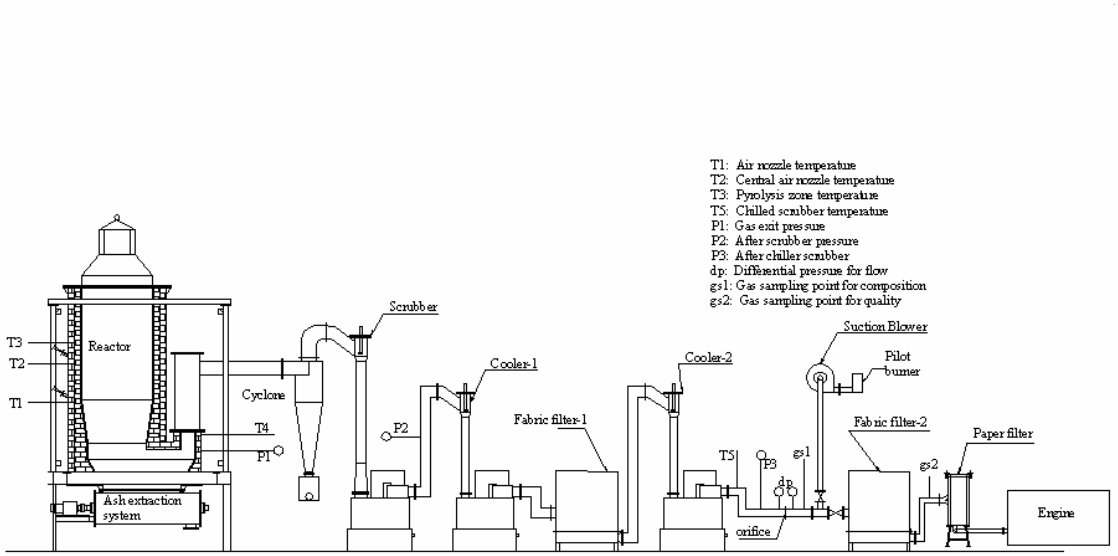
Summary of the work on Producer Gas Engines

Approach

- Systematic Procedure – Experiments & Modeling
- Testing of various capacity Engines ~ 0.5 to 200 kWe ~ at varying CR
- Design of gas circuitry elements ~ Gas carburetor
- Identify key parameters like the optimum ignition timing and establish maximum rating in each case

Testing Arrangement

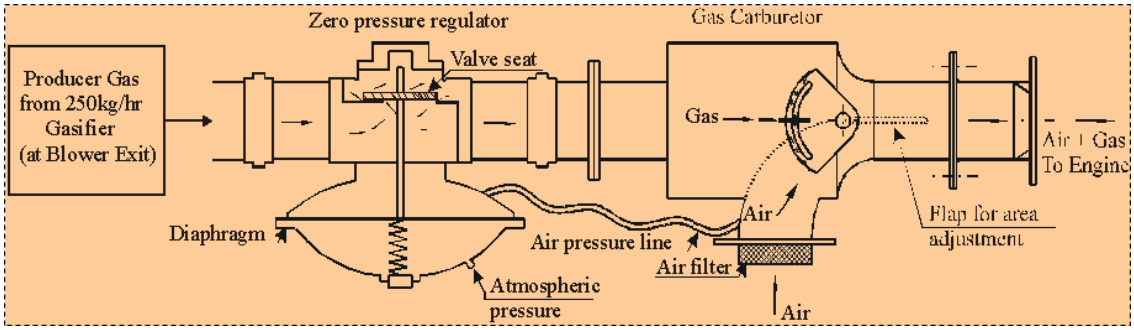


Superior gas quality : P&T < 1 ppm; Gas calorific value : > 5.0 MJ/kg

Summary ~ Experiments

Engine & Rating	Configuration	No. of hours	Site
RB-33 (18 kW)	Converted from CI engine	150	Fundamental study ~ Laboratory
RB-33 (16 kWe)	Converted from CI engine	2000 (on going)	In a farm house
Greaves (200 kWe)	Adaptation – Biogas engine	100	Laboratory/Factory
Cummins G743G (55 kWe)	Adaptation – NG engine	75	Laboratory/Field
Cummins GTA855G (90 kWe)	Adaptation – NG engine	10	Laboratory/Field
Greaves (0.8 kWe)	Adaptation – Kerosene engine	25	Laboratory

