Index

Abbreviations, 245–247
Additives
  antioxidants, 56
diesel fuel
  for cold flow performance, 55–56
detergents, 55
to improve cetane number, 55
lubricity, 56
gasoline
  combustion modifiers, 54
deposit control, 54
  friction modifiers, 54–55
storage- and distribution-related, 56–57
Alkylation, 38
Alternative transport energy sources, 18–22
Antiknock properties of gasoline, 42–43
Antiknock quality, 37, 120–131
  of practical fuels, 123–128
specifications for, 236–238
Aromatics, 238–239
  in diesel fuel, 53
  in gasoline, 45
Autoignition, 109–120, 148
  chemical kinetics modeling, 111–112
  ignition delay and the
    Livengood-Wu integral, 112–119
Autoignition quality, 47–49
  gasoline, 142
  of practical fuels, 119–120
test problems, 144–148
Autoignitive preignition, 163–164
Battery electric vehicles (BEVs), 23–25
Biodiesel, 53
  injector deposits, 71–72
Biofuels, 18–20, 40
CA50, 132–133
  variation with octane index, 135–136
Carbon rap, 88
Catalytic cracking, 38
Catalytic reforming, 38
Cetane index (Cl), 48
Cetane number (CN), 34, 47–49,
  141–132
  additives to improve, 55
Cloud point (CP), 51, 56
Coal, 6–10
Coking processes, 37–38
Cold filter plugging point (CFPP), 51–52, 56
Cold flow properties, 51–52
Cold flow performance additives, 55–56
Combustible gases, 21–22
Combustion chamber deposit interference (CCDI), 88
Combustion chamber deposits (CCDs), 75–80
effects of
  carbon rap, 88
  emissions, 86–88
  flaking and associated problems, 85–86
  fuel economy, 84–85
  octane requirement increase, 83–84
  in ring belt area, 89
  spark plug fouling, 88–89
growth of, 76–78
  properties of, 78–80
Combustion delay (CD), 188, 208–209, 215
Combustion modifiers for gasoline, 54
Combustion phasing, 196–200
Compression ignition (CI) combustion, 185–226
  with diesel fuels, summary, 222–226
  fuel implications of engine development trends, 239–240
  gasoline
    fuel efficiency, 221
    full-load operation, 221
    summary, 202–204
see also Premixed compression ignition combustion
Index

Controlled autoignition number (CAN), 140–141

Crude oil, 35–36

Dehazers, 56–57

Density
  of diesel fuel, 50
  of gasoline, 45

Deposit control additives, 54, 91–92

Deposits
  combustion chamber, 75–80
  control of, 89–92
  effects on engine performance and emissions, 81–89
  fuel injector, 69–72
  intake system, 72–75
  introduction to, 63–67
  nature and formation of, 68–80

Derived cetane number (DCN), 48

Detergents, 55, 91–92

Developing detonation (DD), 172–173, 176–177

Diesel engines, 185–188
  fuel effects in, 192–204

Diesel fuel, 47–51, 141–142
  aromatics in, 53
  autoignition quality, 47–49
  biodiesel, 53
  cetane number, 34, 47–49
  cold flow properties, 51–52
  demand for, 15–17
  density and viscosity, 50
  distillation properties, 50
  effects in conventional autoignition range, 192–204
  heat release and noise, 193–196
  with premixed compression ignition, 196–200
  effects on compression ignition combustion, 185–226
  flash point, 52
  in full-HCCI scenario, 143
  higher loads with, 200–201
  injector deposits, 71–72
  lubricity, 50–51
  performance additives, 55–56
  properties of, 33–34
  sulfur in, 52–53

Direct injection spark ignition (DISI) injector deposits, 65, 70–71

Distillation properties, of diesel fuel, 50

Driveability index (DI), 44

Dual-fuel operation, 220–221

Electricity, levelized cost of, 12

Electrification, 22–25

Emissions, 17, 86–88, 196–200
  engine deposit effects on, 81–89
  fuel effects on, 41–53
  standards, 41

Energy
  efficiency improvements, 14
  global demand, 1–5
  global resources and supply, 6–14
  nuclear, 13
  renewable, 12–13
  transport, 14–25
  transport, summary of, 25–26

Energy conversion factors, 6t

Ether synthesis, 40

Exhaust gas recirculation (EGR), 93, 187

Flaking, 85–86

Flash point, 52

Fossil fuels, 6–11

Friction modifiers for gasoline, 54–55

Fuel economy, 84–85

Fuel efficiency, 221, 223

Fuel injection, 217–220

Fuel injector
  deposits in, 69–75
  effects of, 81
  diesel deposits, 71–72
  direct injection spark ignition deposits, 70–71
  intake valve deposits, 72–75
  port deposits, 69–70

Fuels
  additives, 53–57
  alternative sources, 18–22
  antiknock quality, 120–131
  autoignition quality test problems, 144–148
  biofuels, 18–20
  combustible gases, 21–22
  composition and properties of, 41–53
compression ignition, implications of engine development trends, 239–240
effects on autoignition in premixed systems, 109–149
effects on engine performance and emissions, 41–53
effects on homogeneous charge compression ignition combustion, 131–144
effects on preignition, 168–171
fossil, 6–11
gas-to-liquids, 20–21
homogeneous charge compression ignition engine requirements, 142–144
practical, 35–40
antiknock quality of, 123–128
autoignition quality of, 119–120
manufacture, composition, and properties of, 33–57
spark ignition, implications of engine development trends, 236–239
standards, 41
surrogate, 111–112
synthetic, 20–21
transport
conventional, 14–17
electrification, 22–25
implications for future, 235–242
properties of, 15f
summary of, 25–26
see also Diesel fuels, Gasoline

