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ANNUAL REPORT TO: Dr. Steven Ramberg, Ocean Engineering Division

PROJECT TITLE: Effects of Three-Dimensional Imposed Disturbance on Bluff-Body Near Wake Flows, N00014-90-J4083

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PRINCIPAL INVESTIGATOR:
Professor Albin A. Szewczyk
Department of Aerospace and Mechanical Engineering
University of Notre Dame
Notre Dame, IN 46556-9956
Telephone: (219) 239-6608
FAX: (219) 239-8341
E-Mail: Szewczyk@NDCVX.cc.ND.EDU

CO-PRINCIPLE INVESTIGATOR:
Professor Peter Bearman
Department of Aeronautics
Imperial College of Science, Technology and Medicine
Prince Consort Road
London SW7 2BY
ENGLAND
Telephone: 071-589-5111
FAX: 071-584-8120
E-Mail: UMEA010%VAXA.cc.Imperial.AC.UK
@pucc.Princeton.EDU

PROJECT ABSTRACT

LONG TERM GOALS:

1. Mechanics of the development, modification and control of the near wake behind a nominally two-dimensional bluff body.

2. Understanding the effects of controlled three-dimensional disturbance on the region of absolute instability. Comparison of classical bluff body wake flow entrainment mechanisms by Gerrard with instability concepts.

3. Implication of the imposed disturbances for cut-off blunt trailing edge (BB) vis a vis a circular cylinder (CC).

4. Mechanics of uniform and nonuniform flow past a circular cylinder with a free-end.

IMMEDIATE OBJECTIVES IN FY'91:

1. Circular Cylinder with a splitter plate: We are focusing our attention on circular cylinders with sinuous splitter plates. With sinuous splitter plates of varying amplitude and wavelength three-dimensional disturbances are introduces into the wake region. Flow visualization photos indicate a curious spanwise cellular flow pattern along the separation line and a second reattachment line close to the splitter plate as a result of the introduction of such disturbances into the wake region. In the short period in FY'90 we have completed some base pressure and flow-visualization studies. In the present year we are concentrating on hot-wire investigations in the wake coupled with flow visualization and unsteady pressure measurements.

2. Blunt-trailing edge body with periodic spanwise geometry: The BB results have many of the same characteristics as those observed for the CC. However, a stronger three-dimensional effect from geometric changes is observed then with the sinuous splitter plate. Strong three-dimensional effects are felt by the base pressure. Shedding is in cells across the span and under some conditions appears to have an intermittent break down. Some interesting effects which will be discussed below have been observed but are still quite far from a full explanation. In the present year it is proposed to make unsteady pressure measurements along the base which together with cross correlation measurements will help to provide a more quantitative conformation for our observations.

TASKS COMPLETED IN FY'90 AND APPROACHES USED

1. Circular Cylinder with a splitter plate: Preliminary experiments on a circular cylinder with splitter plates were performed in the 3' x 3' low speed wind tunnel at Imperial College. The experiments were made on a two-inch cylinder (blockage ratio 5.5%) for seven Reynolds numbers between 3.6×10^4 to 1.4×10^5. Three types of splitter plates were employed, straight with L/D = 1/2 and 1, fluted with L/D = 0.2 and sinuous with a wavelength ratio $\lambda/D = 3$ for various maximum amplitude ratios of a/D = 0.25, 0.5 and 1.

Results from mean base pressure measurements indicate that the base pressure depends on the shape of the splitter plate but appears to be weak dependence. The C_{pb} at the peak was always greater than the C_{pb} at the valley and always smaller than that of a equivalent straight splitter plate.

Flow visualization using surface oil technique indicated a cellular flow pattern along the separation line. The cell lengths curiously did not correlate with the splitter plate wavelength or amplitude ratios used in the experiment. This needs further systematic investigation.

Statement "A" per Dr. Ramberg
ONR/CODE 1121.

