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FARM (gas-fired) ENGINES AND BIOGAS

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Abstract: *The biogas technology has been steadily developed within the last fifty years from small individually designed units to industrial plants with sophisticated boundary technology. The development, however, has largely taken place on the side of biogas production and anaerobic waste treatment. The utilization of the gas has only recently been given more attention as larger and more sophisticated biogas systems require or depend on a sensible utilization of the larger gas quantities. Transforming the energy from biogas into the thermodynamically higher valued mechanical energy marks one of the sensible options wherever appropriate.*
Key words**:** *methane, etanol,engines,otto,diesel,combustion.*

INTRODUCTION

In this chapter we shall discuss the importance of recent developments in agriculture upon the world's energy resources and the impact on the world population and environment. We shall focus mainly on agriculture producing fuel as this is currently controversial. We will briefly discuss the historic link between agriculture and petroleum then we will explore aspects of methane, biodiesel and ethanol production, before a brief summary on the strategic importance of a strong agricultural sector

EFFECT AND DISSCUTION

Since the 1940's agriculture has dramatically increased its productivity. This is due in part to the use of petrochemical derived pesticides and fertilizers and increased mechanization. The vast majority of energy used to produce food in addition to sunlight comes from fossil fuel sources. Because of modern agriculture's heavy reliance on petrochemicals there are signs that decreases in oil supply will inflict damage on the world's modern agricultural system and cause long term food shortages. Oil shortages mean that organic agriculture and sustainable farming are now of more importance than ever. However, the current controversy is due to the fact that farmers have increasingly been raising crops such as corn for non-food use in an effort to help mitigate peak oil. This is turn has contributed to a 60% rise in wheat prices recently and may cause serious social unrest. Increased interest in food commodities from the world's financial markets has also increased the cost of food worldwide. Let us look at several main areas of agricultural fuel production.

METHANE

Methane is the principal component of natural gas.The relative abundance of methane and its clean burning process makes it a very attractive fuel.Methane is usually now transported in its natural gasform by pipeline or LNG carriers. Methane is very important for electrical generation when burned as a fuel in a gas turbine or steam boiler. Compared to other hydrocarbon fuels burning methane produces less carbon dioxide for each unit of heat released. Methane inthe form of compressed natural gas can also be used in vehicles and NASA is looking to methane's potential as rocket fuel as it is abundant in many parts of the solar system. In addition methane has industrial uses, especially in industrial chemical processes and may betransported as refrigerated LNG.The link between agriculture and methane occurs because apart from gas fields, an alternative method of obtaining methane is via biogas generated by the fermentation of organic matter, including manure, wastewater sludge, municipal solid waste or any other biodegradable feedstock under anaerobic conditions.As an aside methane hydrates, which are basically icelike combinations of methane and water on the sea floor, are also a potential future source of methane. Cattle belch methane accounts for 16% of the world's annual methane emissions and the livestock sector in general is responsible for 37% of all human influenced methane production. In fact let’s take a look at some of the statistics on anthropogenic methane. This accounts in total for approximately 55% of all methane emissions. Of this 18% is due to our energy use, 7% due to landfills, 19% due to livestock, 4% waste treatment, and 7% biomass burning.We can thus see the links between agriculture and methane production but of course so far very little of this is harnessed for fuel.

ETHANOL

The fermentation of sugar into ethanol is one of the earliest organic reactions known to humanity. Ethanol is also produced from by-products of petroleum refining but here we are concerned at the links between agriculture and fuel production. The largest single use of ethanol is as a motor fuel and fuel additive. The largest national fuel ethanol industries exist in Brazil.

Thanks to advances in engine design today almost half of Brazilian cars are able to use 100% ethanol as fuel via ethanol only engines and flex-fuel engines. In the US flex-fuel engines can run on 0% to 85% ethanol since higher ethanol blends are not allowed. Brazil produces ethanol from domestically grown sugar cane which has a greater concentration of sucrose than corn but is also easier to extract. In addition the bagasse generated by the process is not wasted but is used in power plants to produce electricity In 2007 the UN's expert on the right to food called for a 5 year moratorium on biofuel production from food crops to prevent a catastrophe for the poor as food prices escalate. The effects of increasing food prices due to the ripple effect of a rise in corn prices have been felt worldwide. However, it is not all doom and gloom because as we said earlier the case for ethanol from sugar cane has been made so agriculture has a huge contribution to make to fuel production in an efficient manner in fact if we move away from corn.

