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APOGEE PEAK OF FLIGHT NEWSLETTER

Hibachi Effect - Slow Roasted Rockets

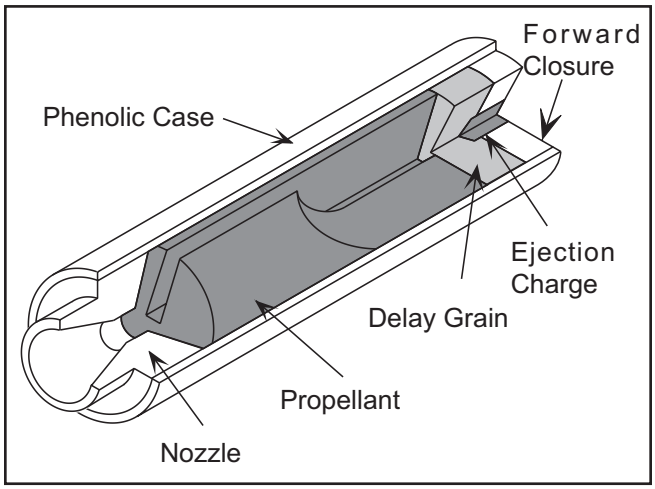
By Tim Van Milligan

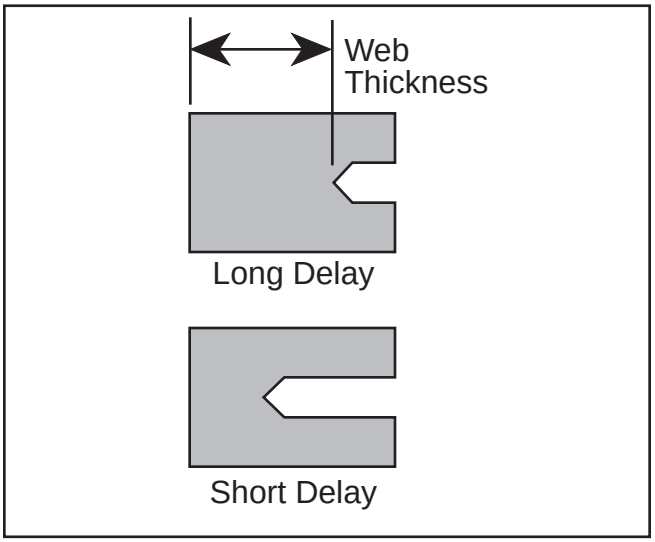
Every now and then, someone tells me: "Tim, the ejection charge of your composite motors is too hot. It scorched my rocket pretty good." I thought I'd try to explain why this happens, and what you can do about it in your rockets.

First, the problem is not caused by the ejection charge. It is the after-burning of the delay grain. It is sometimes called the "hibachi effect." Unfortunately, it is a by-product of insuring accurate delay times. I'll attempt to illustrate with words what happens.

In the Apogee single-use composite motors, the delay grains are short cylindrical slugs of slow burning material. They are located on the forward end of the propellant grain. If your familiar with reloadable motors, you probably handled a delay grain and are somewhat familiar with what they look like.

Delay grains are designed to be end-burners; which means they burn straight from one of the flat surfaces; in a linear fashion to the other side. This distance (the column length) it burns is called the "web thickness." The web thickness of the cylinder determines the burn time of the delay -- a long delay grain burns for a greater time than a short one.





In the small Apogee motors, the delay columns are pretty short (much smaller than a reloadable motor). This makes them more difficult to handle -- I've got big clumsy thumbs. So it helps in the assembly process to make them bigger (longer) than they need to be. The other advantage of making them longer is to allow for any irregularities in the burning rate of any particular batches of delay composition. The batches are always pretty good, but I like having some extra safety margins built into the motors.

Because the delay grains are longer than they need to be, a small hole is drilled into the top of the column to "set" the correct delay time for the particular motor. The depth of the hole is what determines the correct delay time. Because what it does is effectively shortens the web thickness of the delay

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grain. The web thickness, to repeat again, is the distance from the bottom burning surface, to the top burning surface. It determines the overall burning time of the delay. So a deep hole -- which makes for a thin web -- makes a short delay. While a shallow hole makes a long delay motor.

To find out how far to drill into the column to set the delay, you must physically assemble a motor, and ignite it to find the burning rate for that batch of delay composition. It is an expensive and time-consuming process. But it allows the delay times for that batch of motors to be extremely accurate -- because you can tweak the depth of the hole to set the exact delay.

The downside of this technique is that a second burn web is created. This is from the inside edge of the hole, outward to the side wall of the delay column. Burning of this web thickness doesn't start until the ejection charge has already fired.

So what happens is that after the ejection charge fires (clearing out the hole), the second web of delay composition begins burning. The hot gases flow out two ends of the motor; the nozzle, and the hole that the ejection charge went out. It is this hot gas of particles that causes the problems and roasts the inside of the tube.

You can tell If you ever had this problem, because the parachute is unharmed, but the tube is really scorched. You'll probably also see smoke that continues to billow out the top of the rocket after the parachute is deployed.

The hibachi effect has the greatest damage within one inch from the front of the motor. So I'd recommend reinforcing the tube in this area. One effective method is to apply a thin layer of epoxy along the walls of the tube in this area.

You might have also noticed that some motors have a worse hibachi effect than others. This is because the length of time that the gases enter the tube is determined by the web thickness. A smaller hole creates a bigger web thickness than a bigger hole. Similarly, a bigger diameter motor (meaning a bigger diameter grain cylinder) has a proportionally thicker web thickness. That is why more people write to me about the 18mm diameter C10 motor than they do the 13mm diameter C6 motor.

Plus, the amount of particles and heat coming out of the motor is determined by the length of the hole. The deeper the hole, the more gas that will cook the inside of your rocket. So a short delay motor will be hotter. (I get a more comments about a C10-4 than a C10-10).

To recap: The hibachi effect isn't a problem if you build your rockets with some extra reinforcement in front of the motor. It has nothing to do with the amount of ejection charge.

It is most pronounced in smaller -- minimum diameter models, because the internal volume of the tube means that the hot gases can't mix easily with air particles. And the heat coming out of the motor is closer to the external wall of the tube. Also, there is more heat from shorter delay motors than longer ones. Finally, smaller motors are more difficult to make, so unfortunately there isn't a lot that can be physically done to reduce the effect.

You don't need to fear the hibachi effect. Just use common sense when building your models, and you'll be fine.

About the Author:

Tim Van Milligan is the owner of Apogee Components (http://www.apogeerockets.com) and the curator of the rocketry education web site: http://www.apogeerockets.com/education. He is also the author of the books: "*Model Rocket Design and Construction*," "*69 Simple Science Fair Projects with Model Rockets: Aeronautics*" and publisher of the FREE e-zine newsletter about model rockets. You can subscribe to the e-zine at the Apogee Components web site, or sending an email to: ezine@apogeerockets.com with "SUBSCRIBE" as the subject line of the message.

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