MAK 3031- İçten Yanmalı Motorlar

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MAK 3031- Internal Combustion Engines

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Combustion reactions

$$C + O_2 \rightarrow CO_2 + Q(Heat)$$

12kg C+32 $kg\ O_2 \rightarrow 44\ kg\ CO_2 + Q(Heat)$

$$1\ kg\ C + \frac{32}{12} kg\ O_2 \rightarrow \frac{44}{12} kg\ CO_2 + Q(Heat)$$

1 kmole C+1 kmole $O_2 \rightarrow$ 1 kmole $CO_2 + Q(Heat)$

$$1\ kg\ C + \frac{1}{12} kmole\ O_2 \rightarrow \frac{1}{12} kmole\ CO_2 + Q(Heat)$$

Combustion reactions

$$2H_2 + O_2 \rightarrow 2H_2O + Q(Heat)$$

$$4\ kg\ H_2 + 32\ kg\ O_2 \rightarrow 36\ kg\ H_2O + Q(Heat)$$

$$1\ kg\ H_2 + 8\ kg\ O_2 \rightarrow 9\ kg\ H_2O + Q(Heat)$$

$$1\ kg\ H_2 + \frac{1}{4}\ kmole\ O_2 \rightarrow \frac{1}{2}\ kmole\ H_2O + Q(Heat)$$

$$2H_2 + O_2 \rightarrow 2H_2O + Q(Heat)$$

$$1\ kmole\ H_2 + \frac{1}{2}\ kmole\ O_2 \rightarrow 1\ kmole\ H_2O + Q(Heat)$$

Combustion reactions

$$S + O_2 \rightarrow SO_2 + Q(Heat)$$

$$32\ kg\ S + 32\ kg\ O_2 \rightarrow 64\ kg\ SO_2 + Q(Heat)$$

$$1\ kg\ S + 1\ kg\ O_2 \rightarrow 2\ kg\ SO_2 + Q(Heat)$$

$$S + O_2 \rightarrow SO_2 + Q(Heat)$$

$$1\ kmole\ S + 1\ kmole\ O_2 \rightarrow 1\ kmole\ SO_2 + Q(Heat)$$

$$1\ kg\ S + \frac{1}{32}\ kmole\ O_2 \rightarrow \frac{1}{32}\ kmole\ SO_2 + Q(Heat)$$

Combustion reactions

$It\ can\ easily\ be\ seen\ that\ we\ need$

$$\frac{1}{12}\ kmole\ of\ O_2 for\ 1\ kg\ of\ C$$

$$\frac{1}{4}\ kmole\ of\ O_2 for\ 1\ kg\ of\ H_2$$

$$\frac{1}{32}\ kmole\ of\ O_2 for\ 1\ kg\ of\ S$$

$for\ complete\ combustion$

Combustion reactions

C % (Ratio of carbon) is designated as c or $\bar{C}$

H % (*Ratio of hydrogen*) is designated as h or $\overline{H}$

S % (Ratio of sulphur) is designated as s or $\bar{S}$

O_y % (Percentage of Oxygen content in fuel) is designated as o_y or $\overline{O_y}$

Combustion reactions

$$O_{\min} = \frac{1}{12}.c + \frac{1}{4}.h + \frac{1}{32}.s - \frac{1}{32}.O_y$$ [kmole O_2 per kgfuel]

$$O_{\min} = \left[\frac{1}{12}.c + \frac{1}{4}.h + \frac{1}{32}.s - \frac{1}{32}.O_y\right].32$$

[kg O_2 per kgfuel]

Combustion reactions

@0 degree Celcius and 760 mm Hg (Mercury column) pressure a kmole of an ideal gas has 22.4 Nm^3 volume

@15 degree Celcius and 760 mm Hg (Mercury column) pressure a kmole of an ideal gas has 24 Nm^3 volume

Combustion reactions

$$O_{min} = 0.232 * L_{min}$$ [kg O_2/kg fuel]

$$L_{min} = \frac{O_{min}}{0.232}$$ [kg air / kg fuel]

Combustion reactions

Lmin can be defined as the amount of air needed for complete combustion of a given fuel.

Lreal is the actual air reacted in a combustion system.

Lreal<Lmin charge/air-fuel mixture ise **RICH**.
Lreal=Lmin charge/air-fuel mixture ise chemically ideal or so called **STOICHIOMETRIC**.

Lreal>Lmin charge/air-fuel mixture ise **LEAN**

$$\lambda = \frac{Lreal}{Lmin}$$

Combustion reactions

Excessive rich<<<<<0,4 <=λ<=1,4<<<<< Exc. lean

Combustion reactions

Complete Comb.

$$C + O_2 \rightarrow CO_2$$
$$H_2 + 1/2O_2 \rightarrow H_2O$$
$$S + O_2 \rightarrow SO_2$$

Incomplete combustion

$$2C + O_2 \rightarrow 2CO$$

Combustion reactions

$$2C + O_2 \rightarrow 2CO$$

$$24\ kg\ C + 32\ kg\ O_2 \rightarrow 56\ kg\ CO$$

$$1\ kg\ C + \frac{32}{24} kg\ O_2 \rightarrow \frac{56}{24}\ kg\ CO$$

$$1\ kg\ C + \frac{4}{3} kg\ O_2 \rightarrow \frac{7}{3}\ kg\ CO$$

$$1\ kg\ C + \frac{1}{24}\ kmole\ O_2 \rightarrow \frac{1}{12}\ kg\ CO$$

Combustion reactions

Incomplete fraction of a combustion reaction is calculated by measuring the amount of CO exhausted. Which can be formulated as the CO mole fraction as x while CO_2 fraction can then be (1-x).

CO $$1\,kg\,C \rightarrow \frac{4}{3}\,kg\,O_2 \qquad cx \rightarrow cx * \frac{4}{3}\,kg\,O_2$$

CO_2 $$1\,kg\,C \rightarrow \frac{8}{3}\,kg\,O_2 \qquad c(1-x) \rightarrow c(1-x) * \frac{8}{3}\,kg\,O_2$$

$$O_{min} = \frac{8}{3}\bar{C}(1-x) + \frac{4}{3}\bar{C}x + 8\bar{H} + \bar{S}$$

Combustion reactions

$$O_{\ddot{o}n} = \lambda . O_{\min} + O_y = \lambda(\frac{8}{3}.c + 8h - O_y) + O_y$$

$$\lambda(\frac{8}{3}.c + 8h - O_y) + O_y = \frac{8}{3}.c(1 - x) + \frac{4}{3}c.x + 8h$$

Combustion reactions

$$x = \frac{3}{4c}(1-\lambda).O_{\min} \quad O_{min}=0,232.L_{min}$$

$$x = \frac{3}{4c}(1-\lambda).0,232.L_{\min}$$

$$\lambda_{kr} = 1 - \frac{4c}{3.0,232.L_{\min}}$$