The combustion of a fuel in a mixture with air (or actually oxygen O_2) is an exothermal process in which the chemically bound energy of the fuel is released to generate heat energy while the chemical binding is changed and the combustion product remains at a lower level of energy. For the components of hydrocarbons (i.e. carbon C and hydrogen H) such as petrol, diesel fuel, methane, natural gas, etc. the combustion equations are given in the above table.

Compounds taking part in combustion		**Combustion product**	**Heat energy released**
Carbon:	$C + O_2$	CO_2	+406.9 kJ/kmol
	$C + O$	CO	+123.8 kJ/kmol
Hydrogen:	$H_2 + ½ O_2$	H_2O	+242kJ/kmol

For complete combustion a certain relation between the amount of fuel and of oxygen or air is required, the "stoichiometric ratio". Should the air/fuel ratio in a mixture be different from the stoichiometric ratio the combustion will be either incomplete at air shortage, or unutilized "excess air" will be present in the process. A very helpful parameter to describe an actually given air/fuel ratio is the "excess air ratio" λ:

$$\lambda = \frac{\text{actual amount of air}}{\text{air necessary for stoichiometric combustion}}$$

λ♣♣ = 1 stoichiometric air/fuel ratio

λ♣♣ > 1 air excess (mixture lean)

λ♣♣ < 1 air shortage (mixture rich)

The best combustion performance will always occur at values near λ = 1. Mixtures at values below λ = 0.5 rich or above λ = 1.5 lean usually do not properly ignite from an ignition spark. The supply of the right mixture of air and fuel is therefore of utmost importance for the performance of a spark ignition (Otto) engine. Diesel engines can however operate at high excess air ratios (λ = 1.5 . . . 4.0) as the fuel is injected into the combustion chamber in a liquid form and the combustion takes place around the circumference of the fuel spray droplets. The droplets evaporate and mix with the surrounding air. At a certain distance from the core a stoichiometric mixture will automatically be established. This is where the combustion takes place. In a still or laminar flowing gaseous air/fuel mixture the burning velocity has a maximum at λ = 0.9 but decreases when the mixture is richer or leaner.In principle all internal combustion engines can be operated with liquid fuels (which are in vapor/gaseous form when they ignite) or with gaseous fuels. The given framework of this publication however calls for the narrowing of the scope of engines towards types that can be modified and operated with acceptable efforts:

PPower range to abt. 50 kW;

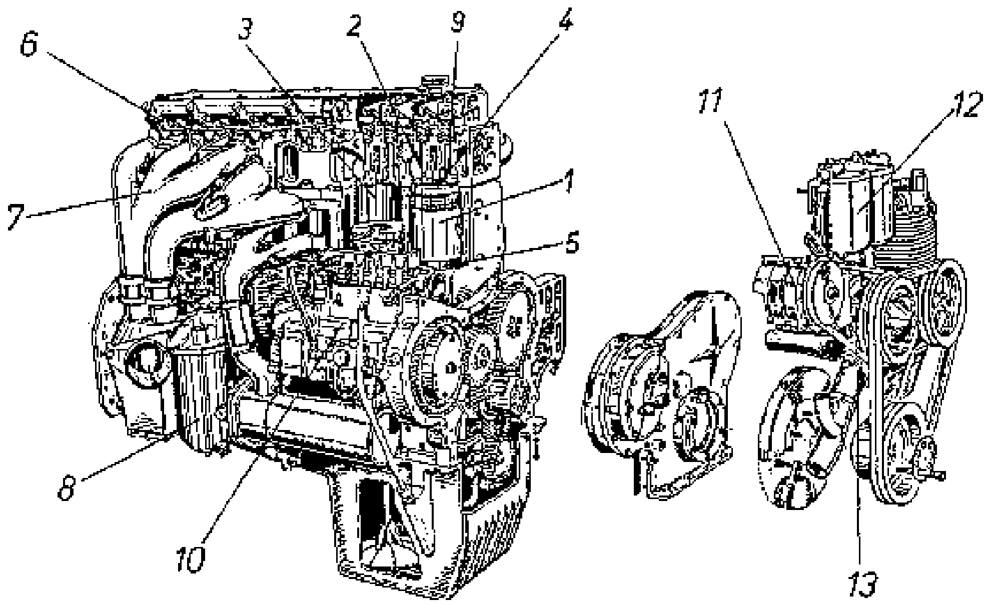
- Engines considered should be based on standard engine types produced in larger series;
- 2-stroke engines, as the smaller types do not nave a very good reputation for long engine life and often use lubrication in a mixture with the liquid fuel. This excludes the use of a gaseous fuel.

