AUM
جامعة الشرق الأوسط الأمريكية
American University Of The Middle East

In Affiliation With
PURDUE
UNIVERSITY

Summer
2021

EliteClass

luc 10

مذكرة م. علي عبدال

لـ مادة

THERMODYNAMICS

Solving OCA3

Suction 02

عزيز الطالب: الخدمة خاصة لجميع الطلبة المشتركين (المسجلين كورس والملتحقين)
كما كل ما يقدم لك من مذكرات وشرح وحلول هو خاص وحصري وسري لك شخصيا.
لذى يرجى عدم نشره (أي غير قابل للنشر)
ولمزيد من التميز والتفوق باذن الله.

للاشتراك

Engmech4

Eng. Ali Abdal
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Thermodynamics I ME 200	–	Basic Mechanic I ME 270	–	AC	–	Thermal and Energy science CVL 299
Thermodynamics II ME 300	–	Fluid Mechanic ME 309	–	Heat Transfer		

Question [1]

An air-standard dual cycle has a compression ratio of 16. At the beginning of compression, $P_1 = 100$ kPa, $V_1 = 15$ liters, and $T_1 = 15$°C.
The pressure doubles during the constant-volume heat addition process.
For a maximum cycle temperature of 1760 K, determine

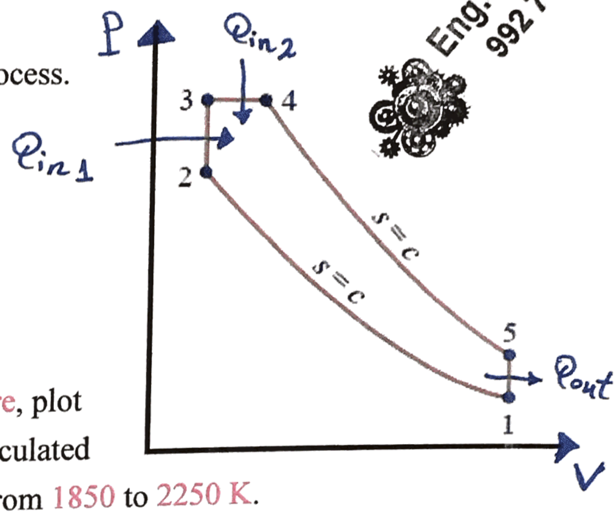
a) the heat addition to the cycle, in kJ.

b) the net work of the cycle, in kJ.

c) the thermal efficiency.

d) the mean effective pressure, in kPa

e) To investigate the effects of varying maximum cycle temperature, plot (using Excel or any convenient software) each of the quantities calculated in parts (a) through (d) for maximum cycle temperatures ranging from 1850 to 2250 K.



P (kPa)	T (K)	V (m³)
$P_1 = 100$	$T_1 = 288$	$V_1 = 0.015$ m³
	$T_4 = 1760$	

First, let's get m & All T's

$P_1 V_1 = m R T_1 \longrightarrow m = 0.0181$ Kg

$T_2 = T_1 r^{k-1} \longrightarrow T_2 = 873.1$ K

$r = V_1 / V_2 \longrightarrow V_2 = 9.375 \times 10^{-4}$ m³

$P_2 V_2 = m R T_2 \longrightarrow P_2 = 4837.86$ Kpa

$P_3 = P_4 = 2 P_2 = 9675.72$ Kpa

$P_3 V_3 = m R T_3 \longrightarrow T_3 = 1746.2$ K

$P_4 V_4 = m R T_4 \longrightarrow V_4 = 9.449 \times 10^{-4}$ m³

$r_c = V_4 / V_3 \longrightarrow r_c = 1.008$

$T_5 = T_4 [r_c / r]^{k-1} \longrightarrow T_5 = 582.4$ K

a) $Q_{in} = Q_{in_1} + Q_{in_2}$

$Q_{in} = m c_v [T_3 - T_2] + m c_p [T_4 - T_3]$

$\rightarrow \boxed{Q_{in} = 11.598 \text{ KJ}}$

$Q_{out} = m c_v [T_5 - T_1]$

$Q_{out} = 3.826$ KJ

b) $W_{net} = Q_{in} - Q_{out}$

$\boxed{W_{net} = 7.772 \text{ KJ}}$

c) $\eta_{th} = \dfrac{W_{net}}{Q_{in}}$

$\boxed{\eta_{th} = 0.67 = 67\%}$

d) $MEP = \dfrac{W_{net}}{V_1 - V_2}$

$MEP = 552.68$ KPa

e)

