AAE 451
MATLAB Software for Preliminary Design of a Propulsion System for and Electric Powered Aircraft

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Refer to the WWW site
http://roger.ecn.purdue.edu/~andrisan/Courses/AAE451_Fall_2001/PropulsionAnal/Propulsion.html

What follows if the output from MATLAB running the script found in file http://roger.ecn.purdue.edu/~andrisan/Courses/AAE451_Fall_2001/PropulsionAnal/Main_System_Design.m

>>> Start of script. <<<

```
% Script to design an end-to-end propulsion system for an
% electric-powered propeller-driven aircraft.
% Given:
%   drag polar,
%   aircraft weight, air density,
%   pitch to diameter ratio of the prop and prop data,
%   motor constants for a particular motor.
%
% Find:
%   speed for maximum endurance,
%   propeller diameter,
%   gear ratio,
%   voltage at which to operate the motor,
%   battery sizes to acheive the desited battery voltage,
%   endurance for single strand and dual strand batteries,
%   for an aircraft flying straight and level.
%
% PHASE 1: AIRCRAFT SUBSYSTEM
%
% This data is roughly for the Boiler Express Aircraft
CD0=.0240; % drag coefficient when CL=0.
A=9; % aspect ratio span squared divided by reference area
e=.75; % Oswalds efficiency factor
V=10:1:40; % velocity in ft/sec
rho=.002377; % air density in slugs/ft^3
W= 10.25;    % aircraft weight in pounds (lbf)
S=   13.5;   % wing area
echo off
```

Minimum power of 18.1174 ft-lbf/sec is achieved at a speed of 22.7378 ft/sec.
At what speed would you like to operate the aircraft? Default=Ve (speed for min. power required) >>>>30

AIRCRAFT SUMMARY
  You are asking the Propeller to deliver 20.6899 ft-lbf/sec of power at a speed of 30 ft/sec.
The operating efficiency of your aircraft is 0.87566

```
Data for hypothetical propeler with tau=p/D=.631
tau=.631;
J = [     0    0.1000    0.2000    0.3000    0.4000    0.5000    0.6000 0.7000    0.8000];
CT =[0.0933    0.0867    0.0773    0.0667    0.0553    0.0427    0.0293 0.0160    0.0013];
CP =[0.0400    0.0393    0.0387    0.0367    0.0333    0.0293    0.0227 0.0147    0.0027];
echo off
```

PRELIMINARY PROPELLER ANALYSIS
  If the propeller of diameter 23.8826 inches spins at 1507.3725 rpm,
  the propeller efficiency will be maximum at Eta*= 0.77445,
  at the airspeed of 30 ft/sec,
  and the prop will be generating the required 20.6899 ft-lbf/sec of power.

What propeller diameter in inches do you want to use? Default=D* >>>>12

PROPELLER SUMMARY
A propeller of 12 inches
spinning at 4355.2232 RPM at a translational speed of 30 ft/sec
produces an output power of 20.6899 ft-lbf/sec,
has an efficiency of 0.67283,
and absorbes an input power of 29.7892 ft-lbf/sec or 0.054162 HP.
You have selected a 12x7.572 prop.

Which of the 8 available motors do you want to use? Default=1 >>>>3

You have selected the motor 3, the Astro Cobalt-15 Sport Motor #615 motor.

PRELIMINARY MOTOR AND GEARBOX ANALYSIS
The output power of this motor has to be 42.0772 watts or 0.056426 Hp.
For maximum motor efficiency this motor must be provided with 5.0157 input volts.
Under these conditions, the input current will be 12.0574 amperes
and the input power will be 60.4759 watts.
The motor shaft will be spinning at 6225.3397 RPM.
The motor efficiency will be 0.69577.
To match this motor to the propeller requires an optimal gear box ratio (m*) of 1.4294.

What gear box ratio (m) do you want to use? Default=m* >>>>2

You have selected the gear ratio 2.

At this point the motor RPM and output power of the motor are specified, so motor inputs can be found.
Motor RPM= 8710.4463 RPM and motor output power= 42.0772 watts

MOTOR AND GEAR BOX DESIGN SUMMARY
The output power of this motor is 42.0772 watts or 0.056426 Hp.
The motor input voltage is 6.4878 volts.
The motor input current is 9.188 amperes.
and the motor input power is 59.6097 watts.
The electric motor shaft is spinning at 8710.4463 RPM.
The gear box output shaft is spinning at 4355.2232 RPM.
The gear box ratio (m) is 2.
The motor efficiency is 0.70588.
The gear box efficiency is 0.96.

COMMENTS ON THE MOTOR OPERATING CONDITIONS
You are asking a motor with nominal horsepower of 0.26647 to produce a horsepower of 0.056426.
Since the produced power is less than the nominal power you are underdriving the motor.
Consider a smaller motor!