No gas turbines as they are comparatively expensive and require sensitive operation and maintenance;

- No rotary piston (Wankel) engines because of generally bad reputation for reliability and engine life;
- No turbocharged engines because of their relatively sophisticated control systems.

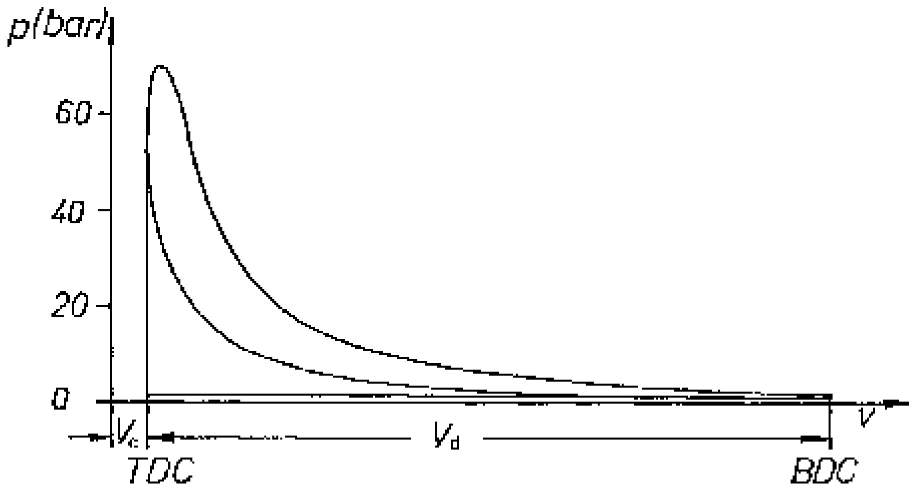
The engine types to be considered here are therefore:

- Otto (gasoline) engines, 4-stroke; - diesel engines, 4-stroke.



1 piston, 2 inlet valve, 3 cylinder, 4 combustion chamber, 5 connection rod, 6 injector nozzle, 7 suction mainfold, 8 oil filter, 9 outlet valve, 10 injector pump, 11 alternator,12 fuel filter, 13 cooling water pump.

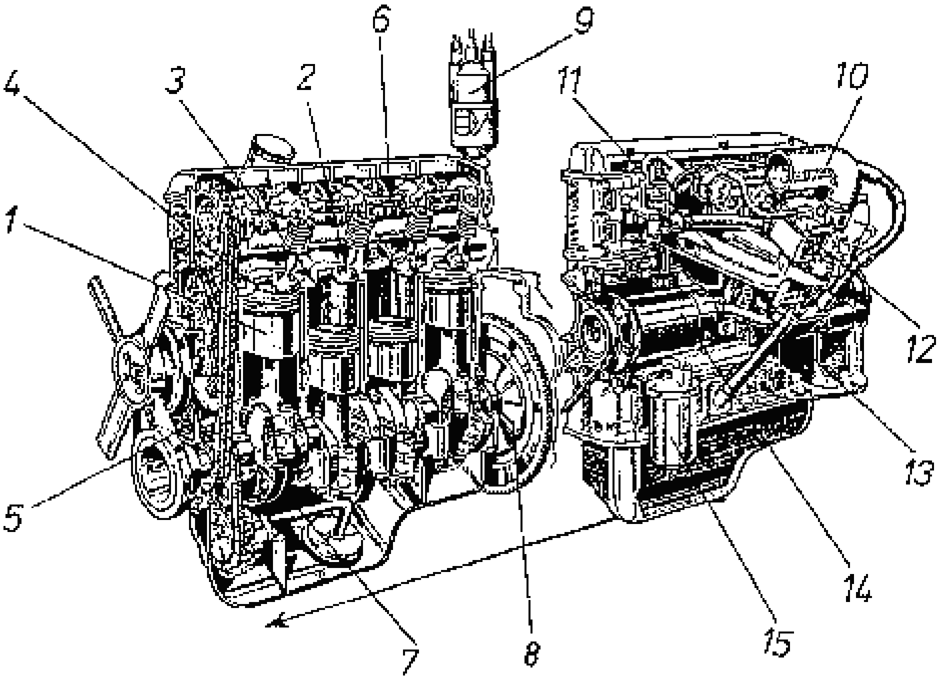
The diesel engine and its process are shown in the diagrams Figs. 3.7 and 3.8. The engine sucks air at ambient conditions and compresses it to a pressure around 60 bar and above whereby the air reaches temperatures around 600°C. Shortly before the piston reaches TDC, fuel is injected and ignites immediately at these conditions. An external source for ignition is usually not necessary. Only at low ambient temperatures a"glow plug" is sometimes used to facilitate the start-up. The point or crank angle £i of injection is chosen (£i about 25°) considering that the pressure rise through combustion reaches a peak shortly after the piston has passed TDC.