Tmax   heat addition   network   thermal efficiency   Mean effective pressure

1..10	T_4 [K]	Q_{in} [KJ]	W_{net} [KJ]	η_{th}	MEP [Kpa]
Run 1	1850	13.27	8.885	0.6696	631.9
Run 2	1894	14.08	9.421	0.6691	669.9
Run 3	1939	14.89	9.954	0.6684	707.8
Run 4	1983	15.7	10.48	0.6677	745.6
Run 5	2028	16.51	11.01	0.6669	783.1
Run 6	2072	17.32	11.54	0.666	820.5
Run 7	2117	18.13	12.06	0.6651	857.7
Run 8	2161	18.94	12.58	0.6641	894.7
Run 9	2206	19.76	13.1	0.6631	931.5
Run 10	2250	20.57	13.62	0.662	968.2

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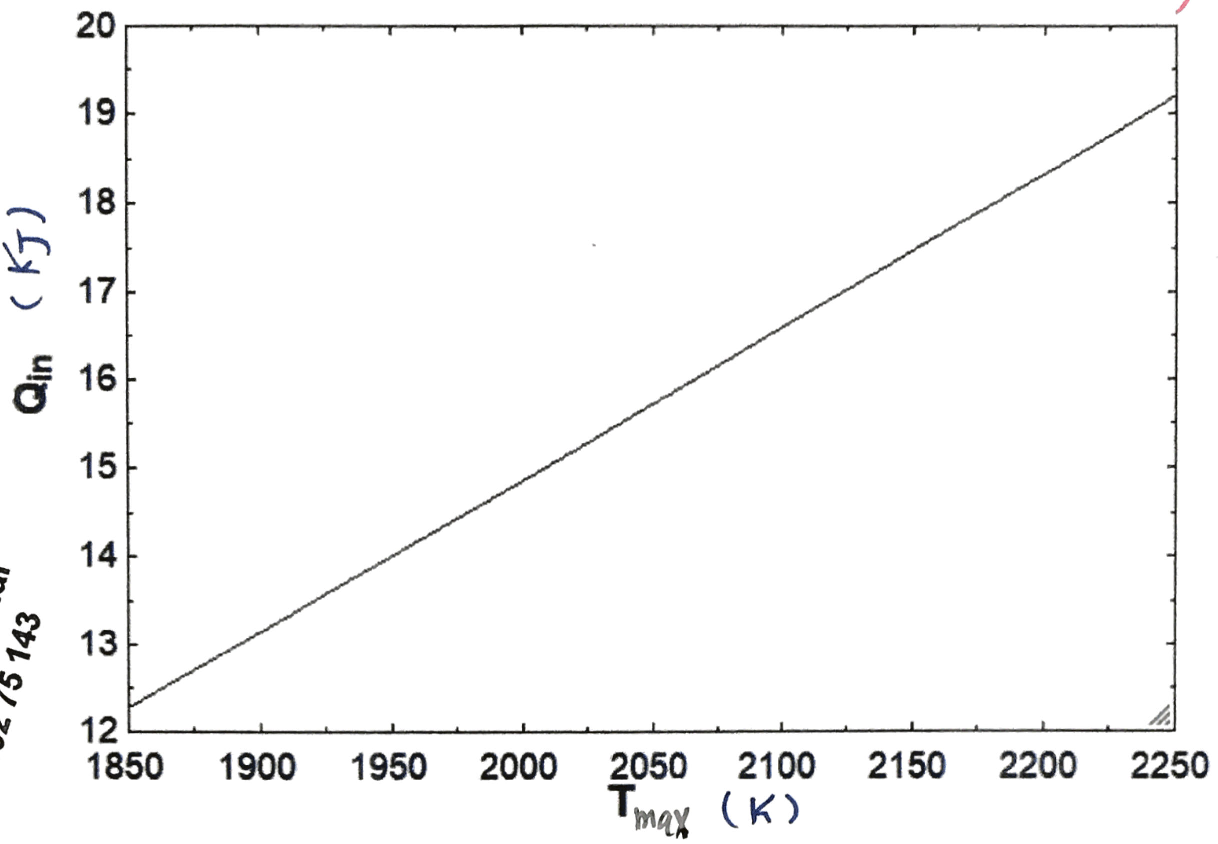
- بجربيه ترسم excell

