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APOGEE

PEAK OF FLIGHT

NEWSLETTER

Maximum Simulation Accuracy for RockSim Part 2

By Tim Van Milligan

In last week's issue, I talked about the what thing in RockSim limits the simulation accuracy. The item I concentrated on was the factor known as the Coefficient-of-Drag.

But there are other items that might also limit the accuracy of the simulation results. As reader Len Fehskens points out in an email:

> *"This is true, but it assumes two things that are simply not true in practice: that the motor thrust time profile is perfectly known; and that it never varies from flight to flight.*
>
> *I suspect the variability in delivered total impulse and the shape of the thrust time profile easily swamps any uncertainty in C_d. Even if motors could be manufactured to arbitrary consistency, variations due to ambient temperature and pressure, and ignition variations, would introduce uncertainty."*

I agree with Len when we are talking about small motors; and in particular black powder propellant variety. Black powder is a really finicky propellant, and the way it is pressed into the motor has a lot of fluctuations. The grain density depends on a ton of factors that are difficult to control. So they can swing by pretty big margins.

The result of this is that there will be some fluctuations in the shape of the thrust curve, and the total impulse of the motor. Because of this, the simulations may be off some. In my experience, the smaller the motor, the more pronounced the effects become.

But it is hard to make this determination without test firing the motor prior to flight. At that point, the motor is used up, and the results may not be applicable to the next motor. The best we can hope for is that motors made in the same batch will be somewhat similar in performance.

As we get to bigger motors using composite propellants, however, I'm not so certain that they vary too much (although I'm sure I'll get some disagreement). I base my statement on experience. I've been making composite motors for a number of years now, and I'm impressed by how consistent they can be. They are manufactured much differently than black powder motors, so motors within the same batch should be much more consistent.

In small composite motors (like my B7), you have to watch out for voids (air pockets) in the propellant. These could have a major effect on the burn characteristic of the motor. In the worst case, it could cause the motor to come apart horizontally. My motors are made using the Aerotech propellant formulations. When Aerotech makes the propellant, they have a number of quality control safeguards in place to keep it consistent from batch to batch. Over the years, they have been continuously refining their methods to give better uniformity and quality. So I don't worry about voids and other irregularities in the propellant mix as I did in the past.

The method by which the motors are made is also pretty good from batch to batch. If the operator knows what he's doing (and the guys at Aerotech do), then the grain geometries are pretty good too. The grain geometry is what you really have to worry about, as it can really affect the thrust profile.

That still leaves ambient temperature and ignition variations. The propellant temperature at launch can really effect the total impulse delivered. One of the tricks I tell the guys on the international competition teams to do is to let the motors bake in the sun for a while. This warms up the propellant, and makes the motor burn hotter. The downside is that it may burn quicker. If it doesn't make the motor explode, you can get a significant bump in total impulse.

When mentioning ignition variations, Len is talking about

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transients that happen when the igniter fires. For example, we've all seen the motor chuff at one time or another. What happens is that the propellant catches on fire, but for some reason, it snuffs out. But because there is a lot of residual heat in the motor, it reignites. But since some of the propellant has burned off, and the grain geometry has changed slightly. This is going to change the thrust curve of the motor.

To see a video of a motor chuff, watch the static test of the F10 motor to the right. In this particular video, the motor makes a single, but brief chuff right at ignition. It was probably caused by the igniter not being far enough into the motor to insure proper heat transfer to the propellant.

There are actually a lot of other variations that could cause simulation inaccuracies. Here is some of them that I can think of:

* Inaccurate prediction of the atmospheric conditions
* Inaccurate launch rod angle - we all just eye-ball the launch angle. Have you ever seen anyone with a protractor?
* A gust of wind as the rocket clears the rod
* Misalignment of parts on the rocket; which might cause it to veer off course.

In conclusion, there are a lot of factors that might affect the simulation accuracy. If you build your rocket good, pick good launch conditions, and prepare diligently for the launch, you can minimize a lot of these effects. But I personally think the biggest unknown is the C_d of the rocket.

About the Author:

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