

VIPER

Very high PERFORMANCE valve for flow control separation

State of the art – Background

The VIPER (Valve high PERformances for flow control separation in aircraft) Cleansky project aims at developing, manufacturing and testing piezoelectric-based high speed valves to accurately control the air flow (Active Flow Control Actuators) on transport and business aircrafts. The objective is to delay the separation of the boundary layer in flows over airfoils which results in drag reduction.

The project is coordinated by Cedrat Technologies and performed with the help of Onera DMS, acting as subcontractor and Fraunhofer ENAS, acting as topic manager. CEDRAT TECHNOLOGIES (CTEC) & ONERA DMS have been working together for over 4 years in a close partnership over high-performance pulsed jets valves based on APA® (Amplified piezoelectric Actuators). The main advantages of using piezoelectric technology for this type of valves lie in the controllability and fast-response time allowed.

Objectives

Increasing concern on the part of the government and industry resulted in creation of the ambitious Clean Sky research partnership to develop technologies that reduce the environmental impact of air transport. Wings are an excellent target for such programmes because smooth laminar flow contributes to drag reduction that in turn reduces noise and vibration as well as fuel consumption and emissions related to efforts to steady the plane.

Flow separation refers to a sort of detachment of the air flow from the aircraft and it creates vortices and eddies that can increase drag. The EU is funding the project 'Valve high performances for flow control separation in aircraft' (http://www.cedrat-technologies.com/fileadmin/user_upload/cedrat_groupe/Technologies/Actuators/Electro%20fluidic%20devices/Viper/VIPER_fiche-techno_v2.pdf (VIPER)) to minimise flow separation with electrical systems. This will maintain more favourable aerodynamic conditions over wing surfaces and will support more-electric aircraft with fewer hydraulic and pneumatic systems.

The targeted performances of the valve (ejection speed and mass flow) are beyond the state of the art:

- Air exit velocity : 340m/s
- Air linear mass flow : 425 g/s/m
- Actuation frequency range : 0 - 500Hz

Description of work

VIPER is developing an active flow control device to produce a quasi-sonic (500 Hz) pulsed jet of air to increase lift and decrease drag. It is the first time that such high frequencies of pulsed air will be investigated. High-lift capability will reduce required thrust during take-off and landing, reducing noise and emissions in the vicinity of airports. Increased lift and decreased drag translate into lower fuel consumption and fewer emissions.

The technology exploits amplified piezoelectric actuators. Piezoelectric materials convert a pressure into a voltage or vice versa. Amplified piezoelectric actuators are specialised piezoelectric actuators that essentially amplify the displacement relative to the voltage of traditional piezoelectric actuators.

In the first year, the team considered several configurations to meet the specifications and chose the most promising valve configuration. Some composite actuators have been manufactured and tested, with results comprising the subject of a publication for the Actuator 2014 International Conference and Exhibition on New Actuators and Drive Systems in Bremen, Germany. The following years have been used to develop an engineering model of VIPER valve with its electronics for driving and control, and to test it as regard electromechanical and flow performances. Finally the results are in line with the objectives.

VIPER's active flow control device will significantly decrease noise and emissions associated with air travel, providing important relief from the pressures faced by the public and the planet. Customers have demonstrated great enthusiasm for the actuator technology, which could have widespread application in addition to the current one.



Results

a) Timeline & main milestones

The duration of the VIPER project is 48 months. It started in November 2012 and ends in April 2016.

b) Results

In the continuously blowing case first, the homogeneity of the flow at the slot exit has been assessed and showed to be very good.

Moreover, it was shown that for a mass flow rate around 37g/s, it is possible to reach a sonic regime almost all along the slot.

Then in the pulsed blowing case, an inlet relative pressure equal to 2 bars upstream of the valve openings enables to get the same mass flow rate (in amplitude), therefore insuring a sonic exit flow for this pressure setting value.

It was also shown that in these conditions, the frequency response is quite flat over the all bandwidth tested.

After testing, the experimental performances of VIPER can be summarized in the following table.