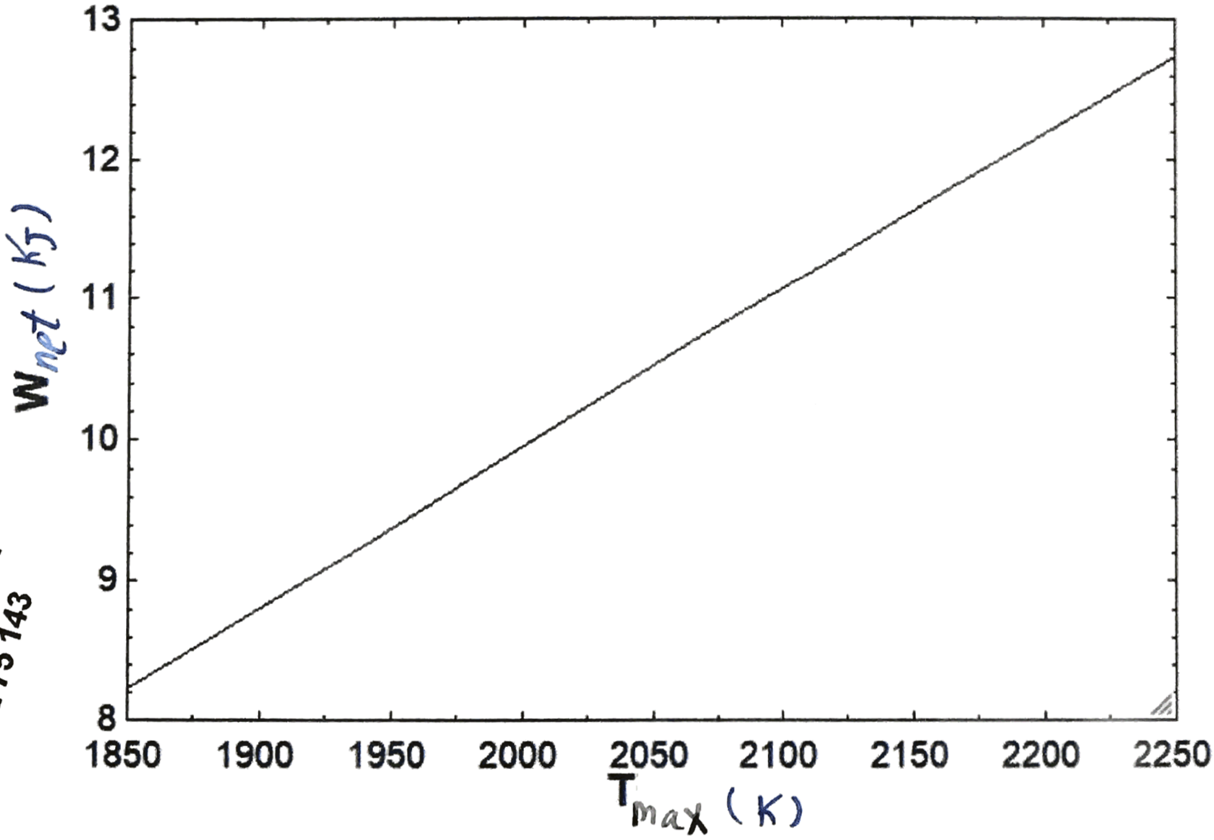
أو أي برنامج ثاني

[٤ رسمات]

