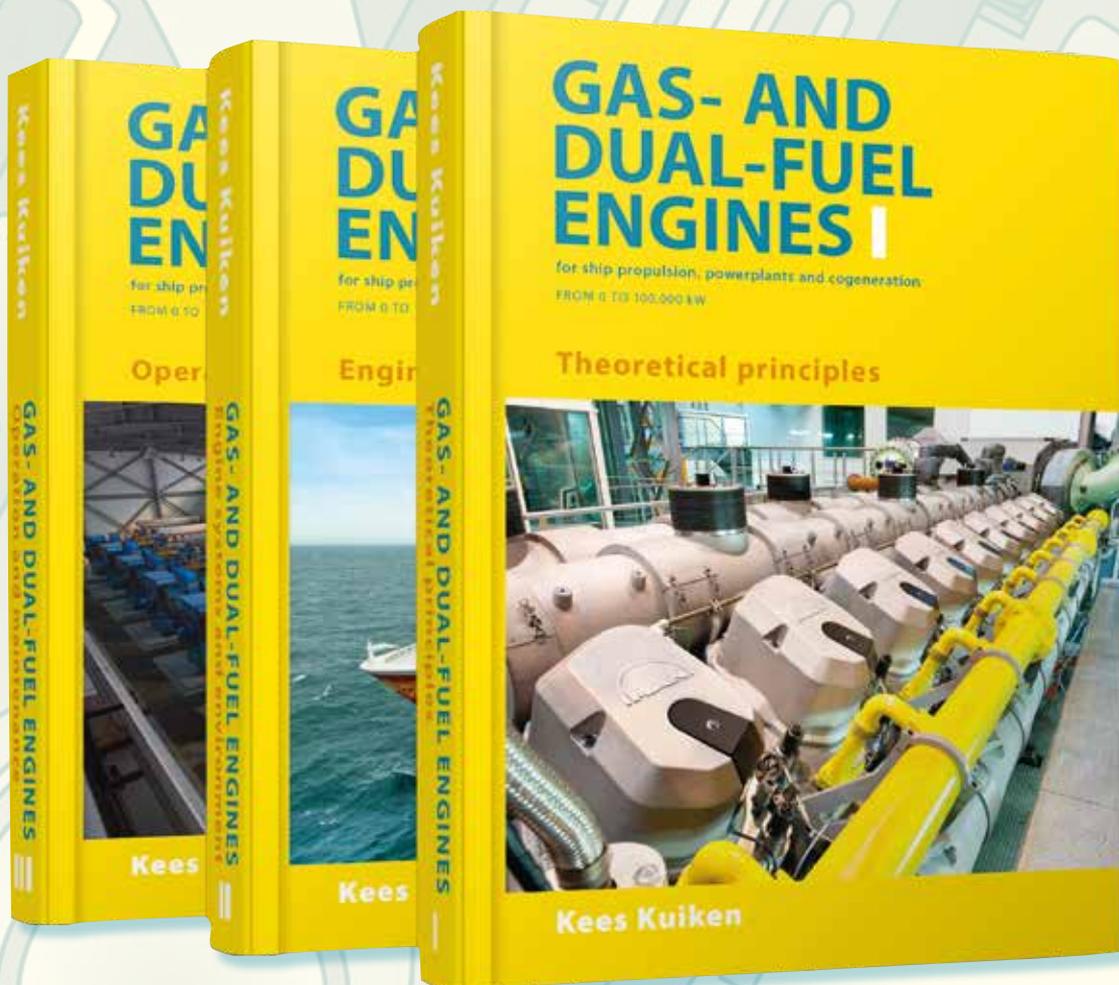


The new gas- and dual-fuel engine book

for ship propulsion, power plants
and cogeneration



Kees Kuiken
Target Global Energy Training

GAS- AND DUAL-FUEL ENGINES

for ship propulsion, power plants and cogeneration from 0 to 100,000 kW



This first edition of a three-part book on gas- and dual-fuel engines is intended for all who work with gas- and dual-fuel engines for maritime propulsion, power generation and cogeneration:

- Maritime training institutes and maritime universities;
- Maintenance and reconditioning companies;
- Shipping companies deep-sea, inland, towage, dredging and heavy-load cargo;
- Insurance companies, classification bureaus, surveyors;
- Shipping industry suppliers, suppliers of engine parts, fuel and lubricating oil;
- Engine manufacturers and dealers;
- Power Plants;
- Cogeneration.

