



Α.Π. : 41807
Αθήνα, 25/7/19

ΚΟΣΜΗΤΟΡΑΣ

Προς τα Μέλη ΔΕΠ της
Σχολής Μηχ/γων
Μηχ/κών

ΠΡΟΣΚΛΗΣΗ

Σας προσκαλούμε στην παρουσίαση της Διδακτορικής Διατριβής του Υ.Δ. κ. **Καπέλλου Χρήστου**, διπλωματούχου Μηχανολόγου Μηχανικού του ΕΜΠ, την οποία εκπόνησε στον Τομέα **Ρευστών**. Η παρουσίαση θα πραγματοποιηθεί τη Δευτέρα 7 Οκτωβρίου 2019, ώρα 15:00 το μεσημέρι στην αίθουσα Τηλεκπαίδευσης στο κτίριο της Κεντρικής Βιβλιοθήκης ΕΜΠ - Πολυτεχνειούπολη Ζωγράφου. Ο ελληνικός τίτλος της Διδακτορικής Διατριβής είναι ο εξής :

«Η ΣΥΝΕΧΗΣ ΣΥΖΥΓΗΣ ΜΕΘΟΔΟΣ ΓΙΑ ΤΗΝ ΑΕΡΑΚΟΥΣΤΙΚΗ
ΒΕΛΤΙΣΤΟΠΟΙΗΣΗ ΜΟΡΦΗΣ ΣΤΗΝ ΑΥΤΟΚΙΝΗΤΟΒΙΟΜΗΧΑΝΙΑ»

και ο Αγγλικός Τίτλος ως εξής:

«THE CONTINUOUS ADJOINT METHOD FOR AUTOMOTIVE
AEROACOUSTIC SHAPE OPTIMIZATION»

Ο Κοσμήτορας της Σχολής

N. Μαρμαράς
Καθηγητής Ε.Μ.Π

the following order: the adjoint wave equation is solved first by considering a monopole source term at the location where the objective function is defined. The propagation of the adjoint interior pressure in the cabin is computed and used thereupon as a source term for the adjoint bending wave equation, solved at the window. The resulting adjoint deflection is then used in the expression of the sensitivity derivative term on the window. This term is used later to couple the interior and exterior domains and additional emphasis is laid upon its discretization. A hand-differentiated expression is proposed to ensure its accuracy. The developed method is verified against Finite Differences and, then, is applied to the cabin of the SAE body to minimize interior noise using synthetic pressure waves as a load on the window.

The continuous adjoint method for the flow-induced sound radiation with the Kirchhoff Integral is proposed where the differentiated Kirchhoff Integral is used to compute the boundary condition of the adjoint velocity on the noise radiating (Kirchhoff) surface and, then, the unsteady adjoint Navier-Stokes equations are solved backwards in time. It should be noted that the time window where the simulation is performed and the one over which the objective function is evaluated do not coincide. This is reflected on the adjoint boundary conditions along the body and the time integration of the sensitivity derivatives. Furthermore, to ensure the consistency of the continuous adjoint-based gradients, grid sensitivities are taken into account which gives rise to the adjoint grid displacement equations along with an additional term in the sensitivity derivatives expression. The proposed method is verified against Finite Differences on a 3D turbulent flow around a cylinder and, then, applied to the SAE body. Firstly, a sensitivity map analysis is conducted to investigate the influence the sensitivity derivative integration time window has on its computation but, also, to prove the importance of including the adjoint grid displacement equations. Finally, an optimization of the side mirror is performed, targeting at minimizing the radiated flow-induced sound at the vehicle's side window.

After the formulation and verification of the continuous adjoint method for the systems of equations in the interior and exterior domains, their coupling is presented. Through the solution of the adjoint aeroacoustic chain, the sensitivity of the interior acoustic pressure with respect to a normal displacement of the mirror is computed to indicate the way the mirror shape should change, in order to improve the aeroacoustic performance of the vehicle. The method is applied to compute the adjoint aeroacoustic sensitivity map on the side mirror of the generic SAE vehicle and successfully perform several optimization cycles. In addition, the impact that optimizing for each individual step of the noise prediction chain has on interior noise is investigated.

Finally, two approaches are proposed, in order to perform the aforementioned adjoint analysis, focusing however on a specific frequency range; the first approach uses an objective function which includes the Fourier Transform and is integrated over frequencies whereas the second one uses a signal processing filter that preserves only the necessary frequency components. The adjoint formulation, advantages and drawbacks of each approach are discussed. The adjoint aeroacoustic chain including the filtering process is finally used to compute sensitivity maps on the mirror for the frequency range 800Hz-4000Hz and also for each 1/3 Octave Band in this range.

Keywords: Computational Fluid Dynamics, Continuous Adjoint Methods, Shape Optimization, Computational Aeroacoustics, Vehicle Aeroacoustics