Chapter 18 Problem 71 [†]

Given

$\frac{\Delta W}{\Delta t} = 360\ MW$

$\frac{\Delta U}{\Delta t} = -670\ MW$(internal energy loss of fuel)

Solution

Does the turbine meet the standard of the council?

The first law of thermodynamics states

$$\Delta U = Q + W$$

When we consider the rate at which heat is released, the first law of thermodynamics can be written as

$$\frac{\Delta Q}{\Delta t} = \frac{\Delta U}{\Delta t} - \frac{\Delta W}{\Delta t}$$

Internal energy consists of the potential and kinetic energy of the molecules in the gas. During the burning of the natural gas the chemical composition changes and there is a release of internal energy at the rate of 670 MW. Since this internal energy is changed into work at a rate of 360 MW, the remaining energy must be given off as a loss of heat.

$$\frac{\Delta Q}{\Delta t} = 670\ MW - 360\ MW = 310\ MW$$

Since efficiency is defined as the percent of energy turned into work, the efficiency is

$$\varepsilon = \frac{360\ MW}{670\ MW} \times 100\% = 53.7\%$$

Since the council set minimum efficiency at 50% and the maximum thermal waste at 400 MW, the turbine meets the standard.

[†]Problem from Essential University Physics, Wolfson