Chapter 9, Question 2:
Energy Exchange with Moving Blades

The oxygen turbopump for the Space Shuttle Main Engine takes liquid oxygen \( c_p = 1660 \text{ J/kg-K} \) 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
Chapter 9, Question 2 Answer:

The correct answer is 3) 16 MW

**Euler Turbine Equation:**

\[
\text{POWER} = \dot{m}C_p\left[T_{out} - T_{in}\right] = \dot{m}C_p\left[(\Gamma V_{tang})_{out} - (\Gamma V_{tang})_{in}\right]
\]

**Temperature:**

\[
C_p\left[T_{out} - T_{in}\right] = \dot{m}\left[(\Gamma V_{tang})_{out} - (\Gamma V_{tang})_{in}\right]
\]

\[
T_{out} = 90 + \frac{2481}{1.66 \times 10^3}\left[0.08 \left(0.08 \cdot 2481\right)\right] = 113.7 \text{ K}
\]

**Power:**

\[
\text{POWER} = \dot{m}C_p\left[(\Gamma V_{tang})_{out} - (\Gamma V_{tang})_{in}\right]
\]

\[
\text{POWER} = 407 \cdot 2481 - 0.08 \cdot 0.08 \cdot 2481 = 16,033 \text{ kW}
\]

Class performance (2003):
Question 3: Question 3

Class performance (2001):
Quiz 2 started at 10:41:35 AM

52 students logged in.

1% 3% 67% 9% 15% 1%

1 2 3 4 5 NR

Show Percentage Numerical Value