heat addition Qin Versus maximum Temperature



net work versus maximum Temperature



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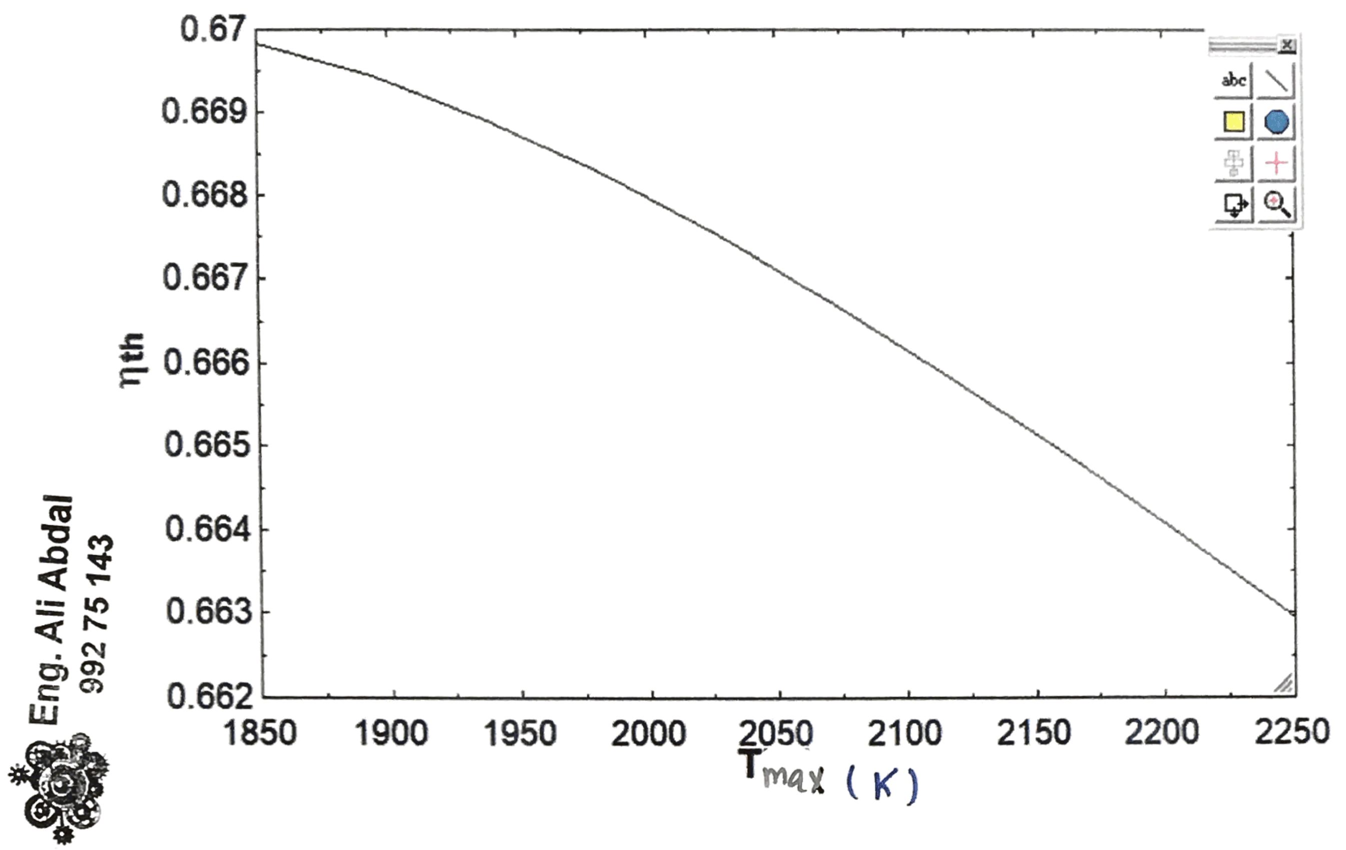
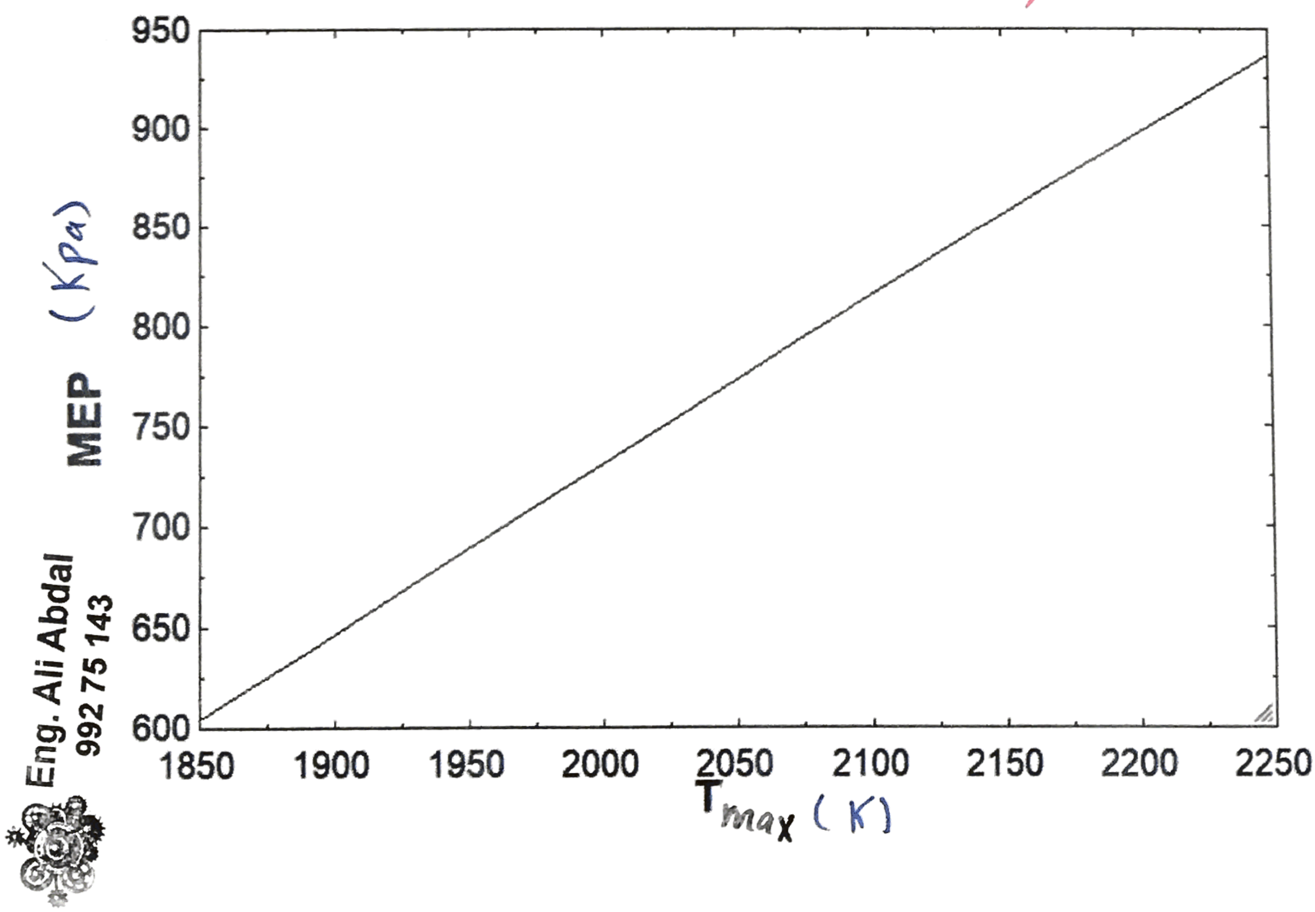
thermal efficiency Versus maximum Temperature



