HIP Increasingly Used for Upgrading of Castings as Process Becomes More Economical

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Since its invention about 45 years ago, hot isostatic processing (HIP) has grown from a laboratory curiosity to an important commercial process of increasing importance to investment casters and to other industries as well.

The HIP process subjects components to the simultaneous application of heat and high pressure in an inert gas medium. The pressure is uniform in all directions or isostatic.

The HIP process is of unique benefit in the precision casting, powder metallurgy, metal bonding, and ceramics industries. It improves the performance and yield of precision castings.

The process is quite simple. Parts or components are placed in a pressure furnace with inert gas and heated to high temperatures. Using "hot isostatic pressure," the material is changed, in simpler terms, to a "plastic state," which collapses the voids. The clean surfaces of the voids bond together making components stronger. In most cases the voids that were collapsed do not change or alter the shape of the parts or components.

Currently the most widely used applications for HIPing are in the following areas.

Upgrading of castings-- HIP is used rather widely in the production of high-integrity castings. The process closes internal porosity. The quality of investment and sand or graphite mold castings has increased tremendously with the use of *hot isostatic processing* to seal internal voids, thereby improving the properties and reliability of castings.

Consolidation of powders-- metal, ceramic, or composite powders are consolidated by HIP. During this application of pressure and temperature, the powder is compacted to fully dense parts of various intermediate and finished products, including billets to be further worked by forging and rolling from which parts are machined.

High-quality structural ceramic parts-- HIP is used for the production of near net shape parts of structural ceramics, such as silicon nitride, silicon carbides, aluminides, etc.

Rejuvenation of fatigue-damaged parts-- It has been shown that HIP can be used to extend the fatigue life in fatigue-damaged aircraft components.

Diffusion bonding-- Originally, the process was developed to produce larger components of small Zircalloy clad pin type nuclear fuel elements.

Of these five applications, the greatest current commercial application is the upgrading of castings.

Casting Upgrading

Cast alloys are subject to defects that may result in their having lower and more variable mechanical properties than their wrought counterparts. These defects include shrinkage and gas porosity, hot tears, inclusions, and alloy segregation.

Reasonable control of these defects is possible by proper mold design and good foundry practice. However, the complete elimination of other defects, notably shrinkage, from cast shapes is not always possible without applying some external force to accomplish the deformation necessary to close voids and porosity. HIP provides the ideal mechanism for the application of this driving force.

The simultaneous application of heat and pressure combine to collapse voids or porosity by creep mechanisms and plastic deformation to "heal" the material by diffusion bonding the void surfaces together. The isostatic nature of the applied pressure is well suited to healing defects in castings. Void closure is accomplished with minimum, often not measurable, distortion. Workpieces of complex geometry can be treated without the use of complex or expensive tooling.

The many investigations conducted on several classes of materials show that HIPing results in startling improvements in mechanical properties, as well as significantly reduced scrap losses and decreased rework and weld repair requirements.

Of high significance is the marked reduction in the statistical spread or scatter usually associated with cast material properties. Minimum observed values are usually increased. The net result is improved reliability and efficiency of material utilization in cast components. HIP can also render castings fit for applications formerly requiring more expensive forged or wrought and machined materials to meet design specifications.

By incorporating HIP as a part of the manufacturing process, casting producers and users are beginning to reap many benefits. Production yields are increased as the quality of HIPed castings grows. Perhaps most importantly, casting manufacturers who use HIP are experiencing greater freedom in producing their products. Mold design can be simplified to save material formerly used in complex gating, and the placement of chills becomes less critical.

Also, alloys once considered uncastable because of problems with hot tears or the formation of undesirable phases during solidification, now can be redissolved by HIP. In other words, a concept of cast-to-fill and HIP-to-density can

be developed to take full advantage of hot isostatic processing.

HIP offers the casting industry many new opportunities to supply castings, where wrought or forged products were previously used.

Keeping Costs Down

In its early stages of development, hot isostatic processing was expected to be limited to relatively low-volume uses; however, it is now possible to process several tons of material in a single cycle that generally requires only a few hours.

As with most newly developed processes, costs were initially high. As a result, most work using the process involved only very expensive and difficult-to-fabricate materials and generally was limited to a few relatively low-volume applications. The small-volume capabilities further limited the uses of the process. Available equipment also was expensive to use.

The HIP industry now can accommodate high and low-volume users in the same manner by *piggybacking* many customers into one cycle of the larger HIP units. This method makes the process affordable to the smallest investment foundries.

Advantages of piggybacking are:

- no minimum lot size, ideal for short production runs;
- per pound pricing for standard cycles;
- standard cycles are run regularly for fast turnaround; and
- sharing space with other customers means that no single foundry has to pay more that its share of the load price.

Since its development, HIP has matured to a stage where it is used on an industrial scale. It is now used in the aerospace, commercial, military, automotive, and recreational industries. Education in the application and benefits of hot isostatic processing is essential for further development.

While the extent of HIP applications cannot yet be fully defined, the demonstrated benefits make it important to identify areas where technical or cost advantages might be realized.

Kittyhawk Products to Expand HIP Capacity

Kittyhawk Products, a hot isostatic processing (HIP) company which has been a member of the Investment Casting Institute since 1987, is expected to expand its capacity by the first of the year.

A woman-owned small business founded by Lois, G. J., and Charles Barre' to provide service to the casting industry, the company began operation in 1981 with a National Forge HIP unit that has a working zone of 18" x 60" capable of 15,000 PSI and temperatures of up to 2350° F.

In 1986, Kittyhawk Products recognized the need for a larger furnace. A 40" x 60" vessel was commissioned and brought on line. In 1995, Kittyhawk outgrew its facility and doubled its square footage with the purchased its present location. This move also allowed Kittyhawk to upgrade to state-of-the-art controls.

The company is bringing on line a larger, third unit with a 45" x 90" capacity which is expected to be up and running by the first of the year (1999).

Kittyhawk Products achieved ISO 9002 registration in August, 1997. Customers include companies from the aerospace, commercial, military, automotive, and recreational industries. The company is source approved by major prime contractors such as Allied Signal, G.E., Pratt Whitney and Rolls Royce.

Kittyhawk Director of Strategic Planning Charles Barre said the company's goal is to be a quality company that gives personalized service to its customers. "We are committed to saving time and lowering costs. We continue to reach out to different industries through our research and development department to help others that may also benefit from the use of HIP," he said. "Kittyhawk's senior personnel are qualified experts in the field of hot isostatic processing able to provide individualized consultation to the industry. Kittyhawk Products approaches the next century as a complete Toll HIP Service."

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