Preliminary Investigations of Aeroelastic Panel Vibration with respect to Performance Boost of Airplane Wings

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The authors of the website www.deturbulator.org have presented phenomena that may be very important with respect to increasing the efficiency of wind turbine blades and aircraft wings. However, said authors have no “credible” explanation of what the underlying physics is. Several dramatic cases of performance boost have been documented during the past decade; they are published at said website.

Since ANKER-ZEMER Engineering (AZE) have a unique analysis tool developed by Jari Hyvärinen et al (for reference see www.linflow.com) at our disposal and also have extensive experience within aerodynamics and aerelastics, AZE were contacted by said authors (the originators of the deturbulator) and asked for the possibility to help. There has been a vivid correspondence during the past 5-6 years and also visits to the USA, the originators have lately distributed deturbulator technology to external researcher, so that external researcher are free to study the phenomena independently of the originators.

With this background, ANKER-ZEMER Engineering AB has initiated an in-house project with the goal to answer questions related to the deturbulator, that can be considered a “thin panel system”. Some of the questions we have raised are

- What makes the thin panel work and dramatically improve the performance of an aircraft ?
- Why is the effect so strongly dependent on speed ?
- How can the effect be made independent of speed (is it possible at all) ?
- Is the effect present at all wing profiles and at all wing stiffnesses ?
- Is there an optimum wing stiffness ?
- Is there an optimum wing profile ?
- Will the thin panel system work with any gas or fluid ?

It was clear to us that the best way to find answers to the questions above (and other questions) would be to build on the work performed by the deturbulator originators.

First Flight Tests 2011

A flight test program was started in early summer 2011. The concept was to get some data and compare them with numerical simulations to see if there would be some agreement. For that purpose, a flight data acquisition system was established. The test flight data acquisition system's main components are:

- National Instrument DAQ system.
- National Instrument Signal Express Software
- Mini PC and IPAD 2 as user interface
- WiFi mini Router.
- Sensors: Surface Microphone and pressure sensor.

Displayed is experimental hardware used.

Sensor Installation

GoPro HD camera for video monitoring.

Standard Cirrus Glider used in flight tests

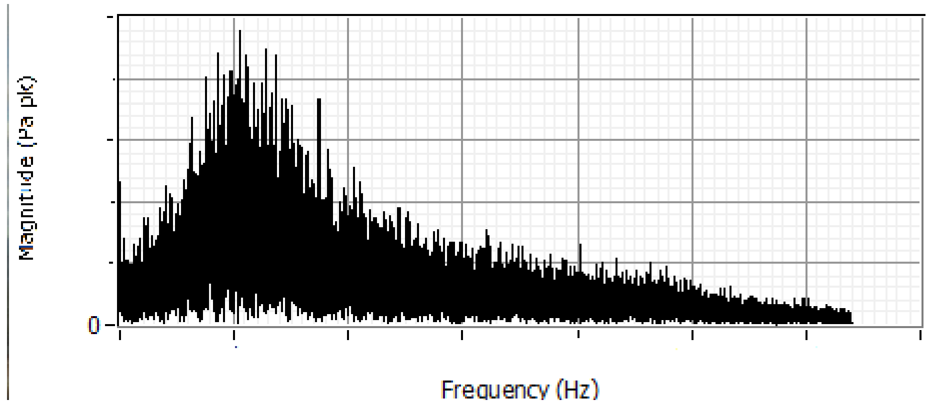
First Flight Test Data

The first sets of test data is currently being investigated. Several configurations have been tested. Example on wing configurations that have been studied are a) Flight with clean wing configuration and b) Flight with wing having leading edge tape.

Flight conditions ranging from 80 km/h to 150 km/h have been investigated. As an example on results from these tests, results for the above described configurations are presented here for flight speed of 100 km/h.

a) Flight with clean wing configuration

Clean wing spectrum:

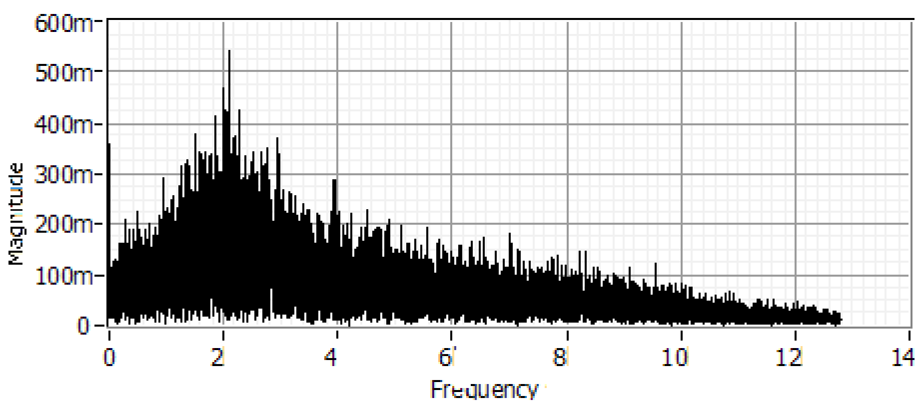


Pressure a.f.o Frequency for clean wing.

