



# PEAK OF FLIGHT

N E W S L E T T E R

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## *Terminology Of Model Rocketry*

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## Terminology of Model Rocketry Explained

By Ken Kosanke

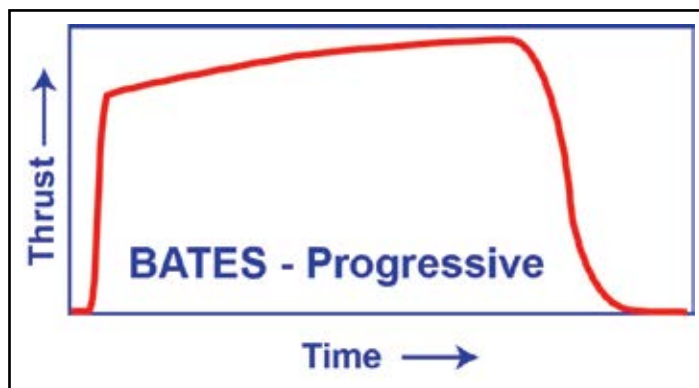
*{editor's note: Ken Kosanke has released a new product called the Encyclopedic Dictionary of Pyrotechnics. To promote this new reference dictionary, Ken has allowed us to reprint a few of the entries here that pertain to model rocketry. This thing is massive, and you'll want to get a copy for yourself. For information about this publication contact [Bonnie@JPyro.com](mailto:Bonnie@JPyro.com). Also, if you're ever thinking about writing for the Peak-of-Flight, this could be used as an idea generator. Take a topic, explain its importance, give background information and then take the subject even deeper.}*

### Types of Propellant Burning

The configuration of the propellant determines its mass burn rate as a function of time over the period of its burning. (For the most part this is a function of the amount of burning surface area as a function of time.) The amount of propellant gas being produced, and the resulting chamber pressure in a rocket motor is a function of mass burn rate. The mass burn rate (and burning surface area) can increase, remain approximately constant, or decrease as the propellant burns. Thus, for a rocket motor, its thrust will also increase, remain approximately constant, or decrease as the propellant burns. These types of propellant burning are described as progressive, neutral, and regressive, respectively; in addition, there is also erosive burning.

**Progressive Burning** – (Also progressive grain or progressive-burning grain) – Propellant burning where the reacting surface area increases during the interval of combustion. This is burning in which the mass burn rate increases with time.

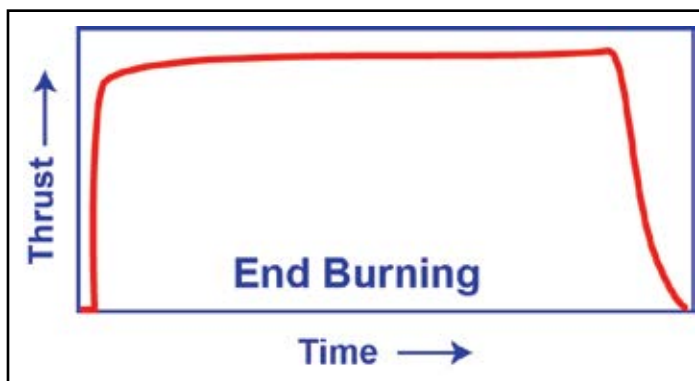
Progressive burning occurs when the thrust produced by a rocket motor increases over the burning period. A simple configuration that exhibits progressive burning is a case-bonded grain with a cylindrical core. As burning proceeds, the diameter of the core increases, causing the burning surface area to increase, resulting in increased gas production and thrust. One example of a progressive-burning grain is illustrated below. This is a typical thrust profile for a rocket motor with a BATES grain in which the individual grain segments are relatively long.



**Progressive Burning** - The thrust increases the longer the motor burns.

**Neutral Burning** – (Also neutral grain or neutral-burning grain) – Propellant burning where the reacting surface area remains approximately constant during the interval of combustion. In this type of burning, the mass burn rate remains approximately constant over time.

Neutral burning occurs when the thrust produced is approximately constant over the burning period. Many propellant grain geometries can be configured to approximate neutral burning. The thrust profile for a simple, end-burning propellant grain is illustrated below, where the slight increase in thrust (typically a temperature effect) is ignored.