When compiling this book, a practical approach was chosen using ample authentic graphic material with detailed explanations allowing the reader to gather pertinent information without laboriously going through the main text.

Important subjects: principles, gaseous and liquid fuels for gas-, dual-fuel- and diesel engines, ignition systems, new technologies, engine systems and environment, endoscopy and measurements, cogeneration.

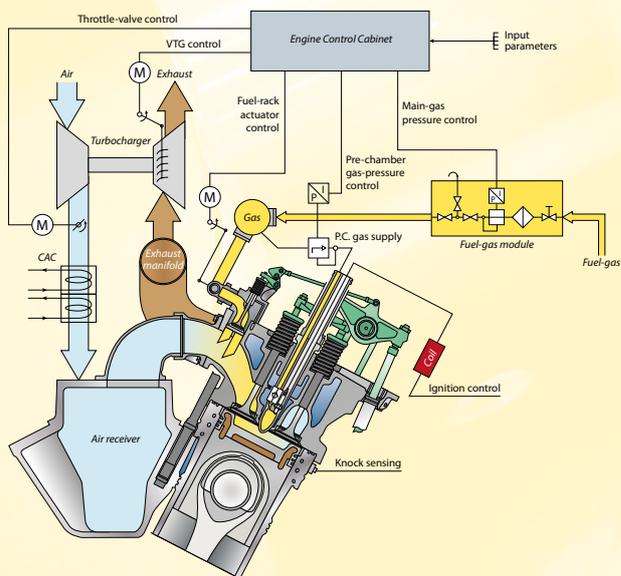
Leading companies and institutes have contributed to the realisation of this book by providing information, photographs and interviews. Ninety per cent of the more than 2900 pictures are in colour.

The three volumes consist of 488, 544 and 534 pages each.

Price of one book (three parts) 2016: The Netherlands, € 210,- inclusive packing, shipping and 6% VAT; EU I, II and III €225,-; Rest of the world € 250,- all-inclusive packing and shipping costs.

Discounts for orders over 25 books. Maritime Institutes and Training Centres up to 20% discount.

The three parts will be sealed and delivered in heavy-duty carton packaging at cost price.





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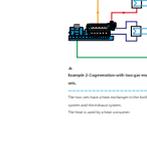
1.1 Introduction

Over the last few decades, the internal combustion engine has become an indispensable part of modern society. It is used in a wide range of applications, from power generation to transportation. The internal combustion engine is a complex machine that converts the chemical energy of fuel into mechanical energy. It consists of several cylinders, each containing a piston and a connecting rod. The pistons are driven by the combustion of fuel, which is ignited by a spark plug. The mechanical energy is then converted into electrical energy by a generator or into motion by a crankshaft.



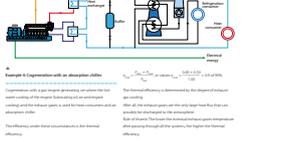
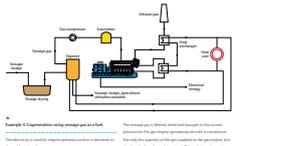
4.2.1 Operation

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Greenhouse utilization

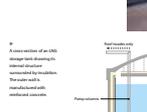
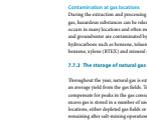
All the heat generated by the gas engine will be used for greenhouse utilization. The heat is transferred to the greenhouse through a network of pipes and radiators. This allows the greenhouse to maintain a constant temperature, even in cold weather. The heat is also used for heating the water in the greenhouse, which is used for growing plants.



