger damage	484
6.8.2	Lubrication inadequacies	491
6.8.3	Turbocharger housing leaks.....	494
6.8.4	Turbocharger operation in zero pressure regime.....	495
6.8.5	Noise complaints	496
Chapter 7 - Preventing Combustion		
Engine Damage	497	
7.1	Preliminary remarks.....	497
7.2	Introduction.....	498
7.3	Loss statistics	499
7.4	Advice for the prevention of damage by product faults.....	502
7.4.1	Planning and design	502
7.4.2	Fabrication and assembly	504
7.5	Advice for loss prevention by operational faults.....	506
7.6	Engine cooling.....	508
7.6.1	Information on cooling water treatment.....	508
7.6.2	Cooling water shortage	510
7.6.3	Examples of damage incidents	510
7.7	Engine lubrication	511
7.8	Engine fuel.....	512
7.9	Combustion air.....	513
7.10	Maintenance and inspection	514
7.10.1	Maintenance	514
7.10.2	Inspection	514
Appendix.....	517	
List of Acronyms	525	
References.....	527	
Bibliography	535	
Illustration Credits.....	553	
Index	557	
About the Authors	567	