Mean effective Pressure Versus maximum Temperature



$N_c = 4$ 2 rev Question [2] $\dot{n} = 2400/60 = 40$ rps

A four-cylinder, four-stroke internal combustion engine operates at 2400 rpm. The processes within each cylinder are modeled as an air-standard Otto cycle with a pressure of 100 kPa, a temperature of 25°C, and a volume of 0.4 liters at the beginning of compression.

The compression ratio is 10, and maximum pressure in the cycle is 6000 Kpa.

Determine, using a cold air-standard analysis with k = 1.4

a) the power developed by the engine, in horsepower.

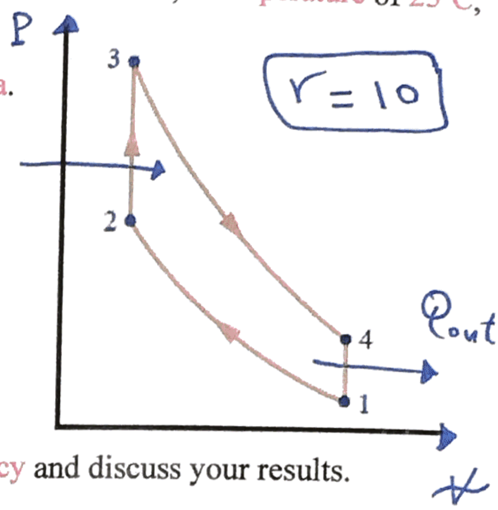
b) the mean effective pressure, in kPa;

c) the thermal efficiency of the engine.

d) Calculate the theoretical limit of the engine efficiency and discuss two methods to increase this efficiency.

e) If the compression ratio increases to 12, calculate the new thermal efficiency and discuss your results.

f) Explain why the compression ratio should be limited between 8 and 11 for Otto cycle.