BATTERY SUBSYSTEM
The battery pack will be made up of individual cells with the following properties:
1.2 volts per cell, and 3000 milliamp hours per cell, and 57.24 grams per cell.

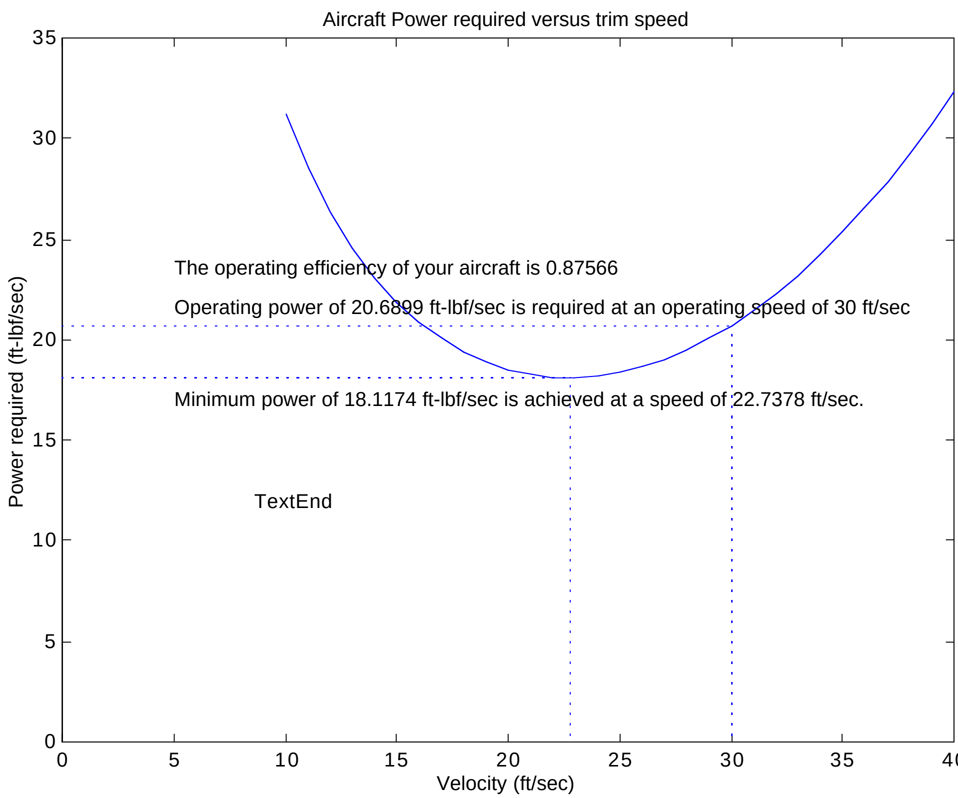
A single string battery pack designed for the above conditions will have the following properties.
6 total cells, arranged in a 1x6 array.
producing 7.2 volts, and giving a predicted endurance of 21.7414 minutes,
and weighing 0.75706 lbf.

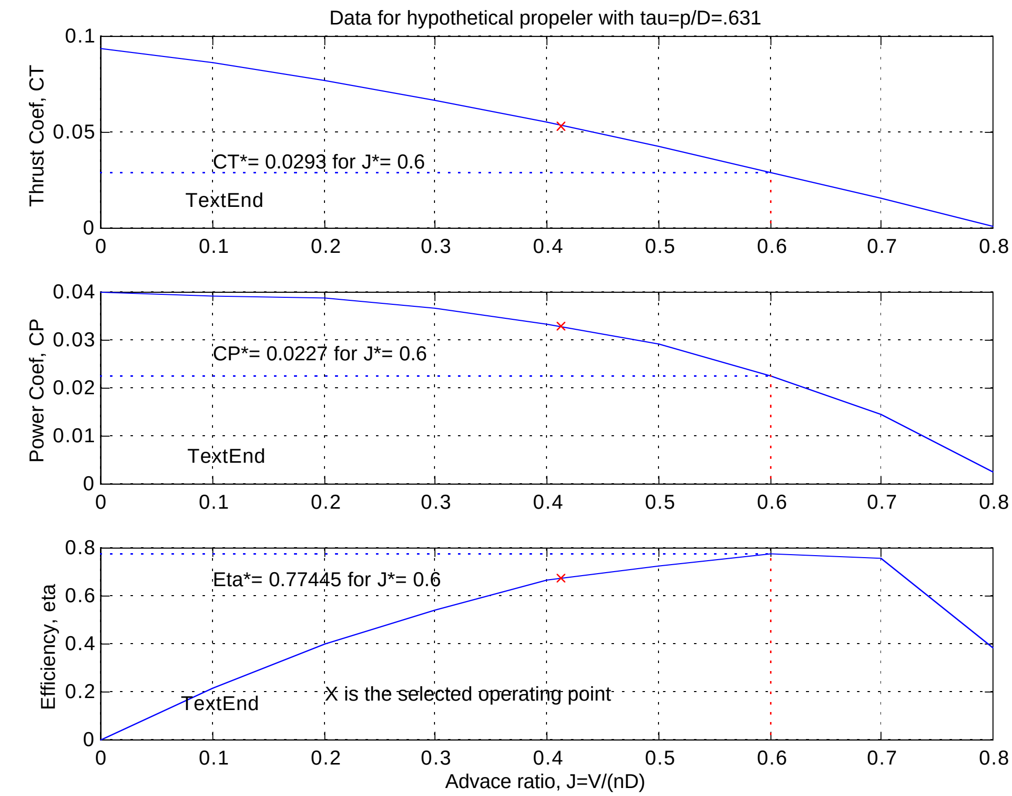
A dual string battery pack designed for the above conditions will have the following properties.
12 total cells, arranged in a 2x6 array.
producing 7.2 volts, and giving a predicted endurance of 43.4828 minutes
and weighing 1.5141 lbf.

