① A)

The gas turbine plant is working b/w Temperatures 627°c and 16°c.

So, Maximum temperature, $T_{max} = 627°c = 900K$

Minimum temperature, $T_{min} = 16°c = 289K$

As, Air is the working substance.

So, $C_p = 1.005 \frac{KJ}{KgK}$, $C_v = 0.718 \frac{KJ}{KgK}$.

max^m work output $\{W_{max}\}$.

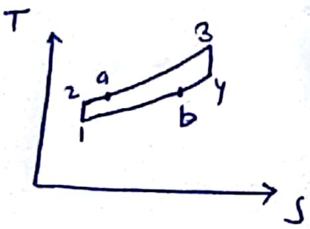
$$W_{max} = C_p \cdot [\sqrt{T_H} - \sqrt{T_L}]^2 \frac{KJ}{Kg}.$$

where T_H is T_{max} and T_L is T_{min}

$$\text{So, } W_{max} = 1.005 [\sqrt{900} - \sqrt{289}]^2$$
$$= 1.005 [30 - 17]^2$$
$$= 1.005 \times 169$$
$$= 169.845 \frac{KJ}{Kg}.$$
→ Answer.

B) d) improve plant efficiency.

Reason :-



Before regeneration | After regeneration

$W_{net} = (h_3 - h_4) - (h_2 - h_1) = (h_3 - h_4) - (h_2 - h_1)$

$\text{Heat supplied} = (h_3 - h_2) > (h_3 - h_a)$

As, $\eta = \frac{W_{net}}{\text{Heat supplied}}$, So, If W_{net} remains same & Heat supplied decreases, η increases.

c) Given,

Net Power produced = 400 KW

(r_w), Work ratio = 40%

$$r_w = \frac{(Work)_{Turbine} - (Work)_{compressor}}{(Work)_{Turbine}} = 0.4$$

Net power = (Work) Turbine − (Work) compressor

= 400 kw

So, $\frac{400}{(Work)_{Turbine}} = 0.4$

$(Work)_{Turbine} = 1000$ KW

So, $(Work)_{compressor} = (Work)_{Turbine} - \text{Net power}$

= 1000 − 400

= 600 kw. → Answer

Answer no. — 2

S. No.	Aspects	Four-stroke cycle engines	Two-stroke cycle engines
1.	Completion of cycle	The cycle is completed in *four strokes of the piston* or in *two revolutions of the crankshaft*. Thus one power stroke is obtained in every two revolutions of the crankshaft.	The cycle is completed in *two strokes of the piston* or in *one revolution of the crankshaft*. Thus one power stroke is obtained in each revolution of the crankshaft.

