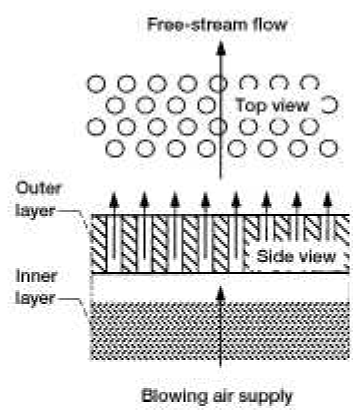
# Microblowing Technique Demonstrated to Reduce Skin Friction

One of the most challenging areas of research in aerodynamics is the reduction of skin friction, especially for turbulent flow. Reduced skin friction means less drag. For aircraft, less drag can lead to less fuel burned or to a greater flight range for a fixed amount of fuel. Many techniques and methods have been tried; however, none of them has significantly reduced skin friction in the flight environment.

An innovative skin-friction reduction technique, the Microblowing Technique (MBT), was invented in 1993. This is a unique concept in which an extremely small amount of air is blown vertically at a surface through very small holes. It can be used for aircraft or marine vehicles, such as submarines (where water is blown through the holes instead of air). As shown in the figure, the outer layer, which controls vertical flow, is a plate with high-porosity (high open area), laser-drilled vertical holes. The inner layer, which produces evenly distributed flow, is a low-permeability porous plate. Microblowing reduces the surface roughness and changes the flow velocity profile on the surface, thereby reducing skin friction.




*Microblowing Technique skin.*

In 1995, a Phase-I proof-of-concept experiment was conducted in NASA Lewis Research Center's Advanced Nozzle and Engine Components Test Facility. Of seven porous plates tested, three were identified as MBT skins. An MBT skin is one that has an unblown skin friction (i.e., the skin friction of a porous plate without blowing) not more than 20 percent above the skin friction of a solid flat plate. For these MBT skins, microblowing flow rates less than 0.5 percent of the free-stream flow rate reduced the skin friction below that of a solid flat plate by up to 60 percent.

In 1996, a Phase-II experiment to evaluate the increased pressure drag penalty associated with this technique was conducted in the same facility. The results showed the increase in pressure drag caused by MBT skins, especially for high Reynolds number flow (i.e., conditions such as those in which commercial airplanes fly). Considering these results, we predicted that a skin friction reduction of up to 30 percent below that of a solid flat plate is possible under certain conditions.

In September 1997, a joint program of NASA Lewis, United Technologies Research Center, Northrop Grumman Corporation, and Pratt & Whitney was completed. A 30-in. engine nacelle with an MBT skin was tested in the United Technologies' wind tunnel. Results of the experiment indicate that skin friction reductions of 50 to 70 percent are possible over portions of the nacelle, with the addition of only small amounts of blowing air. Tests applying MBT to supersonic flow (i.e., flow conditions greater than the speed of sound) and the search for an optimal MBT skin are continuing.

# Bibliography

Hwang, D.P.: A Proof of Concept Experiment for Reducing Skin Friction by Using a Micro-Blowing Technique. AIAA Paper 97-0546 (NASA TM-107315), 1997.

Hwang, D.P.; and Biesiadny, T.J.: Experimental Evaluation of Penalty Associated With Micro-Blowing for Reducing Skin Friction. AIAA Paper 98-0677, 1998.

Tillman, T.G.: Drag Reduction on a Large-Scale Nacelle Using Micro-Porous Blowing. UTRC Report R97-4.910.0001, 1997.

**Lewis contact:** Dr. Danny P. Hwang, (216) 433-2187, Danny.P.Hwang@grc.nasa.gov
**Authors:** Dr. Danny P. Hwang and Tom J. Biesiadny
**Headquarters program office:** OASTT
**Programs/Projects:** Propulsion Systems R&T, FQE

**Special recognition:** Superior Accomplishment Award, Space Act Award, and Space Act Board Award (NASA Inventions and Contributions Board)