temperature continues downward. Mixtures from 0.0725 fuel/air ratio to 0.080 fuel/air ratio are called best power mixtures, since their use results in the greatest power for a given airflow or manifold pressure. In this fuel/air ratio range, there is no increase in the total heat released, but the weight of nitrogen and combustion products is augmented by the vapor formed with the excess fuel. Thus, the working mass of the charge is increased. In addition, the extra fuel in the charge (over the stoichiometric mixture) speeds up the combustion process, which provides a favorable time factor in converting fuel energy into power.

If the fuel/air ratio is enriched above 0.080, there is loss of power and a reduction in temperature. The cooling effects of excess fuel overtake the favorable factor of increased mass. This reduced temperature and slower rate of burning lead to an increasing loss of combustion efficiency. If, with constant airflow, the mixture is leaned below 0.067, fuel/air ratio power and temperature decrease together. This time, the loss of power is not a liability but an asset. The purpose in leaning is to save fuel. Air is free and available in limitless quantities. The object is to obtain the required power with the least fuel flow. A measure of the economical use of fuel is called specific fuel consumption (SFC), which is the fuel weight in pounds per hour per horsepower.

$$SFC = \frac{\text{pounds fuel/hour}}{\text{horsepower}}$$

By using this ratio, the engine's use of fuel at various power settings can be compared. When leaning below 0.067 fuel/air ratio with constant airflow, even though the power diminishes, the cost in fuel to support each horsepower hour (SFC) also is lowered. While the mixture charge is becoming weaker, this loss of strength occurs at a rate lower than that of the reduction of fuel flow. This favorable tendency continues until a mixture strength known as best economy is reached. With this fuel/air ratio, the required hp is developed with the least fuel flow or, to put it another way, the greatest power produced by a given fuel flow. The best economy fuel/air ratio varies somewhat with rpm and other conditions, but for cruise powers on most reciprocating engines, it is sufficiently accurate to define this range of operation as being from 0.060 to 0.065 fuel/air ratios on aircraft where manual leaning is practiced.

Below the best economical mixture strength, power and temperature continue to fall with constant airflow while the SFC increases. As the fuel/air ratio is reduced further, combustion becomes so cool and slow that power for a given manifold pressure gets so low as to be uneconomical. The cooling effect of rich or lean mixtures results from the excess fuel or air over that needed for combustion. Internal cylinder cooling is obtained from unused fuel when fuel/air ratios above 0.067 are used. The same function is performed by excess air when fuel/air ratios below 0.067 are used.

Varying the mixture strength of the charge produces changes in the engine operating condition affecting power, temperature, and spark-timing requirements. The best power fuel/air ratio is desirable when the greatest power from a given airflow is required. The best economy mixture results from obtaining the given power output with the least fuel flow. The fuel/air ratio which gives most efficient operation varies with engine speed and power output.

In the graph showing this variation in fuel/air ratio, note that the mixture is rich at both idling and high-speed operation and is lean through the cruising range. *[Figure 2-1]* At idling speed, some air or exhaust gas is drawn into the cylinder through the exhaust port during valve overlap. The mixture that enters the cylinder through the intake port must be rich enough to compensate for this gas or additional air. At cruising power, lean mixtures save fuel and increase the range of the airplane. An engine running near full power requires a rich mixture to prevent overheating and detonation. Since the engine is operated at full power for only short periods, the high fuel consumption is not a serious matter. If an engine is operating on a mixture that is too lean, and adjustments are made to increase the amount of fuel, the power output of the engine increases rapidly at first, then gradually until maximum power is reached. With a further increase in the amount of fuel, the power output drops gradually at first, then more rapidly as the mixture is further enriched.

There are specific instructions concerning mixture ratios for each type of engine under various operating conditions. Failure to follow these instructions results in poor performance and often in damage to the engine. Excessively rich mixtures result in loss of power and waste of fuel. With the engine operating near its maximum output, very lean mixtures cause a loss of power and, under certain conditions, serious overheating. When the engine is operated on a lean mixture, the cylinder head temperature gauge should be watched closely. If the mixture is excessively lean, the engine may backfire through the induction system or stop completely. Backfire results from slow burning of the lean mixture. If the charge is still burning when the intake valve opens, it ignites the fresh mixture and the flame travels back through the combustible mixture in the induction system.

Carburetion Principles

Venturi Principles

The carburetor must measure the airflow through the induction system and use this measurement to regulate the amount of fuel discharged into the airstream. The air