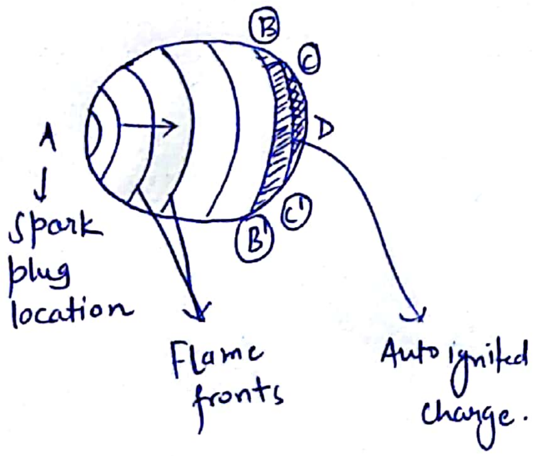
2.	*Flywheel required -heavier or lighter*	Because of (*i*) turning-movement is not so uniform and hence *heavier* flywheel is needed.	More uniform turning movement and hence *lighter* flywheel is needed.
3.	*Power produced for same size of engine*	Again because of one power stroke for two revolutions, power produced for same size of engine is *small* or for the same power the engine is heavy and bulky.	Because of one power stroke for one revolution, power produced for same size of engine in *more* (theoretically twice, actually about 1.8 times) or for the same power the engine is light and compact.
4.	*Cooling and lubrication requirements*	Because of one power stroke in two revolutions *lesser* cooling and lubrication requirements. Lesser rate of wear and tear.	Because of one power stroke in one revolution *greater* cooling and lubrication requirement. Great rate of wear and tear.
5.	*Value and valve mechanism*	The four-stroke engine *contains* valve and valve mechanism.	Two-stroke engines have *no* valves but only ports (some two-stroke engines are fitted with conventional exhaust valves).
6.	*Initial cost*	Because of the heavy weight and complication of valve mechanism, *higher* is the initial cost.	Because of light weight and simplicity due to absence of valve mechanism, *cheaper* in initial cost.
7.	*Volumetric efficiency*	Volumetric efficiency *more* due to more time of induction.	Volumetric efficiency *less* due to lesser time for induction.
8.	*Thermal and part-load efficiencies*	Thermal efficiency higher, part load efficiency better than two stroke cycle engine.	Thermal efficiency lower, part load efficiency lesser than four stroke cycle engine.
9.	*Applications*	Used where efficiency is important ; in *cars, buses, trucks tractors, industrial engines, aeroplane, power generators etc*.	In two-stroke petrol engine some fuel is exhausted during scavenging. Used where (*a*) *low cost*, and (*b*) *compactness and light weight important*. Two-stroke (air-cooled) petrol engines used in very small sizes only, *lawn movers, scooters motor cycles* (lubricating oil mixed with petrol). Two-stroke diesel engines used in *very large sizes* more than 60 cm bore, for *ship propulsion* because of low weight and compactness.

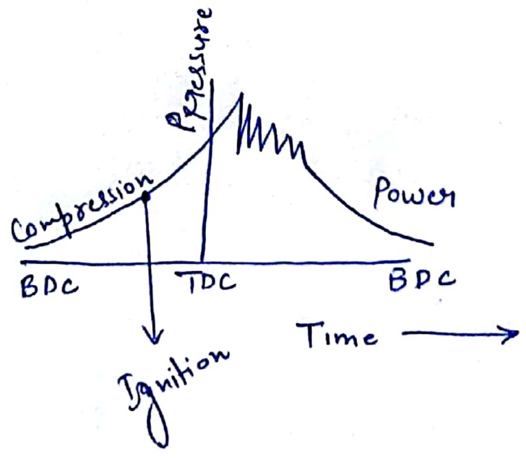
3)

PHENOMENON OF KNOCK IN SI ENGINES.

In a SI engine combustion which is initiated between spark plug electrodes spreads along combustible mixtures. A definite flame front which seperates the fresh mixture from the products of combustion travels from spark plug to other end of combustion chamber. Heat released increases tempera-ture and pressure of the unburnt mixture. For pressure equalisation the burned part of mixture will expand which increases the pressure & temperature of unburned mixture. This process continues as flame front advances through the mixture and the temperature and pressure of unburned mixture are increased further.

If the temperature of the unburned mixture exceedes the self- ignition temperature of the fuel and remains at or above this tempe-rature and pressure during period of preflame reactions {ignition lag}, spontaneous ignition or autoignition occurs at various pin locations. This phenomena is Called knocking which leads towards engine knock.





Because of auto ignition another flame front {at end} starts travelling in opposite direction & when the two flame fronts collide, a severe pulse is generated. This is pressure pulse which causes the walls to vibrate at same frequency of gas.