Gas Circuitry Elements



Optimum Parameters

CR	Ign Timing, BTC
17	6 - 10
14 - 15	10 - 12
12 - 13	12 - 14
11 - 12	15 - 17
10 - 11	22 - 24
8 - 9	26 - 28

*for a gas composition of: 18-20% each of H_2 and CO, and 2% CH_4

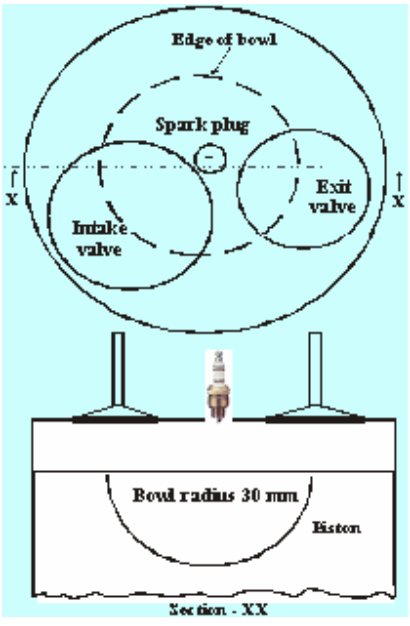
Emissions

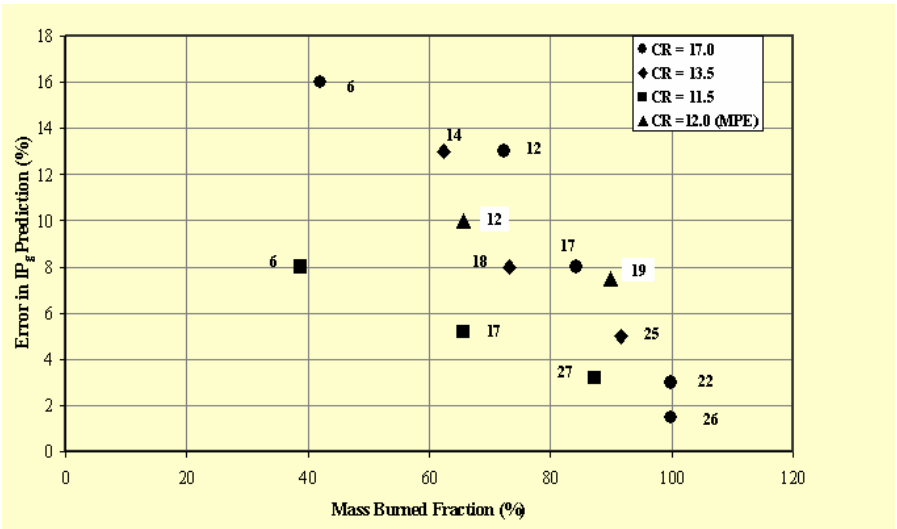
Parameter/Country	USA	EU	Japan	India
CO	3.06	1.4 - 1.8	1.67	1.25 (3.9)
Nox	2.56	2.56	2.6 – 3.06	2.22(5.0)
HC	0.36	0.36	0.4 – 0.56	0.3(0.98)
PM	0.15	0.15 – 0.24	-	0.1 – 0.2 (<3.5 Bosch)
KOEL Engine results between 6 to 20° CA for all CRs at Φ = 1.0 - 1.2				
Parameter/CR	17.0	14.5	13.5	11.5
CO	1.1 – 11.0	11.0 – 15.0	4.0 –16.0	9.0 –14.0
Nox	0.03 – 0.28	0.02 – 0.22	0.03 –0.20	0.05
PM		< 0.0005		
Greaves Engine results between 12 to 24° CA for CR=12.0 at Φ = 0.94 - 0.97				
CO		0.58 – 1.2		
NOx		0.32 – 0.7		
PM		< 0.0005		
Cummins Engine results between 22 to 24° CA for CR=10.0 at Φ = 1.01 -1.03				
CO		0.4 – 1.8		
NOx		0.2 – 0.7		
PM		<< 0.0005		