These endurance numbers do not include energy spent in other mission phases, (e.g., take off, climb, turning).

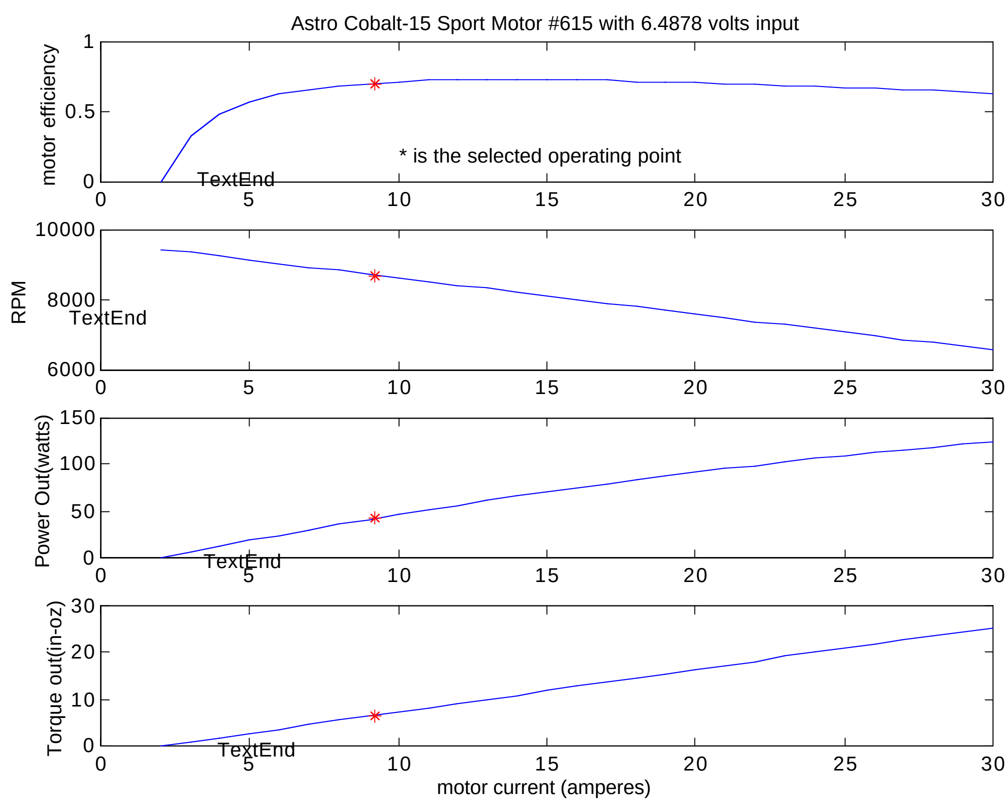
SYSTEM SUMMARY
The overall efficiency of your design in the product of the individual subsystem efficiencies
The overall efficiency is 0.39925.

What follows are the three figures generated by this script.





Data for hypothetical propeler with tau=p/D=.631
Thrust Coef, CT
CT*= 0.0293 for J*= 0.6
TextEnd
Power Coef, CP
CP*= 0.0227 for J*= 0.6
TextEnd
Efficiency, eta
Eta*= 0.77445 for J*= 0.6
X is the selected operating point
TextEnd
Advace ratio, J=V/(nD)



Astro Cobalt-15 Sport Motor #615 with 6.4878 volts input
motor efficiency
* is the selected operating point
TextEnd
RPM
TextEnd
Power Out(watts)
TextEnd
Torque out(in-oz)
TextEnd
motor current (amperes)