A more recent area of emphasis is its use in strengthening the rotor blades in so-called "turbocharger" gas compressors. Propelled by the hot exhaust gases of combustion engines, turbochargers compress intake air and boost significantly overall engine efficiencies. Nickel aluminide not only stands up to the extreme heat of the exhaust gases, but also exhibits a much longer life before failing due to cyclic stresses and fatigue. It also costs less than competing "superalloys" and other high-temperature withstanding materials.

Because the alloy is made partly of aluminum, it is 10 percent lighter than steel. Also, because of its strength, a part made from the alloy can be designed smaller, further reducing its weight. Hence, the alloy also has potential applications in the aerospace industry as a substitute for heavier materials now required for strength, such as fasteners, rivets, and certain structural components.

Finally, another valuable property of the alloy is that once it has formed an initial, protective layer of aluminum oxide, it is nearly impenetrable to further corrosion and oxidation. Its corrosion resistance has been measured at 1,000 times better than competing steels. As a result, it is now being investigated for use in heat processing equipment subjected to fouled environments, such as steam boiler tubes and hot exhaust gas heat recovery equipment in industry.

Technically, nickel aluminide is part of a larger family of materials known as "ordered" intermetallic alloys, so named because of the precise ordering and interweaving of the atomic structures or lattices of the two metals. This particular situation, called a low "free energy" condition, makes it difficult to remove an atom from its position in the lattice, which gives the material its strength and chemical stability.

Intermetallic alloys were well known in the 1950's and 1960's for their extraordinary strength. Unfortunately, the problem with them in the past had always been that they were too brittle for most practical applications. Although single crystals of some of these alloys were known to be ductile, bulk quantities in polycrystalline form fractured, like glass.

The basic problem was with the microscopic interfaces, called grain boundaries, where the crystals which constitute the bulk material join together. It is at these interfaces where the crystals tended to pull apart or slip against each other under stress, causing the material to break.

This problem could be solved, it was hypothesized, if means were found for increasing the adhesiveness of these surfaces. Perhaps the addition of small amounts of alloying elements, to be used as "impurities" in the larger matrix of nickel and aluminum, could somehow cause a strengthening of metal-to-metal bonding at these surfaces. Little knowledge was available to guide this search, however, and progress in solving the brittleness problem slowed.

In the late 1970's, Basic Energy Sciences researchers were working on a seemingly unrelated problem. In retrospect, this work laid a foundation of basic knowledge and improved laboratory capabilities in the use of a key instrument. Both investments later helped to explain a startling new discovery and set into motion a resurgence of research activity on ordered intermetallic alloys.

These researchers were studying the effects of neutron radiation damage on certain types of stainless steels used in nuclear reactors. They would stress the steel until it would break. Then they would study the chemical and atomic composition of the fractured surfaces.

They found that, while the steel had remained in solid polycrystalline form, certain alloying elements, such as phosphorus, tended to migrate to the intergranular fracture surfaces and concentrate there in amounts much larger than normal bulk proportions would predict. Further, they determined that other alloying elements, such as carbon, oxygen, and chromium, did not exhibit this migrating phenomenon, suggesting atomic selectivity.

Importantly, the researchers increased their capabilities in the use of one special research tool called Auger electron spectroscopy. This instrument bombards the top few layers of atoms on a given surface with low energy electrons. This temporarily disturbs the equilibrium nature of the electron shells of these atoms, ultimately resulting in the emission of an identifying spectrum of electrons, whose abundance and energies can be detected and measured. From this spectrum, the constituent elements of the top-most surface layers of a material, including their relative atomic proportions, can be accurately inferred.