A six cylinder four stroke diesel engine has a power output of 280 kW at 1500 rpm. The fuel consumption is 0.24 kg/kWh. The pressure in the cylinder at the beginning of injection is 40 bar and maximum cylinder pressure is 70 bar. The injection is expected at 200 bar and maximum pressure at the injector is set to be about 600 bar. Determine the orifice area required per injector if the injection takes place over 150 crank angles. Take the effective pressure difference to be the average pressure difference over the injection period. Assume the coefficient of discharge for the injector 0.8, specific gravity of fuel 0.86 and the atmospheric pressure 1.013 bar.

$n = 6$

4 stroke $N = N/2$

$BP = 280$ kW

$N = 1500$ rpm

$bsfc = 0.24$ kg/kwh

$P_{c1} = 40$ bar

$P_{c2} = 70$ bar

$SP = 0.86$

$\rho_f = 860$ kg/m^3

$P_{i1} = 200$ bar

$P_{i2} = 600$ bar

$\theta = 15°$

$A_f = ?$

$C_d = 0.8$

$P_{atm} = 1.013$ bar

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$\dot{m}_f = C_d \, A_f \sqrt{2 \rho_f (P_i - P_c)}$

$\equiv$ ✓ ↑ ✓ → Avg. pressure Difference of initial & final

Pressure Difference at beginning

$= P_{i2} - P_{c1} = 200 - 40 = 160$ bar

Pressure Difference at end

$= P_i - P_c = 600 - 70 = 530$ bar

$P_i - P_c =$ Avg. Pressure $= \frac{160 + 530}{2} = 345$ bar

$0.14933 = 0.8 \times A_f \times \sqrt{2 \times 860 \times 345 \times 10^5}$

$A_f = 7.66 \times 10^{-7} \, m^2$ $\boxed{= 0.766 \, mm^2}$

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$$\dot{m}_f = \frac{m_f}{t} = \frac{2.4889 \times 10^{-4}}{1.6667 \times 10^{-3}} = 0.1493 \text{ kg/s/cycle}$$

Time for injection $t = \frac{\theta}{360} \times \frac{60}{N} = \frac{15}{360} \times \frac{60}{1500} = 1.6667 \times 10^{-3}$ sec

$$m_f = \frac{\text{fuel consumption/cylinder}}{\text{No. of cycle}} = \frac{0.18667}{750} = 2.4889 \times 10^{-4} \text{ kg/cy}$$

$$\Rightarrow \frac{N}{2} = 750 \text{ cycl/min}$$

$$\text{fuel consumption/cylinder} = \frac{B.P}{\text{No. of cylin}} \times bsfc = \frac{280}{6} \times 0.24$$

$$= 11.2 \text{ kg/hr/cylinder}$$

$$= \frac{11.2}{60} = 0.18667 \text{ kg/min/cy}$$

$$= 0.18667$$

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