Chapter 9, Question 2:
Energy Exchange with Moving Blades

The oxygen turbopump for the Space Shuttle Main Engine takes liquid oxygen (c_p = 1660 J/kg-K) from the propellant tank and delivers it at elevated temperature and pressure to the combustion chamber of the main engine. The 407 kg/s enters the centrifugal pump axially at a stagnation temperature of 90K with no tangential velocity and leaves with a tangential velocity approximately equal to the speed of the edge of the rotor disk. If the rotor is spinning at 2481 radians/s and is 0.16m in diameter, how much power is added to the fluid?

1) 0.08 MW **2) 0.45 MW** **3) 16MW** **4) 64 MW**

5) I don't know

L.O. I & J

Chapter 9, Question 2 Answer:

The correct answer is 3) 16 MW

EULER TURBINE EQUATION:

$$\text{POWER} = \dot{m} C_p \left[T_{T_{OUT}} - T_{T_{IN}}\right] = \dot{m} \omega \left[(r V_{tang.})_{out} - (r V_{tang})_{IN}\right]$$

TEMPERATURE —

$$C_p \left[T_{T_{OUT}} - T_{T_{IN}}\right] = \omega \left[(r V_{tang})_{OUT} - (r V_{tang})_{IN}\right] \qquad V_{TANG\ OUT} = r\omega$$

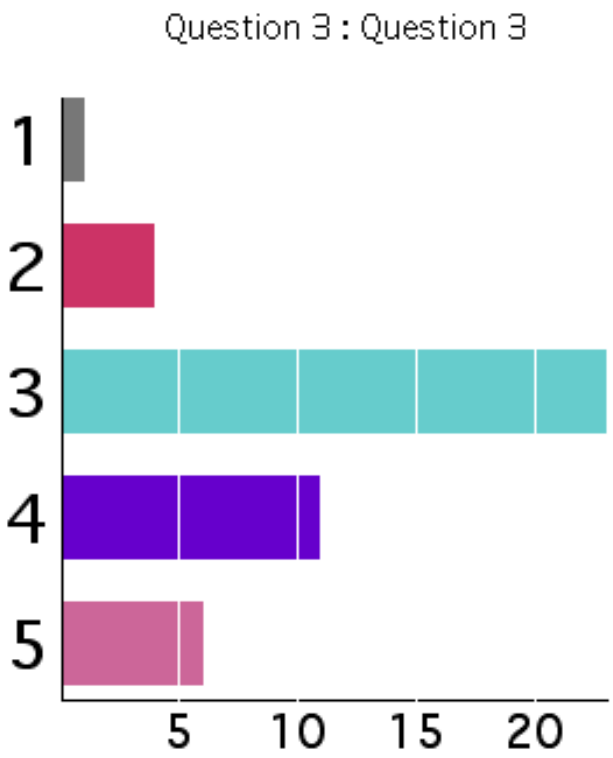
$$T_{T_{OUT}} = 90K + \frac{2481}{1.66 \times 10^3}\left[0.08\,(0.08 - 2481)\right] = 113.7\ K$$

POWER —

$$P = \dot{m} \omega \left[(r V_{tang})_{OUT} - (r V_{tang})_{IN}\right]$$

$$P = 407 \cdot 2481 \cdot 008 \cdot 0.08 \cdot 2481 = 16{,}033\ kW$$

Class performance (2003):



Class performance (2001):

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