4). Given :-

Rate of air consumption, $\dot{m}_a = 60.2$ kg/s

Enthalpy change for nozzle, $\Delta h = 230 \frac{kJ}{kg}$

Velocity co-efficient, $z = 0.96$

Air fuel ratio $= 70:1$

Ca, Aircraft velocity $= 1000 \frac{km}{hour}$

$= 1000 \times \frac{5}{18} = 277.8$ m/s

a) Exit Velocity of jet, Cj

$$C_j = z\sqrt{2\Delta h \times 1000} \quad \{\Delta h \text{ in kJ}\}$$

$$= 0.96\sqrt{2 \times 230 \times 1000}$$

$= 651$ m/s. Answer.

b) Fuel flow rate : $\dot{m}_f = \frac{\text{Rate of consumption \{air\}}}{\text{Air-fuel ratio}}$

$$= \frac{60.2}{70} = 0.86 \text{ kg/s.}$$

c) Propulsive Power, $P_{prop} = \dot{m}_a \times \left[\frac{C_j^2 - C_a^2}{2}\right]$

$$= \frac{60.2}{1000} \times \left[\frac{651^2 - 277.8^2}{2}\right] \text{kW}$$

$= 10433.5$ kW

d) Propulsive efficiency, $\eta_{prop} = \frac{2C_a}{C_j + C_a}$

$$= \frac{2 \times 277.8}{651 + 277.8} = 0.598$$

$= 59.8\%$

e) Thrust specific fuel consumption

Thrust produced = $\dot{m}_a (C_j - C_a)$, neglecting mass of fuel.

$= 60.2 \{651 - 277.8\}$

$= 22466.6 \, N$

So, Thrust specific fuel consumption =

$$= \frac{\text{Fuel consumption}}{\text{Thrust}}$$

$$= \frac{0.86}{22466.6}$$

$= 3.828 \times 10^{-5}$ kg/N of thrust/s.

5) **Solution.** *Given* : $T_1 = 15 + 273 = 288$ K, Pressure ratio, $\frac{p_2}{p_1} = \frac{p_3}{p_4} = 4$, $\eta_{compressor} = 82\%$.

Effectiveness of the heat exchanger, $\varepsilon = 0.78$,

$\eta_{turbine} = 70\%$, Maximum temperature, $T_3 = 600 + 273 = 873$ K.

Efficiency of the cycle, η_{cycle} :