7.1.1 Floating LNG

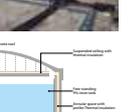


7.2.1 Floating LNG



7.2.2 Floating LNG

The floating LNG vessel is a large ship that carries liquefied natural gas. It is designed to be able to operate in all weather conditions. The vessel is equipped with a large storage tank for the LNG. The LNG is stored at a very low temperature, around -162 degrees Celsius. The vessel is also equipped with a large engine to power the pumps and compressors.



7.2.3 Floating LNG

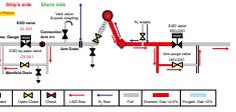
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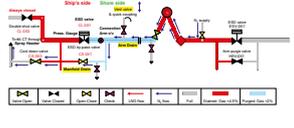
Table with technical specifications for the floating LNG vessel, including dimensions, capacity, and equipment.

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7.3.2 Floating LNG

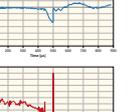


7.3.3 Floating LNG



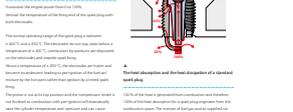
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10.16.2 The Selenia

The Selenia is the world's largest offshore supply vessel. It is a 200,000-tonne vessel with a length of 200 m and a beam of 32 m. It is equipped with a 10,000 kW diesel engine and a 10,000 kW generator. It is used for the supply of offshore platforms and is equipped with a 10,000 kW diesel engine and a 10,000 kW generator.

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20.16.4 3D measurements

3D measurements are used to measure the geometry of a part. This is done by using a 3D scanner to capture the geometry of the part. The 3D scanner then creates a 3D model of the part, which can be used for various purposes, such as for manufacturing or for quality control.

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20.2.1.17 Adjustment of the Top Dead Center (TDC)

The Top Dead Center (TDC) is the point in the engine cycle where the piston is at its highest point. It is an important parameter for the engine, as it affects the compression ratio and the timing of the valves. The TDC can be adjusted by changing the position of the crankshaft.

20.2.1.18 Performance graphs

Performance graphs are used to show the performance of an engine. They typically show parameters such as torque, power, and fuel consumption as a function of engine speed. These graphs can be used to compare the performance of different engines or to monitor the performance of an engine over time.

20.2.1.19 Torque vs RPM

Torque vs RPM graphs show the relationship between torque and engine speed. The torque typically increases with engine speed up to a certain point, after which it begins to decrease. This is due to the increasing friction and air resistance at higher engine speeds.

20.2.1.20 Fuel injection

Fuel injection is the process of delivering fuel to the combustion chamber of an engine. It is a critical part of the engine cycle, as it determines the amount of fuel that is available for combustion. Fuel injection can be done in a variety of ways, including carburetors, fuel injectors, and direct injection.

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27. Example V-Man BSW ME GL, two-stroke crosshead engine, CATERSHIP IV

The V-Man BSW ME GL is a two-stroke crosshead engine. It is a 10-cylinder engine with a total power output of 10,000 kW. It is used for the propulsion of large vessels and is known for its high efficiency and low emissions.

27.1.1 Engine Control System (ECS)

The Engine Control System (ECS) is responsible for controlling the engine's operation. It receives input from various sensors and outputs control signals to the engine's actuators. The ECS is a complex system that must be able to handle a wide range of operating conditions.

27.1.2 ECS

The ECS is a complex system that must be able to handle a wide range of operating conditions. It is responsible for controlling the engine's operation and ensuring that it runs smoothly and efficiently.

28.3 Gear transmission

Gear transmission is used to change the speed and torque of an engine. It consists of a series of gears that are mounted on shafts. The gears are connected to each other, and as they rotate, they transfer power from the engine to the output shaft.