VHG 2/13/91

2. Blunt-trailing edge body with periodic spanwise geometry: A series of preliminary experiments on a blunt-trailing edge body were completed since August 1990. The results can be summarized as follows:

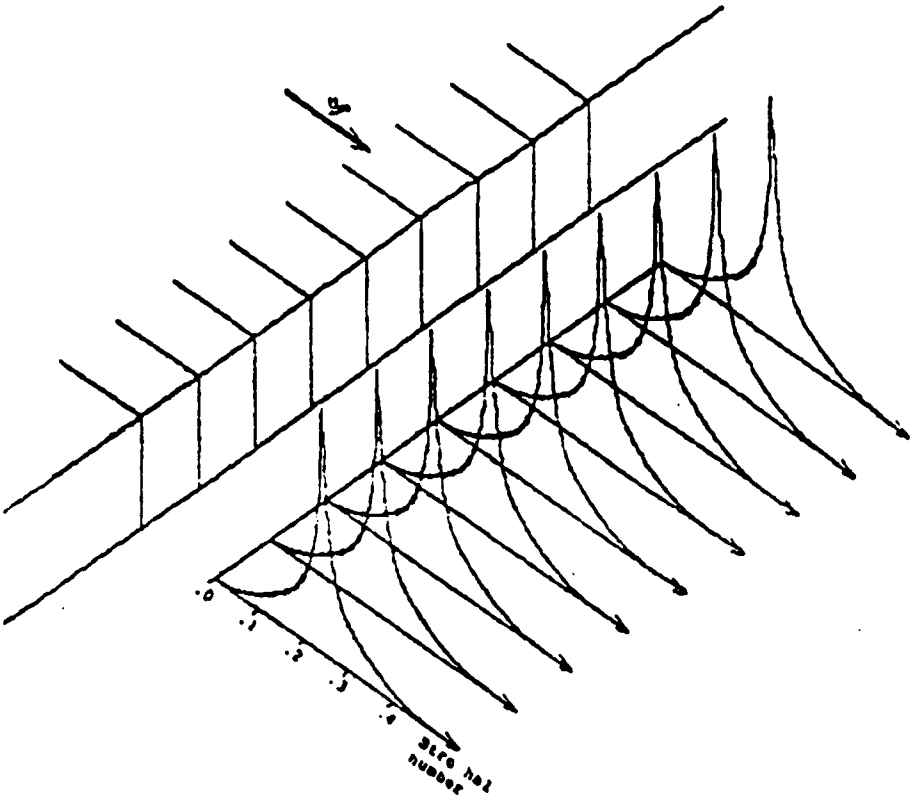
i) Base pressure measurements were the same as those found for the sinuous splitter plate. Base pressure coefficient C_{pb} was found to be larger (less negative) at the peaks than at the valleys which led to an overall reduction of base drag by 10%.

ii) Shedding frequency measurements indicated that the wavy model appeared to have two predominant shedding frequencies with Strouhal number of 0.238 (two-dimensional body frequency) and 0.277. These are shown in the attached figure.

