Journal of Applied Mechanics Discussion

Creeping Viscous Flow Around a Heat-Generating Solid Sphere[1]

P. R. Dawson.[2] The author has provided a useful analytical solution for the problem of thermally induced motion of a heat-producing sphere. The magnitude of the velocities was compared to numerical results for a similar problem. However, the comparison was not totally valid. In the report by Dawson and Tillerson [2] cited by the author, the steady-state velocities were obtained as upper bounds of canister motion by computing the velocities that would result if the heat sources did not decay and the temperatures reached steady state. The velocities predicted in these cases are much higher than those predicted for decaying sources. These computations were intended to show that even under such unrealistic conditions significant canister motion would not occur.

The report also included the predicted motion of a heat source with a 30 year half-life for a period of 150 years. A direct comparison to Krenk's work is not possible since our numerical analysis included the effects of a temperature-dependent viscosity. The report does mention that for a constant viscosity and decaying heat source, the velocity predicted after 10 years is 1.5 pm/s. This value is quite close to the value apparent from Fig. 4 of the author's article (1.6 to 1.7 pm/s).

Thus, when the proper comparison of the two analyses is made, the results appear to be consistent. The minor differences can be a result of the variations in solid sphere geometry and material properties between the two analyses.

Author's Closure

I appreciate the comments of Dr. Dawson concerning the consistency of the two methods of calculation. Unfortunately reference [2] does not include a full transient analysis under the simplifying assumptions used in [1]. An essential difference between the two methods is the lack of finite boundaries in [1], and as a consequence no steady-state solution exists in this model. The steady-state velocity from [2] was therefore included to indicate an upper limit. As expected, the time delay of the buoyancy in the transient problem leads to a maximum upward velocity considerably below this value.

A central point in comparing the two methods is the difference in boundary conditions. The influence of this difference is expected to increase with time, and although the 10-year velocities mentioned by Dr. Dawson look encouraging, it appears that a definite conclusion would require additional computations.

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[1] Krenk, S., and published in the June 1981, issue of the ASME Journal of Applied Mechanics, Vol. 48, pp. 239–242.

[2] Dawson, P. R., and Tillerson, J. R., "Nuclear Waste Canister Thermally Induced Motion," Report SAND-78-0566, Sandia National Laboratories, June 1978.

Nonlinear Harmonic Oscillations of Gyroscopic Structural Systems and the Case of a Rotating Ring[1]

C. W. Bert[2]. This problem was first attacked by Padovan [1] in 1976. He used the Lindstedt-Poincaré procedure, but achieved results somewhat different from those of Professor Maewal. Padovan found that all branches, backward and forward, exhibit a softening behavior, whereas Maewal found the backward waves to have a hardening behavior and the forward waves to transition from a hardening behavior to a softening behavior as the rotational speed is increased.

References

1 Padovan, J., "Coriolis Effects on Nonlinear Oscillations of Rotating Cylinders and Rings," *Advances in Engineering Science* (13th Annual Meeting, Society of Engineering Science, Hampton, Va., Nov. 1976), NASA CP-2001, Vol. 2, pp. 409–416.

Author's Closure

I am thankful to Professor Bert for his interest in my paper.

It is perhaps evident from the introductory section of the paper that the primary motivation of the developments therein is the phenomenon of disappearance of circumferentially standing waves as normal modes of free vibrations of rotating shells of revolution. A primary result of my analysis is a description of this phenomenon in terms of secondary bifurcation, with the conclusions being valid for arbitrary shells of revolution in view of the rather general formulation. Inasmuch as this issue is not even explicitly addressed in the paper [1] cited by Professor Bert, I find it difficult to agree with his characterization of the relationship between the two investigations.

As has been demonstrated in a related context in references [6] and [7] of my paper, satisfactory solution of a nonlinear harmonic oscillations problem, correct to the lowest order, can be obtained only if an expression for strain energy, which is accurate up to and including the quartic terms, is utilized. The strain energy functional used in Padovan's work [1] differs from the one I have used even in the quadratic term. Because of this difference, and due to the different assumption made by Padovan on the membrane stiffness of the ring, it is not expected that the solution obtained by him should necessarily be the same as what I obtained, mainly to illustrate my more general results.

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[1] By A. Maewal, and published in the September, 1981, issue of the ASME Journal of Applied Mechanics, Vol. 48, pp. 627–633.

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