Engine Modeling

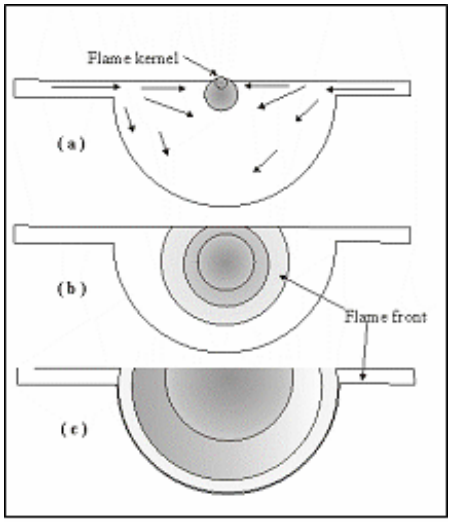
- Zero-Dimensional modeling simulating four processes
- Eddy Entrainment and Laminar Burn-up model to simulate heat release part
- CFD studies conducted on a engine geometry - 20 kW engine; piston with bowl geometry - motoring

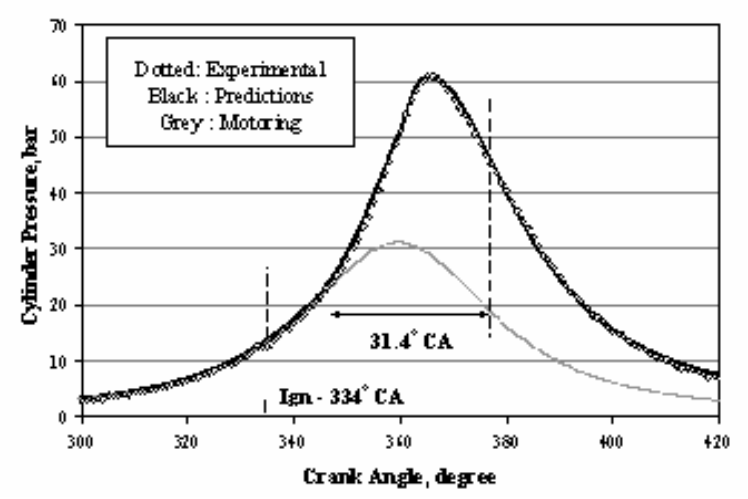