**Neutral Burning** - The thrust stays constant throughout the motor's burn.

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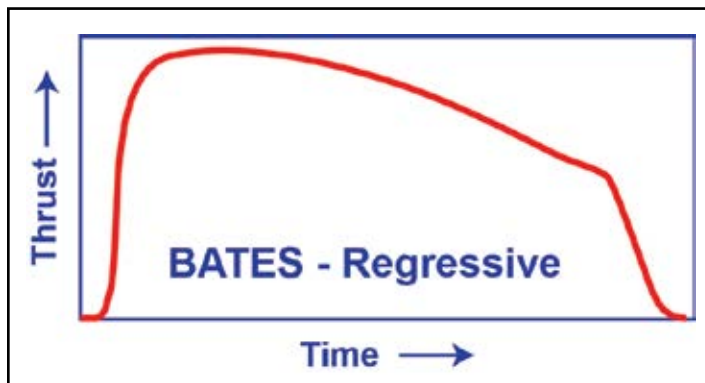


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## Terminology of Model Rocketry Explained

**Regressive Burning** – (Also degressive burning, regressive-propellant grain or regressive-burning grain) – Propellant burning where the reacting surface area decreases during the interval of combustion. In this type of burning, the mass burn rate decreases with time.

Regressive burning occurs when the thrust produced by a rocket motor decreases over the burning period. A regressive-burning grain shape is such that the total amount of burning surface area decreases as burning continues. An example of a configuration that has regressive burning is illustrated below. This is a typical thrust profile for a motor with a BATES grain in which the individual grain segments are relatively short.

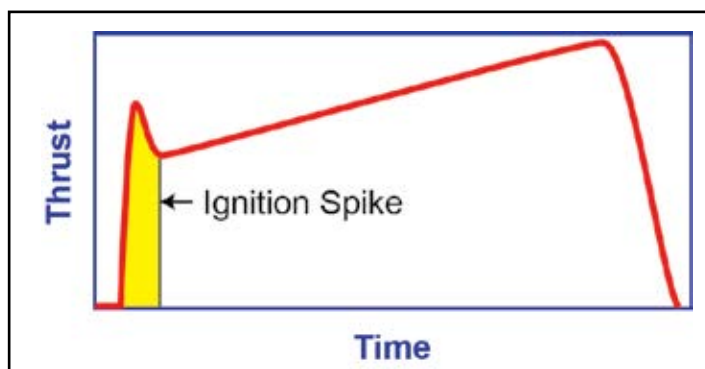


**Regressive Burning** - The thrust decreases throughout the motor's burn.

**Erosive Burning** – Propellant burning in which the normal burn rate is augmented or increased by high velocity gas moving past or directed against a burning surface. (There are other theories attempting to explain erosive burning, but this seems to be the simplest explanation for a first approximation.)

Erosive burning is a burning mode caused by en-

hanced thermal energy feedback when burning surfaces are in close proximity. Erosive burning can be caused by having a core diameter close to that of the nozzle diameter (i.e., a low port-to-throat ratio). Erosive burning can produce sonic or near sonic gas velocities and shock waves within the propellant core. Motor designers generally avoid erosive burning, but it can be used to increase the initial thrust for a so-called hot start. This manifests itself as the ignition spike often seen in model rocket motors. An example of this is illustrated below in the thrust profile of a core-burning motor.



**Erosive Burning** - An ignition spike in a composite motor is typically an example of Erosive Burning.

A severe type of erosive burning may occur because of physical properties of the grain. Propellants with poor physical properties may have chunks of propellant literally torn out of the grain surface and exposed to gas flow. These propellants should not be used in rocket motors because their performance is very difficult to control or predict.

### Catalyzed Propellant Burning

Burn catalysts can be used to increase the burn rate of

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propellants. Metal oxides are commonly used as catalysts in model and high-power rocket motors.

The use of some lead-based catalysts often produces especially useful deviations from the burn rates predicted by the Vieille equation as a function of pressure. The green curve (linear) in the illustration below is the relationship predicted by the Vieille equation and approximates that of a typical, non-catalyzed, double-based propellant. The red curve is typical of the pressure-dependent burn rate when using lead-based catalysts such as lead salicylate or lead stearate. Typical burn rate behavior for catalyzed propellants can be divided into three regions, discussed below.