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Book I: Principles

1 The use of industrial gas- and dual-fuel engines Introduction – The Otto cycle – The Diesel cycle – Internal combustion engines with two fuels, often called 'dual-fuel' engines – Uses of Otto engines – Uses of Diesel engines **2 Classification of gas- and dual-fuel engines** Introduction – Operating principle – Design – Rotational speed – Power output or shaft power – Fuels used – Uses of gas- and dual-fuel engines – Other characteristics of gas- and dual-fuel engines – Numbering the cylinders – Natural aspiration and turbocharging **3 Working principles of gas-, dual-fuel- and diesel engines** Operating principles – Design of the four-stroke gas engine – Two-stroke crosshead engines – A few significant differences between the two-stroke and four-stroke cycles – Important terms and definitions in gas-, dual-fuel- and diesel engines – Examples of engine names **4 Efficiencies and losses in gas- and dual-fuel engines** Efficiencies and losses – The Indicator diagram – Parameters of both operating principles – The engine formula – Indicated thermal efficiency – Mechanical and total efficiency – Specific fuel consumption – Mean effective pressure – Thermal energy balances or Sankey-diagrams – Efficiencies of installations using gas- or dual-fuel engines as power generators – Marine propulsion – Cogeneration and pumps and compressor drivers **5 Parameters of gas- and dual-fuel engines** Mean effective pressure – Mean piston speed – The load parameter – The compression ratio – The power density – The speed of gas- and dual-fuel engines and the relationship with the dimensions of the engine stroke volume – Speeds for generator operation **6 Construction of various types of gas- and dual-fuel engines** The difference between gas- and dual-fuel engines and diesel engines – Differences in the construction between diesel engines and gas- and dual-fuel engines – Category I: Industrial gas engines of 0 to 100 kW shaft power, gaseous fuel, four-stroke, high-speed – Category II: Industrial gas- and dual-fuel engines of 100 to 10,000 kW shaft power, gaseous fuel or a combination of gas and diesel oil/heavy fuel oil – Category III: Industrial gas- and dual-fuel engines of 500 to 30,000 kW shaft power, gaseous fuel or gas/diesel oil/heavy-fuel oil, four-stroke, medium-speed – Category IV: Industrial gas- and dual-fuel engines of 1500 to 100,000 kW shaft power, gaseous fuel or gas in combination with diesel oil or heavy-fuel oil, two-stroke crosshead engines, low-speed **7 Gaseous and liquid fuels for gas-, dual-fuel- and diesel engines** **A GASEOUS FUELS:** Introduction – Pure-gas engines, Otto-principle – Gaseous fuels – Physical properties of natural gas – Physical properties of biogas – The calorific value of gases – The production of fuel gases **B LIQUID FUELS** Introduction – Development of internal combustion engines – Composition of liquid fuels – Definition of heavy oil – Refining crude oil – Chemical composition of hydrocarbon compounds – Standardisation of liquid fuels – Fuel properties – Additional fuel specifications – Decreasing the sulphur content in fuels – Bunkering – Fuel-line systems according to the engine classification, pure diesel engines – Modular fuel-treatment systems – Bunkering fuels – Methanol – A good alternative for ferries and short sea shipping **8 Fuel-injection systems for gas-, dual-fuel- and diesel engines** Introduction – Fuel-supply systems – Fuel-supply systems for pure gas engines Spark Gas (SG) – Fuel-supply systems for pure diesel engines (D) – Fuel-supply systems for dual-fuel engines (DF) – Bunkering of liquid natural gas, LNG, transfer arms and manifold draining, purging and disconnection procedure **9 Ignition systems for gas- and dual-fuel engines** Ignition of gas engines – Ignition of dual-fuel engines – The use of both principles – Ignition systems for gas engines with the Otto-principle – Location of the spark plug in the combustion space – Spark-plug construction – Electrode shape – Electrode materials – The heat rating of the spark plug – Spark erosion and chemical corrosion – Spark-plug types – Examples from Denso – Ignition systems – Ignition coils – Triggering – High-tension leads and accessories – Primary Leads – Extensions – Wiring Rail Systems – Tools and test equipment – Spark plugs and accessories **10 New technologies** Introduction – Gas- and dual-fuel engines – Established technology and the current developments (2016) – Improving the engine response to power-output variations without decreased engine efficiency – Increasing power density and the application of fixed-pitch propeller-propulsion – Prospects – A concept by ABB: the Power 2, ABB two-stage turbocharging system – The use of gas engines in the maritime industry – Gas engines operational in the maritime industry – A few of the obligatory regulations for marine-gas engines – Safety and classification issues – The composition of liquefied natural gas, LNG – Emissions – LNG bunkering – Ship types suitable for LNG operation – Future developments – LNG – liquefied natural gas for use in gas- and dual-fuel engines – Five pilot projects – Comparison between two different operating principles for two-stroke crosshead engines **11 Speed control** Introduction – Summary – Types of governors – Examples of engine configurations with different types of governors – Theoretical background of governors – Governor-operating principle – Example: The 1100 series from Regulateurs Europa located in Roden, The Netherlands – Example: 1115-4G governor 4–20 mA speed setting – The speed control

