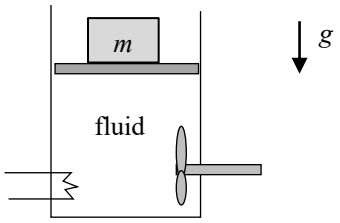
A fluid contained within a piston-cylinder device is designed to lift a load of m = 100 kg. How high can this load be lifted if 1 A of current passes through the fluid over a 12 V potential for two minutes and a shaft is rotated at 100 rpm with a torque of 1 N.m for one minute? Assume that all of the work that goes into the fluid due to the electricity and shaft goes into raising the load.



SOLUTION:

The system consists of the fluid. The work done on this system by the electricity is,

$$W_{elec,on\ sys} = VI\Delta t = (1\ A)(12\ V)(120\ s) = 1440\ J. \quad (1)$$

The work done on the system by the rotating shaft is,

$$W_{shaft,on\ sys} = \omega T\Delta t = \left(100\ \tfrac{rot}{min}\cdot\tfrac{2\pi\ rad}{rot}\cdot\tfrac{min}{60\ s}\right)(1\ N.m)(60\ s) = 628\ J. \quad (2)$$

To lift the mass m a height Δh, the work done by the system must be,

$$W_{by\ sys} = mg\Delta h = (100\ kg)\left(9.81\ \tfrac{m}{s^2}\right)(\Delta h) = \left(981\ \tfrac{kg.m}{s^2}\right)\Delta h. \quad (3)$$

Since we're told that all of the work by the electricity and rotating shaft goes into lifting the mass,

$$W_{by\ sys} = W_{elec,on\ sys} + W_{shaft,on\ sys}, \quad (4)$$

$$\left(981\ \tfrac{kg.m}{s^2}\right)\Delta h = 1440\ J + 628\ J, \quad (5)$$

$$\boxed{\Delta h = 2.11\ m.} \quad (6)$$