Several flights have been completed with the clean wing for the purpose of evaluating how sensitive the spectrum was to change in external conditions. These data sets are still being studied (as time permits).

b) Flight with wing having leading edge tape

Spectrum for wing having leading edge tape. The installed tape is very thin, hence it does not trip the laminar boundary layer flow to a turbulent boundary layer.

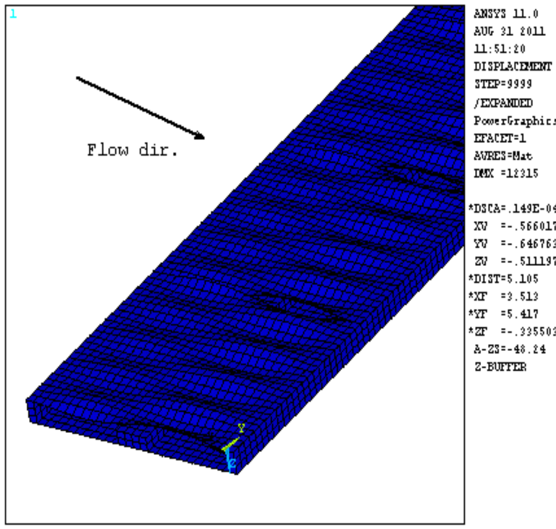


Pressure a.f.o Frequency for wing.with 60 um thick leading edge tape installed.

The above diagram shows that the spectrum in this case has a strong peak at 2 units of frequency; this peak is stronger as for the clean wing. Noteworthy is also that this peak has a larger gradient on both sides of the peak than is the case for the clean wing spectrum.

Numerical Aeroelastic Analysis

Numerical aeroelastic analysis is essential to the study of the flow field over the wing and to understand the phenomena that are present. It is therefore of vital importance to demonstrate that test data can be duplicated numerically. The aeroelastic analyzes that have been completed so far for the elastic membrane installation that is excited my sources from the leading edge tape. The elastic panel (deturbulator) installed show modes having frequencies close to the 2 unit frequency discussed in previous section of this brief. These modes are according to the calculations very sensitive to excitation.



Numerically predicted aeroelastic surface panel vibration
at flow speed (corresponding to approx. 100 [km/h] flight speed)

Evidence that the numerically calculated mode type is of the same type that is actually excited in true flight can be seen when studying the photo below. This photo has been taken with the HD camera monitoring the modes of vibration appearing during flight. When the airplane is not in the air, the panel is perfectly flat.

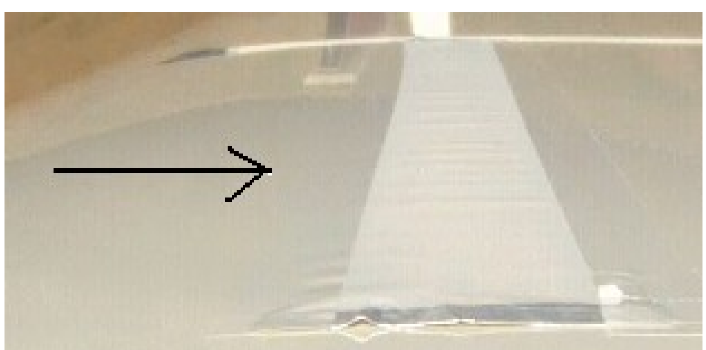


Photo of vibration shape at about 100 kph (52 knots).
Arrow in picture shows flow direction

Comments, Conclusions, and Outlook

This brief has been made for those interested in the project, we plan to publicize our finding when more flight data becomes available. One should also keep in mind that the project is at its beginning, much work remains to be done.

However, what we have seen so far looks very promising (see the comparison under "Numerical Aeroelastic Analysis" above). It is very comforting that the results from test and numerical analysis agree so well at "the first shot" and without any tricks applied. It can be concluded that the project should be continued at a greater pace.

We hope that we can find funding so that the project can be performed as a full time project (and not as a project run in our spare time). In any case, the results are so promising that we will put all available resources into it.