

Efficiency Problems

By Bob Smith

Most modelers (and electric modelers in particular) realise that the energy we use to power our model aircraft is limited. It is limited in several areas, but these limitations usually manifest themselves in terms of flight performance and duration. In electric flight we use an on-board battery to provide the energy to drive a system which results in the rotation of a propeller (or fan or rotor etc.) which in turn provides the thrust essential to flight.

One of the disadvantages of early electric model flight was that we had VERY limited amounts of energy available in our flight batteries, and we therefore had to be very careful not to waste any. Even now, with batteries, motors, etc. which are many times better than in the early days, it is good practice to minimise losses so far as is possible. The way in which most technical systems are assessed for energy waste (including your home for example) is by expressing the numerical values in a percentage figure which we normally refer to as "Efficiency". It then follows that the higher this value, the less are our losses, and since most of the energy losses are converted into heat, the cooler will our power-train (battery, ESC, motor etc.) operate.

It is possible to theoretically calculate the efficiency of the power-train, and you may have seen some examples of this type of calculation, but it is a very complex relationship to analyse. Even if you deal with each component in turn and then combine the results it is not a simple process. You have probably seen graphs which, for example, plot the efficiency of a motor against some other variable such as RPM or power input, with the suggestion that the motor should be set up so that it operates at the peak of the curve and hence at maximum efficiency.

There are certain advantages in doing so, such as the cool operation mentioned above, and you will certainly prolong the power-on duration of the system i.e. the flight time, but the disadvantage is that the model performance is likely to be disappointing, and this is the crux of the matter. To put it into common parlance, "Efficiency is cool man, but power is exciting!" Most of us fly model planes because we enjoy doing so, and the more exciting the flight, the more enjoyable it is (excluding crashes of course). Even those of us who do not take part in competitions and are not trying to climb higher or fly faster (or even, in some cases, fly longer) than others still want our models to perform with authority. We may not want to fly flat-out all of the time, but we usually want to be able to do so when the occasion arises.

Power to the People.

Remember that efficiency curve? What happens if we change the parameters so that we move along the curve and away from the peak? We already know that operating at the peak will only provide us with moderate power so there is no point in moving to the left of the peak as this will reduce the power even further as well as reducing the efficiency. If, however, we move to the right then we are increasing power and RPM, and the model is starting to fly with authority. We are operating at a reduced efficiency (which generally means more losses in the form of heat and the components in the power train will get hotter) but the magnitude of the reduction in efficiency depends on the shape of the curve. If the system has a steep efficiency curve (typical for a brushed motor) the reduction can be significant. In extreme cases the reduction in efficiency can be so large that you are using more power but getting less performance.

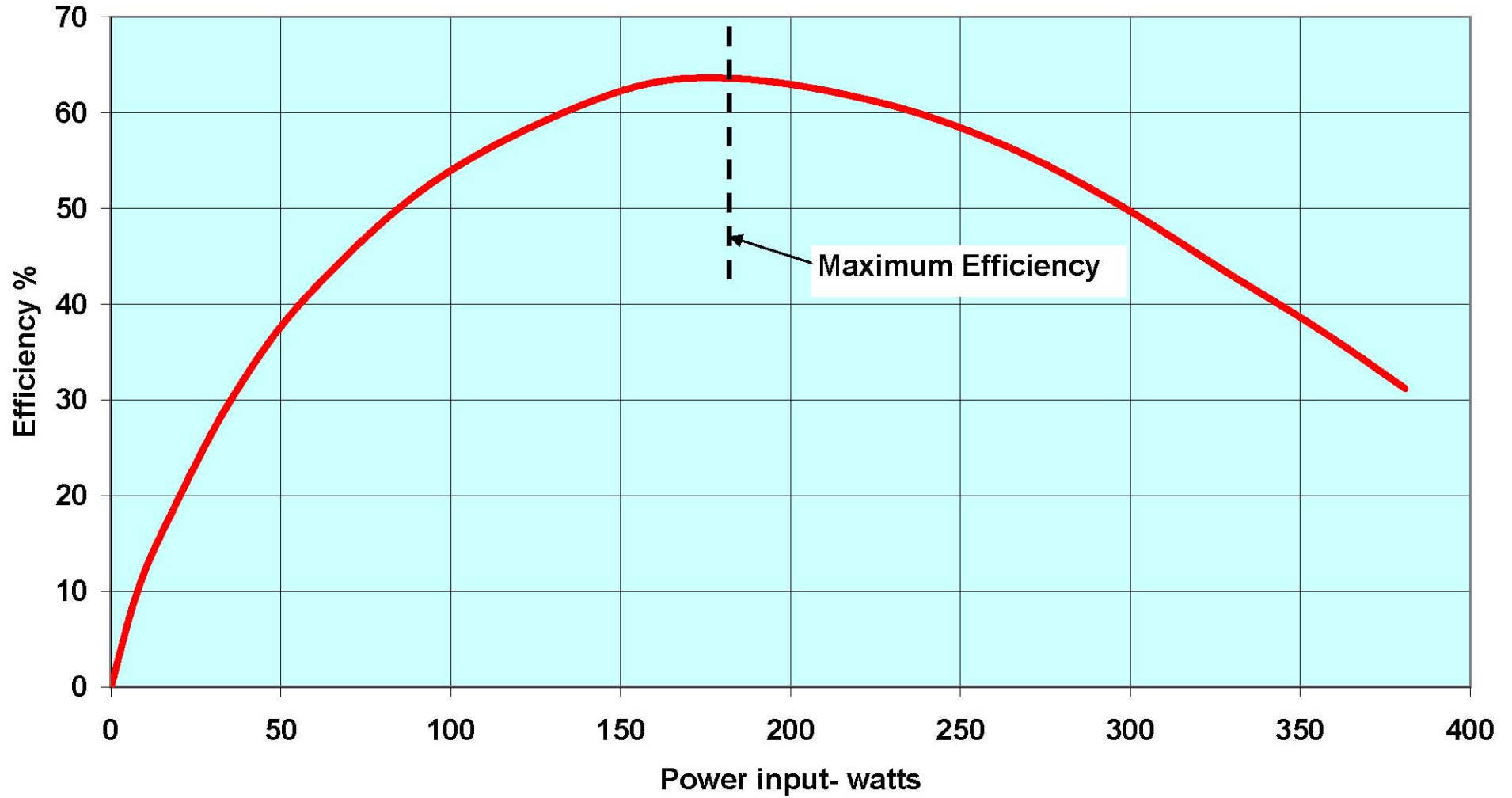
If the efficiency curve is flat (typical for a brushless motor) then the loss of efficiency can be so small that it can be more or less ignored. Now you know one of the reasons why brushless motors are more flexible than brushed (i.e. they will operate efficiently over a much wider range of RPM), and also why they tend to run cooler at the same power levels. You should still arrange for a flow of cooling air over the power train components, high temperatures can be a killer and should be avoided if possible. Of course the situation is complicated by the fact that the electro-mechanical design of brushless motors means that they have higher efficiencies than brushed motors in general, but the principle still applies.

I know, I know, principles have a habit of letting you down on the landing approach, but that's where good pilots replace principles with reflexes (better known as experience for us more senior citizens). I did not set out here to give a lecture in electric power train theory (stand up that person at the back who laughed out loud!) but just to plant a few seeds regarding the dissemination of knowledge. You never know just when these might come in handy.

Photo Captions

- 1. A typical curve of efficiency V power.**
- 2. Comparison of efficiency curves for brushed and brushless motors.**

Graph 1 - Typical Motor Efficiency Curve



Graph 2 - Efficiency Curves Brushed and Brushless