Computational Results



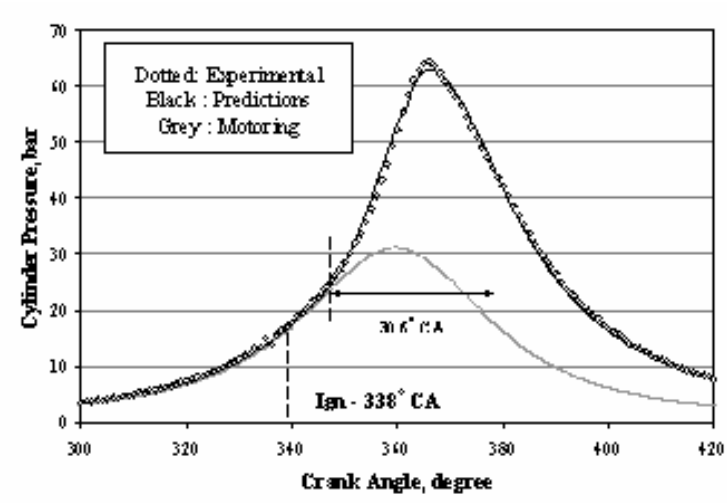


Computational Results @ advanced ign timing

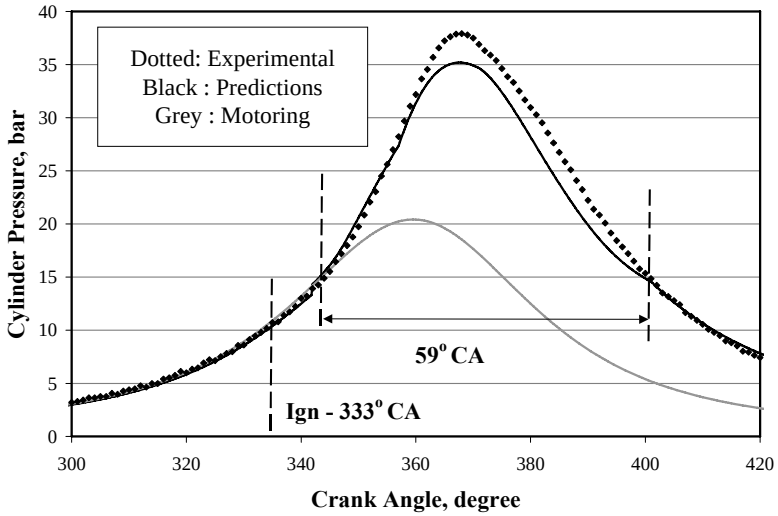




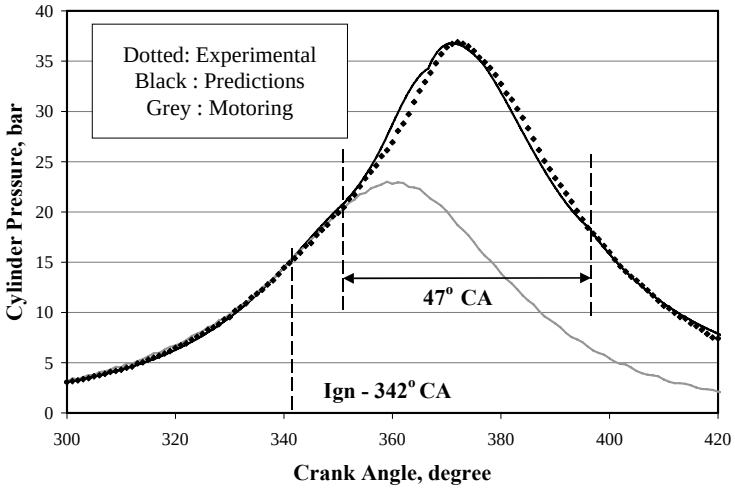
26° CA @ CR=17



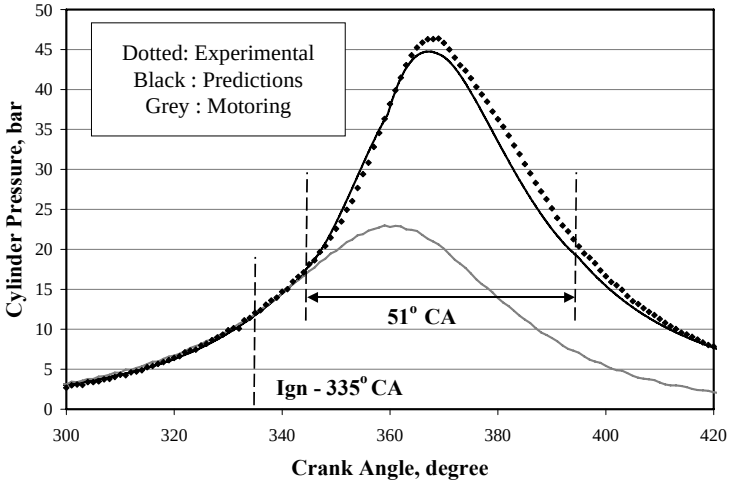
22° CA @ CR=17



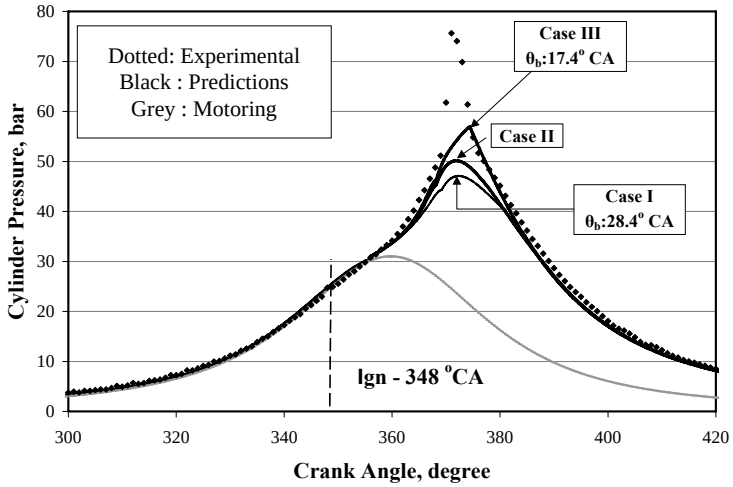
