Thrust and Explosives

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Thrust

Thrust is the force which moves an aircraft through the air. Thrust is used to overcome the drag of an airplane, and to overcome the weight of a rocket. Thrust is generated by the **engines** of the aircraft through some kind of propulsion system.

Thrust is a mechanical force, so the propulsion system must be in physical contact with a **working fluid** to produce thrust. Thrust is generated most often through the reaction of accelerating a mass of gas. Since thrust is a force, it is a vector quantity having both a magnitude and a direction. The engine does work on the gas and accelerates the gas to the rear of the engine; the thrust is generated in the **opposite direction** from the accelerated gas. The magnitude of the thrust depends on the amount of gas that is accelerated and on the difference in velocity of the gas through the engine.

The physics involved in the generation of thrust is introduced in middle school and studied in some detail in high school and college. To accelerate the gas, we have to expend energy. The energy is generated as heat by the combustion of some fuel. The thrust equation describes how the acceleration of the gas produces a force. The type of propulsion system used on an aircraft may vary from airplane to airplane and each device produces thrust in a slightly different way. We will discuss four principal propulsion systems at this web site; the propeller, the turbine,or jet, engine, the ramjet, and the rocket.

Thrust compared to power

A very common question is how to compare the thrust number of an airplane engine with the mechanical power of a piston engine (the kind of engine in cars and in many airplanes with propellers). It is hard to compare these two. This is because they are not measuring the same exact thing. A piston engine does not move the plane. It just turns the propeller, which moves the plane. Because of this, piston engines are rated by how much power they give to the propeller.

Thrust compared to weight

When the thrust of a rocket or an engine is compared to the weight, it is called the **Thrust-to-weight ratio**. The number that comes from this comparison does not have any units, because it is a ratio. A ratio in this case means that the thrust of the engine (in Newtons) is divided by the weight (in Newtons). The purpose of this comparison is to show how well the engine or vehicle performs, for example how much acceleration. It is a number that can be used to compare various types of motors like airplane motors, jet engines, rocket engines, or car engines.

This comparison number can change while the engine is running. This is because the weight of the engine gets lighter as fuel is used. The thrust-to-weight ratio is used to actually compare engines is the number found when the engine is first running.

Thrust is measured in “pounds of thrust” in the U.S. and in Newtons in the metric system. 4.45 Newtons of thrust equals 1 pound of thrust. A pound of thrust is how much thrust it would take to keep a one-pound object unmoving against the force of gravity on earth.

Examples

An airplane makes forward thrust when air is pushed in the direction opposite to flight. The thrust is made by the spinning blades of a propeller. Thrust can also be made by a rotating fan pushing air out from the back of a jet engine. Another way is by ejecting hot gases from a rocket engine.

Reverse thrust is the opposite of forward thrust. In this way air is pushed in the same way as the motion of the body. Reverse thrust can be used to help braking after landing. This can be done by redirecting the thrust in a turbofan or jet engine or by changing the blade angle of a propeller driven aircraft.

Birds normally achieve thrust during flight by flapping their wings.

A boat with a motor makes thrust or reverse thrust when the propellers are turned to push water backwards (or forwards). The thrust that this makes pushes the boat in the opposite direction than the water is being pushed.

Explosive

An **explosive** (or **explosive material**) is a reactive substance that contains a great amount of potential energy that can produce an explosion if released suddenly, usually accompanied by the production of light, heat, sound, and pressure. An **explosive charge** is a measured quantity of explosive material, which may either be composed solely of one ingredient or be a mixture containing at least two substances.

The potential energy stored in an explosive material may, for example, be

- chemical energy, such as nitroglycerin or grain dust
- pressurized gas, such as a gas cylinder, aerosol can, or BLEVE
- nuclear energy, such as in the fissile isotopes uranium-235 and plutonium-239

Explosive materials may be categorized by the speed at which they expand. Materials that detonate (the front of the chemical reaction moves faster through the material than the speed of sound) are said to be "high explosives" and materials that deflagrate are said to be "low explosives". Explosives may also be categorized by their sensitivity. Sensitive materials that can be initiated by a relatively small amount of heat or pressure are primary explosives and materials that are relatively insensitive are secondary or tertiary explosives.

A wide variety of chemicals can explode; a smaller number are manufactured specifically for the purpose of being used as explosives. The remainder are too dangerous, sensitive, toxic, expensive, unstable, or prone to decomposition or degradation over short time spans.

In contrast, some materials are merely combustible or flammable if they burn without exploding.

The distinction, however, is not razor-sharp. Certain materials—dusts, powders, gases, or volatile organic liquids—may be simply combustible or flammable under ordinary conditions, but become explosive in specific situations or forms, such as dispersed airborne clouds, or confinement or sudden release.

Properties

To determine the suitability of an explosive substance for a particular use, its physical properties must first be known. The usefulness of an explosive can only be appreciated when the properties and the factors affecting them are fully understood. Some of the more important characteristics are listed below:

Sensitivity

Sensitivity refers to the ease with which an explosive can be ignited or detonated, i.e., the amount and intensity of shock, friction, or heat that is required. When the term sensitivity is used, care must be taken to clarify what kind of sensitivity is under discussion. The relative sensitivity of a given explosive to impact may vary greatly from its sensitivity to friction or heat. Some of the test methods used to determine sensitivity relate to:

- **Impact** – Sensitivity is expressed in terms of the distance through which a standard weight must be dropped onto the material to cause it to explode.

- **Friction** – Sensitivity is expressed in terms of the amount of pressure applied to the material in order to create enough friction to cause a reaction.

- **Heat** – Sensitivity is expressed in terms of the temperature at which decomposition of the material occurs.

Specific explosives (usually but not always highly sensitive on one or more of the three above axes) may be idiosyncratically sensitive to such factors as pressure drop, acceleration, the presence of sharp edges or rough surfaces, incompatible materials, or even—in rare cases—nuclear or electromagnetic radiation. These factors present special hazards that may rule out any practical utility.

Sensitivity is an important consideration in selecting an explosive for a particular purpose. The explosive in an armor-piercing projectile must be relatively insensitive, or the shock of impact would cause it to detonate before it penetrated to the point desired. The explosive lenses around nuclear charges are also designed to be highly insensitive, to minimize the risk of accidental detonation.

Sensitivity to initiation

The index of the capacity of an explosive to be initiated into detonation in a sustained manner. It is defined by the power of the detonator which is certain to prime the explosive to a sustained and continuous detonation. Reference is made to the Sellier-Bellot scale that consists of a series of 10 detonators, from n. 1 to n. 10, each of which corresponds to an increasing charge weight. In practice, most of the explosives on the market today are sensitive to an n. 8 detonator, where the charge corresponds to 2 grams of mercury fulminate.

Velocity of detonation

The velocity with which the reaction process propagates in the mass of the explosive. Most commercial mining explosives have detonation velocities ranging from 1800 m/s to 8000 m/s. Today, velocity of detonation can be measured with accuracy. Together with density it is an important element influencing the yield of the energy transmitted for both atmospheric over-pressure and ground acceleration. By definition, a "low explosive", such as black powder, or smokeless gunpowder has a burn rate of 171–631 m/s. In contrast, a "high explosive", whether a primary, such as detonating cord, or a secondary, such as TNT or C-4 has a significantly higher burn rate.