thrust. Because of the high fuel consumption during afterburner operation and the adverse effect on endurance, the use of the afterburner should be limited to short periods of time. In addition, there may be limited time for the use of the afterburner due to critical heating of supporting or adjacent structure in the vicinity of the afterburner.

The specific fuel consumption of the basic engine will increase with the addition of the afterburner apparatus. The losses incurred by the greater fluid friction, nozzle and flameholder pressure drop, etc. increase the specific fuel consumption of the basic engine approximately 5 to 10 percent.

The principal advantage of afterburner is the ability to add large amounts of thrust with relatively small weight penalty. The application of the afterburner is most common to the interceptor, fighter, and high speed type aircraft.

The use of *water injection* in the turbojet engine is another means of thrust augmentation which allows the combustion of additional fuel within engine speed and temperature limits. The most usual addition of water injection devices is to supplement takeoff and climbout performance, especially at high ambient temperatures and high altitudes. The typical water injection device can produce a 25 to 35 percent increase in thrust.

The most usual means of water injection is direct flow of the fluid into the combustion chamber. This is illustrated in figure 2.14. The addition of the fluid directly into the combustion chamber increases the mass flow and reduces the turbine inlet temperature. The drop in temperature reduces the turbine power and a greater fuel flow is required to maintain engine speed. Thus, the mass flow is increased, more fuel flow is allowed within turbine limits, and greater energy is imparted to the exhaust gases.

The fluid injected into the combustion chambers is generally a mixture of water and alcohol. The water-alcohol solution has one immediate advantage in that it prevents fouling of the plumbing from the freezing of residual fluid at low temperatures. In addition, a large concentration of alcohol in the mixture can provide part of the additional chemical energy required to maintain engine speed. In fact, the large concentration of alcohol in the injection mixture is a preferred means of adding additional fuel energy. If the added chemical energy is included with the water flow, no abrupt changes in governed fuel flow are necessary and there is less chance of underspeed with fluid injection and overspeed or overtemperature when fluid flow is exhausted. Of course, strict proportions of the mixture are necessary. Since most water injection devices are essentially an unmodulated flow, the use of this device is limited to high engine speed and low altitude to prevent the water flow from quenching combustion.

THE GAS TURBINE-PROPELLER COMBINATION. The turbojet engine utilizes the turbine to extract sufficient power to operate the compressor. The remaining exhaust gas energy is utilized to provide the high exhaust gas velocity and jet thrust. The propulsive efficiency of the turbojet engine is relatively low because thrust is produced by creating a large velocity change with a relatively small mass flow. The gas turbine-propeller combination is capable of producing higher propulsive efficiency in subsonic flight by having the propeller operate on a much greater mass flow.

The turboprop or propjet powerplant requires additional turbine stages to continue expansion in the turbine section and extract a very large percent of the exhaust gas energy as shaft power. In this sense, the turboprop is primarily a power producing machine and the jet thrust is a small amount of the output propulsive power. Ordinarily, the jet thrust of the turboprop accounts for 15 to 25 percent of the total thrust output. Since the turboprop is primarily a power producing machine,