

A piston and cylinder machine contains a fluid system which passes through a complete cycle of four processes. During cycle, the sum of all heat transfers is -170 kJ . The system completes 100 cycles per min. Complete the following table showing the method for each item and complete the net rate of work output in kJ/min .

Process	Q (kJ/min)	W (kJ/min)	ΔU (kJ/min)
a-b	2100×10	2170	-
b-c	21000	0	-
c-d	$1000 \times 10 = 10000$	-	-36600
d-a	-	-	-

$$Q_{a-b} = \Delta U + W_{a-b}$$

$$21000 = \Delta U + 2170$$

$$\Delta U = 21000 - 2170 = 21000 \text{ kJ/min}$$

$$Q_{b-c} = \Delta U + W_{b-c}$$

$$21000 = \Delta U + 0$$

$$\Delta U = 21000 \text{ kJ/min}$$

$$Q_{c-d} = \Delta U + W_{c-d}$$

$$10000 = \Delta U + W_{c-d}$$

$$-36600 = \Delta U + W_{c-d}$$

$$W_{c-d} = -36600 - \Delta U$$

$$Q_{d-a} = \Delta U + W_{d-a}$$

$$-17000 = \Delta U + W_{d-a}$$

$$W_{d-a} = -17000 - \Delta U$$

The system complete by 100 cycles/min

$$Q_{a-b} + Q_{b-c} + Q_{c-d} + Q_{d-a} = -17000 \text{ kJ/min}$$

$$0 + 21000 + (-36600) + Q_{d-a} = -17000$$

$$Q_{d-a} = -35900 \text{ kJ/min}$$

Now $\oint \delta u = 0$ Since cyclic Integral of any property is zero

$$\Delta E_{a-b} + \Delta E_{b-c} + \Delta E_{c-d} + \Delta E_{d-a} = 0$$

$$-2170 + 21000 + (-36,600) + \Delta E_{d-a} = 0$$

$$\Delta E_{d-a} = 17,770 \text{ kJ/min}$$

$$N_{d-a} = P_{d-a} - \Delta E_{d-a}$$

$$= -35900 - 17770$$

$$= -53670 \text{ kJ/min}$$

Since

$$\sum_{\text{cycle}} \dot{Q} = \sum_{\text{cycle}} \dot{W}$$

$$\text{Rate of work output} = -17,000 \text{ kJ/min.}$$

$$= -283.3 \text{ kW}$$