Computers

Going with the flow in jet engines

In a jet engine, hot gases sweep past sets of curved blades, some attached to freely rotating hubs and others fixed in position. Now a researcher at the NASA Ames Research Center at Moffett Field, Calif., has completed a computer model that simulates the fluctuating, three-dimensional air flow past such rotor-stator combinations in a turbine. The model allows aircraft engineers to track changes in air pressure, temperature and velocity within a turbine in greater detail than ever before. "With this kind of information, we hope to come up with new engine designs that are safer and more reliable," says NASA's Man Mohan Rai, who developed the computer model.

NASA

In this computer simulation of gas flow through a three-dimensional rotor-stator combination in a typical jet-engine turbine, the left-hand set of blades is stationary while the right-hand set moves downward. Hot gases enter from the left. The colors indicate different levels of pressure.

Rai's simulation required solving complicated mathematical equations describing unsteady fluid flow. In this case, the problem was particularly difficult because some engine parts were in motion with respect to others. This meant the usual practice of drawing a fixed box around the region of interest – say, a turbine blade – and computing the value of quantities such as pressure for points within the box wouldn't work. To include both moving and stationary parts, such a box would become more and more distorted as time passed, making the computations trickier to perform. Rai's answer was to treat stationary and moving parts separately by putting them into individual boxes. He developed a scheme for accurately connecting what happens in a stationary box with what happens in an adjacent moving box. To put together a brief movie showing temperature, pressure and velocity fluctuations around a turbine's stator and rotor blades, Rai needed about 100 hours on a Cray-2 supercomputer and sophisticated graphics equipment for handling 2 billion data points.

Engineers are interested in studying where rapid and extreme pressure and temperature fluctuations occur because engine parts buffeted by such forces are more likely to fail. By checking simulations, engineers can determine whether to modify the engine geometry to reduce stress or to strengthen the affected parts by using tougher alloys – without having to go through the expense of building and testing scale and full-size models. With modifications, Rai's computer program is suitable for modeling a wide variety of turbomachinery, from gas turbines in power plants and pumps in nuclear submarines to helicopter rotors.

Earth Sciences

Tearing a tectonic plate in two

Fifty million years ago, a huge submerged plateau in the Indian Ocean split into two pieces that began to separate and now sit 2,000 kilometers apart. Previously, scientists seeking to explain the origin of this break have been unable to choose between two rival rifting theories, but geophysicists recently pulled up evidence from the ocean floor that they say settles the debate.

In May and June, the crew and scientists on Leg 121 of the Ocean Drilling Program (ODP) collected sediments from the top of a feature called Broken Ridge, which currently lies off the west coast of Australia and was half of the once-connected platform. Its estranged sibling, the Kerguelen plateau, is the world's largest submerged plateau and sits north of Antarctica (SN: 6/25/88, p.410). The original, intact plateau grew from the ocean floor more than 90 million years ago, when a series of volcanic eruptions poured out vast volumes of molten basalt onto the Antarctic plate.

During the Eocene epoch, a long rift cleaved the plate and cut off its northern section, which held the Broken Ridge part of the plateau. This renegade plate section latched onto its neighbor, the Indian plate, and started a journey northward, while the Kerguelen plateau moved southward.

As one explanation for the break, geophysicists had suggested this event may be an example of active rifting, a process now splitting apart East Africa. According to this theory, a rift can develop when a rising flow of hot magma buoys and warps the crust. Yet the newly collected sediments indicate Broken Ridge was sinking immediately prior to breaking from the rest of the plateau, which means active rifting did not cause the split, says Leg 121 co-chief investigator Jeffrey Weissel of Columbia University's Lamont-Doherty Geological Observatory in Palisades, N.Y. As confirming evidence, Weissel notes that instruments inserted into boreholes on Broken Ridge measured normal heatflow from the crust. If active rifting had occurred, the temperatures should have remained high even 50 million years after the main action.

On the basis of the new evidence, the ODP scientists have embraced an alternate explanation, involving a process called – not surprisingly – passive rifting. According to this theory, the Indian plate broke because it was pulled apart by horizontal forces from the far-off edges of the plate. While the stress runs throughout the entire plate, rifts develop only where fractures in the lithosphere predispose it to snap. Therefore, the original spot under the plateau must have been inherently weak, Weissel says.

On the second portion of the cruise, the researchers focused on the Ninetyeast Ridge, a ruler-straight underwater mountain chain that runs 5,000 km south from the Bay of Bengal. The ridge formed as the Indian plate passed over a so-called hotspot, where a thin plume of magma rises from the mantle up to the earth's surface. Using basalts drilled from three sites along the chain, the investigators can date the hotspot eruptions and thereby trace the progress of India as it moves north into a continuing collision with the Eurasian plate.

As an unexpected bonus on Leg 121, investigators pulled up a "nicely preserved" section of the 65-million-year-old Cretaceous-Tertiary boundary, which marks one of the major mass extinctions in Earth history. Though the section adds no new evidence to resolve the infamous debate over the causes of the extinctions (see p.70), it can serve as a record of how ocean animals near the South Pole reacted to the environmental upheaval at that time. A preliminary examination of the core reveals that plankton species reappeared relatively slowly at this site compared with sites in today's Mediterranean region, suggesting that ecological stresses were greater at the near-pole site, Weissel says.