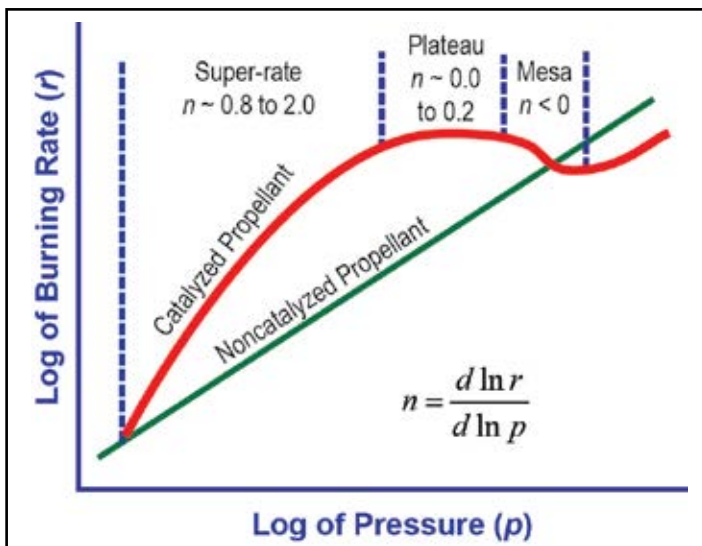


Illustration credit: Naminosuke Kubota

**Super-rate burning** – A catalyzed propellant's burning in a pressure region where its burn rate is substantially increased over its non-catalyzed rate. In this region, the burn rate pressure exponent (n) is increased over that for the non-catalyzed propellant.

**Plateau burning** – A catalyzed propellant's burning in a pressure region where its burn rate is mostly pressure independent, with the burn rate pressure exponent being near zero. In this region, burn rate is also mostly temperature independent. Accordingly, propellants (described as platonized) that are formulated to operate in this pressure region have especially reliable performance, independent of ambient conditions.

**Mesa burning** – A catalyzed propellant's burning in a region where its burn rate decreases significantly with increasing pressure. In this region, the burn rate pressure exponent (n) is negative.

## Nozzleless rocket motor

This is a rocket motor that does not use a distinct exhaust nozzle. Several benefits are provided by eliminating the nozzle; these include a reduction in the motor's weight, allowing more propellant in the same total motor volume, a simpler design and easier construction.

In many cases, the propellant grain may have only a simple core; while in others, the exhaust-end of the propellant grain's core is manufactured in the shape of the diver-

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gent portion of a conventional rocket nozzle. An example of this type of propellant grain is illustrated below in cross section.



### Nozzleless propellant

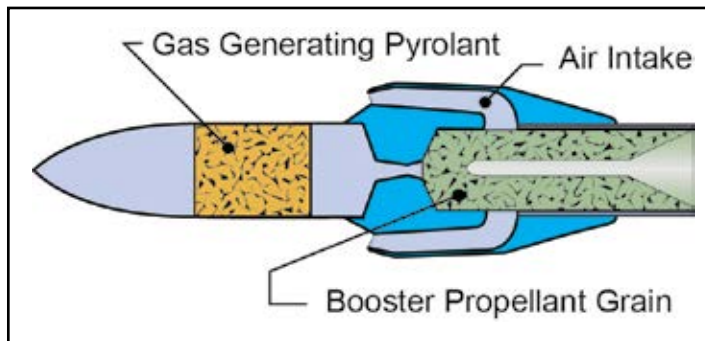
With careful design, a nearly constant thrust profile can be achieved. However, there are also disadvantages. The thrust coefficient and specific impulse (Isp) obtained from a nozzleless rocket will not be as high as that for a rocket motor with a conventional convergent-divergent nozzle. The Isp may be only approximately 80% that of a well-designed motor having a nozzle.

While simpler in design, it requires care in ensuring that the design provides critical flow at the exit plane without producing excessively high head-end pressures. An interesting variation of the nozzleless motor is the use of a nozzle made of another propellant that burns out at the same time as the main propellant.

