

# Taking a bearing on quality

Porous air bearings are a critical element of high-precision machinery thanks to their essentially frictionless operation, high speed, and accuracy. ASM Assembly Automation Ltd of Hong Kong uses such bearings for the design and manufacture of its electronic-assembly and packaging equipment. In fact, this is the largest supplier of such equipment in the world. Rather than rely on commercial bearings, the company manufactures its own to meet very specific operating requirements. Thanks to their use of COMSOL Multiphysics, ASM engineers essentially eliminated the need for more than one prototype of a new bearing design before going into production, thereby saving months of development time.

## Air through millions of paths

Any air bearing uses a thin film of pressurized air between machine elements to support a load so there is no solid-to-solid contact. Traditional orifice-type air bearings send pressurized air

through a small hole in the bearing itself and then direct it further through the gap between the bearing and machine element. Porous air bearings, in contrast, use a porous material so the air penetrates into the gap through millions of paths. When fed with high-quality clean compressed air, these bearings are more difficult to completely clog than orifice-ba-

sed bearings and can also continue to glide even after being severely scratched. Further, because these bearings uniformly send the compressed air into the gap over a wider surface area, they can achieve higher load capacities with higher stiffness, lower air consumption, and greater overall reliability. “The same air gap that makes an air bearing so effective in the machinery also makes modeling challenging”, notes S.W. (Alex) Ng, a senior CAE engineer at ASM in Hong Kong. “The model interface between the air film and bearing surface has a non-standard boundary condition that involves a partial differential equation.” Ng tried to model this type of bearing with existing tools on hand but was unsuccessful because of the PDE that plays such an important role and yet is difficult to solve numerically. He then searched for a package that could handle the job and finally found COMSOL Multiphysics, the only

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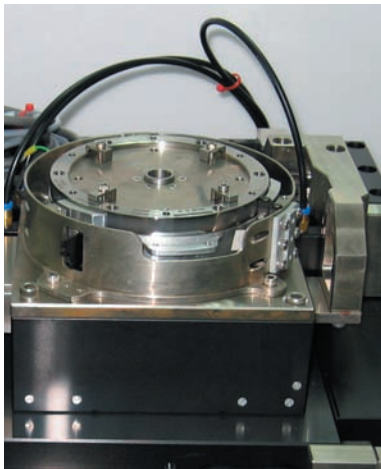


Figure 1: A motion system for electronics manufacturing that employs an air bearing.

Figure 2: This air bearing uses porous graphite as the path for the air to flow into the air gap between the two surfaces being separated.

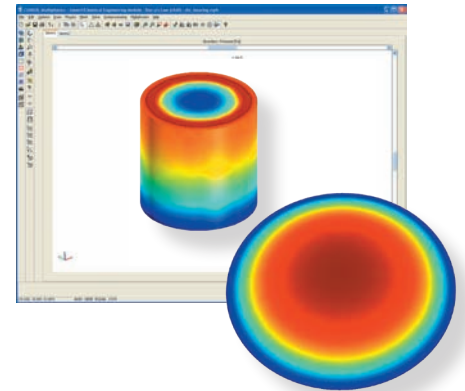
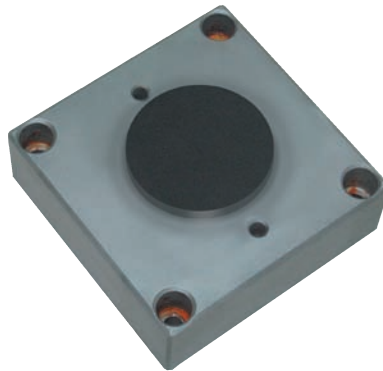


Figure 3: The normalized pressure distribution in the 3D porous material (left) and the 2D air film (right). COMSOL Multiphysics' unique feature allowing coupling in different dimensions saves a lot of memory through modeling the air film in 2D.

one that let him work with nonstandard boundary conditions. “Without COMSOL Multiphysics”, adds Ng, “you basically cannot solve this kind of problem, not with any other commercial software.”

To create a model that handles the nonstandard boundary condition, Ng divided the problem into two domains, one for the porous media and a second for the air film. The bearing subdomain models 3D porous media flow using Darcy’s Law, while the model handles the film in 2D assuming compressible laminar flow. The ability to approximate the fluid flow in the air gap in 2D rather than 3D saves considerable time and computational memory. Coupling the physics between different geometric dimensions is normally a difficult process to set up numerically, but in COMSOL Multiphysics it is an automatic feature.

Then, based on model results, he determined the load capacity and flow rate, which also indicates the consumption of compressed air.

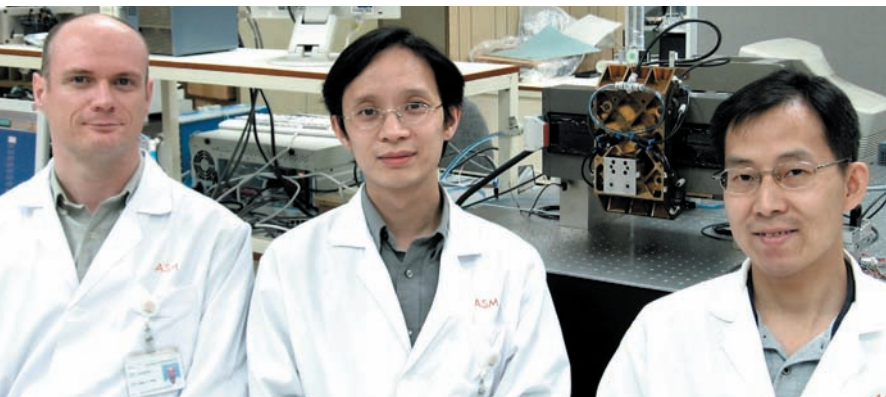
### The desired results with one prototype

Why go to all this bother to make a model of what might seem like such a straightforward component? “Before putting a bearing into production,” explains Ng, “we must have a very good estimate of its load capacity and stiffness. The engineers designing the equipment must come up with an error budget for the total design including these and other components.”

Another strong reason for modeling the bearings deals with time to market. Ng notes that sometimes he must wait for a few months before he can see a prototype, so if he wants any design changes at all, each iteration requires another few months. Thanks to the COMSOL Multiphysics model, he got exactly what he wanted the first time through.

To validate the model, he sent the prototype to an outside partner for testing. Professor S. Yoshimoto at the Tokyo University of Sciences was able to show a high level of agreement between the model’s prediction and actual performance.

When summarizing his use of the software in this project, Ng says, “COMSOL Multiphysics provides a powerful tool that allows us to solve a highly complex problem especially thanks to the coupling capability that allows us to model between different dimensions.”



The air-bearing development team, left to right: chief engineer Gary Widdowson, senior CAE engineer Alex Ng, and senior CAE engineer John Yao.