27° CA @ CR=13.5



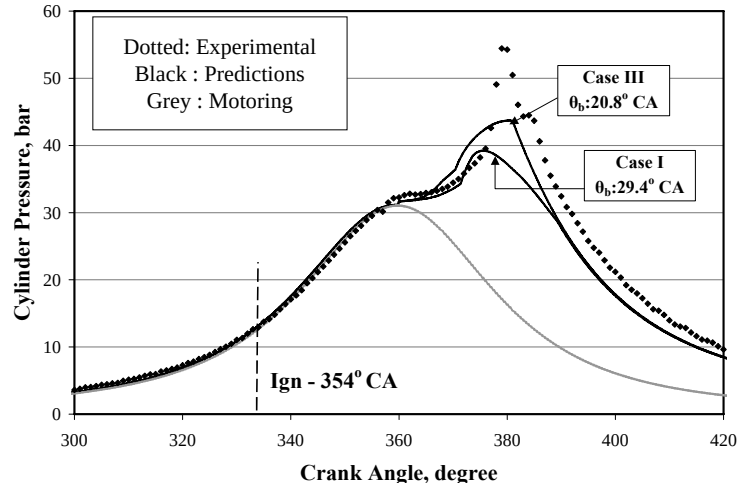
18° CA @ CR=13.5



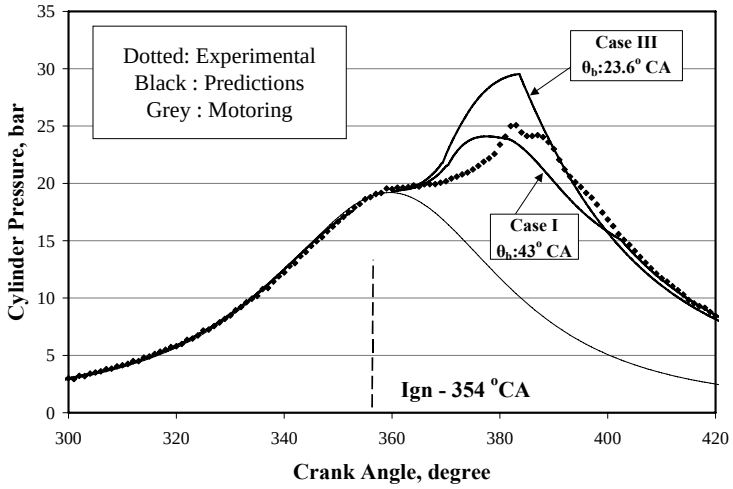
25° CA @ CR=13.5



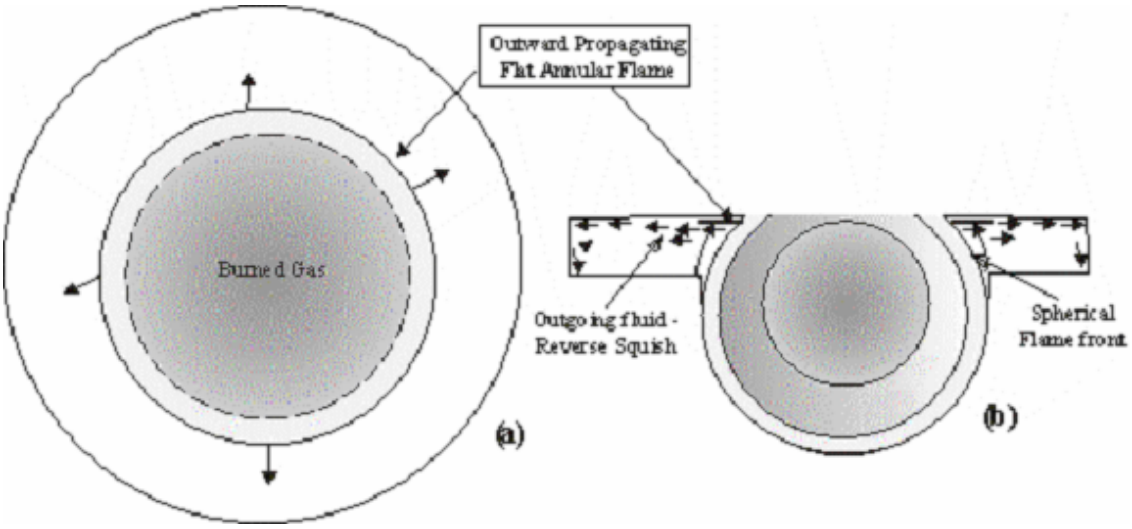
12° CA @ CR=17



6° CA @ CR=17

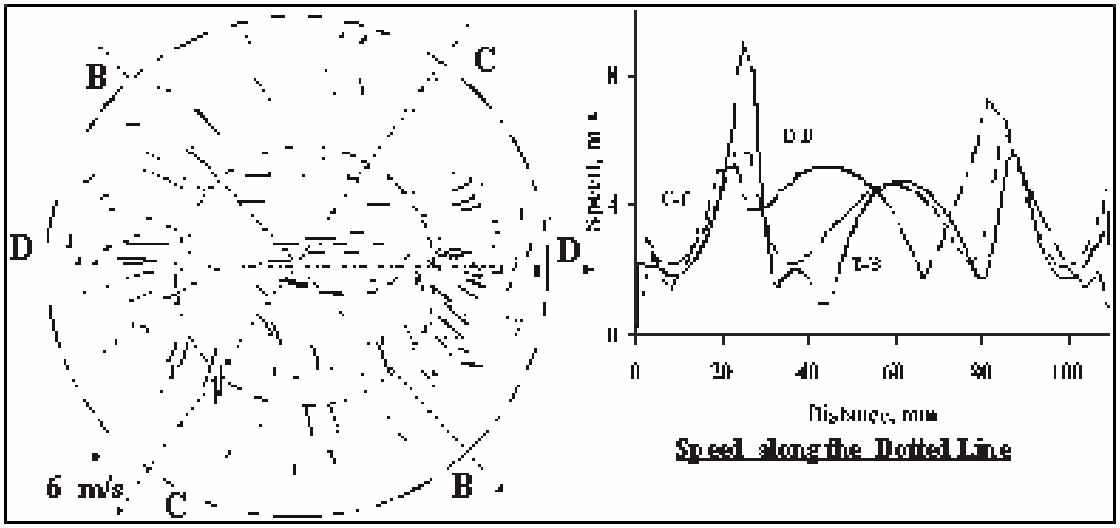


6° CA @ CR=11.5

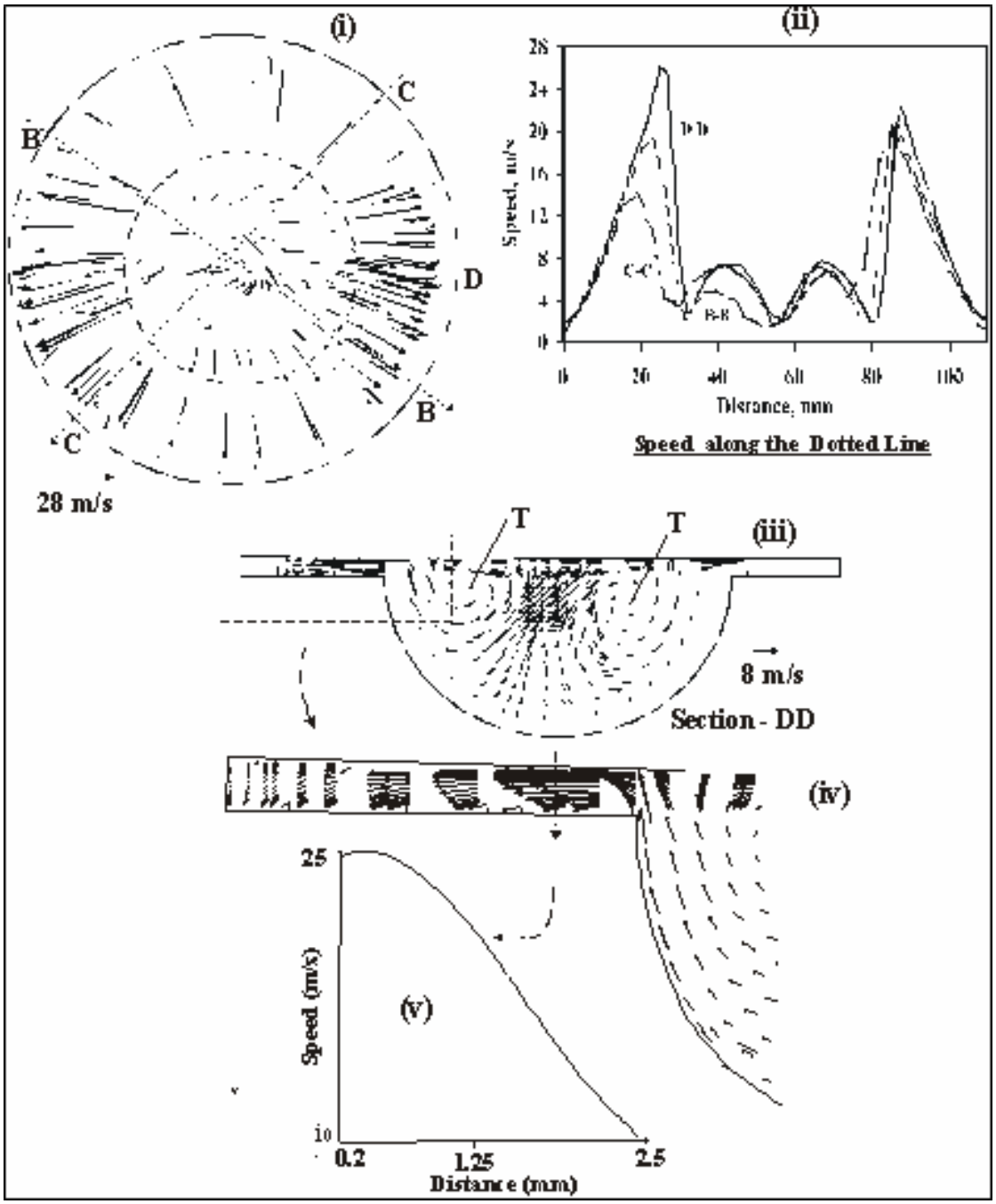


RSF Hypothesis

CFD Studies



CR: 11.5


(i)
C
B
D
B
C
28 m/s
(ii)
Speed, m/s
Distance, mm
Speed along the Dotted Line
T
T
(iii)
8 m/s
Section - DD
(iv)
25
Speed (m/s)
(v)
10
0.2
1.25
2.5
Distance (mm)

CR: 17.0

Summary

- Adaptation procedure for PG engine identified and complete
- Longer duration field trails awaited in order to establish reliability of operations
- The predictions match reasonably with the experimental results at lower CR (~11.5); most of the commercial gas engines are in the CR bracket (< 12.0)
- The 0-D model can therefore be used to get a first estimate of engine output using producer gas