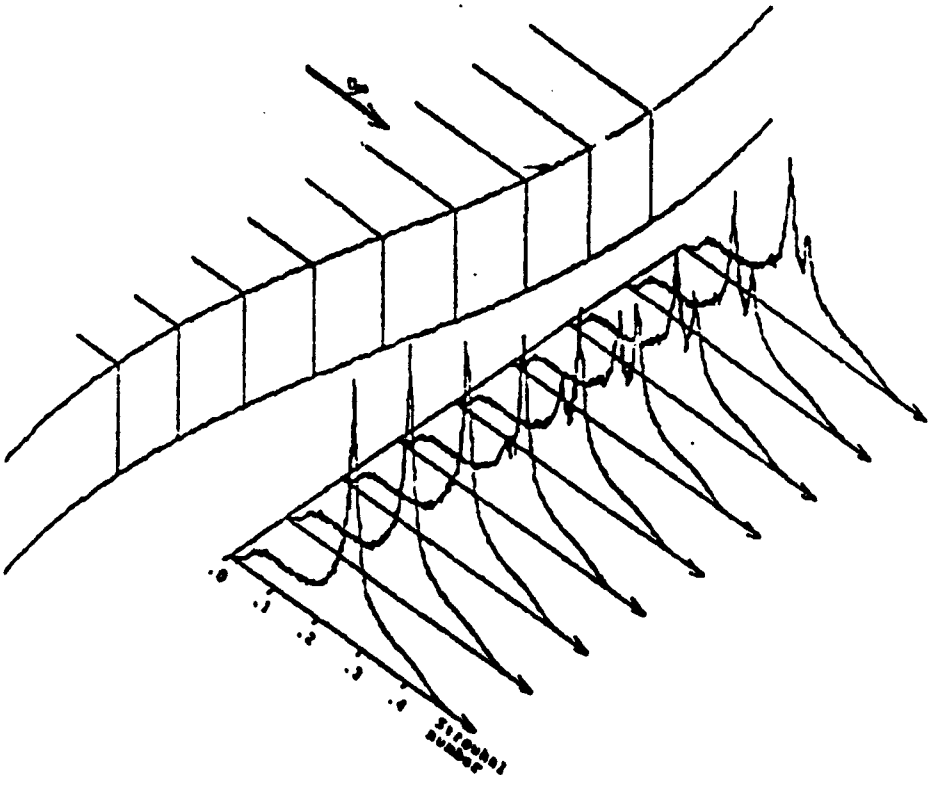
iii) Water tunnel flow visualization observation together with hot wire measurements indicate that mode A, the sinuous mode is responsible for the high shedding frequency present along the whole wavelength whereas mode B, the varicose mode is responsible for the presence of the low frequency in the region of the peak.

WORK TO BE CONTINUED

Further experiments on the BB and CC models which include hot-wire measurements, unsteady pressure measurements and flow visualization are planned.



The frequency spectrum for the 2-D model along the span.



The frequency spectrum for the wavy model along the span. Note how the high frequency magnitude grows as we move towards the valley while the low frequency magnitude dies off.

PUBLICATIONS FROM ONR SPONSORED WORK - FY89/FY90
Professor Albin A. Szewczyk
December 1990

90 - C "Effects of Three-Dimensional Disturbances Generated by Splitter Plates on the Near-Wake Flow behind a Circular Cylinder." Presented at the Forty-Third Annual Meeting of the Division of Fluid Dynamics. APS Bulletin, vol. 35, no. 10, November, 1990.

OFFICE OF NAVAL RESEARCH
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Contract/Grant Title: Effect of Three-Dimensional Imposed Disturbances on Bluff-Body Near Wake Flows

Principal Investigator: Professor Albin A. Szewczyk

Mailing Address: Department of Aerospace and Mechanical Engineering
University of Notre Dame
Notre Dame, IN 46556-9956

Phone Number: (219) 239-6608

E-Mail Address: Szewczyk@NDCVX.cc.ND.EDU

a. Number of Papers submitted to Refereed Journals but not yet Published: 0

b. Number of Papers Published in Refereed Journal: 0 (list attached)

c. Number of Books or Chapters Submitted but not yet Published: 0

d. Number of Books or Chapters Published: 0 (list attached)

e. Number of Printed Technical Reports & Non-Refereed Papers: 0 (list attached)

f. Number of Patents Filed: 0

g. Number of Patents Granted: 0 (list attached)

h. Number of Invited Presentations at Workshops of Prof. Society Meetings: 0

i. Number of Presentations at Workshops or Prof. Society Meetings: 0

j. Honors/Awards/Prizes for Contract/Grant Employees: (list attached, this might include Scientific Soc. Awards/Offices, Promotions/Faculty Awards/Offices, etc.)

k. Total number of Graduate Students and Post-Docs Supported at least 25% this year on the contract/grant:

Grad Students 1 and Post-Docs _____ including
Grad Students Female _____ and Post-Docs Female _____
Grad Students Minority _____ and Post-Docs Minority _____

Minorities include Blacks, Aleuts, AmIndians, Hispanics, etc.
NB: Asians are not considered an under-represented or minority group in science and engineering.