Book II: Engine systems and environment

12 Air supply Introduction – The Otto-process, the principle of mixture compression – Some specific facts for gas engines – Air-supply systems for gas- and dual-fuel engines – General: mixing air and fuel-gas – The amount of air – Air supply to the engine – Principle of turbocharging – Turbocharger manufacturers – Capacity curves – Description of three turbocharger manufacturers – development of modern turbochargers – Small turbochargers, engine categories I and II – Turbocharger with a separate power turbine – Power turbines with generator – Air supply in four-stroke engines – Air supply in two-stroke crosshead engines – Various approaches to turbocharging in two-stroke crosshead engines – Some important points of interest with regard to the air supply in diesel engines – Maintenance of turbochargers – Problems with turbocharging – Engine load – Flow performance of scavenging- and combustion-air in a four-stroke trunk-piston engine and a two-stroke crosshead engine **13 Cooling of gas-, dual-fuel- and diesel engines** Introduction – Cooling agents for gas-, dual-fuel- and diesel engines – Cooling-water treatment – Corrosion – Products for cooling-water treatment – Cooling-water treatment products, brands – Cleaning cooling-water systems contaminated with oil – Bacteriological contamination – Testing cooling water – Macro-biological growth in seawater-cooling systems – Design of cooling-water systems – Cooling-water system defects – Damaged engine parts – Standard cooling-water system – Cooling systems according to the engine classification – Examples of cooling methods for engine parts – Examples according to the engine classification – Combustion-air cooling – Special cooling systems – Pipe coolers and plate coolers – Cooling systems in a diesel-power plant – Cogeneration systems – Cooling systems for gas- and dual-fuel engines – Summary for cooling-water systems **14 Lubrication of engines** Introduction – The purpose of lubrication – Three types of lubrication – Engine parts that require lubrication and cooling – Common lubricating-oil system – Examples of lubricating-oil systems following the four classification categories – Lubricating-oil properties – Cleaning lubricating oil – Lubricating-oil analysis – Lubricating-oil analysis for gas-, dual-fuel- and diesel engines – Nitration of lubricating oil in gas engines – Examples of gas-engine lubricants – Examples of engine manufacturers' specifications for lubricating oil in gas- and dual-fuel engines **15 Starting systems for gas-, dual-fuel- and diesel engines** Introduction – Starting methods – Reversing the engine **16 Vibrations and balancing** Introduction – Methods to reduce torsional vibration using dampers – Main causes of vibration – Forces exerted on the driving gear and engine block – Resonance – Balancing diesel engines – Principle of an internal combustion engine – Crank- and connecting-rod mechanism – Forces in a two-stroke crosshead engine – Vibrational levels, acceptable values – Tangential-force diagram – Degree of cyclic irregularity – Vibrations in engine frame and propeller shaft – Axial vibrations – Engine balancing: theoretical background – Forces and moments – Resultant forces and moments in the engine block – External forces and moments – Example of the balancing used in a Wärtsilä 9L46 four-stroke engine, category III – Balancing V-engines – Balancing examples for two-stroke crosshead engines, category IV – Shaft generators in two-stroke crosshead engines – Vibration numbers and orders – Vibrational frequencies – Example 1: adjusting the engine speed because of damaged cylinder liners – Example 2a: simulation on six cylinders – Example 2b: simulation on five cylinders – Example 3: simulation of two engines and one propeller shaft – Examples of engine-frame tearing – Measurements for vibration dampers – Measuring equipment – Vibrational energy – Design of a propulsion installation – Effects of vibrational frequencies – Flywheel – Examples of crankshafts either with or without counterweights – Combustion forces exerted on the driving gear – Vibrations in gas- and dual-fuel engines **17 Engine noise: origin and damping** Introduction – Origin of noise in diesel engines – Sound transmission – Silencers for diesel engines – choosing a silencer – Noise reduction of diesel engines in categories I and II – Turbocharger noise – Sound levels in diesel engines – Examples of the engine arrangement with silencers – Power plants with gas- and dual-fuel engines **18 Gas- and dual-fuel engine manufacturers** Introduction – Classification in four categories – MTU Friedrichshafen GmbH, Germany – ABC, Ghent, Belgium – Caterpillar Global Petroleum, Houston, United States of America – Caterpillar Marine Power Systems, Hamburg, Germany – Daihatsu, Tokyo, Japan – GE Power & Water, Distributed Power, Atlanta, Georgia, United States of America – Hyundai Heavy Industries, Ulsan, South Korea – MAN Diesel & Turbo –



