Unfortunately, there can be no such heat engine, so the efficiencies of all engines are less than 1.0. The smaller the fraction of usable energy that an engine can provide, the lower its efficiency is.

The equation also provides some important information for increasing engine efficiency. If the amount of energy added to the system as heat is increased or the amount of energy given up by the system is reduced, the ratio of Q_c/Q_h becomes much smaller and the engine's efficiency comes closer to 1.0.

The efficiency equation gives only a maximum value for an engine's efficiency. Friction, thermal conduction, and the inertia of moving parts in the engine hinder the engine's performance, and experimentally measured efficiencies are significantly lower than the calculated efficiencies (see **Table 3**).

SAMPLE PROBLEM C

Heat-Engine Efficiency

PROBLEM

Find the efficiency of a gasoline engine that, during one cycle, receives 204 J of energy from combustion and loses 153 J as heat to the exhaust.

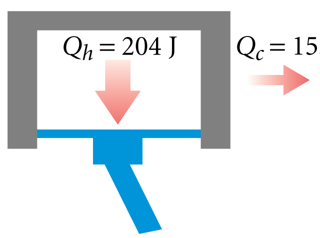
SOLUTION

1. DEFINE

Given: $Q_h = 204$ J $\qquad Q_c = 153$ J

Unknown: $eff = ?$

Diagram:



2. PLAN

Choose an equation or situation:
The efficiency of a heat engine is the ratio of the work done by the engine to the energy transferred to it as heat.

$$eff = \frac{W_{net}}{Q_h} = 1 - \frac{Q_c}{Q_h}$$

3. CALCULATE

Substitute the values into the equation and solve:

$$eff = 1 - \frac{153\ \text{J}}{204\ \text{J}} = 0.250$$

$$\boxed{eff = 0.250}$$

4. EVALUATE

Only 25 percent of the energy added as heat is used by the engine to do work. As expected, the efficiency is less than 1.0.