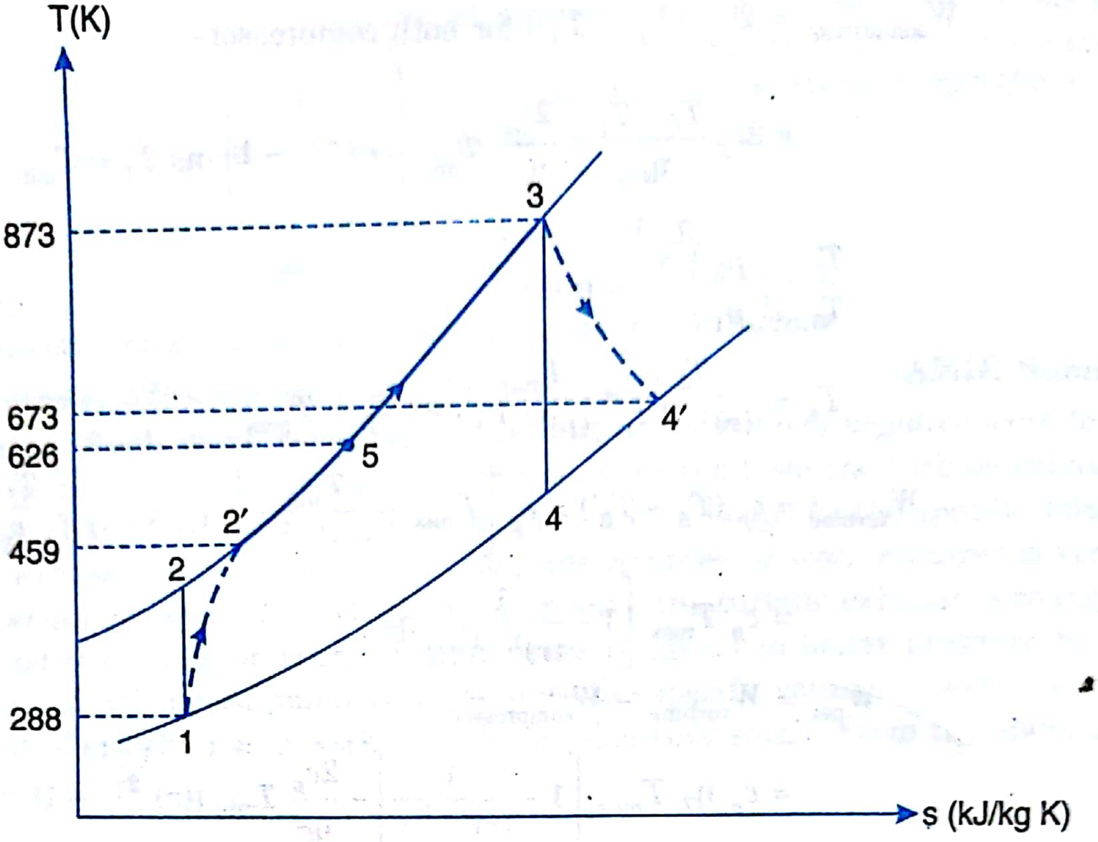


Fig. 25.30

Considering the *isentropic compression 1–2*, we have

$$\frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}} = (4)^{\frac{1.4-1}{1.4}} = 1.486$$

$\therefore$ $$T_2 = 288 \times 1.486 = 428 \text{ K}$$

Now, $$\eta_{compressor} = \frac{T_2 - T_1}{T_2' - T_1}$$

i.e., $$0.82 = \frac{428 - 288}{T_2' - 288}$$

$\therefore$ $$T_2' = \frac{428 - 288}{0.82} + 288 = 459 \text{ K}$$

Considering the *isentropic expansion process 3–4*, we have

$$\frac{T_3}{T_4} = \left(\frac{p_3}{p_4}\right)^{\frac{\gamma-1}{\gamma}} = (4)^{\frac{1.4-1}{1.4}} = 1.486$$

$\therefore$ $$T_4 = \frac{T_3}{1.486} = \frac{873}{1.486} = 587.5 \text{ K.}$$

Again, $$\eta_{turbine} = \frac{T_3 - T_4'}{T_3 - T_4} = \frac{873 - T_4'}{873 - 587.5}$$

i.e., $$0.70 = \frac{873 - T_4'}{873 - 587.5}$$

$$T_4' = 873 - 0.7\,(873 - 587.5) = 673 \text{ K}$$

$\therefore$ $$W_{compressor} = c_p(T_2' - T_1)$$

But $$c_p = R \times \frac{\gamma}{\gamma - 1} = 0.287 \times \frac{1.4}{1.4 - 1} = 1.0045 \text{ kJ/kg K}$$

$\therefore$ $$W_{compressor} = 1.0045\,(459 - 288) = 171.7 \text{ kJ/kg}$$

$$W_{turbine} = c_p(T_3 - T_4') = 1.0045\,(873 - 673) = 200.9 \text{ kJ/kg}$$

$\therefore$ $$\text{Network} = W_{turbine} - W_{compressor} = 200.9 - 171.7 = 29.2 \text{ kJ/kg.}$$

Effectiveness for heat exchanger, $\varepsilon = \dfrac{T_5 - T_2'}{T_4' - T_2'}$

i.e., $$0.78 = \frac{T_5 - 459}{673 - 459}$$

$\therefore$ $$T_5 = (673 - 459) \times 0.78 + 459 = 626 \text{ K}$$

$\therefore$ **Heat supplied by fuel per kg**

$$= c_p(T_3 - T_5) = 1.0045\,(873 - 626) = 248.1 \text{ kJ/kg}$$

$\therefore$ $$\eta_{cycle} = \frac{\text{Network done}}{\text{Heat supplied by the fuel}} = \frac{29.2}{248.1} = \mathbf{0.117 \text{ or } 11.7\%}. \quad \textbf{(Ans.)}$$