MAN Nutzfahrzeuge, Werk Nurnberg, Germany – Mitsubishi Heavy Industries, Tokyo, Japan – MWM, Mannheim, Germany – Niigata Power Systems, Tokyo, Japan – Perkins, Peterborough, United Kingdom – Rolls-Royce PowerSystems, London, United Kingdom – Rumo, Nizhny Novgorod, Russia – Scania, Södertälje, Sweden – Wärtsilä, Helsinki, Finland – Yanmar, Osaka, Japan – Dresser Rand, Houston, United States of America – Fairbanks Morse, Beloit, Wisconsin, United States of America – Guangzhou, China – Junan, Junan city, China – Lister-Petter, Dursley, England – Liebherr, Bulle, Switzerland – Cummins Westport, Vancouver, British Columbia, Canada – Cummins, Columbus, Indiana, United States of America – EMD-Electromotive Diesel, LaGrange, Illinois, United States of America

19 Emissions in gas-, dual-fuel- and diesel engines Emissions in gas- and dual-fuel engines – Introducing ‘the fossil fuel’ society – Exhaust-gas composition – Units of contamination – Methods for the reduction of noxious emissions in exhaust-gases – Primary methods – Secondary methods – Reduction of sulphur oxides in exhaust gases – Removal of fine particles from exhaust gases – Examples of the techniques that engine manufacturers apply to reduce emissions – Measures taken on-board large modern sea-going vessels – New techniques: the Miller process – New developments: the Hercules project – Noxious emissions in gas-and dual-fuel engines: nitrogen oxides, carbon monoxides and hydrocarbons – Development of gas-and dual-fuel engines – The composition of exhaust gases in gas- and dual-fuel engines – Greenhouse gases – Emission regulations for the international shipping industry established by the IMO – Exhaust-gas emissions in dual-fuel engines – An example of a Wärtsilä 50DF dual-fuel engine – Exhaust-gas purification for gas-, dual-fuel-, diesel- and heavy-fuel oil engines – Particulate matter – International Association of Ports and Harbours IAPH – The Baltic Dry Index – Ships either LNG fuelled or capable of running on LNG

