**ARBed Aluminum as Strong as Iron**

T here have been increasing attempts in recent years to expand the range of uses for aluminum base alloys as lightweight metallic materials in vehicles such as cars, trains, and airplanes and in structural fields such as construction or civil engineering. Due to difficulties in terms of increasing the strength of aluminum base alloys to rival that of iron and steel, however, stronger alloys and new materials have been desired.

Associate Professor Tsuji Nobuhiro from the Department of Adaptive Machine Systems, Graduate School of Engineering at Osaka University, and Risoe National Laboratory in Denmark announced in Science magazine that they have succeeded in producing an aluminum-based alloy with the same strength as iron. The newly unveiled alloy is nearly four times as strong as existing aluminum, offering more or less the same levels of strength as low carbon steel. What is more, it is effectively an alloy that combines lightness and strength with the easy formability of aluminum. This new aluminum base alloy is the result of Tsuji’s efforts to develop a new metal processing technology called Accumulative Roll Bonding (ARB). A type of severe plastic deformation processing designed to subject metallic materials to huge plastic strain, ARB has already been used successfully in the ultra-refinement and strengthening of crystal grains of metallic materials such as iron, copper, and titanium.

Aluminum and other metallic materials are ordinarily composed of a number of crystal grains. Although it is well-known that it is possible to increase the strength and toughness of metallic materials by making the crystal grains finer, it has never really been possible to go below 10µm (1µm = 0.001mm) previously. Also, although it had already been discovered that it is possible to obtain nanocrystalline grains by subjecting iron or steel powder to severe plastic deformation, the inability to obtain bulk materials (metallic ingots) made such methods unsuitable for practical application. However, as well as repeatedly subjecting metallic materials to pressure metal rolling, cutting, and lamination (bonding) to refine crystal grains to submicrons (0.0001mm), the ARB technique developed by Tsuji and his colleagues is also capable of rolling bulk materials by subjecting them to severe plastic deformation. These are the first research results to date relating to the strengthening of metallic materials through the ultra-refinement of crystal grains. As automation is also possible, there are high hopes in terms of research into practical application. Metallic materials strengthened using this technique are also drawing considerable attention from an environmental perspective. The fact that there is no need to add large amounts of alloy elements such as chromium or nickel to the likes of iron and copper makes materials easier to recycle, thereby reducing the environmental impact from waste products.

**CO₂ Transporter Fleas**

A research team made up of members of organizations including the Fisheries Research Agency’s Tohoku National Fisheries Research Institute has discovered that *Neocalanus*, a species of zooplankton similar to the water flea that lives in the North Pacific, carries large volumes of carbon dioxide (CO₂) down into the deep seas. The team is conducting a research project with the aim of explaining the structure of deep-sea ecosystems and their relationship with organisms that live nearer the sea surface in order to improve marine resource management.

The team’s research has revealed that *Neocalanus* throughout the North Pacific transport a total of 160 million tons of CO₂ to the deep layers of the sea every year, which is equivalent to 46% of Japan’s annual CO₂ emissions. At such depths, seawater moves around via deep circulation, ensuring that it doesn’t come into contact with the earth’s atmosphere again until it returns to the surface layers of the sea several hundred years later. In other words, despite being tiny zooplankton organisms, *Neocalanus* perform the task of taking large volumes of CO₂ down into the depths of the sea, where it is isolated from the atmosphere for a long time.

According to Saito Hiroaki, chief of the Biological Oceanography Section at the Fisheries Research Agency, *Neocalanus* are a large species of zooplankton that measure 5–10 mm in length and are distributed in groups around cold-water areas of the North Pacific, where they lead an unusual way of life. After building up nutrients in spring by eating phytoplankton at surface layers, *Neocalanus* submerge themselves down to depths of between 500 and 1,500 m, where they lie inactive during the period from the end of spring to summer. They then shed their skin and spawn down in the deep layers of the sea, at which point adult *Neocalanus* lose their feeding appendages and live off the nutrients absorbed at the surface instead. It is as part of this process that *Neocalanus* carry CO₂ down to the deep seas. In fact, observations recorded during year-round research expeditions in the Pacific off Hokkaido have revealed that *Neocalanus* carry an annual total of 4.6g of carbon per square meter (16.9g when converted into CO₂). The process of transporting carbon down to the deep layers of the sea as part of organism activity is called biologic pump, a phenomenon that is crucial to the earth’s circulation of CO₂. Whereas it had previously been thought that zooplankton did not contribute to biologic pump to any great extent compared to phytoplankton, this discovery has proved that the volume of CO₂ carried by zooplankton is actually equal to that carried by phytoplankton when they die and become submerged in the subarctic North Pacific.