Specification	Value	Unit
Slot dimensions	1*80	mm ²
Pitch angle of the slot exit	< 30°	°
Exit peak velocities	1	Mach
Exit peak mass flow	462	g/s/m
Actuation Max Frequency	500	Hz
Duty Cycle	50-75	%
Volume	45.4*79.6*208.9	mm ³
Efficiency (Flow + Actuator)	37.5	%

Table 1 - VIPER experimental performances synthesis.

c) Dissemination / exploitation of results

ACTUATOR 2014 : *Compact, Lightweight, and Efficient Piezo Actuation Chain for Aeronautical Applications* - A. Kras, M. Brahim, T. Porchez, C. Bouchet, F. Claeysen

http://www.cedrat-technologies.com/fileadmin/user_upload/cedrat_groupe/Services/FOCUS/Piezo_Actuation_Chain.pdf

New high power amplifiers SA75 products (being finished): <http://www.cedrat-technologies.com/en/mechatronic-products/driving-electronics/switching-power-amplifiers.html>

Aerodays 2015, London, 20-23rd October 2015

Aerospace Techdays 2016 : Lyon 7/8th 2016

ACTUATOR 2016 : *Pulsed air high-performance valves improve aerodynamic flow over airplane wings* – C. Bouchet, M. Fournier, F. Claeysen, F. Ternoy, J. Dandois, A. Choffat.
http://www.cedrat-technologies.com/fileadmin/user_upload/CTEC/Publications/Publications/2016/Pulsed_Air_High_Performances_Valves_Improve_Aerodynamic_Flow_Over_Airplane_Wings.pdf

An application of the know-how gain in ASPIC project is found in the development of Synthetic Jet Actuators (SJA), performed in the ASPIC project : http://www.cedrat-technologies.com/fileadmin/user_upload/CTEC/Services/Engineering/Projects/ASPIC/ASPIC.pdf

d) Communication

VIPER Project presentation On CTEC website:
http://www.cedrat-technologies.com/fileadmin/user_upload/cedrat_groupe/Technologies/Actuators/Electro%20fluidic%20devices/Viper/VIPER_fiche-techno_v2.pdf

Best Wishes 2014 Letter:
<http://ymlp.com/zbyOEj>

See also c)

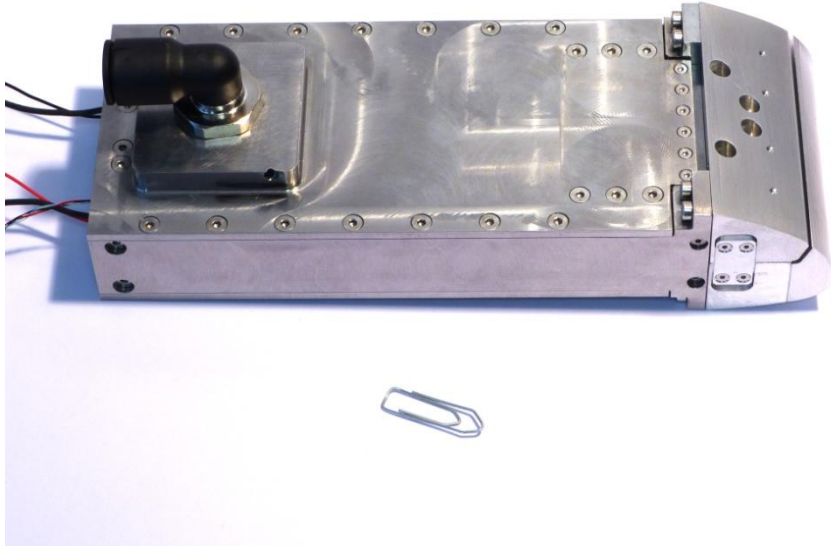


Figure 2 : VIPER pulsed Jet actuator

Project Summary

Acronym: VIPER

Name of proposal: Valve high PERformances for flow control separation in aircraft

Involved ITD: Smart Fixed Wing Aircraft ITD

Grant Agreement: 323540

Instrument: Clean Sky

Total Cost: 399 875€

Clean Sky contribution: 299 906 €

Call: SP1-JTI-CS-2012-01

Starting date: 01/11/12

Ending date: 30/04/16

Duration: 48 months

Coordinator contact details: F.Claeyssen (CEO) Cedrat Technologies

Project Officer: Sebastien DUBOIS (CSJU)
sebastien.dubois@cleansky.eu

Participating members: C.Bouchet (project Manager) Cedrat Technologies
F.Ternoy (DMS manager) ONERA Lille
A. Choffat (DMS engineer) ONERA Lille

