Modeling of Flow-Induced Vibrations in Heat Exchangers and Nuclear Reactors[1]

C. F. CHEN.[2] The authors have made an exhaustive study of the pertinent literature and arrived at a set of scaling laws for the model study of flow-induced vibrations of banks of cylinders as found in heat exchangers and nuclear reactors. They explained that it is impossible to match both Strouhal number and Reynolds number simultaneously when a reasonable geometric scaling factor is used between the prototype and the model. They recommend that the Strouhal number of the model be made the same as that of the prototype and accept the lower values of the Reynolds number. With this kind of modeling law the vibrations of the tubes due to self-excitation from vortex shedding is not correctly simulated. The authors argue that in closed packed banks of tubes in high Reynolds number flow the excitation due to vortex shedding may not be important. I agree with their recommendation.

It may be of some interest to point out that in heat exchangers and nuclear reactors, the approaching flow may not be uniform along the entire length of the tubes. Our experiments[3] on vortex shedding from cylinders in sheared flow showed that the shedding frequency varies directly with the local approach velocity. The Strouhal number using the local approaching velocity and shedding frequency remains sensible constant at 0.21. If indeed the approaching flow is non-uniform along the tubes, then the shedding frequency will be different along the tubes, thus making the coherent excitation that much more difficult. This is one more reason to discount the importance of the self-excited vibration due to vortex shedding.

[1]By G. S. Beaver and R. Plunkett, published in the December, 1974, issue of the JOURNAL OF FLUIDS ENGINEERING, TRANS. ASME, Series I, Vol. 96, No. 4, p. 358.

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[3]Chen, C. F., and Mangione, B. J., "Vortex Shedding from Circular Cylinders in Sheared Flow," *AIAA J.*, Vol. 7, No. 6, 1969, pp. 1211–1212.

J. B. MILES.[4] Certainly the authors have addressed a subject of importance and one needing additional attention. In my opinion, the section of the article dealing with scaling laws for flow-induced vibrations was the major contribution of the article. This summary of the significant parameters for the mechanical system, the fluid system, and for the fluid-mechanical interaction was quite beneficial.

I felt that the article was difficult to read considering that it was not mathematically complex.

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R. H. SCANLAN.[5] This paper possesses the advantage that it suggests that a problem of complex fluid-structure interaction be studied experimentally. If offers a careful "tour d'horizon," with comments, among the very well-known scaling choices open to experimenters in the area. It regrettably does not, however, offer any firm conclusions about actual or expected results. What would be new, and what one would most like to know about models of flow-induced vibrations, is what the expected and inevitable violations of similarity really lead to in the end.

The general system described—that of a high Reynolds number flow traversing a multiple array of tubes—inevitably develops a highly turbulent flow condition with characteristic scale and spectrum. This flow excites a mechanical system having its own natural response spectrum. If excitation of the latter is deemed undesirable, then mechanical properties—notably stiffness—must be brought to levels which tend to separate the two spectra. Occasionally fluid or structure damping may be shrewdly manipulated to this end.

Usually, designs of systems of the type under consideration stem from a "driving force" or concept which is far removed from the concerns of fluid-structure interaction, and the latter enters in only as an undesirable "side effect." It has become important, however, in the design of a great many systems which involve fluid-structure interaction not merely to examine, analytically or experimentally, the performance of a given projected configuration, but to seek, a priori, a configuration which either does not elicit an undesirable force spectrum, or, if this is inevitable, to palliate, mainly through stiffness, the unavoidable application of that force spectrum. Stiffer systems generally exhibit less fluid interaction.

The type of test which the authors outline very often takes place then in the absence of full defensive design measures against the phenomenon under study because the designers were focused on other concerns. Just how well the authors may have succeeded, with their classic but necessarily imperfect similarity study, in proving out such designs is the real story which the profession would like to read.

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Authors' Closure

We thank Messrs Miles, Scanlon, and Chen for their interest in our paper. We agree that the final results are what count and we hope eventually that either we or the General Electric people will report the results of scale model experiments. We cannot agree that it is possible in all cases to decouple the excitation and response frequencies. In particular, if our assumptions are correct, the spectrum associated with entering turbulence should be very broad, so broad that stiffening would do no good. This is, however, speculation and the answer will depend on measurement. As a result of this and other analyses, hydraulic tests on a 1/10 scale model and a partial 1/4 scale model are now underway.

Design and Construction of a Wind Tunnel for Mass Transfer Studies in Incompressible Boundary Layers[1]

J. MATHIEU.[2] The paper presented by K. C. Watts, E. Brundrett, W. B. Nicoll, A. B. Strong, is an accurate investigation in order to improve experimental data about the development of transpired boundary layers. Important experimental facilities were settled by previous workers; only they were used by the authors. One of the greatest interest of this paper is to present accurate values of the skin friction coefficient for transpired boundary layers. There is not doubt that such values are

[1]By K. C. Watts, E. Brundrett, W. B. Nicoll, and A. B. Strong, published in the December, 1974, issue of the JOURNAL OF FLUIDS ENGINEERING, TRANS. ASME, Series I, No. 4, p. 311.

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