Scale Propeller Size

Is bigger better? Well, if we are talking about propellers on an engine (not a motor) then maybe not! Like many scale builders, I find a point of frustration is that my flying propeller diameter is not true to scale. We find them looking too small. Let's explore some of the metrics and science about why this is so.

Many aircraft designs, especially those with radial cowls, make it apparent that the model's flying propeller is smaller than what we see in our photo documentation. As our models get larger in scale this discrepancy diminishes. Not everything in our modeling world can adhere to the scale that we select. Things like air density, combustion rates and Reynolds numbers refuse to adhere our scale selection.

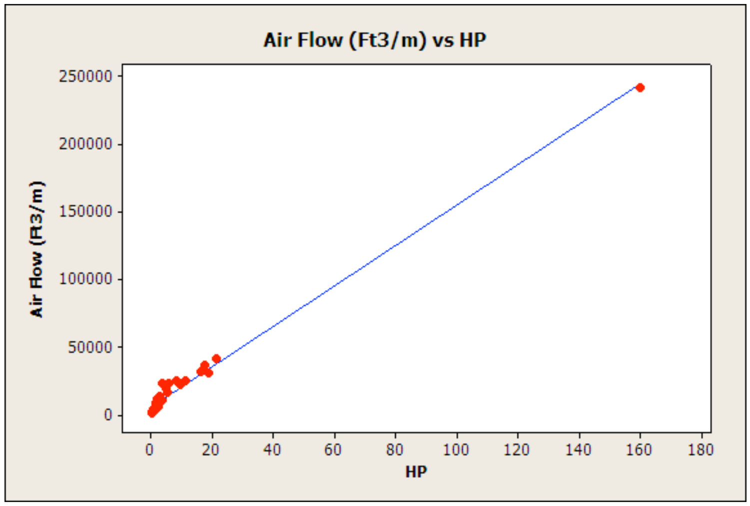
I collected some data from model engine specifications including their power, recommended propeller diameter, pitch and rpm. From this data, the air flow that is generated by each engine can be calculated:

$$\text{Air Flow} = \pi\,(D/2)^2 \times \text{Pitch} \times \text{RPM}$$

Where:

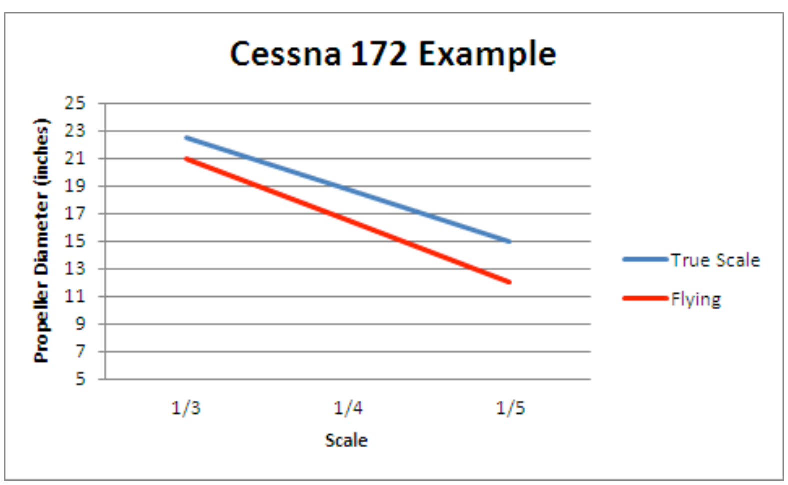
D = Prop Diameter
Pitch = the prop pitch (= distance traveled in 1 revolution)

As scientist, I am always looking for trends. Plotting the air flow versus horse power you can see a linear trend. I extrapolated it to include the same information for a full scale Cessna 172 and guess what? The data fits a straight line quite nicely even to include a full-scale machine.



Several on-line resources suggest that the piston speed is limited, independent of size of the engine at about 3700 ft/min, for non-racing tuned engines. If this is so, then the smaller stroke length of a smaller engine would allow it to complete the trip down and back through the cylinder in less time than in a larger engine with the same linear piston speed. Hence a quicker cycle (time-wise) and a faster RPM result. Because the propeller is rotating faster than its scale counterpart, we need less of it. This forces the size of the propeller to reduce faster than the linear scale factor would predict. A natural question would be why not just lower the pitch and leave the diameter alone? I believe the answer is in aerodynamics. This would force the propeller to have a higher aspect ratio and become less effective (too much drag for the thrust produced). You may have experienced the unhappy performance of an engine that is "over-propped". Our small engines don't like spinning propellers larger than they are designed to use.

There is some compensation in that many models carry more than scale horse power. With the agreeable power-to-weight ratios of our modern model engines, this is often done. As such, we can carry a bigger (diameter) propeller, but still fall short of the correct scale size. I plotted the correct propeller size along with the flying propeller sized for a range of Cessna 172 scales. You can see the difference become more extreme as the model gets smaller.



These rules apply only to internal combustion engines. Electric motors, on the other hand, are not bound by things such as stroke length, piston speed and combustion rates. They are able to carry the load of a scale propeller quite well.

1:1 scale Piper Tri-pacer with properly sized propeller.