20 Endoscopy and measurements Borescope: design and capabilities – Monitoring the state of repair of engine parts as part of a condition based maintenance – Examples of damage – Measurements: foil strain gauge with respect to piezo resistors – Preparing the engine for inspection using, for example, indicator cocks – Attaching and configuring the TDC-sensors for a four-stroke engine – Attaching and configuring the TDC-sensors for a two-stroke crosshead engine – Recording additional data during the measurement process on a performance sheet – Removing the sensors from a hot engine after the measurement process – Measurements with the IMES EPM-XP Visualization software – Measuring and fine-tuning with the DocSoft e-3 software – Different methods to achieve fuel savings – Measurements captured with the software *The Doctor* – The ISO correction according to ISO 3046-1: 2002 for shipping – Power indicator diagrams – Measuring the shaft power with strain gauges – The state of repair of gas- and dual-fuel engines: inspections with borescopes and electronic measurements – Measurement methods that can be used with the borescope – The use of borescopes in engines, turbochargers and gear boxes – False brinelling – Two-stroke Wärtsilä crosshead engines measurements – Example of an Engine Management System category III, MAN 51/60 DF – Measurements with electronic equipment, such as, *The doctor* and/or IMES and others – Balancing of no load engine at stationary speed (idle) – Crystals used for measurements – Examples of measurements – Organ pipe resonance effect or the source of the higher measured pressures than actual pressures in the engine cylinder – Specific features of measurements for gas- and dual-fuel engines

21 Cogeneration Introduction – Natural gas discoveries – Traditional generation using steam boilers and steam turbines – Contemporary generation of electricity with a combination of a steam- and gas turbine (STAG) – Generation of electricity with an internal combustion engine – Comparing separate and combined generation of heat and power – Reduced emissions with cogeneration – The speeds in gas- and dual-fuel engines – The uses of the thermal output by gas- and dual-fuel engines in cogeneration installations – Examples of cogeneration with gas engines – The ratio of the electrical power of a gas-engine generating set with respect to the available thermal output – Heat buffers and cogeneration – Assimilation – Tariffs for natural gas, electricity and heat – A few design factors involved in cogeneration with gas engines (power output of one gas engine between 10 and 20,000 kW) – The integration of a cogeneration system in installations – Continuation of examples of cogeneration – Summary of cogeneration with gas engines – Data for Wärtsilä 34 SG gas engines operating at full load

Book III: Operation and maintenance

22 Use of materials for gas-, dual-fuel- and diesel engines General use of materials – Cast iron – Steel – Cast steel – Forged steel – Steel alloys – Aluminium – Ceramic materials – Specific materials for engine parts: engine classification according to the four categories – Special finishes and heat treatments – Examples of modern material usage

23 Casting, forging and welding engine parts Introduction – Cast-iron parts for diesel engines – Advantages of cast engine-parts – Foundries – Casting process – Casting location – Moulds – Filling the casting dies – Mould assembly – Cleaning the castings – Casting stresses – Checking for air inclusions and damage – Dimensional checks – Operations at the machining factory – Forging crankshafts – Forging gear parts for two-stroke crosshead engines – Building a two-stroke crosshead engine A-frame – Forging crankshafts, 2009 report – Manufacturing pistons – Manufacture of inlet and outlet valves – Manufacturing cylinder liners

24 Reconditioning engines and their parts Introduction – Four-stroke engines – Two-stroke engines – Reconditioning gas- and dual-fuel engines – The Swedish Club: Main Engine Damage

25 Maintenance and repairs Introduction – Types of maintenance – Instruction manuals/ Maintenance manuals – Engine maintenance – Maintenance for small engines, category I – Examples of maintenance for engines, category III – Some examples of maintenance for large two-stroke crosshead engines, category IV – Excessive wear or ‘scuffing’ of the cylinder liners in a two-stroke crosshead engine – Trouble shooting excessive cylinder liner wear – Damage report Wärtsilä Vasa 4R32 – Sleeve bearings, theory and damage – Special maintenance for gas- and dual-fuel engines

26 Calculating fuel- and lubricating-oil consumption Introduction – Diesel-engine efficiency – Shaft power in kW or MW – Specific fuel consumption – Fuel consumption – Fuel consumption for engines in diesel power-plants – Fuel consumption for propulsion diesel engines – Fuel consumption for gas- and dual-fuel engines – Lubricating-oil consumption and specific lubricating-oil consumption – Measuring fuel consumption – Fuel consumption measured in trials – Oil-price development – Sailing at reduced engine power or ‘slow steaming’ – VAF Instruments T-Sense® torque and power measurement of the propeller shaft