Simplified p, v-diagram of a diesel process

The Otto engine sucks a readily composed mixture of air and fuel.

The mixture is compressed to pressures around 20 bar and temperatures around 400 °C (see Equ. 3.7). At these conditions the mixture cannot selfignite. A spark plug is used to ignite the mixture at a suitable moment or crank angle before TDC for optimum performance



1 piston, 2 inlet valve, 3 cylinder, 4 combustion chamber, 5 connection, 6 overhead camshaft, 7 crankshaft bearing, 8 flywheel, 9 distributor, 10 suction from air filter, 11 suction mainfold, 12 carburetor, 13 starter motor, 14 generator, 15 oil filter

PROPERTY	**PETROL**	**DIESEL**	**METHANOL**	**ETHANOL**
Formula	C_4 - C_{12} Hydrocarbons	C_{12} -C_{19} Hydrocarbons	CH_3OH	C_2H_5OH
Composition (wgt %) **Carbon** **Hydrogen** **Oxygen**	 85 - 88 12 - 15 negl.	 85 - 88 12 - 15 negl.	 37.5 12.5 50.0	 52.2 13.1 34.7
Stoichiometric Air/Fuel Ratio	14.5 to 1	14.5 to 1	6.5 to 1	9 to 1
Heat of combustion (Btu/lb)	18,900	18,500	8,570	11,500
Heating Value (MJ/L)	31.9	35.6	15.8	21.2
Boiling Temp. (^oC)	27 - 225	185 - 380	65	78
Research Octane Number (RON)	91 - 97	not appl.	106 - 115	105 - 121*
Motor Octane Number (MON)	82 - 88	not appl.	82 - 92	90 - 95*
Cetane Number	not appl	45 - 55	not appl	not appl

CONCLUSION

1. Methane, which is the main component of natural and biogases, is known to be a very strong greenhouse gas with long lasting effect in the atmosphere that contributes actively to global warming. Releases of the gas commonly described as "Fugitive Gas Emissions" are an important source of methane emissions.

2. A possible approach to reduce the harmful effects of such methane emissions is to introduce the fugitive methane into a device that can convert it through combustion to less environmentally harmful products. It has been shown that the bulk of such methane can be converted into much weaker green house gases in an IDI diesel engine. However, such applications can bring about changes to engine combustion processes and the resulting performance.

3. The present contribution reports the results of an investigation of the effect on combustion characteristics, emissions and performance of introducing very small concentrations of methane into the intake of an operating diesel engine. It is shown that for wide ranges of gas admission concentrations in the air, unlike with other conventional combustion devices such as burners and furnaces, much of the methane added was indeed oxidized in the IDI diesel engine and increased the power output and thus saving some diesel fuel.

4. Such methane admissions tended to increase carbon monoxide emissions, indicating that part of the methane may not have been fully oxidized. NOx emission increased slightly, but when compared to the diesel operation for the same fuel energy input, it represented a reduction. Consuming a small amount of fugitive methane in the engine could bring about reductions to the global warming effect well in excess of that due to the entire engine exhaust gases resulting from diesel fuel combustion.

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ДВИГАТЕЛИ НА ГОРИВЕН ГАЗ И БИОГАЗ

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Ключови думи: *метан, етанол, двигатели, дизел, горене*
Анотация*: Технологията за биогаз се разработва упорито през последните петдесет години от малките индивидуално проектирани агрегати и индустриалното производство със сложна гранична технология. Значителна част от разработките обаче са свързани с производството на биогаз и анаеробна обработка на отпадъците. Използването на газ съвсем наскоро попадна в центъра на вниманието, тъй като по-големите и усложнени системи, работещи на биогаз изискват или зависят от разумното използване на по-значителни количества газ. Преобразуването на получената от биогаз енергия в по-ценната от термодинамична гледна точка механична енергия е една от разумните възможности, там, където е подходящо.*