INSTATIONARY FLOW PHENOMENA IN REACTOR CIRCUIT COMPONENTS*

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In many cases the assumption that the flow pattern in reactor components is purely stationary is a useful simplification. Pressure drop and heat transfer e.g. are calculated on the basis of theoretical or empirical formulas, in which the mean values of the flow velocity and density are used.

In reality, pressure- and velocity fluctuations are superposed to the mean values, if for instance in pipe flow Reynolds number exceeds a critical value. In other cases the wake behind bluff bodies (heat exchanger tubes) shows an instationary behaviour. An other example for irregular flow pattern is the flow in bends and straight pipes with changes in cross-section. Experience shows that a detailed knowledge of these flow phenomena is needed, because the instationary hydrodynamic load on reactor components may become so high that mechanical failure will happen.

The main topic of this paper is to discuss experimental results of investigations about the flow in heat exchangers and in ducts with 90° bends.

In the first case experiments show that in many tube arrays pressure fluctuations occur, the spectrum of which shows discrete frequencies. The tubes may be forced to mechanical resonance if the frequency of the flow induced pressure fluctuations coincides with one of the natural mechanical frequencies of the tubes. In other cases the heat exchanger acts as an acoustical resonator; standing waves of high level (170 db) were measured.

It shows, that a dimensionsless description of the results is possible, thereby giving the possibility to extrapolate from model tests to given conditions.

Measurements in ducts with 90° bends were done to find out whether local pressure fluctuations in zones where the flow separates from the wall may become harmful to thermal shieldings in hot gas ducts.

To obtain relevant data for the construction of such components, pressure fluctuations in the range from 0.05 c/s up to 20 kc/s were measured. The autocorrelation at neighbouring points and the spectral density distribution were determined.

*Paper not received.

DISCUSSION

Q C. H. A. TOWNLEY, U. K.

Ultimately we are interested in determining the fatigue life of the tubes, and to do this we need to know the stress levels induced by the vibrations. Can Mr. Heinécke suggest how we can estimate these stress levels from the acoustic results which he has obtained.

A E. HEINECKE, Germany

Acoustical measurements give us data about the alternating forces acting on the tubes of a heat exchanger. Separate measurements are needed to get information, because the resultant instationary forces depend on pressure distribution around the tubes, the correlation of the separation of the boundary layer along the axis of the tube on the position of the line of separation and its variation in time.

Q S. CURIONI, Italy

In your experience you have found that it is possible to use the same characteristic number for extrapolating the results from model tests to prototype for straight and bend tube. What are the limits for this possibility due to the fact that the fluctuation depends also from the amplitude of vibration of the tube and that the loads acting on a straight or bend tube are different ?

A E. HEINECKE, Germany

1. As much as is known from A. Roshko's experiments on single cylinders, bend tubes behave as far as vortex shedding is concerned, as straight tubes, if the ratio of bending radius to tube diameter is within certain limits.
An additional hint is, (as Dr. Fritz mentioned), that tube banks with bend tubes (helically wound tubes) behave, as far as pressure drop and heat transfer data are concerned, as if they were straight tube-banks.
2. The influence of the movement of circular tubes on the wake flow has been studied by R. Gregorig for large ratios of deflection to diameter (10%). Further experiments are not known.