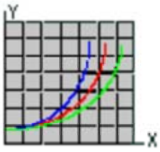
Richard Nakka's *Experimental Rocketry* Web Site



Solid Rocket Motor Theory -- Introduction

Introduction

The primary goal of the *Solid Rocket Motor Theory* Web Pages is to present the theoretical basis for the functioning of a solid propellant rocket motor. Emphasis is placed on the theory as it applies to small (relatively speaking) amateur motors, which are typically of lower performance and efficiency than their "professional" counterparts. In certain regard, the standard "textbook" methods must be modified to take these factors into account.

The secondary goal is to present the fundamental "tools" that may be used in the design of amateur rocket motors. This topic will be covered in a later Web Page.

I will attempt to follow a logical path in this presentation, with one topic leading into the next topic. Starting with the **Basic Assumptions** that must be made in order to "simplify" the highly complex nature of the functioning of a rocket motor. The **Propellant** is then discussed, although mainly with regard to certain aspects that have direct application to rocket motor theory. For example, propellants are considered to consist of a fuel/binder and oxidizer, without regard to specific formulations. The shape that the propellant is formed into (the *grain*) has a direct and important bearing on the motor's overall performance characteristics.

As the fundamental operation of the rocket motor requires that the propellant be burned, the topic that follows deals with the **Combustion** process. In other words, the conversion of the propellant grain to high temperature gases and condensed particles (smoke). This combustion must occur in a manner that is suitable to obtain the desired operating requirements -- a certain thrust profile over a certain burn time, while operating within certain physical limits with regard to chamber pressure and temperature. Thus, burn rate, combustion temperature, and products of combustion all play a crucial role in establishing a rocket motor's performance.

Almost certainly the most critical component of a solid rocket motor is the nozzle. The nozzle can "make or break" a rocket motor, most literally. But what exactly does a nozzle do, and how? What is the signficance of the convergent and divergent profile? These questions are addressed in the section on **Nozzle Theory**.

The expulsion of the exhaust products through the nozzle at high velocity produces thrust, the "power" of a rocket motor. Thrust may be measured through fairly simple means, but how does one predict what the theoretical thrust will be for a given motor design? The sections that follow discuss the means to calculate thrust, as well as **Total Impulse** and **Specific Impulse**. The latter two parameters are the "yardsticks" to measure the useful "propulsive power" of a motor, and the "worth" of a specific propellant in this regard.

Anyone who has familiarity with rocket motors knows that they operate under high **Pressure**. It is this chamber pressure, produced by the combustion of propellant, that forces the exhaust out of the motor via the nozzle. Controlling this pressure is the key to more successful, and safer, rocket motor design and operation. What parameters determine the pressure, which can be looked upon quite realistically as a "controlled explosion" within the combustion chamber?

The final topic dealt with in the theory of rocket motors is the "**Corrections**" that must be considered in order to bridge the theoretical predictions to the true results that will be obtained in an "**Actual**" rocket motor. These corrections are a direct result of the topic first dealt with, that is, the simplified assumptions that make such an analysis at all possible.

The final two topics covered deal with one of a number of software tools that greatly eases the most difficult and laborious procedure in analysing the operation of a rocket motor -- the combustion process. This software exists in various forms, such as PROPEP, but also referred to as GUIPEP, NEWPEP, PEP (which are all essentially the same program), as well as CET. The acronyms are as follows: PEP = **P**ropellent **E**valuation **P**rogram; CET = **C**hemical **E**quilibrium with **T**ransport Properties. The meaning of the various (often cryptic) terms that are printed in the output file is explained, as well as how these results are derived. Additionally, a brief writeup describing the basic workings of the program is presented.

These programs have certain shortcomings that may not be of importance to large scale "professional" rocket motors and propellants, but may certainly have a significant impact on the predicted performance of amateur propellants. This topic is dealt with in the final section of the *Solid Rocket Motor Theory* Web Pages.

Next -- Basic Assumptions

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