27 Operational management and automation Introduction – Example I: Wärtsilä 34 DF, four-stroke, category III – Example II: MAN 51-60 DF IMO Tier II, four-stroke, category III – Example III: Rolls-Royce gas engine, four-stroke engine, category III – Example IV: Sandfirden SGI 16 Marine generator sets, four-stroke engine, category II – Example V: Man B&W ME GI, two-stroke crosshead engine, category IV

28 Transmission gears, flexible couplings, vibration dampers, shafting and shaft generator drives Introduction – Diesel-engine arrangements – Gear transmission – Constructions and designs of gear transmissions – Position of the input- and output shaft – Types of teeth – Gear transmission for shaft generators – Couplings – Torsional-vibration dampers – Engine shafts – Examples of complete systems with diesel engines, reduction gearing, shafting, couplings and vibration dampers – Vibration dampers below the engine block or frame – Examples of engine arrangements with flexible vibration dampers – Flexible connections to the diesel engine – Double-spring alignment: a new design

29 Bedplates and engine alignments, gearboxes, shafts, propeller shafts and generators Introduction – Ship propulsion – Construction of the bedplate, engine category IV – Examples of rigid mounting, engine category III – Flexible mounting of propulsion engines; engine categories I, II and III – Engine alignment – Flexible arrangement of diesel engines and the piping, wiring and other equipment attached to the engine – Mounting methods for propulsion engines and other components with critical alignments

30 Regulations for propulsion engines, classification, repair and damage Introduction – The IMO: International Maritime Organization – Classification societies – Periodic inspection of the diesel engine and its parts – Examples: Germanischer Lloyd – Materials for diesel engines – Tests and trials – Testing mass-produced engines – Shipboard trials – Some important points – Regulations for propulsion engines – Engine alignment – The standard measurements and calculations to determine the crankshaft deflection measurement (r_c) for four different types of crankshafts – Procedure for reconditioning parts – New parts – Special cases of wear and damage to engine parts – Damages to the engine or engine parts – Damage – Examples of certificates – Interim guidelines on safety for natural gas-fuelled engine installations in ships

31 Ship propulsion Introduction – Ship types and hull resistance – Load lines of a ship – Ship dimensions – Hull shape – Ship’s resistance R – Screw propulsion – Propeller types – Flow conditions around the propeller – Propeller dimensions – Operating conditions of a propeller – Increasing ship speed – Parameters causing heavy running conditions – Manoeuvring speeds – Direction of propeller rotation: lateral forces – Engine layouts and load diagrams – Propulsion- and engine characteristics – Electronic governors with load limitation – Use of diagrams – Summarising the effects of the various types of resistance on engine operation – Comments – Future improvements in propulsion efficiency and reduction of CO₂ – March 2016 – Some distinctive issues – Slow steaming of merchant ships – Ship propulsion with gas-and dual-fuel engines





The author

Kees Kuiken started his career in 1963 by enrolling as a marine engineering student at the Maritime Institute at Terschelling, The Netherlands.

After graduation, he joined the United Dutch Shipping Company (Verenigde Nederlandse Scheepvaartmaatschappij, VNS).

In 1978, he went on to become a lecturer in marine engineering at the Maritime Academy at Delfzijl and Groningen, and also worked in the mechanical engineering- and operational technology departments. He was passionate about building a large and advanced practical lab for both intermediate and higher maritime education, as well as for trade and industry.

In 1995 he founded the European Training Centre for engine technology, the ETM, an educational foundation.

In 2000, he left regular teaching and established Target Global Energy Training.

The company conducts training sessions worldwide in diesel- and gas engine technologies, gas- and steam turbines, compressors and cogeneration.

Furthermore, Target provides solutions for a myriad of technical problems and publishes books and manuals.

All the training programs are tailor-made and given on location.

In 2012 the second edition of the diesel engine book came onto the market and in 2016 this new book *Gas-and dual-fuel engines for ship propulsion, power plants and cogeneration*.



This book can be ordered directly from
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