Gas Power Cycles Example

Given: – Air as an Ideal Gas in an Air-Standard Otto Cycle
– Compression Ratio = 8.5
– $T_1 = 300K$
– Heat Addition = 1400 KJ/Kg

Determine: – The net work per Kg
– Thermal Efficiency

State ①	State ②	State ③	State ④
$T_1 = 300K$	$r = \frac{v_{r1}}{v_{r2}}$ $v_{r2} = \frac{v_{r1}}{r}$		$r = \frac{v_{r4}}{v_{r3}}$

1-2

$$\frac{W_{12}}{m} = u_2 - u_1$$

Table A => @ 300K $\boxed{u_1 = 214.07 \text{ KJ/Kg}}$
$v_{r1} = 621.2$

$$v_{r2} = \frac{621.2}{8.5} = 73.082$$

Table A

$v_r = 75.50$ $u = 496.62$ KJ/Kg
$v_r = 72.56$ $u = 504.45$ KJ/Kg

$$\boxed{u_2 = 503.06 \text{ KJ/Kg}}$$

$$\frac{W_{12}}{m} = 503.06 \text{ KJ/Kg} - 214.07 \text{ KJ/Kg}$$

$$\boxed{\frac{W_{12}}{m} = 288.99 \text{ KJ/Kg}}$$

2-3

$$\frac{Q_{23}}{m} = u_3 - u_2 \qquad \frac{Q_{23}}{m} = 1400 \text{ KJ/Kg}$$

$$1400 \text{ KJ/Kg} = u_3 - 503.06 \text{ KJ/Kg}$$

$$\boxed{u_3 = 1903.06 \text{ KJ/Kg}}$$

3-4

$$\frac{W_{34}}{m} = u_3 - u_4$$

Table A

$u = 1872.4$ KJ/Kg $v_r = 2.012$
$u = 1921.3$ KJ/Kg $v_r = 1.864$

Interpolating, $v_{r3} = 1.9192$

$$v_{r4} = 8.5(1.9192) = 16.3132$$

$v_{r4} = 16.3132$

Table A

$v_r = 16.946 \qquad u = 880.35 \text{ KJ/Kg}$

$v_r = 16.064 \qquad u = 897.91 \text{ KJ/Kg}$

Interpolating, $\boxed{u_4 = 892.95 \text{ KJ/Kg}}$

$$\frac{W_{34}}{m} = 1903.06 \text{ KJ/Kg} - 892.95 \text{ KJ/Kg}$$

$$\boxed{\frac{W_{34}}{m} = 1010.11 \text{ KJ/Kg}}$$

4-1

$$\frac{Q_{41}}{m} = u_4 - u_1$$

$$= 892.95 \text{ KJ/Kg} - 214.07 \text{ KJ/Kg}$$

$$\boxed{\frac{Q_{41}}{m} = 678.88 \text{ KJ/Kg}}$$

$$\frac{W_{cycle}}{m} = \frac{W_{34}}{m} - \frac{W_{12}}{m} = 1010.11 \text{ KJ/Kg} - 288.99 \text{ KJ/Kg}$$

$$\boxed{\frac{W_{cycle}}{m} = 721.12 \text{ KJ/Kg} = \text{Net Work}}$$

$$\frac{Q_{cycle}}{m} = \frac{Q_{23}}{m} - \frac{Q_{41}}{m} = 1400 \text{ KJ/Kg} - 678.88 \text{ KJ/Kg}$$

$$\boxed{\frac{Q_{cycle}}{m} = 721.12 \text{ KJ/Kg}}$$

$$\eta = \frac{W_{cycle}/m}{Q_{23}/m} = \frac{721.12 \text{ KJ/Kg}}{1400 \text{ KJ/Kg}} = 0.515 = \boxed{51.5\%}$$