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NASA TECH BRIEF

This NASA Tech Brief is issued by the Technology Utilization Division to acquaint industry with the technical content of an innovation derived from the NASA space program.

Oil-Smeared Models Aid Wind Tunnel Measurements

The problem: Several methods have been used to aid in visualizing flow characteristics over the surfaces of test models in wind tunnels. The methods which have been commonly used have a number of deficiencies, however. One of these uses the ink flow technique, in which a colored liquid is injected into the surface flow through orifices in the surface of the model. For this method, the model must be specially built with a number of orifices precisely distributed over its surfaces and connected internally by means of tubing and reservoirs. Although this method provides for proper flow visualization under varying operating conditions of the wind tunnel, it usually presents an extremely complicated construction problem. Other approaches use the sublimation method, in which the model surfaces are coated with a volatile solid that leaves a visible foglike trail conforming to the flow pattern, and the luminescent-lacquer method, in which the model surfaces are coated with a lacquer that becomes fluorescent as it dries in the wind tunnel. These two methods, however, can generally be used for only one operating condition of the wind tunnel. For studying the flow under another operating condition, the wind tunnel must be shut down and the model recoated. For tests in a large high-speed wind tunnel, these methods are costly and time-consuming.

The solution: The surfaces of the model to be tested are smeared with any of the common petroleum-base oils, which fluoresce under ultraviolet light. The flow patterns over the model illuminated with ultraviolet light in the wind tunnel can be seen as patches of varying brightness and orientation caused by the variations in thickness of the oil film. The shearing action of the boundary layer, regions of laminar and turbulent flow, regions of reversed flow, and regions of significant lateral flow are readily visualized. Other important information is often apparent, such as the locations of shocks, pressure peaks, and appreciable lateral pressure gradients.

The basic advantage of the method is that the coating of oil, even after it is thinned by wind shear during a long test, remains fluid enough to redistribute itself over the model when the operating conditions of the air flow are changed. It is thus not necessary to shut down the tunnel and apply a new coat of oil in order to study a new operating condition. Since only the oil film is rendered visible under the ultraviolet light, there is no background light in the wind tunnel to interfere with the observation.

How it's done: A typical, nonporous model needs no special preparation. Models using porous filler material and models made of wood or with wooden additions should be sealed to prevent absorption of the oil and consequent disruption of the fluorescent patterns. Zinc chromate has been successfully used as a sealer. Flat-white lacquer also works well, and has the added advantage of enhancing the brightness of the oil fluorescence. No special technique is needed to apply the oil; it can be daubed or brushed on the surface, without regard for even thickness. If it is desired to determine the direction of boundary-layer crossflow, it may help to apply the oil in small, discrete dabs which will, during the tests, stretch into lines which reveal the direction of surface shear.

(continued overleaf)

Notes:

1. In general, selection of the proper hydrocarbon oil is not critical. Most of the common petroleum-base lubricating oils may be used without special preparation. The prime factor in selecting one, however, is viscosity, which determines the ease with which the oil forms patterns and the length of time it remains on the surface. For wind tunnel tests involving low airspeeds and low temperatures, kerosene or other low-viscosity oils (of low vapor pressure) must be used. If these oils have low natural fluorescence, oil-soluble fluorescent dyes may be added to strengthen the fluorescence. Fluorescent dyes may be added also to the more viscous oils to increase the brightness of the fluorescent patterns obtainable.
2. The oil should, of course, be capable of wetting the model surfaces. If difficulty is encountered in this regard, a suitable wetting agent (e.g., particular organic acids) should be added to the oil.
3. Under repeated tests, the oil film may eventually become so thin that it can no longer redistribute itself properly and also becomes difficult to see under the ultraviolet illumination. Nevertheless, the oil stays on long enough to permit observing several different conditions before its mobility and visibility become too low for trustworthy observation.
4. This method has been used with moderate success for observing flow patterns over surfaces immersed in liquids, such as water, for example.
5. A more detailed description of the method is available in NASA MEMO 3-17-59L.

Patent status: NASA encourages commercial use of this innovation. No patent action is contemplated.

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