A nozzleless rocket motor may be used as the booster motor of an integrated rocket ramjet or ducted rocket motor. In this case, the nozzleless rocket motor occupies what will be the ramburner. This is a simplification because the booster rocket motor and/or nozzle do not need to be ejected once it has completed its function. {How this might be configured is illustrated upper-right in cross section.}

### Rocket Motor Mount

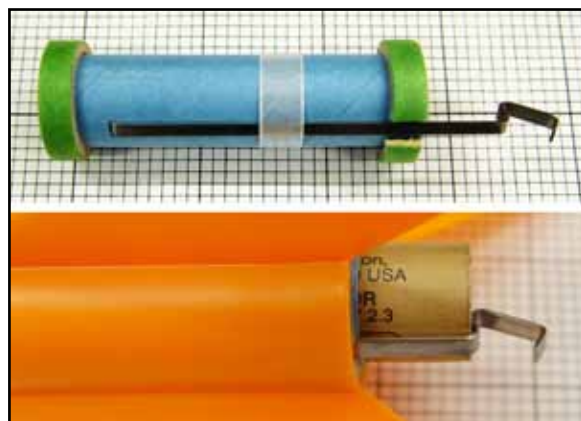
This is a construction used to position and hold a rocket motor securely in the rocket body (i.e., airframe).



**Ramburner rocket.** Illustration credit: Naminosuke Kubota.

The simplest form of a motor mount may be little more than the rocket's body tube itself; in contrast, for a rocket using a cluster of motors, the motor mount may be quite complex.

Typically, a model rocket motor mount will consist of a motor mount tube with a motor hook, possibly with spacers and a motor block. A completed model rocket motor mount is shown below (upper) and then with the motor mount (with a motor inserted) installed into the lower-finned section of a model rocket (lower).



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## Terminology of Model Rocketry Explained

High-power rocket motors often require more substantial methods of motor retention.

**Motor Mount Tube** – (Also engine tube) – A tube whose inside diameter is only very slightly larger than the rocket motor's outside diameter. A small rocket motor (A) having been installed into its motor mount tube (B) is shown below.



**Motor hook** – (Also engine hook) – Typically a flat piece of metal bent at both ends to hold the rocket motor in position once it has been inserted into the motor mount tube. An example of a motor hook (C) along side the rocket motor (A) for which it is intended is shown above-right.

The bottom end of the motor hook (C1) prevents the motor (A) from slipping out before launch or its being ejected rearward when the ejection charge ignites (and yet allows the easy insertion and removal of the motor before and after the rocket's flight). The top end of the motor hook



(C2) prevents the motor from slipping up into the rocket's body tube as the motor functions. For more powerful motors, a motor block may be used and may also back up the top end of the motor hook for extra strength, even with smaller motors.

**Motor block** – (Also engine block) – A thick-walled, short tube or bulkhead used to couple the rocket motor's thrust to the rocket's airframe. The motor block is firmly attached to the body tube of the rocket just ahead of the motor. As the motor functions, it presses against the motor block, transferring its force to the body of the rocket. When the motor has an ejection charge, used to deploy a recovery device, it is necessary that the motor block be designed to allow the ejection charge gases to pass through it. The

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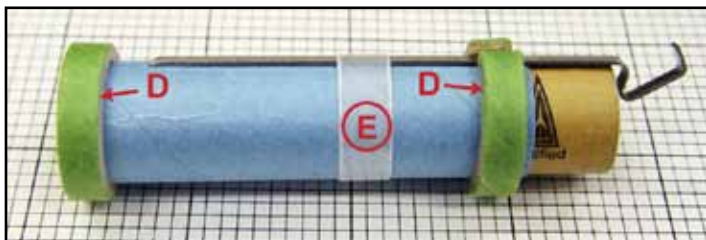
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motor block may be combined with an ejection baffle as a single unit.

**Motor-Mount Centering Ring** – (Also motor-mount adapter) – A device (often a short thick-walled tube) used to fill the gap between the outside diameter of the motor-mount tube and the inside diameter of the rocket's body tube. The two centering rings (D) for the assembled motor mount, and the securing band for the motor hook (E), are shown below.



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