P [kPa]	T [k]	V [m³]
$P_1 = 100$	$T_1 = 298$ K	$V_1 = 4 \times 10^{-4}$
$P_3 = 6000$		

First, let's get m & All T.

$P_1 V_1 = m R T_1 \longrightarrow m = 4.677 \times 10^{-4}$ ~~Kg/s~~

$T_2 = T_1 r^{K-1} \longrightarrow T_2 = 748.5$ K

$r = \dfrac{V_1}{V_2} \longrightarrow V_2 = 4 \times 10^{-5}$ m^3

$P_3 V_3 = m R T_3 \longrightarrow T_3 = 1788$ K

$T_4 = T_3 \times \left[\dfrac{1}{r}\right]^{K-1} \longrightarrow T_4 = 711.8$ K

So, $Q_{in} = m\, c_v \left[T_3 - T_2\right]$

$Q_{in} = 0.349$ KJ

$Q_{out} = m\, c_v \left[T_4 - T_1\right]$

$\longrightarrow Q_{out} = 0.139$ KJ

$W_{net} = Q_{in} - Q_{out}$

$W_{net} = 0.21$ KJ

$\dot{W}_{net} = N_c \times \dot{n} \times W_{net}$

2 ← 4 stroke

$\dot{W}_{net} = 16.80$ KW

×1.34

$\boxed{\dot{W}_{net} = 22.512 \text{ HP}}$

$MEP = \dfrac{W_{net}}{V_1 - V_2}$

$\boxed{MEP = 583.33 \text{ Kpa}}$

$\eta_{th} = \dfrac{W_{net}}{Q_{in}}$

$\boxed{\eta_{th} = 0.602 = 60.2\%}$

(d) $T_{min} = 298\ K$, $T_{max} = T_3 = 1788\ K$

$$\eta_{carnot} = \frac{T_{max} - T_{min}}{T_{max}} = 0.8333 = 83.33\%$$

1) increase $T_{max} \longrightarrow \eta_{carnot}$ increase.
2) increase r_p [pressure ratio] $\longrightarrow \eta_{carnot}$ increase

(e) if $r = 12$,

$T_2 = T_1\, r^{K-1} = 805.2\ K$, $r = \frac{V_2}{V_1} \longrightarrow V_2 = 3.333 \times 10^{-5}\ m^3$

$P_3 V_3 = m R T_3 \longrightarrow T_3 = 1489.8\ K$

$T_4 = T_3 \times \left[\frac{1}{r}\right]^{K-1} \longrightarrow T_4 = 551.4\ K$

$Q_{in} = m\, c_v\, [T_3 - T_2] = 0.230\ KJ$

$Q_{out} = m\, c_v\, [T_4 - T_1] = 0.0851\ KJ$

$W_{net} = Q_{in} - Q_{out} = 0.1449\ KJ$

$$\eta_{th_{new}} = \frac{W_{net}}{Q_{in}} = 0.63 = 63\%$$

* maximum Temperature T_3 decrease
* heat addition Q_{in} decrease
* network W_{net} decrease
* finally Thermal efficiency η_{th} increased

f) Explain why the compression ratio should be limited between 8 and 11 for Otto cycle.

when high compression ratios are used, the temperature of the air–fuel mixture rises above the autoignition temperature of the fuel during the combustion process, causing an early and rapid burn of the fuel at some point or points ahead of the flame front, followed by almost instantaneous inflammation of the end gas. **so , compression ratio should be limited between 8 and 11 To avoid Auto-ignition and engine knock which produces an audible noise.** therefore spark-ignition engines cannot be tolerated because it hurts performance and can cause engine damage. The requirement that autoignition not be allowed places an upper limit on the compression ratios that can be used in sparkignition internal combustion engines.