Gasoline, 42–47
antiknock properties of, 42–43
aromatics in, 45
autoignition quality of, 142
demand for, 15–17
density, 45
in full-HCCI scenario, 143–144
gum specifications, 45
metal additives, 47
olefin in, 45
oxygenates in, 46–47
performance additives, 54–55
premixed compression ignition combustion, 213–217
injector effects, 217–219
modeling, 222
properties of, 33–34
sulfur in, 45–46
volatility, 43–44
Gasoline compression ignition (GCI), 223–225
fuel efficiency, 221
full-load operation, 221
Gas-to-liquids, 40, 20–21
Global energy demand, 1–5
Global energy resources and supply, 6–14
Gum specification for gasoline, 45
Homogeneous charge compression ignition (HCCI) combustion
controlled autoignition number (CAN), 140–141
dual-mode scenario, 144
fuel effects on, 131–144
fuel requirements of, 142–144
idealized full-HCCI scenario, 143–144
limits of operation, 139–140
and octane index, 132–140
octane requirement of, 137–139
other approaches to characterizing fuel performance in, 140–142
Hybrid electric vehicle (HEV), 22–25
Hydrogen, 21–22, 168
Hydroprocessing, 38

Ignition
away from surfaces, 163–164
surface, 162–163
Ignition criterion, fulfillment of, 162–164
Ignition delay (ID), 48, 112–119, 191, 216
Ignition delay limit (IDL), 216
Ignition dwell, 190
Ignition quality test (IQT), 48
Initiation criterion, fulfillment of, 164–166
Intake valve deposits, 72–75
effect of, 81–82
Index

Internal combustion engines deposits in, 63–93
practical fuels for, 33–57
Isomerization, 38

K value, 123–128
variation in HCCI combustion, 136–137
Knock, 33–34, 120–131, 148
knock intensity (KI), 121–122
octane requirement, 128–131
Knock-limited performance, 122–123
Knock-limited spark advance, 121–122

Levelized cost of electricity generation, 12
Livengood-Wu integral, 112–119
Lubricity, 50–51, 56

Maximum pressure rise rate (MPRR), 139
Metal content of gasoline, 47
Mixture strength effects on preignition, 167–168
Motor octane number (MON), 34, 42–43

Natural gas, 6–8, 10
Negative temperature coefficient (NTC), 116
Noise, 193–196
Nuclear energy, 13

Octane index (OI), 123–128, 140, 214
fuel effects in HCCI engines, 132–140
variation of CA50 with, 135–136
Octane requirement (OR), 128–131
of an HCCI engine, 137–139
Octane requirement increase (ORI), 83–84
Oil, 6–10
Olefin, 45
Oxygenates, 46–47

Pour point (PP), 51
Pour point depressants (PPDs), 55–56
Practical fuels
antiknock quality of, 123–128
autoignition quality of, 119–120
manufacture, composition, and properties of, 33–57
Preignition, 159–171
autoignitive, 163–164
fuel effects on, 168–171
fulfillment of the ignition criterion, 162–164
fulfillment of the initiation criterion, 164–166
ignition away from surfaces, 163–164
methods for quantifying, 166
mixture strength effects on, 167–168
pressure and temperature effects on, 166–167
surface ignition, 162–163
in turbocharged spark ignition engines, 159–171, 178–179
Preignition resistance, 166
Premixed compression ignition (PCI) combustion, 190–192
diesel fuel effects in conventional autoignition range, 196–200
with fuels with long ignition delays, 204–222
dual-fuel operation, 220–221
high loads, 207–213
injector effects, 217–220
low loads, 204–207
reactivity controlled compression ignition, 220–221
gasoline
effects of fuel properties, 213–217
full-load operation, 221
fuel efficiency, 221
injector effects 217–220
modeling, 222
Premixed systems, fuel effects on autoignition in, 109–149
Pressure effects on preignition, 166–167
Reactivity-controlled compression ignition (RCCI), 220–221
Refinery processes, 36–40
Reid vapor pressure, 44
Renewable energy, 12–13
Research octane number (RON), 34, 42–43
Spark ignition (SI) engines
  fuel implications of engine development trends, 236–239
  knock in, 120–131, 148
  turbocharged
    preignition in, 159–171, 178–179
    super-knock in, 171–179
Spark plug fouling, 88–89
Standards, 41, 238–239
Sulfur
  in diesel fuel, 52–53
  in gasoline, 45–46
Super-knock, 171–177
Surface ignition, 162–163
Surrogate fuel, 111–112
Synthetic fuels, 20–21
Temperature effects on preignition, 166–167
Transport fuels, 14–25
  properties of, 15t
Turbocharged spark ignition engines, 159–179
Visbreaking, 38
Viscosity, of diesel fuel, 50
Volatility, gasoline, 43–44
About the Author

Gautam Kalghatgi joined Saudi Aramco in October 2010 after 31 years with Shell Research in the UK. He has a B.Tech. from I.I.T. Bombay (1972) and a Ph.D. from Bristol University (1975) in aeronautical engineering. From 1975 to 1979, he did postdoctoral research in turbulent combustion at Southampton University.

He is a Fellow of the Royal Academy of Engineering, SAE International, and the Institution of Mechanical Engineers. He is a visiting professor at Imperial College, London, and has been adjunct, part-time, and visiting professor at the KTH, Royal Institute of Technology in Stockholm, Eindhoven Technical University in The Netherlands, and the University of Sheffield in the UK. He has over 100 publications on combustion, fuels, and engine research. He is on the editorial boards of three international journals: the International Journal of Engine Research, Journal of Automobile Engineering, and Journal of Fuels and Lubricants.